Raeder et al. BMC Sports Science, Medicine and Rehabilitation (2021) 13:86
https://doi.org/10.1186/s13102-021-00308-x

BMC Sports Science, Medicine and Rehabilitation

RESEARCH

Open Access

Delayed functional therapy after acute lateral ankle sprain increases subjective ankle instability – the later, the worse: a retrospective analysis

Christian Raeder[1*†], Janina Tennler[2†], Arthur Praetorius[1], Tobias Ohmann[2] and Christian Schoepp[1]

Abstract

Background: The lateral ankle sprain (LAS) is one of the most common injuries in everyday and sports activities. Approximately 20–40 % of patients with LAS develop a chronic ankle instability (CAI). The underlying mechanisms for CAI have not yet been clearly clarified. An inadequate rehabilitation after LAS can be speculated, since the LAS is often handled as a minor injury demanding less treatment. Therefore, the aims of this retrospective study were to determine the CAI rate depending on age and sex and to identify possible determinants for developing CAI.

Methods: Between 2015 and 2018 we applied the diagnostic code "sprain of ankle" (ICD S93.4) to identify relevant cases from the database of the BG Klinikum Duisburg, Germany. Patients received a questionnaire containing the Tegner-Score, the Cumberland Ankle Instability Tool (CAIT) and the Foot and Ankle Disability Index. Additionally, there were questions about the modality and beginning of therapy following LAS and the number of recurrent sprains. There was a total of 647 completed datasets. These were divided into a CAI and non-CAI group according to a CAIT cut-off-score with CAI ≤ 24 and non-CAI > 24 points, representing one out of three criteria for having CAI based on international consensus.

Results: The overall CAI rate was 17.3 %. We identified a higher CAI rate in females and within the age segment of 41 to 55 years. A later start of therapy (> 4 weeks) after acute LAS significantly increases ankle instability in CAIT ($p < .05$). There was a significantly higher CAIT score in patients having no recurrent sprain compared to patients having 1–3 recurrent sprains or 4–5 recurrent sprains ($p < .001$).

Conclusions: Females over 41 years show a higher CAI rate which implies to perform specific prevention programs improving ankle function following acute LAS. A delayed start of therapy seems to be an important determinant associated with the development of CAI. Another contributing factor may be a frequent number of recurrent sprains that are also linked to greater levels of subjective ankle instability. Therefore, we would recommend an early start of functional therapy after acute LAS in the future to minimize the development of CAI.

Keywords: Epidemiology, Functional rehabilitation, Ankle injury, Ankle instability, FADI

* Correspondence: christian.raeder@bg-klinikum-duisburg.de
†Christian Raeder and Janina Tennler contributed equally to this work.
[1]Clinic for Arthroscopic Surgery, Sports Traumatology & Sports Medicine, BG Klinikum Duisburg, Duisburg, Germany
Full list of author information is available at the end of the article

Background

The lateral ankle sprain (LAS) is one of the most common musculoskeletal injuries in everyday and sports-related activities [1]. In the general public, an incidence rate between 2.2 and 7 LAS per 1000 person-years has been reported [2]. Up to 70 % of the general population state having suffered from at least one LAS during their lifetime. In addition, there is a twofold increased risk of re-injury in the year following the initial injury [3]. In sports, an incidence rate ranging between 0.88 and 7 LAS per 1000 exposures has been reported, with indoor and court sports showing the greatest injury risk [4]. There is a high rate of recurrent ankle sprains ranging between 12 and 70 % [5, 6] with a five times increased risk of re-injury [7]. This has been shown in particular to be an important contributor for the development of chronic ankle instability (CAI) [1, 5]. Minimizing the recurrence rate should therefore be an important goal of functional therapy after acute LAS.

The medical treatment, work loss as well as a loss of productivity lead to high socioeconomic costs, especially with recurrent sprains and long-term problems [1]. Epidemiological studies have shown that the total costs of a LAS in the European Union range between 800 € and 1100 € [1]. In the Netherlands, productivity loss due to absence from work was responsible for up to 80 % of the total costs of a LAS [8]. In 2019, there were 60,000 LAS in Germany leading to a total of 550,000 lost workdays (on request at the DGUV from 13.08.2020; DGUV, German Statutory Accident Assurance). Approximately 20–40 % of patients with a LAS will develop a CAI which is defined as a continuum of mechanical and/or functional instability resulting in subjective instability, recurrent sprains and persistent pain lasting > 1 year after the initial LAS [6, 9, 10]. Consequently, the LAS is a serious injury of high social relevance that requires adequate treatment to prevent negative long-term effects and chronic symptoms.

One possible explanation for the high instability rate is an insufficient rehabilitation and/or a too early return to intense sports and workloads [3, 11]. Up to now the LAS is still handled as a minor injury that will resolve quickly with limited treatment although the primary LAS is often the start point for severe and long-lasting symptoms [12, 13]. Several risk factors for incurring a LAS have been proposed such as a younger age, a history of recurrent sprains, impaired postural control and decreased muscle strength of the hip and ankle joint [14]. Regarding the development of CAI, Doherty et al. [15] identified a couple of risk factors including an inability of drop landing or jumping within two weeks of the initial LAS injury as well as a poorer dynamic postural control and lower levels of self-reported function six months after the initial LAS injury. For treating patients with CAI, Donovan and Hertel [10] developed an evidence-based rehabilitation paradigm that takes into account the major functional limitations typically associated with CAI. These impairments were divided into four different assessment domains including deficits in range of motion, strength, postural control or balance and functional tasks that enable targeted neuromuscular training therapy based on individual deficiencies. Miklovic et al. [16] suggested that the impairment domains could also be helpful for the treatment of acute LAS, since patient suffer from similar limitations that are mostly not adequately addressed in the acute or subacute phase. Consequently, the authors recommend considering these functional deficits already at an early stage during rehabilitation after an acute LAS to prevent persistent or even chronic symptoms. However, this concept has not yet been empirically proven within a comprehensive approach. In addition, a large proportion of patients do not receive supervised targeted rehabilitation after acute LAS [16, 17], although there are evidence-based recommendations for the effective treatment and prevention of acute and recurrent sprains, such as early mobilization and exercise therapy, and ankle bracing [18–20].

Therefore, the aims of this four-year retrospective study were firstly to determine the CAI rate depending on age and sex, and secondly to identify possible determinants or contributing factors (i.e., modality of therapy, beginning of therapy) for developing CAI and negative long-term consequences. Both are relevant goals to evaluate and possibly optimize current treatment strategies after incurring acute LAS.

Methods

Study design

A retrospective study design was used (Fig. 1). Between 2015 and 2018 we applied the diagnostic code "sprain of ankle" (ICD S93.4) to identify relevant cases from the database of the BG Klinikum Duisburg, Germany. Participants between the ages of 14 to 55 years were included. Valid ankle sprains were defined as acute ankle sprains with no accompanying bone injuries. Cases that did not meet these criteria were excluded. The used criteria were selected due to the recommendations of the International Ankle Consortium [14]. A total of 1478 cases were detected that matched the inclusion criteria.

All patients of the identified cases received a postal questionnaire containing the Tegner-Score and patient-related outcome measures (PROMs) including the Cumberland Ankle Instability Tool (CAIT) and the Foot and Ankle Disability Index (FADI). Additionally, there were questions about the received modality of therapy (i.e., orthosis, physiotherapy and exercise therapy), the beginning of therapy (i.e., immediate start, 1–4 weeks, > 4

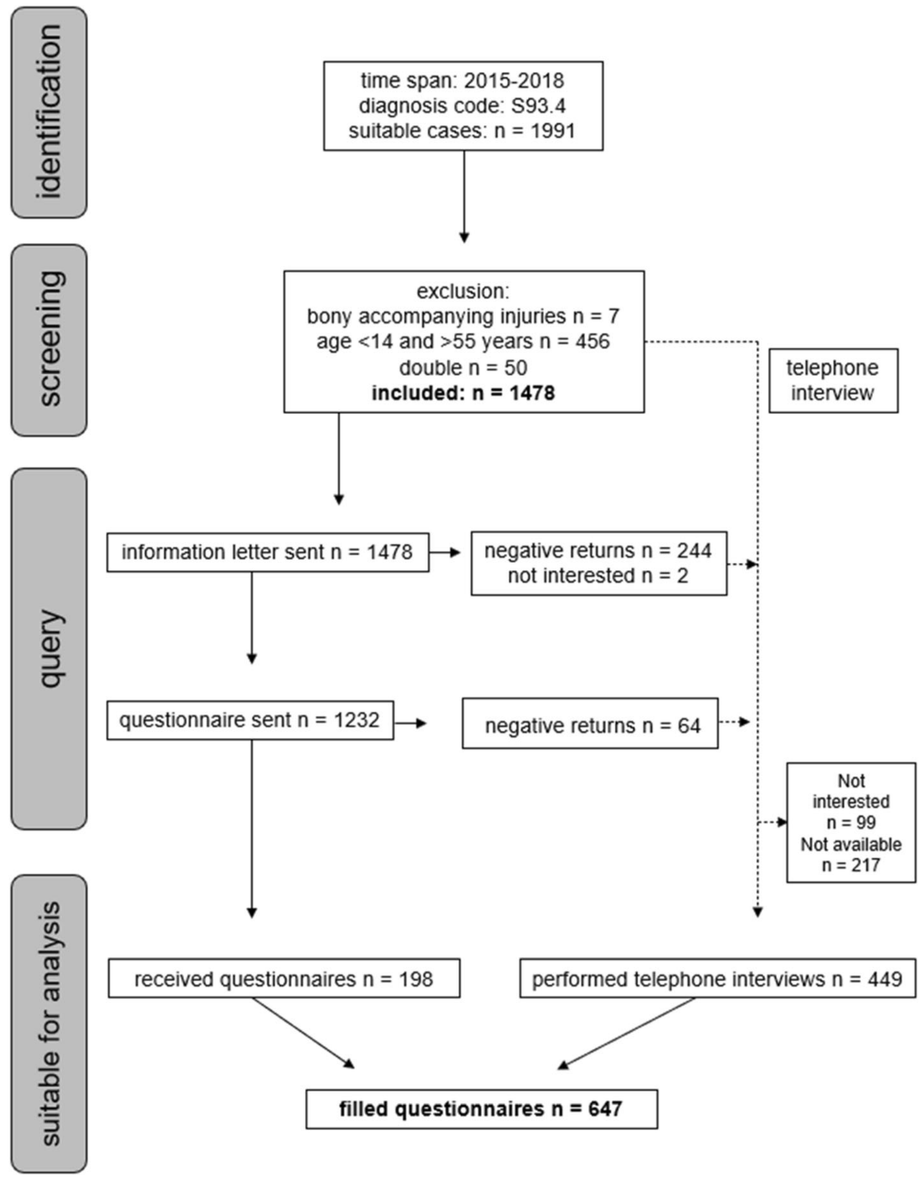


Fig. 1 Flowchart of the study design

weeks or no received therapy), as well as the number of recurrent sprains (i.e., no recurrent sprains, 1-3x, 4-5x). The appropriate answers were marked with a cross by the patients.

The Tegner-Score aims to determine the level of physical activity in patients using different grades on a numerical scale. Its values range from zero to ten, with zero representing being bedridden and ten representing doing competitive sport at a professional level [21]. CAIT and FADI are validated questionnaires to get a subjective insight into regional functional impairments following LAS. The CAIT consists of 9 items measuring the severity of functional ankle instability during the performance of different activities or tasks. The total score ranges from 0 to 30 with 0 representing a painful and strongly instable ankle during low-intense everyday activities and 30 representing a pain-free and subjectively stable ankle even during more intense physical activities. Furthermore, the CAIT is used as a tool to differentiate between individuals suffering from CAI or not by using a predefined cut-off score with CAIT ≤ 24 indicating CAI [22]. The FADI assesses functional limitations of the ankle, consisting of 26 items with the possibility to rate the grade of limitation. It is reported as a percentage of the highest possible score [23, 24]. Due to the low number of valid questionnaires received, an additional phone interview was performed. Because of economic reasons, the phone interview included only the PROMs, CAIT and FADI.

Participants

The received questionnaires ($n = 198$) and additionally performed phone interviews ($n = 449$) led to a total of 647 completed datasets. The sample consisted of 381 male and 266 female participants. Participants were divided into three age groups (14 to 25, 26 to 40 and 41 to 55). Furthermore, they were divided into a CAI and non-CAI group according to the predefined cut-off-score of CAIT ≤ 24, representing at least one out of three selection criteria for having CAI based on international consensus guidelines [22]. Subjects with a CAIT score ≤ 24 points were designated as having CAI, whereas subjects with a CAIT score > 24 points were designated as having non-CAI. Sample characteristics with regard to their level of activity can be seen in Table 1. The study was approved by the local ethics committee (Ärztekammer Nordrhein, 2,018,363) and was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent.

Statistics

Descriptive statistics using frequency analysis were performed to calculate the percentage CAI rate. Since the FADI was not normally distributed, according to the Kolmogorov-Smirnov-Test ($p < .05$), the Mann Whitney U test was performed to assess differences between the CAI and non-CAI groups in the FADI. Independent t-tests were used to analyze the effects of the reported modality of therapy (yes: received vs. no: not received) on the CAIT score. Relative differences in the beginning of therapy between the CAI and non-CAI group were performed using frequency analysis. A one-way ANOVA was used to determine the effects of the beginning of therapy on the CAIT score and to assess the effects of the number of recurrent sprains on the CAIT score. The Tukey post-hoc test was used for pairwise comparisons between the different starting times of therapy. Homogeneity of variance was verified with the Levene's test ($p > .05$). In case homogeneity of variance was violated, a Welch ANOVA using Games-Howell post-hoc analysis was applied. Statistical analysis was done using SPSS Statistics (IBM, Armonk, New York, USA, Version 23.0). Data are presented as mean ± SD unless otherwise stated.

Results

The Tegner score and the frequency of LAS were highest in the younger age group of 14–25 years (46 %) and gradually decreased with advancing age showing the lowest Tegner score and frequency in the older age group of 41–55 years (25 %) (Tables 1 and 2). The overall CAI rate was 17.3 %. Males were consistently less affected than females over all age groups. The highest CAI rate with 22.7 % was found in the 41–55 years age group (Table 2). The total FADI score significantly differed between the CAI and non-CAI group (80.2 ± 16.5 % vs. 97.7 ± 9.2 %; U = 3674.00, Z = -2.237, $p < .05$).

The CAIT significantly differed in the reported frequency categories (mean ± SD; no recurrent sprains, 0x: 28.4 ± 4.7, 1-3x: 18.6 ± 6.9 and 3-5x: 16.0 ± 5.5; $F(2,562) = 81.379$, $p < .001$). Games-Howell post-hoc analysis revealed a significantly higher CAIT score in patients having no recurrent sprain compared to patients having 1–3 recurrent sprains ($p < .001$) or 4–5 recurrent sprains ($p < .001$) (Fig. 2).

There were no significant differences in the CAIT score between the received and non-received modalities of therapy (Fig. 3). Overall, the mean CAIT descriptively decreased with a later beginning of therapy: immediate start (23.4 ± 6.9), 1–4 weeks (20.0 ± 8.5), > 4 weeks (16.4 ± 9.0), no received therapy (18.2 ± 8.1). ANOVA revealed a significant difference between the starting times of therapy ($F(3,145) = 3.34$, $p < .05$) showing a higher CAIT score with an immediate start compared to > 4 weeks following acute LAS ($p < .05$) (Fig. 4). At the group level, a higher percentage in non-CAI started their therapy immediately and after 1–4 weeks. By contrast, there was a higher percentage in CAI starting their

Table 1 Levels of activity separated by age groups

Age group	Tegner-Score	Corresponding level of activity
All	6	Recreational sport: tennis, badminton handball
14–25 years	7	Competitive sport: Tennis, track and field, handball Recreational sport: soccer
26–40 years	5	Heavy physical work Competitive sport: cycling Jogging on uneven terrain
41–55 years	4	Medium heavy physical work Recreational sport: cycling Jogging on even terrain

Table 2 Frequency of LAS, absolute CAI rate and its relative sex distribution in different age groups

	Frequency of LAS (%)	CAI rate (%)	Male (%) of CAI rate	Female (%) of CAI rate
all		17.3	41.4	58.6
14–25 years	45.6	11.7	38.7	61.3
26–40 years	29.4	12.4	47.6	52.4
41–55 years	25.0	22.7	40.0	60.0

therapy after more than 4 weeks or receiving no therapy (Fig. 5).

Discussion

The present study retrospectively analyzed patients with acute LAS treated between 2015 and 2018 in the BG Klinikum Duisburg, Germany. Using PROMs (CAIT & FADI) we collected relevant epidemiological information on the distribution of the CAI rate. We identified a higher CAI rate in females and persons in the age group of 41 to 55 years. We could further show that a later beginning of therapy after acute LAS is associated with increased functional impairments of the ankle. Therefore, early treatment following acute LAS seems to be an effective means in preventing CAI.

The overall CAI rate was about 17 % and thus slightly lower than the CAI rates reported in literature ranging between 20 and 40 % [1, 6, 9, 10, 19]. This could be related to methodological differences in study design such as inclusion criteria and inconsistent terminology according to the definition of CAI. In this study, CAI was classified according to the CAIT score, which is a recommended criteria from the International Ankle Consortium [22]. Our classification is also supported by the FADI since there was a significant difference in the FADI score between the CAI (78.99 %) and non-CAI group (97.05 %).

According to our patients sex we found a higher CAI rate in females (21.2 %) than in males (10.3 %). The females also had higher CAI rates in each of the three age groups. Literature shows that there is in general a higher incidence of ankle sprains in females compared with males (13.6 vs. 6.94 per 1,000 exposures) [4]. This is supported by a higher CAI rate for females in sport (female athletes 32 % vs. male athletes 17 %) [25]. Yet there is no explanation for this prevalence, but there are several assumptions such as increased ankle laxity, increased range of motion, decreased dorsiflexion strength or decreased postural control in females which may contribute to these injuries [26, 27]. Additionally, we speculate that the reduced financial and sportsmedical support in female professional sport compared to their male counterparts might also be a contributing factor. Derived from this, females should focus more on specific prevention programs (e.g. focussing on balance, mobility, strength) to reduce the occurrence of LAS [28].

Doherty et al. [4] state that the incidence of LAS appear to decrease with age. Our data is in line with these findings since we detected a higher LAS frequency in younger compared to older age groups (14–25 years:

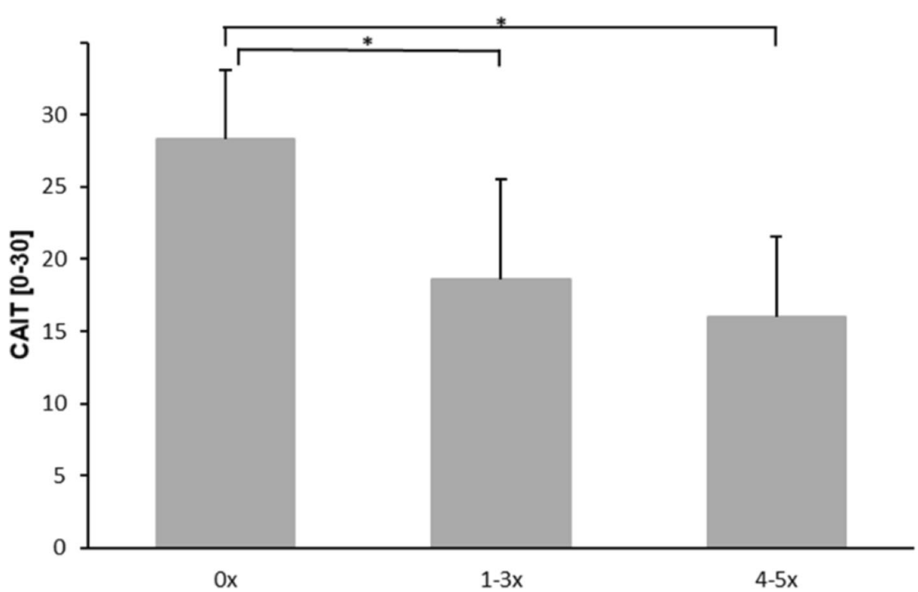


Fig. 2 Functional CAIT outcome depending on the frequency of recurrent ankle sprains. *$p < .001$

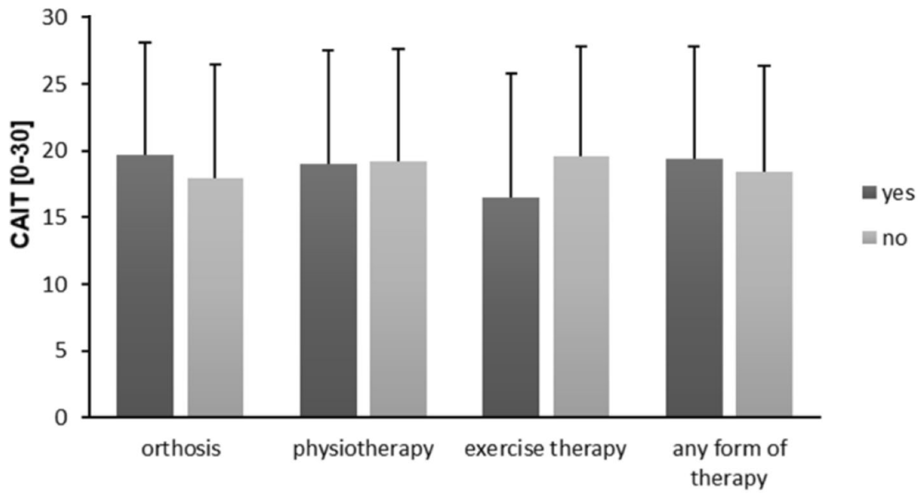


Fig. 3 Functional CAIT outcome depending on the modality of therapy

46 % vs. 26–40 years: 29 % vs. 41–55 years: 25 %). This may be explained by the corresponding level of activity with higher Tegner scores observed in younger (i.e., increased participation in risk sports with stop-and-go characteristics such as soccer) than older populations. Therefore, the implementation of specific prevention routines is recommended prior to sports activity. In contrast, we found a higher CAI rate in older compared to younger age groups (14–25 years: 12 % vs. 26–40 years: 12 % vs. 41–55 years: 23 %). Currently there is no literature investigating the age distribution of CAI. We assume that there is a higher CAI rate with increasing age because older individuals might have a longer history of multiple ankle sprains in their life, which is a major contributing factor for developing CAI [5]. This may provoke adjustments in lifestyle and a reduction in activity levels that could additionally contribute to a greater development of sarcopenia with decreased muscle mass and connective tissue as well as increased impairments in postural or sensorimotor control, causing an increased ankle instability [29–32]. In addition, our data showed that the frequency of recurrent sprains seems to be associated with the degree of subjective ankle instability, since patients who experienced 1–3 and 4–5 recurrent sprains have significantly worse CAIT outcomes than patients having no recurrent sprains. Furthermore,

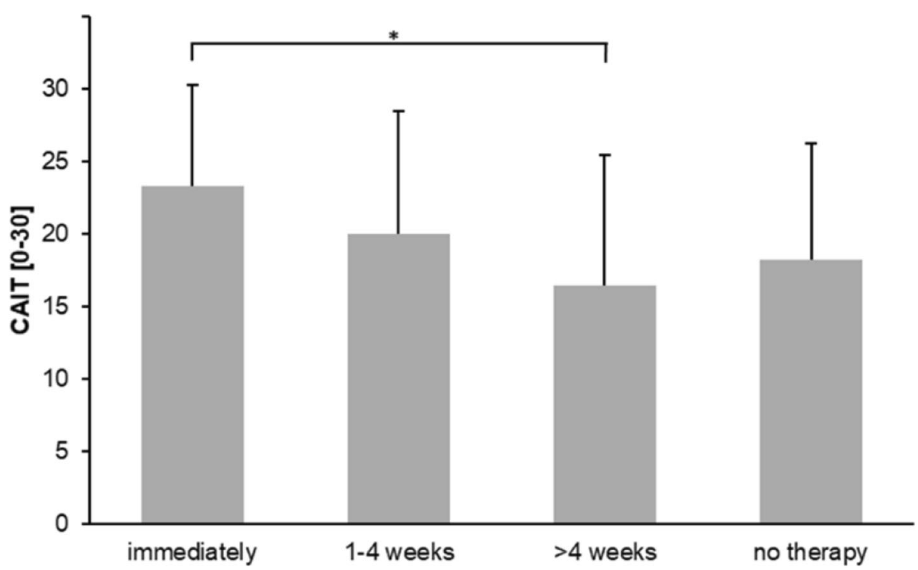


Fig. 4 Functional CAIT outcome according to the beginning of therapy. *$p < .05$

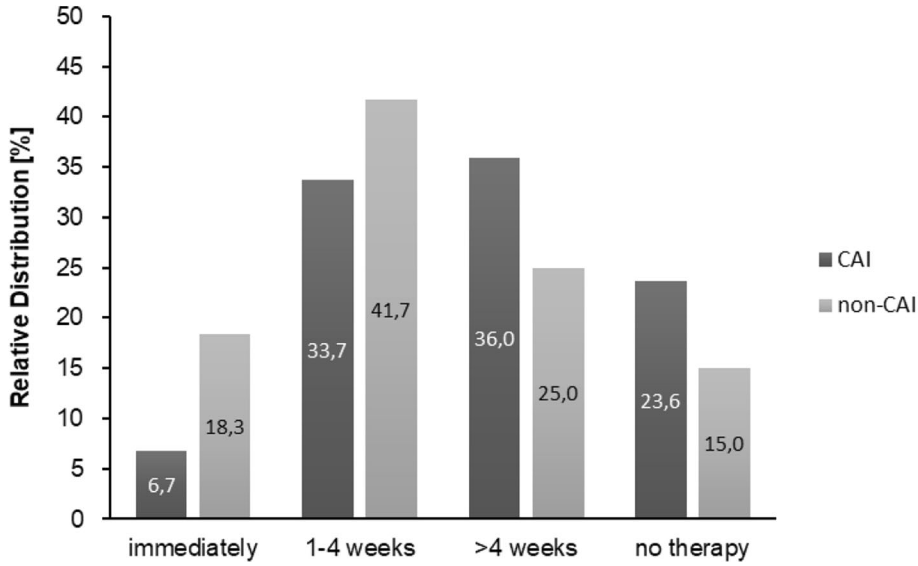


Fig. 5 Relative distribution of CAI and non-CAI according to the beginning of therapy

the CAIT score of the groups with 1–3 and 4–5 recurrent sprains is below the cut-off score of the CAIT (CAIT ≤ 24 indicating CAI), respectively. This implicates that LAS as an injury should be taken seriously and that the focus should be on regaining function as early as possible to prevent recurrent LAS.

With regard to the reported treatment modalities, there were no significant differences in the CAIT score between the received and non-received forms of therapy. Thus, based on the conditions of this study, the functional CAIT outcome does not seem to be generally determined by a specific modality of therapy. As this was a surprising result, we assumed that other factors might play a decisive role on subjective ankle joint function. In this respect, we found that the CAIT score significantly differed between patients receiving their therapy immediately and those who received therapy after more than four weeks. The latter had a worse outcome because of the delayed start of the therapy. This is supported by previous research showing superior treatment effects on subjective ankle function and prevention of CAI in patients with early functional bracing and exercise therapy compared to short-term immobilization [1, 11, 18, 19, 33]. Furthermore, there was a higher percentage of patients in the non-CAI group receiving immediate therapy after acute LAS and, in contrast, a higher percentage of patients in the CAI group receiving therapy after more than four weeks or no therapy at all following acute LAS. We assume that the beginning time of therapy can be seen as an important determinant or contributing factor, respectively, associated with the development of CAI. It seems the later the beginning of therapy after acute LAS the worse the functional outcome.

Limitations

To increase the number of valid PROMs we performed an additional telephone interview. The individual communication might have influenced the perception and response behavior of patients which could have affected the outcome variables. As this was a retrospective study, there is generally a susceptibility to errors since the data might be biased due to the patient's inaccurate recollection of events. That is why relevant information about the quality, intensity, duration and frequency of treatment after acute LAS is currently missing, since we decided to ask more simple questions to improve data quality. However, knowledge of the missing data could have affected the study results. The assignment into a CAI and a non-CAI group is based on only one selection criterion, the cut-off score of CAIT ≤ 24 for the definition of CAI. Future studies investigating CAI patients should therefore consider all three criteria recommended by the International Ankle Consortium [22]. Given diagnoses cannot be proved retrospectively on the basis of the etiology and completeness as well as the grading of the severity of the injury. However, this should be taken into account in future and especially prospective studies.

Conclusions

According to this study, females and older age groups (41–55 years) have a higher risk for developing CAI which implies to focus on specific prevention or therapy programs improving ankle function. Moreover, patients reporting a later start of therapy after acute LAS (> 4 weeks) have a worse functional CAIT outcome, irrespective of the received treatment modality. Thus, a delayed beginning of therapy following acute LAS seems to be an important determinant associated with the development of CAI. A further contributing factor for CAI, suggested by literature, is the number of recurrent sprains which could also be supported by our data. Therefore, we highly recommend an early start of functional therapy after acute LAS in the future to minimize the LAS recurrence rate and the development of CAI. The therapy should be guided by four impairment domains, identified in patients with CAI [16]. These domains consist of range of motion, strength, postural control, and functional tasks. Further research in this area is needed to empirically evaluate the effectiveness of this treatment concept aiming to reduce the CAI rate.

Abbreviations
CAI: Chronic ankle instability; CAIT: Cumberland ankle instability tool; FADI: Foot and ankle disability index; LAS: Lateral ankle sprain; PROMs: Patient related outcome measures

Acknowledgements
This study was supported by REACT e. V. with regard to the cost coverage of postal service.

Authors' contributions
CR, AP and TO contributed to the conception and design of the study. JT performed the data acquisition. JT and CR conducted the data analysis and data interpretation as well as the manuscript preparation and writing. TO, AP, and CS contributed to the revision. All authors read and approved the final manuscript. CR and JT contributed equally to this work.

Funding
The authors received no financial support for the research, authorship, and/or publication of this article.

Availability of data and materials
The datasets generated during and analyzed during the current study are not publicly available due to maintaining control of further data usage or data inclusion in future research projects. In general, we are keen to share our datasets, which is why they are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study and the participation of underage subjects were approved by the local ethics committee (Ärztekammer Nordrhein, 2018363). All participants provided written informed consent before the start of this study.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Author details
[1]Clinic for Arthroscopic Surgery, Sports Traumatology & Sports Medicine, BG Klinikum Duisburg, Duisburg, Germany. [2]Research Department, BG Klinikum Duisburg, Duisburg, Germany.

Received: 22 February 2021 Accepted: 12 July 2021
Published online: 06 August 2021

References
1. Gribble PA, Bleakley CM, Caulfield BM, Docherty CL, Fourchet F, Fong DT. Evidence review for the 2016 International Ankle Consortium consensus statement on the prevalence, impact and long-term consequences of lateral ankle sprains. Br J Sports Med. 2016;50(24):1496–505.
2. Hiller CE, Nightingale EJ, Raymond J, Kilbreath SL, Burns J, Black DA. Prevalence and impact of chronic musculoskeletal ankle disorders in the community. Arch Phys Med Rehabil. 2012;93(10):1801–7.
3. Delahunt E, Bleakley CM, Bossard DS, Caulfield BM, Docherty CL, Doherty C. Clinical assessment of acute lateral ankle sprain injuries (ROAST): 2019 consensus statement and recommendations of the International Ankle Consortium. Br J Sports Med. 2018;52(20):1304–10.
4. Doherty C, Delahunt E, Caulfield B, Hertel J, Ryan J, Bleakley C. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. Sports Med. 2014;44(1):123–40.
5. Herzog MM, Kerr ZY, Marshall SW, Wikstrom EA. Epidemiology of ankle sprains and chronic ankle instability. J Athl Train. 2019;54(6):603–10.
6. Hertel J. Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. J Athl Train. 2002;37(4):12.
7. Ergen E, Ulkar B. Proprioception and Ankle Injuries in Soccer. Clin Sports Med. 2008;27(1):195–217.
8. Kerkhoffs GM, van den Bekerom M, Elders LAM, van Beek PA, Hullegie WAM, Bloemers GMFM. Diagnosis, treatment and prevention of ankle sprains: an evidence-based clinical guideline. Br J Sports Med. 2012;46(12):854–60.
9. Attenborough AS, Hiller CE, Smith RM, Stuelcken M, Greene A, Sinclair PJ. Chronic ankle instability in sporting populations. Sports Med. 2014;44(11):1545–56.
10. Donovan L, Hertel J. A new paradigm for rehabilitation of patients with chronic ankle instability. Phys Sportsmed. 2012;40(4):41–51.
11. Polzer H, Kanz KG, Prall WC, Haasters F, Ockert B, Mutschler W. Diagnosis and treatment of acute ankle injuries: development of an evidence-based algorithm. Orthop Rev. 2012;4(1):5.
12. Birrer RB, Fani-Salek MH, Totten VY, Herman LM, Politi V. Managing ankle injuries in the emergency department. J Emerg Med. 1999;17(4):651–60.
13. McKeon PO, Donovan L. A perceptual framework for conservative treatment and rehabilitation of ankle sprains: an evidence-based paradigm shift. J Athl Train. 2019;54(6):628–38.
14. Delahunt E, Remus A. Risk factors for lateral ankle sprains and chronic ankle instability. J Athl Train. 2019;54(6):611–6.
15. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Recovery from a first-time lateral ankle sprain and the predictors of chronic ankle instability: a prospective cohort analysis. Am J Sports Med. 2016;44(4):995–1003.
16. Miklovic TM, Donovan L, Protzuk OA, Kang MS, Feger MA. Acute lateral ankle sprain to chronic ankle instability: a pathway of dysfunction. Phys Sportsmed. 2018;46(1):116–22.
17. Feger MA, Glaviano NR, Donovan L, Hart JM, Saliba SA, Park JS. Current trends in the management of lateral ankle sprain in the United States. Clin J Sport Med. 2017;27(2):145–52.
18. Vuurberg G, Hoorntje A, Wink LM, van der Doelen BFW, van den Bekerom MP, Dekker R. Diagnosis, treatment and prevention of ankle sprains: update of an evidence-based clinical guideline. Br J Sports Med. 2018;52(15):956–956.
19. Doherty C, Bleakley C, Delahunt E, Holden S. Treatment and prevention of acute and recurrent ankle sprain: an overview of systematic reviews with meta-analysis. Br J Sports Med. 2017;51(2):113–25.
20. Kaminski TW, Needle AR, Delahunt E. Prevention of lateral ankle sprains. J Athl Train. 2019;54(6):650–61.
21. Briggs KK, Lysholm J, Tegner Y, Rodkey WG, Kocher MS, Steadman JR. The reliability, validity, and responsiveness of the lysholm score and tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. Am J Sports Med. 2009;37(5):890–7.
22. Gribble PA, Delahunt E, Bleakley C, Caulfield B, Docherty C, Fourchet F. Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the international ankle consortium. J Orthop Sports Phys Ther. 2013;43(8):585–91.
23. Hale SA, Hertel J. Reliability and sensitivity of the foot and ankle disability index in subjects with chronic ankle instability. J Athl Train. 2005;40(1):35–40.
24. Hiller CE, Refshauge KM, Bundy AC, Herbert RD, Kilbreath SL. The Cumberland ankle instability tool: a report of validity and reliability testing. Arch Phys Med Rehabil. 2006;87(9):1235–41.
25. Tanen L, Docherty CL, van der Pol B, Simon J, Schrader J. Prevalence of chronic ankle instability in high school and division I athletes. Foot Ankle Special. 2014;7(1):37–44.

26. Ericksen H, Gribble PA. Sex differences, hormone fluctuations, ankle stability, and dynamic postural control. J Athl Train. 2012;47(2):143–8.
27. Willems TM, Witvrouw E, Delbaere K, Mahieu N, De Bourdeaudhuij L, De Clercq D. Intrinsic risk factors for inversion ankle sprains in male subjects: a prospective study. Am J Sports Med. 2005;33(3):415–23.
28. Caldemeyer LE, Brown SM, Mulcahey MK. Neuromuscular training for the prevention of ankle sprains in female athletes: a systematic review. Phys Sportsmed. 2020;48(4):363–9.
29. Lang T, Streeper T, Cawthon P, Baldwin K, Taaffe DR, Harris TB. Sarcopenia: etiology, clinical consequences, intervention, and assessment. Osteoporos Int. 2010;21(4):543–59.
30. Larsson L, Degens H, Li M, Salviati L, Lee YL, Thompson W, et al. Sarcopenia: aging-related loss of muscle mass and function. Physiol Rev. 2019;99(1):427–511.
31. Hepple RT, Rice CL. Innervation and neuromuscular control in ageing skeletal muscle: Innervation and neuromuscular control in ageing skeletal muscle. J Physiol. 2016;594(8):1965–78.
32. Granacher U, Zahner L, Gollhofer A. Strength, power, and postural control in seniors: considerations for functional adaptations and for fall prevention. Eur J Sport Sci. 2008;8(6):325–40.
33. Eiff MP, Smith AT, Smith GE. Early mobilization versus immobilization in the treatment of lateral ankle sprains. Am J Sports Med. 1994;22(1):83–8.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Journal of Science and Medicine in Sport 19 (2016) 465–469

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Interventions preventing ankle sprains; previous injury and high-risk sport participation as predictors of compliance

Kasper W. Janssen[a,b,*], Babette C. van der Zwaard[c], Caroline F. Finch[d], Willem van Mechelen[a], Evert A.L.M. Verhagen[a]

[a] Department of Public & Occupational Health and EMGO Institute for Health and Care Research, VU University Medical Center, Van der Boechorststraat 7, 1081, Amsterdam BT, The Netherlands
[b] Department of Sport and Exercise Medicine, De Sportartsengroep, Sint Lucas Andreas Hospital, Jan Tooropstraat 164, 1061, Amsterdam, AE, The Netherlands
[c] Department of General practice and Elderly care medicine and EMGO Institute for Health and Care Research, VU University Medical Center, Van der Boechorststraat 7, 1081, Amsterdam, BT, The Netherlands
[d] Australian Centre for Research into Injury in Sport and its Prevention (ACRISP), Federation University Australia, PO Box 668, Ballarat, VIC, 3353, Australia

ARTICLE INFO

Article history:
Received 27 October 2014
Received in revised form 27 April 2015
Accepted 8 June 2015
Available online 16 June 2015

Keywords:
Ankle injuries
Ligament sprain
Sports
Neuromuscular training
Braces

ABSTRACT

Objectives: To describe the association between participants' person-related potential predictor variables and cumulative compliance with interventions for preventing ankle sprains: neuromuscular training, wearing an ankle brace, and a combined training and bracing.
Design: Secondary analysis of compliance data from a randomized controlled trial (RCT) comparing measures preventing ankle ligament injuries.
Methods: Ordinal regression with a backward selection method was used to obtain a descriptive statistical model linking participants' person-related potential predictor variables with the monthly cumulative compliance measurements for three interventions preventing ankle ligament injuries.
Results: Having had a previous ankle injury was significantly associated with a higher compliance with all of the preventive measures trialed. Overall compliance with bracing and the combined intervention was significantly lower than the compliance with NM training. Per group analysis found that participating in a high-risk sport, like soccer, basketball, and volleyball, was significantly associated with a higher compliance with bracing, or a combined bracing and NM training. In contrast, participating in a high-risk sport was significantly associated with a lower per group compliance with NM training.
Conclusions: Future studies should include at least registration of previous ankle sprains, sport participation (high- or low-risk), experience in NM training, and hours of sport exposure as possible predictors of compliance with interventions preventing ankle sprains. Practitioners should take into account these variables when prescribing preventive neuromuscular training or bracing.

1. Introduction

Preventive interventions are commonly used in various sports to reduce the number of sports injuries. When translating evidence-based preventive interventions into daily practice in sports, an important issue to address is compliance.[1] In sports injury prevention research, compliance is a term used to indicate the athlete's correct execution of the prescribed intervention.[2] In the preferred research design setting for the evaluation of the efficacy of sports injury preventive interventions, i.e., a randomized controlled trial (RCT), compliance can be optimized by the use of a well-defined protocol that must be complied with. This compliance can be monitored by researchers, practitioners, coaches or athletic trainers, or self-monitored by the participants.

In recent years, there has been a trend toward more effectiveness studies, to determine how well efficacious interventions work when applied in a practical context.[3] In a previous ankle sprain prevention trial on home-based neuromuscular (NM) training by our group, only 23% of the participants fully complied with the protocol. A secondary per protocol analyses showed that the established intervention effect was over threefold higher for fully compliant participants when compared to the controls.[2] In line with these

* Corresponding author at: VU University Medical Center, Department of Public & Occupational Health and EMGO, Institute for Health and Care Research, Van der Boechorststraat 7, 1081 Amsterdam, Netherlands. Tel.: +31 618878016.
E-mail address: kasperjanssen@thesportsphysician.nl (K.W. Janssen).

http://dx.doi.org/10.1016/j.jsams.2015.06.005
1440-2440/

results, Steffen et al.[4] found a lower risk for lower extremity injuries in high-compliant athletes versus medium-compliant athletes with the FIFA11+ program in soccer. Furthermore, McGuine[5] et al. recently provided evidence for the use of sports braces, as preventive measures in male and female high school basketball athletes, both with and without a previous history of an ankle injury. In 59% of the training sessions and games, participants were compliant with the preventive brace advice, as monitored by athletic trainers. As this and an earlier study[2] showed, there can be degrees of usage of an intervention whether it is wearing protective equipment or performing a training program. What is lacking from the literature is a direct comparative assessment of the possible predictors of compliance with home-based interventions preventing ankle ligament injuries.

In a recent RCT, the cost-effectiveness of secondary ankle sprain prevention by the use of NM training or bracing was assessed against the combined use of both NM training and bracing.[6] Although bracing was found to be superior to NM training for the prevention of recurrent ankle sprains, as could be expected, the compliance with each intervention varied substantially. In the aforementioned studies, higher compliance resulted in a lower relative risk of a recurrent ankle sprain. To predict compliance with sport injury rehabilitation, Taylor and May[7] applied the protection motivation theory. They concluded that athletes with higher perceptions of susceptibility to reinjury were more likely to adhere to their rehabilitation program. Accordingly, at least in theory, we should be able to optimize preventive effects for the individual if we can tailor intervention advice, taking into account person-related predictor variables associated with higher compliance. Therefore, the aim of this study was to describe the association between person-related potential predictor variables and cumulative compliance with prescribed interventions in this RCT.[6]

2. Methods

This study is a secondary analysis of data from a previously published RCT on the cost-effectiveness of prevention of ankle sprain recurrences.[6,8,9] The main study design and interventions have been described in detail elsewhere.[9] The study design, procedures, and informed consent procedure were approved by the Medical Ethics Committee (number 31785.029.10) of the VU University Medical Centre, the Netherlands. Trial register number NTR 2157.

All participants provided written informed consent. Briefly, an RCT was conducted in athletes ($n = 384$) who had sprained their ankle. All participants received treatment, according to usual care, after which they were randomized to one of the three intervention groups. Participants allocated to the NM training-only group received an 8 week unsupervised NM training program. Participants in this group received a balance board (Avanco AB, Sweden), exercise sheets, and an instructional DVD of the exercises. Participants allocated to the brace-only group received a semirigid ankle brace (Aircast A60, DJO) to be worn during all sports activities for the duration of 1 year and an instruction sheet on brace use. A third combination group received both the NM training program and a sports brace to be worn during all sports activities for the duration of eight 8 weeks. The instruction sheet on brace use, exercise sheet on NM training, and videos of the exercises were also provided on a website that was accessible only to the relevant intervention group.

During a 1 year follow-up, participants self-reported compliance with the prescribed intervention through items in the monthly questionnaire. The item(s) on compliance are presented in Table 1. The term fully compliant was used for participants who reported "always (>75%)" on average for the respective items. The term partially compliant was used for participants who reported "most of the time (about 50%)" on average for the respective items. Participants who reported "never (0%)" or "sometimes (about 25%)" on average for the respective items were considered not to have complied with the prescribed program. Although these three categories were chosen arbitrarily, we believe that adding percentages to the description and combining the first two options "never (0%)" and "sometimes (25%)" into a single category of "not compliant" minimizes central tendency bias and differentiates between participants who did and did not comply with the prescribed program.

Table 1
Compliance item(s) and answer options per intervention group.

Group	Compliance item	Answer options
NM training (one item)	Did you perform the exercises as prescribed in the last 4 weeks?	No, never Yes, sometimes (about 25% of the prescribed training sessions) Yes, most of the time (about 50% of the prescribed training sessions) Yes, always (more than 75% of the prescribed training sessions)
Brace (two items)	Did you wear the brace during training as prescribed in the last 4 weeks? Did you wear the brace during competition as prescribed in the last 4 weeks?	No, never Yes, sometimes (about 25% of the training/competition sessions) Yes, most of the time (about 50% of the training/competition sessions) Yes, always (more than 75% of the training/competition sessions)
Combination (three items)	Did you perform the exercises as prescribed in the last4 weeks? Did you wear the brace during training as prescribed in the last four weeks? Did you wear the brace during competition as prescribed in the last four weeks?	No, never Yes, sometimes (about 25% of the prescribed/training/competition sessions) Yes, most of the time (about 50% of the prescribed/training/competition sessions) Yes, always (more than 75% of the prescribed/training/competition sessions)

As no valid measurement or consensus on self-reported compliance with training programs, or brace use exists, the choice to measure compliance through these items was based on the experience in a previous trial.[10] The monthly compliance item scores were recoded into one overall score. As loss to follow-up was only six% we decided to impute the compliance data via "last observation carried forward" method. The scores were recoded into a numerical variable (i.e., 0% = 0; 25% = 1; 50% = 2, and >75% = 3). A mean compliance score across participants allocated to each intervention was calculated and used in the analyses.

In the current study, the association between person-related potential predictor variables and compliance was the primary outcome. Consistent with other studies,[2] we assumed that a higher compliance with these interventions would generate a larger decrease in injury risk. Person-related potential predictor variables were derived from the available baseline dataset and included: intervention group, age, previous ankle injury, experience with tape/brace use, experience with NM training, high-risk sport participation, education at inclusion, and monthly registered hours of exposure during follow-up. "Intervention group" was included because full compliance to the intervention groups differed substantially (NM training 45%, brace 23%, and combination 28%). Interactions between age and self-motivation for home exercise completion have also been documented.[11] A previous ankle sprain has been showed to be followed by a higher perception of susceptibility to reinjury, and therefore, a higher compliance with the intervention is likely.[12] If NM training has been performed previously, there will be participant insight into the features of the intervention program, and possibly consumer satisfaction with the intervention, which makes a higher compliance likely.[13] For experience with tape/brace use, the previous argument also supports inclusion of this variable. When incidence of injury is high in a specific sport, this could be followed by a higher perception of susceptibility to injury, and therefore, a higher compliance is likely for high-risk sport participation.[12] In medication trials, low education level is shown to be a predictor of non-compliance and treatment discontinuation.[14] Low compliance versus high compliance athletes with an injury prevention program in football were linked to a three times lower exposure.[15]

Several variables were not included in the candidate statistical models because of insufficient evidence or clinical reasoning relating them to compliance. These included: gender, weight, height, sport experience (years), severity of inclusion sprain (minor/severe), and medical treatment (medical/nonmedical). Although, it is known from other research areas that in general, females are more compliant with instructions than males, we are not aware of studies that have shown specifically that females are more compliant to preventive NM training and bracing than men. Furthermore, we had to restrict the number of included person-related potential predictor variables due to the limited number of participants per group, and thus power.

Ordinal regression with a backward selection method was used to obtain a descriptive model of the association between participants' person-related potential predictor variables (Table 3) and the monthly compliance measurements to the three interventions. In the construction of the ordinal regression model, a backward elimination procedure with a $p > 0.10$ criterion for variable elimination was applied. The interventions for the NM training group and combination group lasted only 2 months compared to 12 months for the brace group. Therefore, as a sensitivity analysis, we repeated the procedures of the model with the same variables to evaluate compliance for the brace group in the first 2 months only. The assumption that the relationships between independent variables and different adherence groups are the same for the three adherence groups was tested using a test of parallel lines ($p > 0.05$). We modeled the association between person-related potential predictor variables and the "cumulative compliance," as in our model the outcome compliance was categorized into: no compliance (participants who executed 25% or less of the prescribed intervention), partial compliance (participants who executed about 50% of the intervention), and full compliance (participants who executed 75% or more of the prescribed intervention). For readability, we hereafter use the term "association with compliance," while technically we mean "association with cumulative compliance."

3. Results

Forty-four participants had neither received nor started their allocated intervention and were excluded. Data from 340 participants were included in the analyses. The intervention groups were comparable on all measured variables at baseline. A complete overview of baseline variables has been published elsewhere.[6] The drop-out rate during the trial was also similar between groups.

Forty-nine (45%) of the NM training group athletes, 27 (23%) of the sports brace group athletes, and 34 (28%) of the combination group athletes indicated that they had fully complied with their allocated intervention. The compliance percentages, number of injuries, hours of exposure, and incidence rates for all groups are presented in Table 2.

Overall, a significant positive association between compliance and the interventions was found for participants with a history of "previous ankle sprain." In other words, having had a previous ankle injury increased the likelihood of a higher compliance with any of the interventions (OR 1.72; 95% CI 1.09–2.70). Compliance in the brace and combination group was significantly lower compared to compliance in the NM training group (brace vs. NM training OR 0.28 (95% CI 0.17–0.47) and combination vs. NM training OR 0.58 (95% CI 0.36–0.95)). Furthermore, participants playing a high-risk sport had an increased probability of being more compliant with any of the interventions (OR 1.53; 95% CI 1.02–2.29).

Table 3 summarizes the results of the ordinal regression analyses of variables associated with compliance within the three intervention groups. Within the NM training group, a significant positive association with compliance was found for participants with a previous ankle injury and experience in NM training. A significant negative association with compliance was found for those who played a high-risk sport at inclusion. Furthermore, a higher number of hours of sports per month is associated with a higher compliance. Within the brace and combination groups, a significant positive association with compliance was found for high-risk sport participants.

At 2 months follow-up, 48% of the participants in the brace group fully complied with the intervention versus 45% in the NM training group. We performed a sensitivity analysis by analyzing compliance in athletes participating in a high-risk sport for each intervention group after 2 months of follow-up. This analysis showed that, of the athletes participating in a high-risk sport, 58% were fully compliant with bracing versus 38% who were fully compliant with NM training. This indicates that over a 2 month period, participants in a high-risk sport were more likely to comply with bracing than with NM training.

Table 2
Participants, recurrent ankle sprains, exposure, and incidence rate for the three different intervention groups per compliance category.

Compliance sub-group	Participants		Recurrent ankle sprains	Exposure to sports participation	Incidence rate = recurrent ankle sprains/1000 h
	n	%	*n*	Total h	(95%CI)
NM Training					
Total	110	100	29	11,565	2.51 (1.59–3.42)
Full compliance	49	45	16	5907	2.71 (1.38–4.04)
Partial compliance	31	28	8	3276	2.44 (0.74–4.13)
No compliance	30	27	5	2382	2.10 (0.26–3.94)
Sports Brace					
Total	117	100	17	12,678	1.34 (0.70–1.98)
Full compliance	27	23	4	3309	1.21 (0.02–2.39)
Partial compliance	22	19	4	2018	1.98 (0.04–3.92)
No compliance	68	58	9	7351	1.22 (0.42–2.02)
Combination					
Total	122	100	23	12,931	1.78 (1.05–2.51)
Full compliance	34	28	3	3824	0.78 (0.00–1.67)
Partial compliance	44	36	9	4802	1.87 (0.65–3.10)
No compliance	44	36	11	4305	2.56 (1.05–4.07)

Table 3
Association of person-related potential predictor variables with compliance within the 3 intervention groups–results from the ordinal regression analyses.

A. Significant association of person-related potential predictor variables with compliance for NM Training group

	Variable coding	OR	95% CI	Interpretation
Previous ankle injury	No prior injury* Prior injury	2.23	1.07–5.29	Having had a previous ankle injury is associated with a **higher** compliance
Previous experience NMT	No prior experience* Prior experience	2.23	1.01–4.84	Having had previous experience with NMT is associated with a **higher** compliance
Exposition/Month	Hours/Month	1.07	1.00–1.14	Increased hours of sports participation is associated with a **higher** compliance
High-/Low-risk sport	Low-risk sport (e.g., running, tennis, . . .)* High-risk sport (e.g. soccer, basketball, volleyball, . . .)	0.43	0.19–0.96	Participating in a high-risk sport is associated with a **lower** compliance

B. Association of person-related potential predictor variables with compliance for brace group

	Variable coding	OR	95% CI	Interpretation
High-/low-risk sport	Low-risk sport (e.g., running, tennis, . . .)* High-risk sport (e.g. soccer, basketball, volleyball, . . .)	3.39	1.49–7.44	Participating in a high-risk sport is associated with a **higher** compliance

C. Association of person-related potential predictor variables with compliance for combination group.

	Variable coding	OR	95% CI	Interpretation
High-/Low-risk sport	Low-risk sport (e.g., running, tennis, . . .)* High-risk sport (e.g. soccer, basketball, volleyball, . . .)	2.49	1.27–4.92	Participating in a high-risk sport is associated with a **higher** compliance

A: NM Training group, B: Brace group, C: Combination group.
* Reference group.

4. Discussion

The purpose of this study was to describe the association between participants' person-related potential predictor variables and cumulative compliance with NM training, bracing, and the combined intervention. Our results show that having had a previous ankle injury was significantly associated with a higher compliance with all of the preventive measures trialed. Compliance with bracing and the combined intervention was significantly lower compared to compliance with NM training. Per group analysis found that participating in a high-risk sport was significantly associated with a higher compliance with bracing or a combined bracing and NM training, while participating in a high-risk sport was significantly associated with a lower compliance with NM training.

Research on compliance with interventions preventing ankle ligament injuries has mainly focused on interventions in the clinical setting, for example physical therapy. Basset et al.,[16] conducted one of the few trials that studied compliance with a clinic-based versus a home-based intervention to treat ankle sprains in a study population of mainly athletes ($n = 52$) and reported significant higher levels of compliance with the physical therapy intervention for the home-based intervention group. The home-based intervention group had comparable results in terms of recovery and treatment compliance when compared to the clinic-based intervention group. However, for several reasons, the results from this study cannot be compared to our results. Firstly, the home-based intervention included clinical appointments where patients received treatment information on the home-based program. Secondly, different measures of self-reported compliance were used. Thirdly, this study was concerned with treatment, not prevention, of ankle sprains.

A second study, from Hume et al.,[17] described injuries and the injury prevention behaviors of players requiring treatment during an Australian Netball Championship. Over the 3-day tournament, 131 female players (mean age of 18.4 years) were injured and sought treatment. Despite implementation of injury prevention programs, 49% of injured players had previously sustained the same injury, with a direct related recurrent injury in 36% of the cases. In addition to this high number of recurrent injuries, it was found that there was a low awareness of effective preventive measures such as NM training. To improve compliance with injury prevention initiatives, Hume et al.[17] suggested targeting school students instead of the netball associations. As these results were all obtained from a cross-sectional survey and details of the preventive interventions used were unknown, these results cannot be directly compared to our results. Because the suggestion of targeting specific subgroups of athletes to improve compliance is in line with the current focus on person-related potential predictor variables associated with compliance with the prescribed interventions, then subgroups of athletes with a "history of previous ankle sprain", a "history of experience with NM training", and "high or low-risk sport participation for sustaining an ankle sprain" are to be targeted.

One of the main theoretical approaches to predict compliance with sport injury rehabilitation is the "protection motivation theory".[12] This theory describes two cognitive processes involved in the decision to adopt protective health behaviors, or alternatively, to produce maladaptive responses: i.e., the threat appraisal process and the coping appraisal process. The threat appraisal process involves a perception of the severity of a potentially harmful situation (e.g., an athlete's perception of how likely it is that injury severity is a threat to their health). The coping appraisal process involves a perception of how likely a particular course of action reduces or prevents the threat (labeled response efficacy;

for example, how an athlete's response will be effective). Taylor and May[7] used this theory to predict compliance and reported that athletes with higher perceptions of susceptibility to reinjury were more likely to comply with their rehabilitation program.[7] This is in line with our finding that having had a previous ankle injury significantly increased overall compliance with the preventive measures. In contrast, a recent study found no influence of injury history on adherence to the FIFA 11+ in female soccer, but that study did not assess this in relation to specific injuries.[18] Taylor and May[7] found that stronger self-belief in the ability to complete the prescribed intervention also increased compliance as did greater expectancy in the benefits of rehabilitation. Therefore, it would be advisable for future studies to investigate the tailored prescription of NM training and different brace types based on individual preference of athletes from different sports to optimize the chance of the athlete successfully completing the prescribed intervention.

A main limitation for interpretation of the results of this study is the potential of recall bias, as self-reported compliance was measured via a monthly questionnaire. We assigned percentages to the description of the compliance categories to reduce the risk of misclassification. Furthermore, by using separate items for compliance scores on brace use in training and competition, we tried to lower misclassification of compliance categories in bracing. Although our method of compliance measurement has been used before,[2] there is no consensus on how to measure compliance, and so the internal validity of our study could have been hampered. Even when these limitations are taken into account, our results are of value because the straightforward preventive interventions were applied to a broad population of athletes across a wide age spectrum. Therefore, external validity with respect to athletic populations is high. A major strength of this study is that it was based on the first RCT to directly compare the three interventions: i.e., bracing, NM training and the combined intervention versus each other.[6]

5. Conclusion

In this study, we focused on describing the association of person-related potential predictor variables with compliance with different interventions used to prevent ankle sprains. Our results can give direction to future research conducted to decide which baseline characteristics are of interest as possible predictors of compliance. Future studies should include at least registration of previous injuries (e.g., previous ankle sprains), sport participation (high- or low-risk), experience in NM training and hours of sport exposure as possible predictors of compliance with interventions preventing ankle sprains.

Practical implications

The first 2 months compliance to home-based NM training alone and bracing alone during sports is comparable, while combining the two interventions decreases compliance substantially.

Practitioners prescribing preventive NM training or bracing to athletes should take into account "history of previous ankle sprains", "history of experience with NM training," and "high- or low-risk sport participation for sustaining an ankle sprain", to optimize compliance with these interventions.

Athletes without a history of previous ankle sprains and athletes who did not previously perform home-based NM training are substantially less likely to comply with NM training.

In contrast, athletes who participate in a sport that is high-risk for sustaining an ankle sprain, like soccer, basketball, and volleyball, are substantially more likely to comply with wearing a brace during sports.

Acknowledgments

The study was funded by the Netherlands Organisation for Health Research and Development (ZonMW), grant number 80-82310-97-10063. DJO Europe provided the Aircast A60 Ankle support braces, worth €5000.

References

1. Hagglund M, Atroshi I, Wagner P et al. Superior compliance with a neuromuscular training programme is associated with fewer ACL injuries and fewer acute knee injuries in female adolescent football players: secondary analysis of an RCT. *Br J Sports Med* 2013; 47(15):974–979.
2. Verhagen EA, Hupperets MD, Finch CF et al. The impact of adherence on sports injury prevention effect estimates in randomised controlled trials: looking beyond the CONSORT statement. *J Sci Med Sport* 2011; 14(4):287–292.
3. Verhagen E, Voogt N, Bruinsma A et al. Knowledge transfer scheme to bridge the gap between science and practice: an integration of existing research frameworks into a tool for practice. *Br J Sports Med* 2013; 48.
4. Steffen K, Emery CA, Romiti M et al. High adherence to a neuromuscular injury prevention programme (FIFA 11+) improves functional balance and reduces injury risk in Canadian youth female football players: a cluster randomised trial. *Br J Sports Med* 2013; 47(12):794–802.
5. McGuine TABAHS. The effect of lace-up ankle braces on injury rates in high school basketball players. *Am J Sports Med* 2011; 39(9):1840–1848.
6. Janssen KW, van Mechelen W, Verhagen EA. Bracing superior to neuromuscular training for the prevention of self-reported recurrent ankle sprains: a three-arm randomised controlled trial. *Br J Sports Med* 2014; 48(16):1235–1239.
7. Taylor AH, May S. Threat and coping appraisal as determinants of compliance to sports injury rehabilitation: an application of protection motivation theory. *J Sports Sci* 1996; 14:471–782.
8. Janssen KW, Van Mechelen W, Verhagen EALM. The cost-effectiveness of measures to prevent recurrent ankle sprains; results of a three arm randomised controlled trial. *Am J Sports Med* 2014; 42(7):1534–1541.
9. Janssen KW, van Mechelen W, Verhagen EA. Ankles back in randomized controlled trial (ABrCt): braces versus neuromuscular exercises for the secondary prevention of ankle sprains. Design of a randomised controlled trial. *BMC Musculoskelet Disord* 2011; 12:210.
10. Hupperets MD, Verhagen EA, van Mechelen W. Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomised controlled trial. *BMJ* 2009; 339:b2684.
11. Brewer BW, Cornelius AE, Van Raalte JL et al. Age-related differences in predictors of adherence to rehabilitation after anterior cruciate ligament reconstruction. *J Athl Train* 2003; 38(2):158–162.
12. Maddux JE, Rogers RW. Protection motivation and self-efficacy: a revised theory of fear appeals and attitude change. *J Exper Social Psychol* 1983; 19:469–479.
13. Hall A, Fallon B, Quinn A et al. Confidence, mood, self efficacy and adherence to rehabilitation in recovery from sports injury, *Poster presentation at Australian Conference of Science and Medicine in Sport*, 2002.
14. Herlitz J, Toth PP, Naesdal J. Low-dose aspirin therapy for cardiovascular prevention: quantification and consequences of poor compliance or discontinuation. *Am J Cardiovasc Drugs* 2010; 10(2):125–141.
15. Soligard T, Nilstad A, Steffen K et al. Compliance with a comprehensive warm-up programme to prevent injuries in youth football. *Br J Sports Med* 2010; 44(11):787–793.
16. Bassett SF, Prapavessis H. Home-based physical therapy intervention with adherence-enhancing strategies versus clinic-based management for patients with ankle sprains. *Phys Ther* 2007; 87(9):1132–1143.
17. Hume PA, Steele JR. A preliminary investigation of injury prevention strategies in Netball: are players heeding the advice? *J Sci Med Sport* 2000; 3(4):406–413.
18. McKay CD, Steffen K, Romiti M et al. The effect of coach and player injury knowledge, attitudes and beliefs on adherence to the FIFA 11+ programme in female youth soccer. *Br J Sports Med* 2014; 48(17):1281–1286.

[Physical Therapy]

CEU

Intrinsic Risk Factors of Lateral Ankle Sprain: A Systematic Review and Meta-analysis

Takumi Kobayashi, PhD, PT*†, Masashi Tanaka, MSc, PT†, and Masahiro Shida, MSc, PT†

Context: Lateral ankle ligamentous sprain (LAS) is one of the most common injuries in recreational activities and competitive sports. Many studies have attempted to determine whether there are certain intrinsic factors that can predict LAS. However, no consensus has been reached on the predictive intrinsic factors.

Objective: To identify the intrinsic risk factors of LAS by meta-analysis from data in randomized control trials and prospective cohort studies.

Data Sources: A systematic computerized literature search of MEDLINE, CINAHL, ScienceDirect, SPORTDiscus, and Cochrane Register of Clinical Trials was performed.

Study Selection: A computerized literature search from inception to January 2015 resulted in 1133 studies of the LAS intrinsic risk factors written in English.

Study Design: Systematic review.

Level of Evidence: Level 4.

Data Extraction: The modified quality index was used to assess the quality of the design of the papers and the standardized mean difference was used as an index to pool included study outcomes.

Results: Eight articles were included in this systematic review. Meta-analysis results showed that body mass index, slow eccentric inversion strength, fast concentric plantar flexion strength, passive inversion joint position sense, and peroneus brevis reaction time correlated with LAS.

Conclusion: Body mass index, slow eccentric inversion strength, fast concentric plantar flexion strength, passive inversion joint position sense, and the reaction time of the peroneus brevis were associated with significantly increased risk of LAS.

Keywords: lateral ankle sprain; risk factor; meta-analysis

Lateral ankle ligamentous sprain (LAS) is one of the most common injuries in competitive sports and recreational activities.[7] According to published statistics, 10% to 30% of all athletic injuries are ankle injuries, and in many sports, ankle sprains account for 70% or more of all reported ankle injuries.[7] Ankle sprains are often only partially treated. The rate of recurrent ankle sprain is more than 40%, and repeated ankle sprain in turn can lead to chronic ankle instability (CAI) and ankle osteoarthritis.[17,20,28]

The predictive intrinsic factors of LAS include anatomic characteristics,[4,18] functional deficits in isokinetic strength,[3,16] flexibility,[2,12] joint position sense,[23,25] muscle reaction time,[3] postural stability,[26] gait mechanics,[24] limb dominance,[3,8] previous ankle sprains,[2,16] and body mass index (BMI).[18,21] However, no consensus has been reached on the predictive intrinsic factors for LAS. Although the results of meta-analyses of risk factors leading to ankle injuries have been reported,[27] there are no published systematic reviews that focused solely on LAS.

The objective of this systematic review was to identify the intrinsic risk factors of LAS by using a meta-analysis from data in randomized control trials and prospective cohort studies.

From the †Department of Physical Therapy, Hokkaido Chitose Institute of Rehabilitation Technology, Hokkaido, Japan
*Address correspondence to Takumi Kobayashi, PhD, PT, Hokkaido Chitose Institute of Rehabilitation Technology, 2-10 Satomi, Chitose, Hokkaido, 066-0055 Japan (email: kobatakku@chitose-reha.ac.jp).
The authors report no potential conflicts of interest in the development and publication of this article.
DOI: 10.1177/1941738115623775

METHODS

Literature Search

A computerized literature search through January 2015 of the MEDLINE, CINAHL, ScienceDirect, SPORTDiscus, and Cochrane Register of Clinical Trials databases was completed. The search term used was "Ankle AND Sprain AND (Lateral or Inversion) AND Prospective AND (Risk OR Prediction OR Incidence OR Prevention)." The references of the mined studies were screened to identify additional articles.

Inclusion and Exclusion Criteria

Inclusion criteria consisted of randomized control trials or prospective cohort studies, LAS included in the outcome, intrinsic factors as risk factors, written in English, clear presentation of the number of subjects in the injury and the noninjury groups, and data with mean and SD or 95% CIs presented for both groups.

Quality Assessment

The modified quality index (QI) was used to assess the quality of the design of the papers.[5,14,19] The modified QI contains 15 questions.

Data Analysis

Standardized mean differences (SMD) were used as an index to pool study outcomes. Review Manager 5.3 (The Nordic Cochrane Center, The Cochrane Collaboration, 2014) was used to construct forest plots of multiple study outcomes for the same intrinsic factor and calculate 95% CIs. By using the I^2, which determines the heterogeneity of the pooled data, the fixed model was applied when heterogeneity was present and the random effects model was used when heterogeneity was determined to be absent.[11] In addition, funnel plots were created to assess the influence of publication bias in results where $P < 0.05$.

RESULTS

Study Selection and Quality

The search process is outlined in Figure 1. After the systematic review, 8 articles were included in the meta-analysis (Table 1 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data).[2-4,8,9,15,25,26] The mean QI score of the included studies was 13.75 (range, 11-15).

Body Mass Index

There was a significant correlation between high BMI and LAS[9]; other studies did not show a significant correlation.[4,15,25,26] The results of the meta-analysis with the fixed effects model showed significantly greater BMI in the injury group than in the noninjury group (Figure 2 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data). A symmetric shape was observed in the funnel plot (Figure 3 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data).

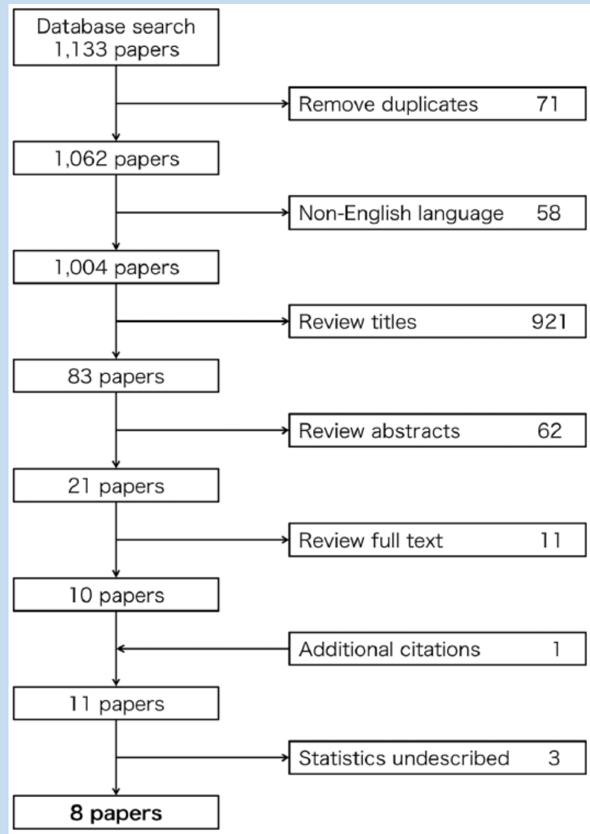


Figure 1. Literature search process.

Range of Motion

There was a significant correlation between deficient ankle dorsiflexion range of motion (ROM) and LAS[25]; other studies did not show a significant correlation.[2-4,9,15,26] The meta-analysis showed no significant difference in the ankle joint ROM (dorsiflexion/plantar flexion/inversion/eversion) between the injury and noninjury groups (Figures 4-7 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data).

Muscle Strength

The meta-analysis showed that decreased slow eccentric ankle inversion strength and increased fast concentric plantar flexion strength significantly correlated with LAS (Figures 8 and 9 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data). Other patterns of muscle strength did not show a significant correlation (Figures 10 and 11 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data).

Postural Stability

There was a significant correlation between poor static postural control and LAS[25]; no other study showed a significant correlation. Meta-analysis results using the random effects model showed that there was no significant difference in the static postural stability between the injury and noninjury groups (Figure 12 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data).

Proprioception

There was a statistically significant difference in the passive inversion joint position sense between the injury and noninjury groups (Figure 13 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data). However, there was no significant difference in active inversion joint position sense (Figure 14 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data). The decreased kinesthesia was not significantly different between the injury and noninjury groups (Figure 15 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data).

Muscle Reaction Time

The fixed-effects model revealed a significantly earlier reaction time of the peroneus brevis (Figure 16 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data). However, no significant differences in reaction time of the peroneus longus and the tibialis anterior were found between the injury and noninjury groups with the random effects model (Figures 17 and 18 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data). With regard to the reaction time of the peroneus brevis, a symmetric shape was observed in the funnel plot (Figure 19 in the Appendix, available at http://sph.sagepub.com/content/by/supplemental-data).

DISCUSSION

The meta-analysis showed that BMI, slow eccentric inversion strength, fast concentric plantar flexion strength, passive inversion joint position sense, and the reaction time of the peroneus brevis have significant correlations with LAS.

The results of this study partially supported the results of the meta-analysis performed by Witchalls et al,[27] but the criteria for meta-analysis used in this study were different from those in the previous review.

Lateral ankle ligamentous sprain commonly occurs during plantar flexion and inversion with excessive ankle supination.[22] Therefore, LAS is associated with decreased ankle eversion strength or delayed ankle evertor muscle reaction time.[10] However, this review did not support these hypotheses. Decreased ankle eversion strength[1] or delayed ankle evertor muscle reaction time[13] were observed in chronic ankle instability. Therefore, these dysfunctions are possibly acquired after LAS and may not be risk factors for LAS itself.

This study has a number of limitations. Since the majority of study subjects included in this meta-analysis were young adults, these findings may not be applicable to children or elderly individuals. This study did not consider the injury mechanism (eg, initial or recurrent, contact or noncontact); this could impact conclusions and its clinical application. Although this review investigated publication bias by funnel plot, the possibility of β-error may be greater because the number of papers included in this meta-analysis was less than 10.[6]

CONCLUSION

Body mass index, slow eccentric inversion strength, fast concentric plantar flexion strength, passive inversion joint position sense, and reaction time of the peroneus brevis showed significant correlations with LAS.

REFERENCES

1. Arnold BL, Linens SW, de la Motte SJ, Ross SE. Concentric evertor strength differences and functional ankle instability: a meta-analysis. *J Athl Train*. 2009;44:653-662.
2. Baumhauer JF, Alosa DM, Renstrom AF, Trevino S, Beynnon B. A prospective study of ankle injury risk factors. *Am J Sports Med*. 1995;23:564-570.
3. Beynnon BD, Renstrom PA, Alosa DM, Baumhauer JF, Vacek PM. Ankle ligament injury risk factors: a prospective study of college athletes. *J Orthop Res*. 2001;19:213-220.
4. de Noronha M, Franca LC, Haupenthal A, Nunes GS. Intrinsic predictive factors for ankle sprain in active university students: a prospective study. *Scand J Med Sci Sports*. 2013;23:541-547.
5. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health*. 1998;52:377-384.
6. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ*. 1997;315:629-634.
7. Fong DT, Hong Y, Chan LK, Yung PS, Chan KM. A systematic review on ankle injury and ankle sprain in sports. *Sports Med*. 2007;37:73-94.
8. Fousekis K, Tsepis E, Vagenas G. Intrinsic risk factors of noncontact ankle sprains in soccer: a prospective study on 100 professional players. *Am J Sports Med*. 2012;40:1842-1850.
9. Hadzic V, Sattler T, Topole E, Jarnovic Z, Burger H, Dervisevic E. Risk factors for ankle sprain in volleyball players: a preliminary analysis. *Isokinet Exerc Sci*. 2009;17:155-160.
10. Hertel J. Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. *J Athl Train*. 2002;37:364-375.
11. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327:557-560.
12. Hiller CE, Refshauge KM, Herbert RD, Kilbreath SL. Intrinsic predictors of lateral ankle sprain in adolescent dancers: a prospective cohort study. *Clin J Sport Med*. 2008;18:44-48.
13. Hoch MC, McKeon PO. Peroneal reaction time after ankle sprain: a systematic review and meta-analysis. *Med Sci Sports Exerc*. 2014;46:546-556.
14. Irving DB, Cook JL, Menz HB. Factors associated with chronic plantar heel pain: a systematic review. *J Sci Med Sport*. 2006;9:11-22.
15. Kobayashi T, Yoshida M, Yoshida M, Gamada K. Intrinsic predictive factors of noncontact lateral ankle sprain in collegiate athletes: a case-control study. *Orthop J Sports Med*. 2013;1:2325967113518163.
16. McHugh MP, Tyler TF, Tetro DT, Mullaney MJ, Nicholas SJ. Risk factors for noncontact ankle sprains in high school athletes: the role of hip strength and balance ability. *Am J Sports Med*. 2006;34:464-470.
17. McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. *Br J Sports Med*. 2001;35:103-108.
18. Milgrom C, Shlamkovitch N, Finestone A, et al. Risk factors for lateral ankle sprain: a prospective study among military recruits. *Foot Ankle*. 1991;12:26-30.
19. Munn J, Sullivan SJ, Schneiders AG. Evidence of sensorimotor deficits in functional ankle instability: a systematic review with meta-analysis. *J Sci Med Sport*. 2010;13:2-12.
20. Nielsen AB, Yde J. Epidemiology and traumatology of injuries in soccer. *Am J Sports Med*. 1989;17:803-807.
21. Tyler TF, McHugh MP, Mirabella MR, Mullaney MJ, Nicholas SJ. Risk factors for noncontact ankle sprains in high school football players: the role of previous ankle sprains and body mass index. *Am J Sports Med*. 2006;34:471-475.
22. Vitale TD, Fallat LM. Lateral ankle sprains: evaluation and treatment. *J Foot Surg*. 1988;27:248-258.

23. Watson AW. Ankle sprains in players of the field-games Gaelic football and hurling. *J Sports Med Phys Fitness*. 1999;39:66-70.
24. Willems T, Witvrouw E, Delbaere K, De Cock A, De Clercq D. Relationship between gait biomechanics and inversion sprains: a prospective study of risk factors. *Gait Posture*. 2005;21:379-387.
25. Willems TM, Witvrouw E, Delbaere K, Mahieu N, De Bourdeaudhuij I, De Clercq D. Intrinsic risk factors for inversion ankle sprains in male subjects: a prospective study. *Am J Sports Med*. 2005;33:415-423.
26. Willems TM, Witvrouw E, Delbaere K, Philippaerts R, De Bourdeaudhuij I, De Clercq D. Intrinsic risk factors for inversion ankle sprains in females—a prospective study. *Scand J Med Sci Sports*. 2005;15:336-345.
27. Witchalls J, Blanch P, Waddington G, Adams R. Intrinsic functional deficits associated with increased risk of ankle injuries: a systematic review with meta-analysis. *Br J Sports Med*. 2012;46:515-523.
28. Yeung MS, Chan KM, So CH, Yuan WY. An epidemiological survey on ankle sprain. *Br J Sports Med*. 1994;28:112-116.

Diagnosis, treatment and prevention of ankle sprains: update of an evidence-based clinical guideline

Gwendolyn Vuurberg,[1,2,3] Alexander Hoorntje,[1,2,3] Lauren M Wink,[1,4] Brent F W van der Doelen,[1,2,3] Michel P van den Bekerom,[5] Rienk Dekker,[6] C Niek van Dijk,[1,2,3] Rover Krips,[7] Masja C M Loogman,[8] Milan L Ridderikhof,[9] Frank F Smithuis,[10] Sjoerd A S Stufkens,[1] Evert A L M Verhagen,[3,4,11] Rob A de Bie,[12] Gino M M J Kerkhoffs[1,2,3]

For numbered affiliations see end of article.

Correspondence to
Gwendolyn Vuurberg, Academic Medical Center, Amsterdam 1105 AZ, The Netherlands; g.vuurberg@amc.uva.nl

Received 26 May 2017
Revised 11 January 2018
Accepted 2 February 2018
Published Online First 7 March 2018

ABSTRACT

This guideline aimed to advance current understandings regarding the diagnosis, prevention and therapeutic interventions for ankle sprains by updating the existing guideline and incorporate new research. A secondary objective was to provide an update related to the cost-effectiveness of diagnostic procedures, therapeutic interventions and prevention strategies. It was posited that subsequent interaction of clinicians with this guideline could help reduce health impairments and patient burden associated with this prevalent musculoskeletal injury. The previous guideline provided evidence that the severity of ligament damage can be assessed most reliably by delayed physical examination (4–5 days post trauma). After correct diagnosis, it can be stated that even though a short time of immobilisation may be helpful in relieving pain and swelling, the patient with an acute lateral ankle ligament rupture benefits most from use of tape or a brace in combination with an exercise programme.

New in this update: Participation in certain sports is associated with a heightened risk of sustaining a lateral ankle sprain. Care should be taken with non-steroidal anti-inflammatory drugs (NSAIDs) usage after an ankle sprain. They may be used to reduce pain and swelling, but usage is not without complications and NSAIDs may suppress the natural healing process. Concerning treatment, supervised exercise-based programmes preferred over passive modalities as it stimulates the recovery of functional joint stability. Surgery should be reserved for cases that do not respond to thorough and comprehensive exercise-based treatment. For the prevention of recurrent lateral ankle sprains, ankle braces should be considered as an efficacious option.

INTRODUCTION

A lateral ankle sprain (LAS) is a frequently incurred musculoskeletal injury, with a high prevalence among the general population and individuals who participate in sports.[1 2] About 40% of all traumatic ankle injuries occur during sports. For indoor sports, an incidence of 7 LAS per 1000 exposures has been reported.[3] Despite the high prevalence and incidence of LAS injuries, it has been reported that only approximately 50% of individuals who incur a LAS seek medical attention.[4] A large proportion of individuals who sustain a LAS will develop chronic ankle instability (CAI).[5–7] CAI may be defined as persistent complaints of pain, swelling and/or giving way in combination with recurrent sprains for at least 12 months after the initial ankle sprain,[8–11] which in turn may lead to (long-term) absenteeism from work and sports. Treatment costs in combination with sick leave lead to a high socioeconomic burden.[4 7 12] Additionally, associations with joint degeneration and osteochondral lesions have been reported over time.[13] Adequate diagnosis, treatment and prevention of injury recurrence could forestall the development of long-term injury-associated symptoms and hence substantially reduced the associated socioeconomic burden.

Despite the increasing number of published studies on this topic, heterogeneity in treatment strategies persists worldwide. This necessitated the development of an international evidence-based clinical guideline.[14] Since the publication of this guideline, additional studies have been undertaken and published on this topic.

In order to provide an update of the multidisciplinary clinical guideline, a multidisciplinary guideline committee was formed. The committee included health professionals who were directly involved in the care of patients with LAS in clinical practice or research environments and included general practitioners, emergency physicians, musculoskeletal radiologists, occupational physicians, orthopaedic surgeons, rehabilitation physicians, physical therapists, athletic trainers, sports massage therapists, sports physicians and trauma surgeons. This clinical guideline incorporates the most recently published peer-reviewed literature on the topic of LAS injury. The aim of this updated evidence-based clinical guideline is to facilitate uniformity of diagnosis and treatment of acute LAS injury, with the primary purpose of reducing the long-term injury-associated symptoms resulting from this prevalent injury.

The multidisciplinary guideline committee developed this update in order to assist all healthcare professionals, in both primary and secondary care settings, involved in the care of patients who have sustained an acute LAS injury. These include general practitioners, emergency physicians, musculoskeletal radiologists, occupational physicians, orthopaedic surgeons, rehabilitation physicians, physical therapists, athletic trainers, sports massage therapists, sports physicians, trauma surgeons and other professionals involved in lower extremity musculoskeletal injuries. This updated Clinical Practice Guideline (CPG) will enable these healthcare

To cite: Vuurberg G, Hoorntje A, Wink LM, *et al. Br J Sports Med* 2018;**52**:956.

professionals to benefit from and implement the most up-to-date evidence-based recommendations concerning LAS.

MATERIALS AND METHODS

The initial guideline was constrained in its recommendations due to limitations in available published literature, limiting assessment by means of meta-analyses.[14] Due to the considerable number of new studies on LAS, it was decided by the guideline committee that an update of the original document was warranted.

Search and data collection

To provide updated recommendations on the diagnosis and treatment of acute LAS injuries and the prevention of injury recurrence, a search was performed to identify all potential relevant articles published from January 2009—the search date of the initial guideline—up to September 2016 (online supplementary appendix 1). The search was performed in Embase, MEDLINE, Cochrane and PEDro using the database-specific search translation on the topics of predisposing and prognostic factors, diagnostics, treatment, prevention and return to work and sports. For each subtopic addressed in this guideline, an individual search was performed, which is available in the appendix. All searches consisted of the common terms 'ankle sprain', 'ankle injury' and their database-specific synonyms, combined with topic specific terms such as 'prevention' and all available synonyms. To ensure all relevant articles were identified, the current search results were combined with the articles identified by the initial guideline and references of all relevant articles were checked for possibly missed inclusions.

Inclusion and exclusion criteria

Studies were deemed eligible for inclusion if they included individuals aged at least 16 years with acute LAS. Studies published in Dutch, English, German, French, Spanish, Danish or Swedish were all eligible for inclusion. Narrative reviews, case reports and cadaveric analyses were excluded. Additional exclusion criteria were reported medial ankle involvement, fractures or other concomitant injuries/pathology and CAI. In addition to the original search, a manual search of all reference lists of included studies was performed to identify relevant articles that may not have been identified by the search strategy. There were no inclusion or exclusion criteria formed regarding outcome measures. In addition to including all outcomes assessed in the previous guideline (see the individual searches in online supplemenatry appendix 1), all other outcomes concerning risk/prognostic factors, diagnostics, treatment, prevention and work/sports resumption were included. If multiple follow-up time points were included in the assessment, the latest postintervention assessment was included.

Data selection

After duplicate removal all studies were screened by two researchers (GV and AH/BFWvdD) independently using the Rayyan[15] screening tool as advised by the Dutch Cochrane Society. Disagreements among the researchers who performed the initial screening were resolved in a consensus meeting. Subsequently, the same pair of researchers assessed full texts independently, followed by another consensus meeting to resolve disagreements. If disagreement persisted, the senior author (GMMJK) was consulted to reach consensus. To avoid loss of original data for systematic reviews, all the included studies were manually checked for eligibility and relevant data.

Table 1 Classification of methodological quality of individual studies

Classification of studies	Intervention	Diagnostic accuracy of research	Damage or side effects, aetiology, prognosis*
A1	Systematic review of at least two independently conducted studies of A2 level		
A2	Randomised double-blind comparative clinical research of good quality and sufficient sample size	Research relative to a reference test (a 'golden standard') with predefined cut-off points and independent assessment of the results of a test, on a sufficiently large series of consecutive patients who all have had the index and reference test	Prospective cohort study of sufficient sample size and follow-up duration adequately controlled for 'confounding' and selective follow-up is sufficiently excluded
B	Comparative research, but not with all the features as mentioned under A2 (this includes patient control research, cohort study)	Research relative to a reference test, but not with all the attributes that are listed under A2	Prospective cohort study, but not with all the features as mentioned under A2 or retrospective cohort study or patient monitoring research
C	Not comparative research		
D	Opinion of experts		

*This classification only applies to situations in which due to ethical or other reasons controlled trials are not possible to perform. If these are possible, then the classification applies to interventions.

Evidence and guideline quality

Quality of evidence of included articles was classified in order of scientific value (tables 1 and 2). Recommendations were based on the best available evidence. Statements formed by evidence from multiple studies, and the summarised level of evidence of the full statement was provided. The same was done for the level of evidence of the recommendations.

As this guideline concerns an update, as recommended by the EQUATOR-network, the CheckUp list was used for this guideline to help emphasise new information and changes implemented in this updated CPG.[16] Additionally, theAppraisal of Guidelines for Research & Evaluation (AGREE) II criteria were followed in order to ensure complete reporting of methods and results and improve transparency and quality.

Data extraction

All outcomes that were described by at least two of the included studies were extracted for the meta-analyses (online

Table 2 Level of evidence of conclusions

Evidence level	Conclusions based on
1	Research of level A1 or at least two examinations of level A2 performed independently of each other with consistent results
2	One examination of level A2 or at least two examinations of level B, performed independently of each other
3	One examination of level B or C
4	Opinion of experts

Table 3 Results of treatment strategies for acute LAS*

Treatment strategy	Effect	Studies	Patients (N)	(S) MD/RR (95% CI)	In favour of
RICE versus control	Swelling (in mL)	1 RCT	44	MD –47.00 (–65.07 to 28.93)	RICE
	Swelling (in mm)	1 RCT	32	MD –2.30 (–3.86 to 0.74)	RICE
	ROM	1 RCT	44	MD 3.00 (–1.35 to 7.35)	None
NSAIDs versus placebo	Pain	1 RCT	60	RR 0.51 (0.38 to 0.68)	NSAIDs
		5 RCTs	942	MD –5.42 (–6.91 to 3.93)	
	Swelling (in mm)	3 RCTs	455	MD –0.94 (–1.35 to 0.52)	NSAIDs
	ROM restriction	1 RCT	51	RR 0.85 (0.50 to 2.40)	None
	Complications	3 RCTs	641	RR 1.17 (0.79 to 1.74)	None
Immobilisation versus functional support	Pain	10 RCTs	571	RR 0.68 (0.54 to 0.85)	Immobilisation
	Swelling	7 RCTs	520	RR 0.68 (0.44 to 1.04)	None
	ROM restriction	3 RCTs	390	RR 1.42 (0.91 to 2.21)	None
	Satisfaction	5 RCTs	347	RR 1.83 (1.09 to 3.07)	Functional support
	PROMs	3 RCTs	336	MD –2.59 (–3.66 to 1.53)	Functional support
	No return to work	3 RCTs	214	RR 2.13 (0.90 to 5.05)	Functional support
	Days until return to work	8 RCTs	837	MD 7.80 (3.07 to 12.52)	Functional support
	No return to sports	8 RCTs	654	RR 1.34 (0.88 to 2.03)	None
	Days until return to sports	3 RCTs	195	MD 4.88 (1.50 to 8.25)	Functional support
Manual mobilisation versus control	Pain	3 RCTs	120	MD –1.20 (–1.68 to 0.72)	Mobilisation
	ROM increase	5 RCTs	161	MD 5.14 (5.01 to 5.26)	Mobilisation
Exercise therapy	Pain	2 RCTs	166	RR 0.92 (0.78 to 1.08)	None
		4 RCTs	287	MD –0.05 (–0.21 to 0.11)	None
	Objective instability	4 RCTs	251	RR 0.68 (0.49 to 0.95)	Exercise
	Subjective instability	3 RCTs	174	RR 0.80 (0.64 to 1.00)	Exercise
	Days until return to work	4 RCTs	231	MD 0.76 (–0.33 to 1.85)	None
	Days until return to sports	2 RCTs	156	MD –2.61 (–4.05 to 1.16)	Exercise
Surgery versus conservative	Pain	14 RCTs	1553	RR 0.75 (0.56 to 1.00)	Surgery
	Swelling	12 RCTs	1423	RR 0.88 (0.58 to 1.32)	None
	ROM restriction	7 RCTs	746	RR 1.95 (1.16 to 3.28)	Conservative
	Complications	14 RCTs	1614	RR 5.01 (2.33 to 10.77)	Conservative
	No return to sports	4 RCTs	409	RR 0.68 (0.35 to 1.35)	None

*For details, analyses and figures, see online supplementary appendix 3.
Control, same therapy without intervention therapy; NSAID, non-steroidal anti-inflammatory drug; RCT, randomised controlled trial; RICE, Rest Ice Compression Elevation; ROM, range of motion; RR, relative risk; (S) MD, (standardised) mean difference; PROM, Patient Reported Outcome Measure.

supplementary appendix 3). If outcomes concerned the same variable and were measured similarly (eg, pain on an 11-point Likert scale), they were pooled using Review Manager (RevMan; V.5.3, The Nordic Cochrane Centre, Copenhagen, The Cochrane Collaboration, 2014). Data that could not be pooled were assessed qualitatively.

Formulation of recommendations

Individual topics were assigned to the appropriate coauthors depending on their field of expertise in order to formulate recommendations based on the collected evidence. They subsequently received the corresponding studies to enable them to write the corresponding paragraph according to the method section predefined content to ensure uniformity. Results of these diagnostic, treatment and preventive recommendations were provided with the corresponding levels of evidence of the included conclusions. Aspects such as potential harm of interventions, patients' perspective, costs and logistics were carefully considered when formulating the final recommendations. Recommendations were explicitly mentioned under 'Recommendations'; including the full recommendation based on all the available evidence and including a statement about whether this recommendation changed since this update.

In addition to recommendations on diagnostics, an overview of treatment and prevention strategies is provided in tables 3 and 4 by pooling the data of studies assessing the same treatment/preventive measure (number of patients (N); relative risk (RR) or mean difference (MD) and 95% CI).

New information was explicitly mentioned under *'What's new?'*.

Implementation

To ensure implementation of a multidisciplinary view in this CPG in all phases of rehabilitation after sustaining a LAS, the guideline committee consisted of an emergency medicine physician, epidemiologists, general practitioner, musculoskeletal radiologist, orthopaedic surgeons, movement scientists, physiotherapists and rehabilitation specialist (see affiliations). All members, apart from the two senior supervisors (RAdB and GMMJK), participated either in the search and selection of evidence or in reading, extracting and implementing data into this CGP. Apart from full review by all coauthors, the two senior authors additionally functioned as external reviewers by means of full detailed review to ensure this CPG was compliant with the AGREE II criteria and to optimise quality, assess applicability in clinical practise and feasibility of results.

Terminology

- functional treatment: treatment during which the function of the joint (ie, freedom of movement) is retained;

Table 4 Checklist: essential information for healthcare professionals during referral of patients with lateral ankle sprain

Medical discipline	Diagnostic phase	Acute treatment phase	Guidance phase
General for each healthcare professional	Time of accident Trauma mechanism Age, weight, profession, hobby Man, woman Ability to walk after trauma Therapy until visit Concomitant symptoms and damage	(Differential) diagnosis Time schedule and treatment plan Advise follow-up visit Duration of rest When normal weight bearing allowed What to do with deviant drift of symptoms	Diagnosis Result of treatment Advise on activities of daily living and sports participation Medication Recommendations to prevent recurrence
Emergency physician		Thrombosis prophylaxis yes/no?	Not involved in the guidance phase
Radiologist		Fracture yes/no Concomitant pathology Not involved in treatment plan	Not involved in the guidance phase
Orthopaedic and trauma surgeon		Fracture yes/no Treatment options Thrombosis prophylaxis yes/no?	Therapy/treatment
Sports physician, general practitioner		Thrombosis prophylaxis yes/no?	Advise follow-up visit
Sports masseur, physical therapist			Therapy Advise follow-up visit
Medical officer, insurance medical officer, rehabilitation physician			Time schedule and treatment plan/result Advise follow-up visit Prognosis Reintegration protocol

- functional support: support such as tape or brace, preserving joint motion, but limiting extreme joint positions such as maximum inversion;
- functional outcome: outcome of treatment that leads to improvement of function such as pain reduction or range of motion (ROM) increase enabling patients to return to their preinjury level of activity and participation.

RESULTS

To systematically evaluate and summarise all available evidence concerning LAS, a broad literature search was undertaken specifically related to the following areas: (1) predisposing and prognostic factors; (2) diagnostics, (3) treatment, (4) prevention and (5) return to work/sport. This search resulted in the identification of a total of 10 067 studies. After title and abstract screening and reading full texts, a total of 194 articles were eligible for inclusion in this guideline (online supplementary appendix 2). All fields of evidence with regard to relevant diagnostic tools, reliability of diagnostics, different treatment modalities and their efficacy, as well as prevention interventions including their cost-effectiveness will in turn be discussed. Recommendations will be provided based on the available level of evidence (tables 1 and 2).

Predisposing factors

Predisposing factors are defined as factors that increase the risk of sustaining a LAS. Risk factors for LAS can be classified as either intrinsic (patient-related factors, eg, proprioception) or extrinsic (eg, sports or environmental characteristics). An important aspect that should be considered by clinicians when addressing predisposing factors is whether they can be modified or not. Modifiable risk factors may be targeted by (preventive) treatment.

Intrinsic risk factors

There are a number of intrinsic risk factors, which substantially heighten the risk of sustaining a LAS. These include limited dorsiflexion ROM,[17–19] reduced proprioception[18 20–23] and (preseason) deficiencies in postural control/balance (positive single-leg balance test (RR 2.54, 95% CI 1.02 to 6.03)[20–22 24–28] (level 1). In addition, other modifiable risk factors which heighten the risk of sustaining a LAS include body mass index (BMI) and high medial plantar pressures during running[28–33] (level 3). Concerning BMI, included results are conflicting as to whether a higher or lower BMI increases the risk of incurring a LAS. Our meta-analysis showed a greater risk of sprains in patients with a lower BMI (mean difference (MD) −0.08, 95% CI −0.14 to –0.02)[23 34] (level 2). Additional factors that may contribute to an increased risk are reduced strength,[18 20–23 35] coordination,[25] cardiorespiratory endurance,[25] limited overall ankle joint ROM and decreased peroneal reaction time[18 20–23] (level 3).

Concerning non-modifiable risk factors, females have a higher risk of sustaining a LAS compared with males (RR 1.25, 95% CI 1.17 to 1.34)[29 36] (level 3). Despite a history of LAS being described as a strong predictor, pooling results lead to a non-significant risk ratio (RR 1.44, 95% CI 0.96 to 2.16)[18 21 22 37–39] (level 2). Additional factors correlated to an increased risk of sustaining a LAS are physical characteristics such as greater height, ankle joint configuration, foot posture index, anatomical abnormalities in ankle and knee alignment and multiple clinical defects[28–33] (level 3).

What's new: An increase in available data made it possible to identify female sex as well as potentially a lower BMI being risk factors for ankle sprains. Additionally, a recommendation is provided which was missing in the original guideline.

Recommendation (new): When treating patients with an acute LAS, modifiable risk factors such as deficiencies in proprioception and ROM should be identified and if possible included in a prevention and/or rehabilitation programme to mitigate the risk for recurrent sprains (level 3).

Extrinsic risk factors

Irrespectively of patients' wish to switch sports, the main modifiable extrinsic risk factor for LAS appears to be the type of sport practised. The highest incidence of LAS was found for aeroball, basketball, indoor volleyball, field sports and climbing.[29 40 41]

The incidence of LAS was dependent on the level of participation.[29 40 41] In volleyball, landing after a jump is the most important risk factor[41 42] (level 2). Playing soccer on natural grass (vs artificial turf: RR 0.53, 95% CI 0.48 to 0.59)[43–45] as well as being a defender (42.3% of all sprains)[46 47] increased the incidence of LAS (level 2). Concerning shoe wear, high heels (9.5 vs 1.3 cm) heighten the risk of incurring a LAS[48] (level 3).

The only non-modifiable factor was sex. Despite girls having an increased risk of LAS compared with boys, in-competition risk for LAS is higher in boys (RR 3.42, 95% CI 3.20 to 3.66) compared with girls (RR 2.71, 95% CI 2.48 to 2.95)[36] (level 3).

What's new: The new search resulted in a significant increase in data. The subsequent performed meta-analyses made it possible to identify the size of the increased risk of playing soccer on natural grass, the risk associated with being a defender and the risk while playing sports at a competitive level. New recommendations are provided concerning the high impact of sport.

Recommendation (new): Extrinsic risk factors, although outside of the patient, may provide a significant increase in the risk at sustaining a LAS. Healthcare professionals involved in treating patients who sustain a LAS should take notice especially of the type of sport practised but also of other extrinsic risk factors, as modifications may lower the risk at future sprains and other ankle injuries (level 2).

Prognostic factors

Following an acute LAS, pain decreases rapidly within the first two weeks after injury.[49] However, a substantial proportion of patients report long-term unresolved injury-associated symptoms. At a follow-up of 1–4 years, 5%–46% of patients still experience pain,[49–51] 3%–34% of patients experience recurrent sprains[49–51] and 33%–55% of patients report instability.[49 51] Additionally, a higher physical workload load may be associated with an increased risk of recurrent sprains (RR 1.09, 95% CI 0.52 to 1.19; RR 0.96, 95% CI 0.36 to 1.2) and ankle instability (RR 1.16, 95% CI 0.71 to 1.18; RR 1.10, 95% CI 0.57 to 1.19).[51] Even clinical signs of anterior impingement were found in 25% of patients, of which 82% were radiographically confirmed[50] (level 3).

Despite initial treatment consisting of taping/bracing and physical rehabilitation, up to 40% of individuals who have sustained a LAS develop CAI.[52] This may indicate that not all factors contributing to the success or failure of rehabilitation are known. Some of the known unfavourable prognostic factors identified for the development of CAI were an inability to complete jumping and landing within 2 weeks after a first-time LAS, deficiencies in dynamic postural control,[53] altered hip joint kinematics[54] and lack of mechanical stability/increased ligament laxity 8 weeks after an ankle sprain.[55 56] Other factors that may influence the prognosis are sports participation at a high level,[57] being a young male,[52] increased BMI[52] and greater body height[52] (level 3). Finally, acute postural balance impairments persisting after LAS may also contribute to the development of CAI.[58] Due to the neuromuscular origin of some of these prognostic factors, physical therapy might be helpful to improve physical impairments after a LAS and prevent progression to CAI.[59 60] Based on the limited evidence concerning the risk factors for developing CAI following an ankle sprain, further research on prognostic factors is required and may provide additional and more uniform insights.[61 62]

What's new: Over the past years more data have become available on negative prognostic factors that may indicate slow or incomplete rehabilitation. This enabled us to modify the previous recommendation, which lacked a conclusion due to insufficient evidence.

Table 5 Clinical decision rules in acute lateral ankle sprain[67 73 74 78 214–216]

Ottawa ankle rules		**Bernese ankle rules**	
Pain on the dorsal side of one or both malleoli		Indirect fibular stress	
Palpation pain at the basis of the metatarsal bone V		Direct medial malleolar stress	
Palpation pain of the navicular bone		Compression stress of the midfoot and hindfoot	
Inability to walk at least four steps			
Sensitivity 86%–99%; specificity 25%–46%		Sensitivity 69%–86%; specificity 40%–45%	
PPV 24%–48%; NPV 97%–99%			
Reproducibility 45%		Reproducibility 48%	
Leiden ankle rules		**Utrecht ankle rules**	
Deformity/instability/crepitating	5	Deformity/instability/crepitating	4
Weight bearing*	3	Weight bearing/axial compression*	2
Pulseless/weak posterior tibial artery†	2	Pain on palpation/swelling	
Pain and palpation malleoli/metatarsal V‡	2	Pain on palpation/swelling	
Swelling malleoli/metatarsal V	2	Tibia	1
Swelling/pain in Achilles tendon	1	Fibula	1
Age divided by 10		Achilles tendon	1
Radiographs required if	>7	Base of fifth metatarsal	1
Sensitivity 88%; specificity 57%		Haematoma/haemarthrosis	1
		Age divided by 10	
		Radiographs required if	≥8
		Sensitivity 59%; specificity 84%	

*Inability to bear weight was defined as the inability to walk four steps. Axial compression pain was defined as pain on application of axial compression.
†Positive in case of a marked difference with the contralateral side.
‡Of the posterior edge (6 cm) of both the lateral and the inability to walk four steps. Axial and medial malleolus and the base of the fifth metatarsal bone.
NPV, negative predictive value; PPV, positive predictive value.

Recommendation (modified): Following acute LAS, adequate attention should be directed towards the patient's current level of pain, their workload and level of sports participation. These may all negatively influence recovery and increase the risk of future injury recurrence. Hence, they should be addressed early in the treatment process (level 3).

Diagnostics

In case of a severe ankle sprain, a fracture should be excluded by proper use of the Ottawa ankle rules (OAR), and if indicated, conventional radiographic imaging should be undertaken (table 5). Since only 15% of patients with LAS, who are examined using a radiograph, are diagnosed with an ankle fracture, the OAR have been developed to rule out a fracture.[63] The OAR are an accurate and valid tool, which can be used with patients who have a suspected ankle/foot fracture within 1 week after the initial trauma (level 1).[63–67] A high incidence of less serious traumas may lower the predictive value of the OAR in clinical practice.[68 69] To avoid unnecessary use of radiographs, the OAR are recommended as a primary physical examination tool to rule out the likelihood of foot/ankle fractures by emergency physicians, general practitioners or physiotherapists[63 70–73] (level 1). The Bernese ankle rules (BAR) have been developed as response to the high rate of unnecessary radiographs based on

OAR findings. However, the sensitivity of the BAR is too low to promote clinical use[74] (level 2).

In general, ankle ligament injuries are classified into three grades representing increasing injury severity: grade I, mild ankle sprain; grade II, moderate sprain/microligament lesions; and grade III, severe sprain/full ligament lesion.[75] In cases where a haematoma is present, accompanied by pain on palpation around the distal fibula and/or a positive anterior drawer test, a rupture of the lateral ankle ligaments likely exists. The sensitivity (84%) and specificity (96%) of physical examination using the anterior drawer test are optimised if clinical assessment is delayed for between 4 and 5 days post injury[68 69 76 77] (level 2). Ultrasonography has similar sensitivity (92%) but lacks specificity (64%) compared with delayed examination, and additionally depends on the availability of an experienced technician and equipment.[69 78] In case of suspicion of high-grade ligament injuries, osteochondral defects, syndesmotic injuries and occult fractures, an MRI can be performed[78] because of its excellent sensitivity (93%–96%) and specificity (100%) for visualising these injuries.[79–83] Poor availability of MRI in combination with the high prevalence of ankle sprains limits the use of MRI in acute settings, but in case of persisting symptoms it may be used to diagnose underlying joint damage. In case of suspicion of complete uncomplicated rupture of the anterior talofibular ligament, an MRI is not needed as the sensitivity and specificity of delayed physical examination are sufficient.[69] Other diagnostic modalities are stress radiographs and arthrography. Due to the limited diagnostic value of stress views in combination with pain in the acute setting while stressing the ligaments, these are regarded as obsolete and should not be used. As arthrography is an invasive procedure and its sensitivity and specificity are equal to delayed physical examination, it is also not recommended as a diagnostic tool in the acute setting[78] (level 2).

What's new: To ensure readability, the OAR were included in this diagnostics section. To make sure this guideline provides a complete overview of the many decision rules which the OAR belong to, table 5 was added including the parametric properties of the most popular clinical decision rules. The recommendation includes a short summary by providing an overview of the most important diagnostic steps, which was missing in the previous guideline.

Recommendation (new): Regarding the clinical assessment of damage to the anterior talofibular ligament, the sensitivity (84%) and specificity (96%) of assessment using the anterior drawer are optimised if clinical assessment is delayed for between 4 and 5 days post injury. In case of a suspected fracture, the OAR should be applied (level 2).

Treatment

Rest Ice Compression Elevation (RICE)

RICE is a conservative treatment method that has not been rigorously investigated, and the efficacy of this combination is questionable. The individual elements of ice and compression have been the subject of numerous scientific investigations; however, there is little scientific support for their efficacy in reducing injury-associated symptoms following acute LAS.

The limited available evidence showed that the efficacy of cryotherapy for reducing acute LAS injury-associated symptoms is unclear (33 randomised controlled trials (RCTs), n=2337)[84 85] (level 1). There are no indications that the isolated use of ice can increase function, as well as decrease swelling and pain at rest among individuals who have sustained an acute LAS (27 RCTs, n=1670)[84 86–90] (level 2). In combination with exercise therapy, cryotherapy has a greater effect on reducing swelling compared with heat application (one RCT, n=30)[86] (level 2). The combination of cryotherapy and exercise additionally results in significant improvements in ankle function in the short term, allowing patients to increase loading during weight bearing compared with standard functional treatment (one RCT, n=101)[91] (level 3).

Evidence regarding the efficacy of compression therapy after acute LAS is also inconclusive (three RCTs, N=86)[87–89] (level 2).

As a combined therapeutic modality, the use of RICE plus multimodal physiotherapy compared with RICE alone provides no additional benefits. Both treatments provide pain reduction, increase patient function and reduce ankle swelling (one RCT, n=28)[92] (level 2).

Regarding the individual effects of rest and elevation after LAS, no evidence was available.

What's new: No new statements could be made based on the newly identified studies. The increased evidence indicates that the individual aspects of RICE are not effective, apart from cryotherapy, if provided in combination with exercise therapy.

Recommendation (modified): There is no evidence that RICE alone, or cryotherapy, or compression therapy alone has any positive influence on pain, swelling or patient function. Therefore, there is no role for RICE alone in the treatment of acute LAS (level 2).

Non-steroidal anti-inflammatory drugs

NSAIDs are commonly prescribed for patients who have sustained an acute LAS, with the primary purpose of reducing pain. Pooling the results of current studies shows that the use of oral or topical NSAIDs results in less pain in the short term (<14 days) without significantly increasing the risk of adverse events compared with placebo (26 RCTs, n=4225)[93–97] (level 1) (table 3). However, studies that included other NSAIDs instead of a placebo were excluded from this review[98–102]; additionally, the included participants were relatively young and healthy and thus potentially less prone to side effects. A comparison between selective NSAIDs (celecoxib 200 mg two times daily) and non-selective NSAIDs (ibuprofen, naproxen or diclofenac) (four RCTs, n=1490) concluded that celecoxib was non-inferior to non-selective NSAIDs for the primary outcome of pain following an acute LAS injury. Adverse events did not occur more frequently[99 103–105] (level 1). Diclofenac showed superior results at days 1 and 2 compared with piroxicam (two RCTs, n=201) and ibuprofen (one RCT, n=60) for reducing pain during motion in patients with mild-to-severe acute ankle sprains and equal adverse event rates[98 101] (levels 2 and 3). Contradicting results have been reported on the effect of diclofenac for pain during rest, swelling and inflammation,.[98 101] No differences in effect were seen when comparing a fixed dosage (500 mg two times daily) to an as-needed naproxen dosage (one RCT, n=135, MD_{pain} −0.13 (−0.38 to 0.12))[106] (level 3). Despite dose differences, paracetamol (cq. acetaminophen) seems to be equally effective as NSAID usage (three RCTs, n=450) for pain (one RCT, n=86, MD 1.80, 95% CI −1.42 to 5.02), swelling (two RCTs, n=186, MD −0.07, 95% CI −0.29 to 0.14) and ROM (one RCT, n=100, MD 0.70, 95% CI −0.62 to 2.02)[107–109] (level 1). Opioid analgesics are equally effective for pain relief, but lead to significantly more side effects (two RCTs, n=869)[100 110] (level 2). The use of NSAIDs may delay the natural healing process as the inflammation suppressed by NSAIDs is a necessary component of tissue recovery.[111]

Besides these commonly prescribed analgesics, other pharmaceutical treatment modalities were described: venotonic drugs did not result in enhanced outcomes for pain and swelling compared with paracetamol and RICE[112] (level 2); platelet-rich plasma injections were not superior for pain and functional outcomes compared with placebo injections (one RCT, n=37)[113] (level 3), and topically applied Traumeel (one RCT, n=449)[114] (level 2) was not superior compared with diclofenac topical gel for ankle oedema, pain and function. Periarticular hyaluronic acid injections compared with placebo (two RCTs; n=158) did show a positive effect on pain, nor did they result in a quicker time to return to sport or reduced prevalence of recurrent sprains[115 116] (level 2).

What's new: Based on the search results concerning treatment, the committee agreed on implementing a topic on NSAIDs. Over the past years much research has been undertaken on NSAIDs in relation to musculoskeletal injuries, and in many countries they are available without prescription. However, before recommending NSAIDs, their effect in the specific context of an ankle sprain had to be assessed.

Recommendation (new): NSAIDs may be used by patients who have incurred an acute LAS for the primary purpose of reducing pain and swelling. However, care should be taken in NSAID usage as it is associated with complications (level 2) and may suppress or delay the natural healing process.

Immobilisation

A minimum of 4 weeks in a lower leg cast following an acute LAS results in less optimal outcomes compared with functional support and exercise strategies with a duration of 4–6 weeks[117118] (22 RCTs, n=2304) (level 1). More recent evidence (three RCTs, n=694) showed that a short period (<10 days) of immobilisation with a plaster cast or rigid support can be of added value in the treatment of acute lateral ligament injury as it decreases pain and oedema and improves functional outcome[119–122] (level 2).

What's new: Despite the inclusion of new recent studies, there were no new findings.

Recommendation (not changed): Use of functional support and exercise therapy is preferred as it provides better outcomes compared with immobilisation. If immobilisation is applied to treat pain or oedema, it should be for a maximum of 10 days after which functional treatment should be commenced (level 2).

Functional treatment

Functional support

Functional supports in the form of an ankle brace or tape are often used following acute LAS. These external supports differ from rigid immobilisation and allow the patient to load the damaged tissues in a protected manner. Treatment with any type of real ankle support was more effective compared with treatment with less adequate support such as a compression bandage or a tubigrip[5 122] (level 2). Wearing compression stockings beyond the acute phase is not helpful in the treatment of acute lateral ankle ligament injury[123] (level 3). The success of functional treatment is, however, dependent on the severity of the injury. For example, if a sprain is complicated by a ligament avulsion fracture results may be inferior to those in patients with isolated ligament injury.[124]

The superiority of one external support over another is debated rigorously in the literature.[125–127] A meta-analysis (n=892) showed a lace-up brace or a semi-rigid brace should be preferred to the use of an elastic bandage[125] (level 1). Use of an ankle brace results in better outcome compared with other types of functional treatment such as sports tape (non-elastic) or kinesiotape (elastic), without showing any side effects.[128] Based on a small systematic review (n=276), it can be concluded that kinesiotape is unlikely to provide sufficient mechanical support in unstable ankles[129] (level 1).

What's new: New evidence emphasises that the use of external supports (ie, braces) is preferred over immobilisation. Additionally, the preferred time frame during which the use of external support is advised is outlined. Overall, the core message of this section remains unchanged.

Recommendation (modified): Use of functional support for 4–6 weeks is preferred over immobilisation. The use of an ankle brace shows the greatest effects compared with other types of functional support (level 2).

Exercise

Among patients who seek professional healthcare following an acute LAS, exercise therapy is often an integral component of the treatment administered. Exercise therapy programmes mainly consist of neuromuscular and proprioceptive exercises. Exercise therapy programmes that are initiated early following an acute LAS injury have established efficacy. They can reduce the prevalence of recurrent injuries[130–132] (10 RCTs, n=1284) (RR 0.62, 95% CI 0.51 to 0.76), as well as the prevalence of functional ankle instability[131 133] (3 RCTs, n=174) (RR 0.80, 95% CI 0.64 to 1.00). Furthermore, they are associated with a quicker time to recovery and enhanced outcomes[130 133–136] (level 1). Including supervised physiotherapy has shown to have some benefit in patients with a severe ankle sprain compared with a mild LAS as measured by PROMs,[60] and whence compared with a home exercise programme[137 138] (level 1). Additionally, supervised exercise therapy may lead to improvements in ankle strength[138] and proprioception,[138] faster return to work[139] and sport,[134] compared with performing the exercise programme without supervision or guidance (level 1). Many articles, however, contradict these findings, concluding that there is no effect from the addition of supervised exercise therapy to conventional treatment alone (two RCTs, n=130)[140 141] (level 2) nor an improvement of postural balance after exercise therapy[131 142] (level 1).

What's new: New evidence has become available on the specific effects of different types of exercise/rehabilitation programmes; especially the beneficial effect of exercise therapy on preventing recurrent sprains, reducing the risk of functional instability and expediting the recovery of ankle joint function.

Recommendation (modified): Exercise therapy should be commenced after LAS to optimise recovery of joint functionality. Whether exercise therapy should be supervised or not remains unclear due to contradictory evidence and requires further research (level 1).

Manual mobilisation

Manual joint mobilisation can provide a short-term increase in ankle joint dorsiflexion ROM following acute LAS[131 143–147] (12 RCTs, n=427) (level 1). Additionally, joint mobilisation has been reported to decrease pain[143] (level 1). Manual therapy combined with exercise therapy resulted in better outcomes compared with exercise therapy alone[137] (level 3).

What's new: Despite findings by the previous version of this guideline that manual mobilisation only results in short-term treatment effects, current evidence shows added value of manual mobilisation when used in combination with exercise therapy.

Recommendation (modified): A combination with other treatment modalities, such as exercise therapy, enhances the efficacy of manual joint mobilisation and is therefore advised (level 3).

Surgical therapy

Surgical therapy for acute lateral ligament injuries has been performed abundantly until it was recognised that conservative treatment provides equal effects and that not all patients require surgery in order to resolve complaints[148–151] (level 1). Nowadays, surgery is mainly reserved for patients who have chronic instability after a LAS and who have not responded to a comprehensive exercise-based physiotherapy programme. Long-term effects of surgical treatment in cases of acute lateral ligament injury correspond with those of functional treatment. Surgery seems superior at decreasing the prevalence of recurrent LAS, which is important as recurrent LAS in turn may increase the risk for the subsequent development of osteoarthritis (one RCT, n=51)[13] (level 2). There is limited evidence for longer recovery times, higher incidences of ankle stiffness, impaired ankle mobility and complications in patients who received surgical treatment (20 RCTs, n=2562)[150] (level 1). More recent studies show that outcomes in terms of recovery of ankle activity and instability are significantly better for surgical treatment than for functional treatment (12 RCTs, n=1413)[152] (level 1). As a previous sprain is a predictor for recurrent ankle sprains, this may be related to increased ligament laxity. This laxity is resolved during surgery. Based on this indirect evidence, it may be suggested that surgical therapy helps prevent recurrent ankle sprains. However, a large percentage (60%–70%) of individuals who sustain a LAS respond well to non-surgical treatment programmes,[149] and therefore treating all patients with LAS would mean unnecessary exposure to an invasive intervention for many patients, not to mention costs (level 1).

What's new: New evidence supports the rationale for being reserved with the recommendation of surgery for all patients following LAS. This lead to refinement of the recommendation regarding surgery.

Recommendation (modified): Despite good clinical outcomes of surgery after both chronic injuries and an acute complete lateral ligament rupture, functional treatment is still the preferred method as not all patients require surgical treatment. This also helps to avoid unnecessary exposure to invasive (over) treatment and unnecessary risk of complications[149 152] (level 1). However, treatment decisions have to be made on an individual basis. In professional athletes, surgical treatment may be preferred to ensure quicker return to play.[151]

Other therapies

Other treatment modalities less frequently used do not always show a treatment effect. For example, no effect on pain, oedema, function and return to play has been shown for ultrasound[153 154] (level 1), laser therapy[155] (level 1), electrotherapy[156–158] (level 1) and shortwave therapy[159–163] (level 2) in the treatment of acute LAS. Evidence on acupuncture is inconclusive concerning the therapeutic effect due to large heterogeneity between studies[164 165] (level 1). A small cohort study indicated that local vibration therapy may be effective in patients with LAS by increasing dorsiflexion and eversion and decreasing perceived ankle stiffness,[166] while another study indicated the possible beneficial effect of Bioptron light therapy in addition to cryotherapy[167] (level 3).

What's new: Acupuncture, vibration therapy and Bioptron light therapy were added to the present update. Concerning the other identified therapies, new evidence did not change previous statements.

Recommendation (not changed): As no strong evidence exists on the effectiveness of these treatment modalities, they are not advised in the treatment of acute LAS (level 2).

Communication between professionals

Since there are various disciplines involved in the care for patients with LAS, it is preferable to make working arrangements at a regional level on indications for referral, division of tasks and what information is provided by healthcare professionals. The different disciplines involved in primary and secondary care are emergency physicians, sports masseurs and physical therapists, sports physicians and general practitioners, orthopaedic and trauma surgeons, radiologists, medical officers for occupational medicine and rehabilitation physicians. Within referral between healthcare professionals, optimal communication is preferred. What information should be communicated between healthcare professionals depends on the phase of LAS; the diagnostic phase, the treatment phase and the guidance phase.[14 168–170]

What's new: The checklist and statements from the previous version of this guideline were not subject to change. The most important factor remains communication.

Recommendation (not changed): To refine communication between healthcare professionals involved in the treatment of patients with LAS, a communication check list is recommended (table 4).[14 168–170]

Prevention

Functional support

The use of brace or tape reduces the risk of both recurrent (RR 0.30, 95% CI 0.21 to 0.43) and first-time ankle sprains (RR 0.69, 95% CI 0.49 to 0.96), especially in those who participate in sports[4 125 171 172] (level 1). Kinesiotape may also have a preventive effect in patients who have already sustained a LAS due to its effects on postural control[171] (five RCTs, n=276) (level 1). The use of a brace or tape is a personal choice and based on practical usability and costs. Associated adverse events are rare.[4 125 171 172] Ankle brace or tape usage has not shown any beneficial effects on proprioceptive acuity in patients who sustained recurrent ankle sprains or those who have functional ankle instability (eight RCTs, n=152) (level 1). This conclusion was consistent when the two aspects of proprioception, sense of movement and joint position, were considered separately.[129] No differences in prevention of recurrent sprains were found between different types of tape and brace as support.[117 172 173]

What's new: In addition to updating the risk ratios by including new studies, a risk ratio is provided for the preventive effect of tape and brace for first-time ankle sprains. Additionally information on the effect on proprioception and adverse events was included. This new evidence did not change the previous recommendation.

Recommendation (not changed): Both tape and brace have a role in the prevention of recurrent LAS despite limited evidence on mechanisms that leads to these beneficial effects (level 1). The choice of usage should depend on personal preferences.

Exercise therapy

Coordination and balance training have been shown to prevent recurrent ankle sprains.[4] The assessment of the effect of exercise therapy as in neuromuscular training (mainly proprioception) has shown a positive effect towards prevention of LAS[132 139 173–175] and especially recurrent LAS. A meta-analysis (two RCTs, n=130)

Table 6 Results of prevention therapy

Preventive measure	Effect	Studies	Patients (N)	(S)MD/RR (95% CI)	Results in favour of
Immobilisation versus functional support	Recurrent sprains	11 RCTs	844	RR 1.17 (0.86 to 1.59)	None
Functional support	Recurrent sprains	6 RCTs	2307	RR 0.30 (0.21 to 0.43)	Functional support
	First-time sprains	4 RCTs	2933	RR 0.69 (0.49 to 0.96)	Functional support
	Sprains in mixed injured –non-injured groups	6 RCTs	6108	RR 0.39 (0.25 to 0.95)	Functional support
	Muscle activity	1 RCT	60	MD 1.13 (–1.48 to 3.75)	None
	Stability	1 RCT	62	MD –0.44 (– 0.70 to –0.18)	Functional support
Exercise therapy	Recurrent sprains	10 RCTs	1284	RR 0.62 (0.51 to 0.76)	Exercise
	First-time sprains	1 RCT	173	RR 0.45 (0.15 to 1.37)	None
	Sprains in mixed injured –non-injured groups	13 RCTs	8021	RR 0.60 (0.51 to 0.70)	Exercise
Surgery	Recurrent sprains	12 RCTs	1437	RR 0.72 (0.55 to 0.94)	Surgery

Immobilisation: cast; exercise therapy: physical therapy, strength training, proprioceptive training; functional support: brace, tape; surgery, anatomic repair or reconstruction; walker boot.
RCTs, randomised controlled trials; RR, relative risk; (S) MD, standardised mean difference .

illustrated that exercise therapy had a protective effect compared with usual care on preventing recurrent LAS (RR 0.62, 95% CI 0.51 to 0.76). Usual care was defined as 'any form of rehabilitative treatment used by the athlete, without any interference from the authors' (cited from Hupperets *et al*).[176] This effect is even larger in athletes (RR 0.38, 95% CI 0.23 to 0.62)[38 177] (level 1). When exposing athletes with recurrent sprains to proprioceptive training, to improve joint position sense, their risk of recurrence of LAS is reduced to the same level as healthy controls[4 42 177–180] (level 3). Exercise therapy such as coordination and balance training mainly seem to be effective for recurrent ankle sprains up to 12 months after the initial sprain,[4 131 176 181] but not on first-time ankle sprains[21 38 175 182] (level 1).

What's new: More positive effects of different training programmes have become available, strengthening the recommendation of the previous guideline.

Recommendation (not changed): For this reason, it is advised to start exercise therapy, especially in athletes, as soon as possible after the initial sprain to prevent recurrent LAS. Exercise therapy should be included into regular training activities as much as possible as home-based exercise (level 1). The preventive effect of exercise therapy for first-time LAS lacks evidence (table 6).

Footwear

No evident conclusions exist on the role of footwear in the prevention of ankle sprains (level 2). Wearing low-fitted or high-fitted shoes did not show any difference in preventive effect (three RCTs, n=3410)[4 172 183] (level 1). Despite the lack of evidence, some authors prefer high-fitted shoes,[73 117] whereas other authors describe a preference of low-fitted shoes[120] (level 1). Possibly shoes being new is of greater importance compared with the height of the shaft of the shoe in preventing ankle sprains.[4] Also, no difference in LAS incidence is seen when wearing sports shoes with or without a cushioned column.[91]

What's new: New evidence corresponded with the evidence found in the previous guideline.

Recommendation (not changed): Due to the inconclusiveness of evidence, no recommendations can be made concerning shoe wear (level 1).

Resuming work

To facilitate return to work, discrimination between different degrees of injury can support the initial treatment and identification of the prognosis in relation to return to work[184] (level 4). Additionally, a schedule for work resumption (table 7), which takes into account all task requirements, may assist in optimisation of the reintegration process[185 186] (level 3). Two systematic reviews stated wearing a brace provided better functional outcome compared with no brace, without limiting return to work (two RCTs, n=157)[125 128] (level 2). Immediate post-traumatic mobilisation and functional treatment also seem to have a positive effect on the treatment of acute LAS and lead to shorter sick leave and faster return to work compared with immobilisation[131 187–189] (level 1).

What's new: With the current focus on productivity and socioeconomic burden, return to work is of substantial importance. Based on new available evidence, table 7 was expanded and the advice on return to work was further specified.

Table 7 Return to work and sports[185 186]

Degree of inversion injury	Time from injury (weeks)	Restrictions	Overall tips and tricks
Distortion (depending on degree of pain/subjective limitation/severity)	2	Mostly sitting work Not exceeding 10 kg of lifting Limit standing and walking position on uneven surfaces	▶ Phased rehabilitation focusing on work/sport-specific tasks ▶ Scheduled progression of work activities ▶ Work-hardening and functional capacity evaluation ▶ Recognition of the emotional aspect of the situation ▶ Involvement of an occupational physician and therapist
	3–4	Return to full work and sports depending on task requirements	
Partial or total rupture of ligaments	3–6	Mostly sitting work Not exceeding 10 kg of lifting Limit standing and walking position on uneven surfaces	
	6–8	Return to full work and sports depending on task requirements and result of physiotherapy	
In case of surgery	2	Non-weightbearing cast and crutches	
	3–6	Weight bearing as tolerated Sedentary work resumed in case of weight bearing	
	>6	Cast is replaced by a brace	
	12–16	Return to physically demanding job and sports	

Vuurberg G, *et al*. *Br J Sports Med* 2018;**52**:956. doi:10.1136/bjsports-2017-098106

Recommendation (modified): To speed up return to work, a brace and immediate functional treatment in combination with a return to work schedule are advised (level 3).

Sport resumption

LAS may lead to multiple problems such as proprioception disturbances. These disturbances seem to originate from the central nervous system above the level of the spinal reflex (level 2) and may result in functional instability.[190–192] Additionally, delayed response time of the peroneal muscle has been detected, possibly due to traction injury of the peroneal nerve.[193] However, motor-unit insufficiencies seen after a LAS seem to last shorter than those after other lateral ankle injuries not based on an inversion trauma mechanism[178 193–195] (level 2). Strength deficits are present following LAS. For these reasons, early functional treatment is advised and should address proprioception, muscle response time and muscle strength,[196–200] enabling early return to sport participation[187 188] (level 2).

What's new: In addition to the many new and varying types of rehabilitation programmes, recent results showed that supervised exercise provides better outcomes compared with non-supervised training.

Recommendation (modified): Supervised exercises focusing on a variety of exercises such as proprioception, strength, coordination and function will lead to a faster return to sport in patients after a LAS[134] and are therefore recommended (level 1).

Cost-effectiveness

Costs of injury

Estimated societal costs of ankle sprains, as reported in the literature, vary between €360[201] and €1100[202] per individual (level 2). This disparity in reported costs is due to, among others, variations in healthcare system, population, and type and severity of injury. Although most patients with ankle sprain do not receive supervised rehabilitation[203] (level 3), these values indicate that ankle sprains have a substantial financial impact on society. Additionally, added to these costs in the short term, patients with ankle sprain are at risk of developing chronic conditions, which in turn may lead to subsequent costs. Consequently, optimised treatment and prevention will provide economic benefits in addition to clinical effects for the individual.

Diagnostics

The OAR provide a valid and reliable cost-effective tool to diagnose fractures after an ankle sprain[203] (level 3). In 1995, it was shown that implementing the OAR as opposed to existing hospital protocols resulted in cost savings between €7.01 and €30.96 per patient[204] (level 3). More recently, implementation of the OAR through emergency department nurses has been shown to be a cost-effective method to diagnose and manage ankle sprains[205] (level 3). As an alternative to the OAR, the low-risk ankle rule provides a cost-effective tool to diagnose paediatric ankle fractures, with an estimated reduction in required radiographs of around 60%[206] (level 3).

Treatment

Functional treatment is clinically the treatment strategy of choice for ankle sprains. No full cost-effectiveness studies are known to compare functional treatment against immobilisation as treatment. In regards to indirect costs, a functional approach (3–5 days of rest, ice, compression and elevation with early weight bearing, after which active exercise is commenced) leads to the fastest resumption of work and daily life activities compared with any other kind of treatment[207] (level 3). For protection, ankle support may be indicated to facilitate return to work. A semirigid brace is suggested to be the most cost-effective option compared with taping[208] (level 3).

Prevention

Preventive efforts against first-time and recurrent ankle sprains have shown high cost benefits[208] (level 3). Both neuromuscular training and ankle braces have been proven beneficial as a preventive investment due to lower societal costs, mainly achieved through reduced indirect costs[209] (level 2). Comparisons between measures have indicated bracing to be superior to taping[210] and neuromuscular training[211] as a preventive option (level 1). Of note is that the latter statement is only valid for the preventive value of bracing. Neuromuscular training has been associated with clinical benefits other than prevention alone, which should also be considered[212] (level 1) (table 8).

DISCUSSION

After an acute LAS it is important to first exclude the presence of any fractures. To this end the OAR can be used, having a high sensitivity and specificity. Subsequently, functional treatment in the form of exercise and functional support (ie, brace or tape) is preferred over immobilisation. Still a short time of immobilisation may help diminish complaints of pain and swelling in case of a lateral ligament injury. In case of ROM restriction, mobilisation therapy may provide help, but combination with exercise therapy is advised. Surgery should be reserved for patients with lateral ligament ruptures to avoid unnecessary invasive treatment and risk of complications. In the prevention of ankle sprains, functional support is effective in patients with both first-time and recurrent LAS, but seems most effective in preventing recurrent sprains. Exercise therapy, however, has only shown a significant preventive effect for recurrent ankle sprains. For first-time LAS, there was mainly a lack of evidence as studies did not explicitly name whether their included population had previously suffered a LAS or not. Additionally, this may be explained by a lack of research on exercise in a population who has never suffered a LAS as exercise is mostly commenced after injury during rehabilitation.

Overall there is no clear evidence on the role of other forms of therapy such as (high-fitted and low- fitted and sports) shoe wear, vibration and electrostimulation therapy in the treatment and prevention of (recurrent) LAS. There are no conclusions on acupuncture since there were no studies that involved a sham acupuncture group. On the exact role of BMI, we cannot provide any conclusive recommendations. Whereas a lower BMI seems to increase the risk of sustaining an initial ankle sprain, a higher BMI seems to be a prognostic factor for persistent complaints and incomplete recovery.

Apart from the side effects reported for NSAIDs usage and complications resulting from surgery, no complications have been reported for functional support devices such as tape or brace.[213] This is despite some known adverse effects such as rashes, which may need more detailed reporting in articles studying such devices.

By development of this CPG on ankle sprains, all current evidence is considered to provide insight into the best evidence-based practice. To ensure readability, all information was categorised, summarised and recommendations provided separately explicating the effectiveness per treatment or preventive modality. Overall, this guideline provides strong evidence per treatment and preventive modality by combining multiple RCTs

Table 8 Final recommendations per intervention modality

Modality	Recommendation	Level of evidence
Predisposing factors	In the treatment of patients with LAS, modifiable risk factors should be identified and, if possible, addressed.	2–3
Prognostic factors	Assessed of prognostic factors during the rehabilitation process in order to address negative modifiable factors.	3
Diagnostics	Late physical examination is advised to come to conclusions on the severity of the ligament damage.	2
RICE	RICE is not advised as treatment modality after a LAS.	2
NSAIDs	NSAIDs may be used to reduce pain and swelling.	2
Immobilisation	Immobilisation should not be used in the treatment of a LAS.	2
Functional support	Functional support is preferred over immobilisation, especially the use of a brace.	2
	For prevention, both tape and brace may be used. Choice of modality should always be based on patient preferences.	1
Exercise	Exercise therapy should be started as soon as possible to recover joint functionality.	1
	For recurrent ankle sprains, exercise should be included in regular training activities as much as possible.	1
Manual mobilisation	Manual mobilisation is only advised in combination with other treatment modalities to enhance the treatment effect.	3
Surgery	Surgery is only advised for patients that require quick recovery, such as professional athletes, or whose complaints are not resolved by conservative treatment to avoid unnecessary invasive treatment on patients that would just as well recover from conservative treatment.	1
Other therapies	Based on current evidence, other modalities than the once mentioned above are not advised.	2
Interprofessional communication	A communication checklist should be used to ensure communication errors.	1
Footwear	No recommendations can be made concerning footwear due to inconclusiveness of evidence.	1
Work resumption	Immediate functional treatment and a return to work schedule are advised to minimise work absenteeism.	3
Sport resumption	Supervised exercises are advised with the focus on proprioception, strength, coordination and function.	1

LAS, lateral ankle sprain; NSAIDs, non-steroidal anti-inflammatory drugs; RICE, Rest Ice Compression Elevation.

showing consistent results. The AGREE II reporting guidelines have been used in an attempt to optimise the quality of this CPG.

Provided evidence may, however, be influenced by publication bias, indicated by the limited amount of evidence on negative effects or treatment without any clinical effect. Level of evidence and bias assessment using GRADEpro were not possible due to the large amount of included studies. As an alternative, each statement was provided with a level of evidence according to tables 1 and 2. There is also the effect of selection bias. Ankle sprains are very common, and many people sustaining LAS do not seek medical advice. Therefore, the effect of 'no intervention' on the outcome after LAS remains unknown. Most contradictory results were found in small studies showing both positive and negative effects, levelling out to a neutral MD or RR. Additionally, most studies only included injured patients, whereas there is some conflict in the evidence of certain preventive measures in patients with first-time LAS. For this, more research is needed to enable adequate comparison between preventive effects based on a history of ankle sprains, preferably within the same study group. The best available evidence has been included in this guideline. However, the preferred approach by both patients and healthcare professionals in the diagnostic process, treatment and prevention of LAS has not. This is due to a lack of evidence on subjective data, apart from patient satisfaction after undergoing a certain treatment. More evidence on this topic may help identify the best treatment strategy per patient.

By including all steps that may be encountered by a patient from the moment of sustaining an ankle sprain up to full recovery, this guideline also includes all procedures considered and possibly performed by healthcare professionals. Thus, this guideline has a clinical focus and may provide support for all healthcare professionals encountering patients with ankle sprain irrespective of the phase of rehabilitation the patient is in. Many of the steps addressed in this guideline are steps in daily clinical practice, whether they are proven effective or not. There is a need for a clear policy that can be implemented worldwide. By updating the guideline on ankle sprains, the first step is taken towards such a policy. Further awareness regarding this guideline, to enable healthcare providers to follow the state-of-the-art recommendations, must be raised by means of scientific publication, scientific referral, congresses and raising awareness among the various professional associations.

Future perspectives and research

This update provides the most recent evidence on diagnostics, treatment and prevention for acute LAS. As more evidence has become available, often of a higher evidence level, this enabled the use of meta-analyses where there was a lack of evidence in the initial guideline. However, not all recommendations were supported by meta-analysis. Also, some recommendations lack evidence from RCTs. A future update might be required if enough new studies become available. Thus this guideline may be updated after 5–10 years to ensure content and recommendations remain up to date using the same methodology and search strategy. If relevant new treatment methods, preventive techniques or other aspects are identified, these will receive appropriate attention depending on their importance for patients who sustained a LAS. In a future update, the methodological quality may be included to formulate conclusions based on the quality and reliability of results, as may be done using the GRADEpro tool.

Future research is required in the field of different functional treatment and prevention strategies, identifying superiority between different types of support and training and for which specific subpopulations these are effective (eg, recurrent or first-time LAS). Additional research may be performed on preferences of patients and healthcare professionals: what do patients prefer on forehand before undergoing treatment and what were their experiences? Which treatments do healthcare professionals prefer and is this dependent on injury severity, and so on, as this may contribute to formulating future recommendations.

Author affiliations
[1]Department of Orthopedic Surgery, Orthopaedic Research Center Amsterdam, Amsterdam Movement Sciences, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands
[2]Academic Center for Evidence Based Sports Medicine (ACES), Amsterdam, The Netherlands

[3]Amsterdam Collaboration for Health and Safety in Sports (ACHSS), VUmc / AMC IOC Research Centre for Prevention of Injury and Protection of Athlete Health, Amsterdam, The Netherlands
[4]VU Medical Center, Amsterdam Movement Sciences, Amsterdam, The Netherlands
[5]Department of Orthopaedic Surgery, Onze Lieve Vrouwen Gasthuis, Amsterdam, The Netherlands
[6]Dutch Society of Rehabilitation, University of Groningen, University Medical Center, Groningen, The Netherlands
[7]Department of Orthopaedic Surgery, Flevoziekenhuis, Almere, The Netherlands
[8]Dutch College of General Practitioners, Utrecht, The Netherlands
[9]Emergency Department, Academic Medical Center, Amsterdam, The Netherlands
[10]Department of Musculoskeletal Radiology, Academic Medical Center, Amsterdam, The Netherlands
[11]Department of of Public and Occupational Health VU University Medical Center, Amsterdam Movement Sciences, Amsterdam, The Netherlands
[12]Department of Epidemiology, School for Public Health and Primary Care (CAPHRI), Maastricht University Medical Center, Maastricht, The Netherlands

Acknowledgements The authors thank Clare Ardern for her support in the methodological approach for this update and her advice concerning structure and the most efficient approach of the meta-analyses. Additionally they thank F S van Etten, clinical librarian of the AMC.

Contributors The search and full-text inclusion was performed by GV, AH and BFWvdD. Meta-analyses were performed by GV and LMW. All authors were members of the guideline committee and contributed to the content of this guideline. This manuscript was read and approved by all authors.

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement All data used in this study may be found in the reference list or appendix including the flow chart and meta-analyses.

REFERENCES

1 Hertel J, Anatomy F. Functional Anatomy, Pathomechanics, and Pathophysiology of Lateral Ankle Instability. *J Athl Train* 2002;37:364–75.
2 Lynch SA, Renström PA. Treatment of acute lateral ankle ligament rupture in the athlete. Conservative versus surgical treatment. *Sports Med* 1999;27:61–71.
3 Doherty C, Delahunt E, Caulfield B, *et al*. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. *Sports Med* 2014;44:123–40.
4 Verhagen EA, van Mechelen W, de Vente W. The effect of preventive measures on the incidence of ankle sprains. *Clin J Sport Med* 2000;10:291–6.
5 Pijnenburg AC, Van Dijk CN, Bossuyt PM, *et al*. Treatment of ruptures of the lateral ankle ligaments: a meta-analysis. *J Bone Joint Surg Am* 2000;82:761–73.
6 van Rijn RM, van Os AG, Bernsen RMD, *et al*. What is the clinical course of acute ankle sprains? a systematic literature review. *Am J Med* 2008;121:324–31.
7 Gribble PA, Bleakley CM, Caulfield BM, *et al*. 2016 consensus statement of the International Ankle Consortium: prevalence, impact and long-term consequences of lateral ankle sprains. *Br J Sports Med* 2016;50:1493–5.
8 Delahunt E, Coughlan GF, Caulfield B, *et al*. Inclusion criteria when investigating insufficiencies in chronic ankle instability. *Med Sci Sports Exerc* 2010;42:2106–21.
9 Gribble PA, Delahunt E, Bleakley C, *et al*. Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the International Ankle Consortium. *J Orthop Sports Phys Ther* 2013;43:585–91.
10 Gribble PA, Delahunt E, Bleakley C, *et al*. Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the International Ankle Consortium. *Br J Sports Med* 2014;48:1014–8.
11 Gribble PA, Delahunt E, Bleakley CM, *et al*. Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the International Ankle Consortium. *J Athl Train* 2014;49:121–7.
12 Gribble PA, Bleakley CM, Caulfield BM, *et al*. Evidence review for the 2016 International Ankle Consortium consensus statement on the prevalence, impact and long-term consequences of lateral ankle sprains. *Br J Sports Med* 2016;50:1496–505.
13 Pihlajamäki H, Hietaniemi K, Paavola M, *et al*. Surgical versus functional treatment for acute ruptures of the lateral ligament complex of the ankle in young men: a randomized controlled trial. *J Bone Joint Surg Am* 2010;92:2367–74.
14 Kerkhoffs GM, van den Bekerom M, Elders LA, *et al*. Diagnosis, treatment and prevention of ankle sprains: an evidence-based clinical guideline. *Br J Sports Med* 2012;46:854–60.
15 Ouzzani M, Hammady H, Fedorowicz Z, *et al*. Rayyan-a web and mobile app for systematic reviews. *Syst Rev* 2016;5:210.
16 Vernooij RW, Alonso-Coello P, Brouwers M, *et al*. Reporting Items for Updated Clinical Guidelines: Checklist for the Reporting of Updated Guidelines (CheckUp). *PLoS Med* 2017;14:e1002207.
17 Pope R, Herbert R, Kirwan J. Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in Army recruits. *Aust J Physiother* 1998;44:165–72.
18 de Noronha M, Refshauge KM, Herbert RD, *et al*. Do voluntary strength, proprioception, range of motion, or postural sway predict occurrence of lateral ankle sprain?. *Br J Sports Med* 2006;40:824–8.
19 Kobayashi T, Yoshida M, Yoshida M, *et al*. Intrinsic Predictive Factors of Noncontact Lateral Ankle Sprain in Collegiate Athletes: A Case-Control Study. *Orthop J Sports Med* 2013;1:232596711351816.
20 Tropp H, Ekstrand J, Gillquist J. Stabilometry in functional instability of the ankle and its value in predicting injury. *Med Sci Sports Exerc* 1984;16:64–6.
21 McGuine TA, Keene JS. The effect of a balance training program on the risk of ankle sprains in high school athletes. *Am J Sports Med* 2006;34:1103–11.
22 de Noronha M, França LC, Haupenthal A, *et al*. Intrinsic predictive factors for ankle sprain in active university students: a prospective study. *Scand J Med Sci Sports* 2013;23:541–7.
23 Kobayashi T, Tanaka M, Shida M. Intrinsic Risk Factors of Lateral Ankle Sprain: A Systematic Review and Meta-analysis. *Sports Health* 2016;8:190–3.
24 Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. *Br J Sports Med* 2006;40:610–3.
25 Willems TM, Witvrouw E, Delbaere K, *et al*. Intrinsic risk factors for inversion ankle sprains in male subjects: a prospective study. *Am J Sports Med* 2005;33:415–23.
26 Hrysomallis C, McLaughlin P, Goodman C. Balance and injury in elite Australian footballers. *Int J Sports Med* 2007;28:844–7.
27 Wang HK, Chen CH, Shiang TY, *et al*. Risk-factor analysis of high school basketball-player ankle injuries: a prospective controlled cohort study evaluating postural sway, ankle strength, and flexibility. *Arch Phys Med Rehabil* 2006;87:821–5.
28 Watson AW. Ankle sprains in players of the field-games Gaelic football and hurling. *J Sports Med Phys Fitness* 1999;39:66–70.
29 Waterman BR, Belmont PJ, Cameron KL, *et al*. Epidemiology of ankle sprain at the United States Military Academy. *Am J Sports Med* 2010;38:797–803.
30 Rice H, Nunns M, House C, *et al*. High medial plantar pressures during barefoot running are associated with increased risk of ankle inversion injury in Royal Marine recruits. *Gait Posture* 2013;38:614–8.
31 Onate JA, Everhart JS, Clifton DR, *et al*. Physical Exam Risk Factors for Lower Extremity Injury in High School Athletes: A Systematic Review. *Clin J Sport Med* 2016;26:435–44.
32 Frigg A, Magerkurth O, Valderrabano V, *et al*. The effect of osseous ankle configuration on chronic ankle instability. *Br J Sports Med* 2007;41:420–4.
33 Magerkurth O, Frigg A, Hintermann B, *et al*. Frontal and lateral characteristics of the osseous configuration in chronic ankle instability. *Br J Sports Med* 2010;44:568–72.
34 Fousekis K, Tsepis E, Vagenas G. Intrinsic risk factors of noncontact ankle sprains in soccer: a prospective study on 100 professional players. *Am J Sports Med* 2012;40:1842–50.
35 Hagen M, Asholt J, Lemke M, *et al*. The angle-torque-relationship of the subtalar pronators and supinators in male athletes: A comparative study of soccer and handball players. *Technol Health Care* 2016;24:391–9.
36 Swenson DM, Collins CL, Fields SK, *et al*. Epidemiology of U.S. high school sports-related ligamentous ankle injuries, 2005/06-2010/11. *Clin J Sport Med* 2013;23:190–6.
37 McHugh MP, Tyler TF, Tetro DT, *et al*. Risk factors for noncontact ankle sprains in high school athletes: the role of hip strength and balance ability. *Am J Sports Med* 2006;34:464–70.
38 Verhagen E, van der Beek A, Twisk J, *et al*. The effect of a proprioceptive balance board training program for the prevention of ankle sprains: a prospective controlled trial. *Am J Sports Med* 2004;32:1385–93.
39 Engebretsen AH, Myklebust G, Holme I, *et al*. Intrinsic risk factors for acute ankle injuries among male soccer players: a prospective cohort study. *Scand J Med Sci Sports* 2010;20:403–10.
40 Fong DT, Hong Y, Chan LK, *et al*. A systematic review on ankle injury and ankle sprain in sports. *Sports Med* 2007;37:73–94.
41 Verhagen EA, Van der Beek AJ, Bouter LM, *et al*. A one season prospective cohort study of volleyball injuries. *Br J Sports Med* 2004;38:477–81.
42 Bahr R, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. *Scand J Med Sci Sports* 1997;7:166–71.
43 Ekstrand J, Timpka T, Hägglund M. Risk of injury in elite football played on artificial turf versus natural grass: a prospective two-cohort study. *Br J Sports Med* 2006;40:975–80.
44 Orchard JW, Powell JW. Risk of knee and ankle sprains under various weather conditions in American football. *Med Sci Sports Exerc* 2003;35:1118–23.
45 Hershman EB, Anderson R, Bergfeld JA, *et al*. An analysis of specific lower extremity injury rates on grass and FieldTurf playing surfaces in National Football League Games: 2000-2009 seasons. *Am J Sports Med* 2012;40:2200–5.
46 Kofotolis N, Kellis E. Ankle sprain injuries: a 2-year prospective cohort study in female Greek professional basketball players. *J Athl Train* 2007;42:388–94.

47 Kofotolis ND, Kellis E, Vlachopoulos SP. Ankle sprain injuries and risk factors in amateur soccer players during a 2-year period. *Am J Sports Med* 2007;35:458–66.
48 Foster A, Blanchette MG, Chou YC, *et al*. The influence of heel height on frontal plane ankle biomechanics: implications for lateral ankle sprains. *Foot Ankle Int* 2012;33:64–9.
49 van Rijn RM, van Os AG, Bernsen RM, *et al*. What is the clinical course of acute ankle sprains? A systematic literature review. *Am J Med* 2008;121:324–31.
50 Kemler E, Thijs KM, Badenbroek I, *et al*. Long-term prognosis of acute lateral ankle ligamentous sprains: high incidence of recurrences and residual symptoms. *Fam Pract* 2016;33:596–600.
51 van Middelkoop M, van Rijn RM, Verhaar JA, *et al*. Re-sprains during the first 3 months after initial ankle sprain are related to incomplete recovery: an observational study. *J Physiother* 2012;58:181–8.
52 Hershkovich O, Tenenbaum S, Gordon B, *et al*. A large-scale study on epidemiology and risk factors for chronic ankle instability in young adults. *J Foot Ankle Surg* 2015;54:183–7.
53 Doherty C, Bleakley C, Hertel J, *et al*. Recovery From a First-Time Lateral Ankle Sprain and the Predictors of Chronic Ankle Instability: A Prospective Cohort Analysis. *Am J Sports Med* 2016;44:995–1003.
54 Doherty C, Bleakley C, Hertel J, *et al*. Single-leg drop landing movement strategies in participants with chronic ankle instability compared with lateral ankle sprain 'copers'. *Knee Surg Sports Traumatol Arthrosc* 2016;24:1049–59.
55 Hubbard TJ, Cordova M. Mechanical instability after an acute lateral ankle sprain. *Arch Phys Med Rehabil* 2009;90:1142–6.
56 Hubbard TJ. Ligament laxity following inversion injury with and without chronic ankle instability. *Foot Ankle Int* 2008;29:305–11.
57 Linde F, Hvass I, Jürgensen U, *et al*. Early mobilizing treatment in lateral ankle sprains. Course and risk factors for chronic painful or function-limiting ankle. *Scand J Rehabil Med* 1986;18:17–21.
58 Doherty C, Bleakley C, Hertel J, *et al*. Dynamic Balance Deficits 6 Months Following First-Time Acute Lateral Ankle Sprain: A Laboratory Analysis. *J Orthop Sports Phys Ther* 2015;45:626–33.
59 Punt IM, Ziltener JL, Laidet M, *et al*. Gait and physical impairments in patients with acute ankle sprains who did not receive physical therapy. *Pm R* 2015;7:34–41.
60 van Rijn RM, van Heest JA, van der Wees P, *et al*. Some benefit from physiotherapy intervention in the subgroup of patients with severe ankle sprain as determined by the ankle function score: a randomised trial. *Aust J Physiother* 2009;55:107–13.
61 O'Connor SR, Bleakley CM, Tully MA, *et al*. Predicting functional recovery after acute ankle sprain. *PLoS One* 2013;8:e72124.
62 van Rijn RM, Willemsen SP, Verhagen AP, *et al*. Explanatory variables for adult patients' self-reported recovery after acute lateral ankle sprain. *Phys Ther* 2011;91:77–84.
63 Bachmann LM, Kolb E, Koller MT, *et al*. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. *BMJ* 2003;326:417.
64 Knudsen R, Vijdea R, Damborg F. Validation of the Ottawa ankle rules in a Danish emergency department. *Dan Med Bull* 2010;57:A4142.
65 Jonckheer P, Willems T, De Ridder R, *et al*. Evaluating fracture risk in acute ankle sprains: Any news since the Ottawa Ankle Rules? A systematic review. *Eur J Gen Pract* 2016;22:31–41.
66 Meena S, Gangary SK. Validation of the Ottawa Ankle Rules in Indian Scenario. *Arch Trauma Res* 2015;4:e20969.
67 Wang X, Chang SM, Yu GR, *et al*. Clinical value of the Ottawa ankle rules for diagnosis of fractures in acute ankle injuries. *PLoS One* 2013;8:e63228.
68 van Dijk CN, Lim LS, Bossuyt PM, *et al*. Physical examination is sufficient for the diagnosis of sprained ankles. *J Bone Joint Surg Br* 1996;78:958–62.
69 van Dijk CN, Mol BW, Lim LS, *et al*. Diagnosis of ligament rupture of the ankle joint. Physical examination, arthrography, stress radiography and sonography compared in 160 patients after inversion trauma. *Acta Orthop Scand* 1996;67:566–70.
70 Markert RJ, Walley ME, Guttman TG, *et al*. A pooled analysis of the Ottawa ankle rules used on adults in the ED. *Am J Emerg Med* 1998;16:564–7.
71 Myers A, Canty K, Nelson T. Are the Ottawa ankle rules helpful in ruling out the need for x ray examination in children? *Arch Dis Child* 2005;90:1309–11.
72 Perry JJ, Stiell IG. Impact of clinical decision rules on clinical care of traumatic injuries to the foot and ankle, knee, cervical spine, and head. *Injury* 2006;37:1157–65.
73 Pijnenburg AC, Glas AS, De Roos MA, *et al*. Radiography in acute ankle injuries: the Ottawa Ankle Rules versus local diagnostic decision rules. *Ann Emerg Med* 2002;39:599–604.
74 Derksen RJ, Knijnenberg LM, Fransen G, *et al*. Diagnostic performance of the Bernese versus Ottawa ankle rules: Results of a randomised controlled trial. *Injury* 2015;46:1645–9.
75 Konradsen L, Hølmer P, Søndergaard L. Early mobilizing treatment for grade III ankle ligament injuries. *Foot Ankle* 1991;12:69–73.
76 Lin CW, Uegaki K, Coupé VM, *et al*. Economic evaluations of diagnostic tests, treatment and prevention for lateral ankle sprains: a systematic review. *Br J Sports Med* 2013;47:1144–9.
77 Lin CY, Shau YW, Wang CL, *et al*. Quantitative evaluation of the viscoelastic properties of the ankle joint complex in patients suffering from ankle sprain by the anterior drawer test. *Knee Surg Sports Traumatol Arthrosc* 2013;21:1396–403.
78 Polzer H, Kanz KG, Prall WC, *et al*. Diagnosis and treatment of acute ankle injuries: development of an evidence-based algorithm. *Orthop Rev* 2012;4:5.
79 Yammine K, Fathi Y. Ankle "sprains" during sport activities with normal radiographs: Incidence of associated bone and tendon injuries on MRI findings and its clinical impact. *Foot* 2011;21:176–8.
80 van Putte-Katier N, van Ochten JM, van Middelkoop M, *et al*. Magnetic resonance imaging abnormalities after lateral ankle trauma in injured and contralateral ankles. *Eur J Radiol* 2015;84:2586–92.
81 Roemer FW, Jomaah N, Niu J, *et al*. Ligamentous injuries and the risk of associated tissue damage in acute ankle sprains in athletes: a cross-sectional MRI Study. *Am J Sports Med* 2014;42:1549–57.
82 Margetić P, Pavić R. Comparative assessment of the acute ankle injury by ultrasound and magnetic resonance. *Coll Antropol* 2012;36:605–10.
83 Margetic P, Salaj M, Lubina IZ. The Value of Ultrasound in Acute Ankle Injury: Comparison With MR. *Eur J Trauma Emerg Surg* 2009;35:141–6.
84 Bleakley C, McDonough S, MacAuley D. The use of ice in the treatment of acute soft-tissue injury: a systematic review of randomized controlled trials. *Am J Sports Med* 2004;32:251–61.
85 van den Bekerom MP, Struijs PA, Blankevoort L, *et al*. What is the evidence for rest, ice, compression, and elevation therapy in the treatment of ankle sprains in adults? *J Athl Train* 2012;47:435–43.
86 Coté DJ, Prentice WE, Hooker DN, *et al*. Comparison of three treatment procedures for minimizing ankle sprain swelling. *Phys Ther* 1988;68:1072–6.
87 Airaksinen O, Kolari PJ, Miettinen H. Elastic bandages and intermittent pneumatic compression for treatment of acute ankle sprains. *Arch Phys Med Rehabil* 1990;71:380–3.
88 Rucinkski TJ, Hooker DN, Prentice WE, *et al*. The effects of intermittent compression on edema in postacute ankle sprains. *J Orthop Sports Phys Ther* 1991;14:65–9.
89 Tsang KK, Hertel J, Denegar CR. Volume decreases after elevation and intermittent compression of postacute ankle sprains are negated by gravity-dependent positioning. *J Athl Train* 2003;38:320–4.
90 Bleakley CM, McDonough SM, MacAuley DC, *et al*. Cryotherapy for acute ankle sprains: a randomised controlled study of two differencing protocols. *Br J Sports Med* 2006;40:700–5.
91 Bleakley CM, O'Connor SR, Tully MA, *et al*. Effect of accelerated rehabilitation on function after ankle sprain: randomised controlled trial. *BMJ* 2010;340:c1964.
92 Hing W, Lopes J, Hume PA, *et al*. Comparison of multimodal physiotherapy and "R.I.C.E."self- treatment for early management of ankle sprains. *New Zealand Journal of Physiotherapy* 2011;39:13–19.
93 van den Bekerom MPJ, Sjer A, Somford MP, *et al*. Non-steroidal anti-inflammatory drugs (NSAIDs) for treating acute ankle sprains in adults: benefits outweigh adverse events. *Knee Surgery, Sports Traumatology, Arthroscopy* 2015;23:2390–9.
94 Campbell J, Dunn T. Evaluation of topical ibuprofen cream in the treatment of acute ankle sprains. *Emergency Medicine Journal* 1994;11:178–82.
95 Predel HG, Hamelsky S, Gold M, *et al*. Efficacy and Safety of Diclofenac Diethylamine 2.32% Gel in Acute Ankle Sprain. *Medicine & Science in Sports & Exercise* 2012;44:1629–36.
96 Predel H-G, Giannetti B, Seigfried B, *et al*. A randomized, double-blind, placebo-controlled multicentre study to evaluate the efficacy and safety of diclofenac 4% spray gel in the treatment of acute uncomplicated ankle sprain. *J Int Med Res* 2013;41:1187–202.
97 Serinken M, Eken C, Elicabuk H. Topical Ketoprofen versus placebo in treatment of acute ankle sprain in the emergency department. *Foot Ankle Int* 2016;37:989–93.
98 Bahamonde LA, Saavedra H. Comparison of the analgesic and anti-inflammatory effects of diclofenac potassium versus piroxicam versus placebo in ankle sprain patients. *J Int Med Res* 1990;18:104–11.
99 Ekman EF, Fiechtner JJ, Levy S, *et al*. Efficacy of celecoxib versus ibuprofen in the treatment of acute pain: a multicenter, double-blind, randomized controlled trial in acute ankle sprain. *Am J Orthop* 2002;31:445–51.
100 Ekman EF, Ruoff G, Kuehl K, *et al*. The COX-2 specific inhibitor Valdecoxib versus tramadol in acute ankle sprain: a multicenter randomized, controlled trial. *Am J Sports Med* 2006;34:945–55.
101 Morán M. An observer-blind comparison of diclofenac potassium, piroxicam and placebo in the treatment of ankle sprains. *Curr Med Res Opin* 1990;12:268–74.
102 Morán M. Double-blind comparison of diclofenac potassium, ibuprofen and placebo in the treatment of ankle sprains. *J Int Med Res* 1991;19:121–30.
103 Petrella R, Ekman EF, Schuller R, *et al*. Efficacy of celecoxib, a COX-2-specific inhibitor, and naproxen in the management of acute ankle sprain: results of a double-blind, randomized controlled trial. *Clin J Sport Med* 2004;14:225–31.
104 Nadarajah A, Abrahan L, Lau FL, *et al*. Efficacy and tolerability of celecoxib compared with diclofenac slow release in the treatment of acute ankle sprain in an Asian population. *Singapore Med J* 2006;47:534–42.
105 Cardenas-Estrada E, Oliveira LG, Abad HL, *et al*. Efficacy and safety of celecoxib in the treatment of acute pain due to ankle sprain in a Latin American and Middle Eastern population. *J Int Med Res* 2009;37:1937–51.
106 Hajimaghsoudi M, Jalili M, Mokhtari M, *et al*. Naproxen Twice Daily Versus as Needed (PRN) Dosing: Efficacy and Tolerability for Treatment of Acute Ankle Sprain, a Randomized Clinical Trial. *Asian J Sports Med* 2013;4:249–55.

107 Dalton JD, Schweinle JE. Randomized controlled noninferiority trial to compare extended release acetaminophen and ibuprofen for the treatment of ankle sprains. *Ann Emerg Med* 2006;48:615–23.
108 Kayali C, Agus H, Surer L, *et al*. The efficacy of paracetamol in the treatment of ankle sprains in comparison with diclofenac sodium. *Saudi Med J* 2007;28:1836–9.
109 Lyrtzis C, Natsis K, Papadopoulos C, *et al*. Efficacy of paracetamol versus diclofenac for Grade II ankle sprains. *Foot Ankle Int* 2011;32:571–5.
110 Aghababian RV. Comparison of diflunisal and acetaminophen with codeine in the management of grade 2 ankle sprain. *Clin Ther* 1986;8:520–6.
111 Stovitz SD, Johnson RJ. NSAIDs and musculoskeletal treatment: what is the clinical evidence? *Phys Sportsmed* 2003;31:35–52.
112 Fotiadis E, Kenanidis E, Samoladas E, *et al*. Are venotonic drugs effective for decreasing acute posttraumatic oedema following ankle sprain? A prospective randomized clinical trial. *Arch Orthop Trauma Surg* 2011;131:389–92.
113 Rowden A, Dominici P, D'Orazio J, *et al*. Double-blind, Randomized, Placebo-controlled Study Evaluating the Use of Platelet-rich Plasma Therapy (PRP) for Acute Ankle Sprains in the Emergency Department. *J Emerg Med* 2015;49:546–51.
114 González de Vega C, Speed C, Wolfarth B, *et al*. Traumeel vs. diclofenac for reducing pain and improving ankle mobility after acute ankle sprain: a multicentre, randomised, blinded, controlled and non-inferiority trial. *Int J Clin Pract* 2013;67:979–89.
115 Petrella RJ, Petrella MJ, Cogliano A. Periarticular hyaluronic acid in acute ankle sprain. *Clin J Sport Med* 2007;17:251–7.
116 Petrella MJ, Cogliano A, Petrella RJ. Original research: long-term efficacy and safety of periarticular hyaluronic acid in acute ankle sprain. *Phys Sportsmed* 2009;37:64–70.
117 Kerkhoffs GM, Rowe BH, Assendelft WJ, *et al*. Immobilisation and functional treatment for acute lateral ankle ligament injuries in adults. *The Cochrane database of systematic reviews* 2002;3:CD003762.
118 Naeem M, Rahimnajjad MK, Rahimnajjad NA, *et al*. Assessment of functional treatment versus plaster of Paris in the treatment of grade 1 and 2 lateral ankle sprains. *J Orthop Traumatol* 2015;16:41–6.
119 Uslu M, Inanmaz ME, Ozsahin M, *et al*. Cohesive taping and short-leg casting in acute low-type ankle sprains in physically active patients. *J Am Podiatr Med Assoc* 2015;105:307–12.
120 Lamb SE, Marsh JL, Hutton JL, *et al*. Mechanical supports for acute, severe ankle sprain: a pragmatic, multicentre, randomised controlled trial. *Lancet* 2009;373:575–81.
121 Bilgic S, Durusu M, Aliyev B, *et al*. Comparison of two main treatment modalities for acute ankle sprain. *Pak J Med Sci* 2015;31:1496–9.
122 Prado MP, Mendes AA, Amodio DT, *et al*. A comparative, prospective, and randomized study of two conservative treatment protocols for first-episode lateral ankle ligament injuries. *Foot Ankle Int* 2014;35:201–6.
123 Bendahou M, Khiami F, Saïdi K, *et al*. Compression stockings in ankle sprain: a multicenter randomized study. *Am J Emerg Med* 2014;32:1005–10.
124 Noh JH, Yang BG, Yi SR, *et al*. Outcome of the functional treatment of first-time ankle inversion injury. *J Orthop Sci* 2010;15:524–30.
125 Kerkhoffs GM, Struijs PA, Marti RK, *et al*. Different functional treatment strategies for acute lateral ankle ligament injuries in adults. *The Cochrane database of systematic reviews* 2002;3:CD002938.
126 van den Bekerom MP, van Kimmenade R, Sierevelt IN, *et al*. Randomized comparison of tape versus semi-rigid and versus lace-up ankle support in the treatment of acute lateral ankle ligament injury. *Knee Surg Sports Traumatol Arthrosc* 2016;24:978–84.
127 Kemler E, van de Port I, Schmikli S, *et al*. Effects of soft bracing or taping on a lateral ankle sprain: a non-randomised controlled trial evaluating recurrence rates and residual symptoms at one year. *J Foot Ankle Res* 2015;8:13.
128 Kemler E, van de Port I, Backx F, *et al*. A systematic review on the treatment of acute ankle sprain: brace versus other functional treatment types. *Sports Med* 2011;41:185–97.
129 Raymond J, Nicholson LL, Hiller CE, *et al*. The effect of ankle taping or bracing on proprioception in functional ankle instability: a systematic review and meta-analysis. *J Sci Med Sport* 2012;15:386–92.
130 Zech A, Hübscher M, Vogt L, *et al*. Neuromuscular training for rehabilitation of sports injuries: a systematic review. *Med Sci Sports Exerc* 2009;41:1831–41.
131 van der Wees PJ, Lenssen AF, Hendriks EJ, *et al*. Effectiveness of exercise therapy and manual mobilisation in ankle sprain and functional instability: a systematic review. *Aust J Physiother* 2006;52:27–37.
132 Bleakley CM, McDonough SM, MacAuley DC. Some conservative strategies are effective when added to controlled mobilisation with external support after acute ankle sprain: a systematic review. *Aust J Physiother* 2008;54:7–20.
133 Postle K, Pak D, Smith TO. Effectiveness of proprioceptive exercises for ankle ligament injury in adults: a systematic literature and meta-analysis. *Man Ther* 2012;17:285–91.
134 van Rijn RM, van Ochten J, Luijsterburg PA, *et al*. Effectiveness of additional supervised exercises compared with conventional treatment alone in patients with acute lateral ankle sprains: systematic review. *BMJ* 2010;341:c5688.
135 Hultman K, Fältström A, Öberg U. The effect of early physiotherapy after an acute ankle sprain. *Adv Physiother* 2010;12:65–73.
136 Ismail MM, Ibrahim MM, Youssef EF, *et al*. Plyometric training versus resistive exercises after acute lateral ankle sprain. *Foot Ankle Int* 2010;31:523–30.
137 Cleland JA, Mintken P, McDevitt A, *et al*. Manual Physical Therapy and Exercise Versus Supervised Home Exercise in the Management of Patients With Inversion Ankle Sprain: A Multicenter Randomized Clinical Trial. *Journal of Orthopaedic & Sports Physical Therapy* 2013;43:443–55.
138 Feger MA, Herb CC, Fraser JJ, *et al*. Supervised Rehabilitation Versus Home Exercise in the Treatment of Acute Ankle Sprains. *Clin Sports Med* 2015;34:329–46.
139 van Os AG, Bierma-Zeinstra SMA, Verhagen AP, *et al*. Comparison of Conventional Treatment and Supervised Rehabilitation for Treatment of Acute Lateral Ankle Sprains: A Systematic Review of the Literature. *Journal of Orthopaedic & Sports Physical Therapy* 2005;35:95–105.
140 Hing W, Lopes J, Hume PA, *et al*. Comparison of multimodal physiotherapy and "R.I.C.E." self-treatment for early management of ankle sprains. *New Zealand Journal of Physiotherapy* 2011;39:13–19.
141 van Rijn RM, van Os AG, Kleinrensink GJ, *et al*. Supervised exercises for adults with acute lateral ankle sprain: a randomised controlled trial. *Br J Gen Pract* 2007;57:793–800.
142 Punt IM, Ziltener J-L, Monnin D, *et al*. Wii Fit™ exercise therapy for the rehabilitation of ankle sprains: Its effect compared with physical therapy or no functional exercises at all. *Scand J Med Sci Sports* 2016;26:816–23.
143 Loudon JK, Reiman MP, Sylvain J. The efficacy of manual joint mobilisation/manipulation in treatment of lateral ankle sprains: a systematic review. *Br J Sports Med* 2014;48:365–70.
144 Brantingham JW, Globe G, Pollard H, *et al*. Manipulative Therapy for Lower Extremity Conditions: Expansion of Literature Review. *J Manipulative Physiol Ther* 2009;32:53–71.
145 Mobarakeh M, Oah HJ. Effect of Friction Technique on Ankle Sprain Grade II Treatment. *Biomedical & Pharmacology Journal* 2015;8:523–8.
146 Truyols-Domínguez S, Salom-Moreno J, Abian-Vicen J, *et al*. Efficacy of thrust and nonthrust manipulation and exercise with or without the addition of myofascial therapy for the management of acute inversion ankle sprain: a randomized clinical trial. *Journal of Orthopaedic & Sports Physical Therapy* 2013;43:300–9.
147 Cosby NL, Koroch M, Grindstaff TL, *et al*. Immediate effects of anterior to posterior talocrural joint mobilizations following acute lateral ankle sprain. *Journal of Manual & Manipulative Therapy* 2011;19:76–83.
148 van Ochten JM, van Middelkoop M, Meuffels D, *et al*. Chronic Complaints After Ankle Sprains: A Systematic Review on Effectiveness of Treatments. *Journal of Orthopaedic & Sports Physical Therapy* 2014;44 862–23.
149 Struijs PA, Kerkhoffs GM. Ankle sprain. *BMJ Clin Evid* 2010;2010.
150 Kerkhoffs GMMJ, Handoll HHG, de Bie R, *et al*. Surgical versus conservative treatment for acute injuries of the lateral ligament complex of the ankle in adults. *Cochrane Database Syst Rev* 2007;8:Cd000380.
151 Petersen W, Rembitzki IV, Koppenburg AG, *et al*. Treatment of acute ankle ligament injuries: a systematic review. *Arch Orthop Trauma Surg* 2013;133:1129–41.
152 Han LH, Zhang CY, Liu B, *et al*. A Meta-analysis of treatment methods for acute ankle sprain. *Pakistan Journal of Medical Sciences* 2012;28:895–9.
153 Van Der Windt DA, Van Der Heijden GJ, Van Den Berg SG, *et al*. Ultrasound therapy for acute ankle sprains. *The Cochrane database of systematic reviews* 2002;1:CD001250.
154 van den Bekerom MP, van der Windt DA, Ter Riet G, *et al*. Therapeutic ultrasound for acute ankle sprains. *Eur J Phys Rehabil Med* 2012;48:325–34.
155 de Bie RA, de Vet HCW, Lenssen TF, *et al*. Low-level laser therapy in ankle sprains: A randomized clinical trial. *Arch Phys Med Rehabil* 1998;79:1415–20.
156 Mendel FC, Dolan MG, Fish DR, *et al*. Effect of high-voltage pulsed current on recovery after grades i and ii lateral ankle sprains. *J Sport Rehabil* 2010;19:399–410.
157 Feger MA, Goetschius J, Love H, *et al*. Electrical stimulation as a treatment intervention to improve function, edema or pain following acute lateral ankle sprains: A systematic review. *Physical Therapy in Sport* 2015;16:361–9.
158 Sandoval MC, Ramirez C, Camargo DM, *et al*. Effect of high-voltage pulsed current plus conventional treatment on acute ankle sprain. *Rev Bras Fisioter* 2010;14:193–9.
159 Barker AT, Barlow PS. Porter J. A double-blind clinical trial of lower power pulsed shortwave therapy in the treatment of a soft tissue injury. *Physical therapy* 1985;71:500–4.
160 Michlovitz S, Smith W, Watkins M. Ice and high voltage pulsed stimulation in treatment of acute lateral ankle sprains. *Journal of Orthopaedic & Sports Physical Therapy* 1988;9:301–4.
161 Pasila M, Visuri T, Sundholm A. Pulsating shortwave diathermy: value in treatment of recent ankle and foot sprains. *Archives of physical medicine and rehabilitation* 1978;59:383–6.
162 Pennington GM, Danley DL, Sumko MH, *et al*. Pulsed, non-thermal, high-frequency electromagnetic energy (DIAPULSE) in the treatment of grade I and grade II ankle sprains. *Mil Med* 1993;158:101–4.
163 Wilson DH. Treatment of soft-tissue injuries by pulsed electrical energy. *BMJ* 1972;2:269–70.
164 Park J, Hahn S, Park J-Y, *et al*. Acupuncture for ankle sprain: systematic review and meta-analysis. *BMC Complement Altern Med* 2013;13:55.

165 Kim T-H, Lee MS, Kim KH, *et al*. Acupuncture for treating acute ankle sprains in adults. *Cochrane Database Syst Rev* 2014;46:CD009065.
166 Peer KS, Barkley JE, Knapp DM. THe acute effects of local vibration therapy on ankle sprain and hamstring strain injuries. *Phys Sportsmed* 2009;37:31–8.
167 Stasinopoulos D, Papadopoulos C, Lamnisos D, *et al*. The use of Bioptron light (polarized, polychromatic, non-coherent) therapy for the treatment of acute ankle sprains. *Disabil Rehabil* 2017;39:450–7.
168 NederlandsHuisartsenGenootschap. *Informatie-uitwisseling tussen huisarts en specialist bij verwijzingen. Blad voor de huisarts*, 2008.
169 KNGF. *Richtlijn acuut lateraal enkelbandletsel*, 2011.
170 Belo J, Buis P, Rv R, *et al*. NHG-Standaard Enkelbandletsel (tweede herziening). *Huisarts Wet* 2012;55.
171 Wilson B, Bialocerkowski A. The Effects of Kinesiotape Applied to the Lateral Aspect of the Ankle: Relevance to Ankle Sprains – A Systematic Review. *PLoS One* 2015;10:e0124214.
172 Handoll HH, Rowe BH, Quinn KM, *et al*. Interventions for preventing ankle ligament injuries. *The Cochrane database of systematic reviews* 2001;3:CD000018.
173 Verhagen EALM, Bay K. Optimising ankle sprain prevention: a critical review and practical appraisal of the literature. *Br J Sports Med* 2010;44:1082–8.
174 Taylor JB, Ford KR, Nguyen AD, *et al*. Prevention of Lower Extremity Injuries in Basketball: A Systematic Review and Meta-Analysis. *Sports Health* 2015;7:392–8.
175 Schiftan GS, Ross LA, Hahne AJ. The effectiveness of proprioceptive training in preventing ankle sprains in sporting populations: A systematic review and meta-analysis. *J Sci Med Sport* 2015;18:238–44.
176 Hupperets MDW, Verhagen EALM, Mechelen Wv. Effect of unsupervised home based proprioceptive training on recurrences of ankle sprain: randomised controlled trial. *BMJ* 2009;339:b2684.
177 Tropp H, Askling C, Gillquist J. Prevention of ankle sprains. *Am J Sports Med* 1985;13:259–62.
178 Eils E, Rosenbaum D. A multi-station proprioceptive exercise program in patients with ankle instability. *Med Sci Sports Exerc* 2001;33:1991–8.
179 Holme E, Magnusson SP, Becher K, *et al*. The effect of supervised rehabilitation on strength, postural sway, position sense and re-injury risk after acute ankle ligament sprain. *Scand J Med Sci Sports* 1999;9:104–9.
180 Wester JU, Jespersen SM, Nielsen KD, *et al*. Wobble board training after partial sprains of the lateral ligaments of the ankle: a prospective randomized study. *Journal of Orthopaedic & Sports Physical Therapy* 1996;23:332–6.
181 Emery CA, *et al*. Effectiveness of a home-based balance-training program in reducing sports-related injuries among healthy adolescents: a cluster randomized controlled trial. *Can Med Assoc J* 2005;172:749–54.
182 Cumps E, Verhagen E, Meeusen R. Efficacy of a sports specific balance training programme on the incidence of ankle sprains in basketball. *J Sports Sci Med* 2007;6:212–9.
183 Curtis CK, Laudner KG, McLoda TA, *et al*. The role of shoe design in ankle sprain rates among collegiate basketball players. *J Athl Train* 2008;43:230–3.
184 Institute WLD. *Ankle & Foot (acute & chronic). Corpus Christi (TX*: Work Loss Data Institute, National Guideline Clearinghouse, 2008:152.
185 Kunkel M, Miller SD. Return to work after foot and ankle injury. *Foot Ankle Clin* 2002;7:421–8.
186 Abidi NA. Sprains about the foot and ankle encountered in the workmans' compensation patient. *Foot Ankle Clin* 2002;7:305–22.
187 van den Bekerom MPJ, Kerkhoffs GMMJ, McCollum GA, *et al*. Management of acute lateral ankle ligament injury in the athlete. *Knee Surgery, Sports Traumatology, Arthroscopy* 2013;21:1390–5.
188 Karlsson J, Eriksson BI, Swärd L. Early functional treatment for acute ligament injuries of the ankle joint. *Scand J Med Sci Sports* 1996;6:341–5.
189 Brooks SC, Potter BT, Rainey JB. Inversion injuries of the ankle: clinical assessment and radiographic review. *BMJ* 1981;282:607–8.
190 Anderson KM. *Movement control and cortical activation in functional ankle instability*: University of Minnesota, 2008.
191 Bullock-Saxton J, Janda V, Bullock M. The influence of ankle sprain injury on muscle activation during hip extension. *Int J Sports Med* 1994;15:330–4.
192 Wilkerson GB, Nitz AJ. Dynamic ankle stability: mechanical and neuromuscular interrelationships. *J Sport Rehabil* 1994;3:43–57.
193 Lynch SA, Eklund U, Gottlieb D, *et al*. Electromyographic latency changes in the ankle musculature during inversion moments. *Am J Sports Med* 1996;24:362–9.
194 Vaes P, Van Gheluwe B, Duquet W. Control of acceleration during sudden ankle supination in people with unstable ankles. *Journal of Orthopaedic & Sports Physical Therapy* 2001;31:741–52.
195 van Cingel REH, Kleinrensink G, Uitterlinden EJ, *et al*. Repeated ankle sprains and delayed neuromuscular response: acceleration time parameters. *Journal of Orthopaedic & Sports Physical Therapy* 2006;36:72–9.
196 Hartsell HD, Spaulding SJ. Eccentric/concentric ratios at selected velocities for the invertor and evertor muscles of the chronically unstable ankle. *Br J Sports Med* 1999;33:255–8.
197 Hubbard TJ, Kramer LC, Denegar CR, *et al*. Contributing factors to chronic ankle instability. *Foot Ankle Int* 2007;28:343–54.
198 Santos MJ, Liu W. Possible factors related to functional ankle instability. *J Orthop Sports Phys Ther* 2008;38:150–7.
199 Tropp H. Pronator muscle weakness in functional instability of the ankle joint. *Int J Sports Med* 1986;7:291–4.
200 Wilkerson GB, Pinerola JJ, Caturano RW. Invertor vs. evertor peak torque and power deficiencies associated with lateral ankle ligament injury. *J Orthop Sports Phys Ther* 1997;26:78–86.
201 Verhagen EA, van Tulder M, van der Beek AJ, *et al*. An economic evaluation of a proprioceptive balance board training programme for the prevention of ankle sprains in volleyball. *Br J Sports Med* 2005;39:111–5.
202 Cooke MW, Marsh JL, Clark M, *et al*. Treatment of severe ankle sprain: a pragmatic randomised controlled trial comparing the clinical effectiveness and cost-effectiveness of three types of mechanical ankle support with tubular bandage. The CAST trial. *Health Technol Assess* 2009;13:1–121.
203 Feger MA, Glaviano NR, Donovan L, *et al*. Current Trends in the Management of Lateral Ankle Sprain in the United States. *Clin J Sport Med* 2017;27:145–52.
204 Anis AH, Stiell IG, Stewart DG, *et al*. Cost-effectiveness analysis of the Ottawa Ankle Rules. *Ann Emerg Med* 1995;26:422–8.
205 Derksen RJ, Coupé VM, van Tulder MW, *et al*. Cost-effectiveness of the SEN-concept: Specialized Emergency Nurses (SEN) treating ankle/foot injuries. *BMC Musculoskelet Disord* 2007;8:99.
206 Nikken JJ, Oei EH, Ginai AZ, *et al*. Acute peripheral joint injury: cost and effectiveness of low-field-strength MR imaging--results of randomized controlled trial. *Radiology* 2005;236:958–67.
207 Audenaert A, Prims J, Reniers GL, *et al*. Evaluation and economic impact analysis of different treatment options for ankle distortions in occupational accidents. *J Eval Clin Pract* 2010;16:933–9.
208 Fatoye F, Haigh C. The cost-effectiveness of semi-rigid ankle brace to facilitate return to work following first-time acute ankle sprains. *J Clin Nurs* 2016;25:1435–43.
209 Janssen KW, Hendriks MR, van Mechelen W, *et al*. The Cost-Effectiveness of Measures to Prevent Recurrent Ankle Sprains: Results of a 3-Arm Randomized Controlled Trial. *Am J Sports Med* 2014;42:1534–41.
210 Hupperets MD, Verhagen EA, Heymans MW, *et al*. Potential savings of a program to prevent ankle sprain recurrence: economic evaluation of a randomized controlled trial. *Am J Sports Med* 2010;38:2194–200.
211 Mickel TJ, Bottoni CR, Tsuji G, *et al*. Prophylactic bracing versus taping for the prevention of ankle sprains in high school athletes: a prospective, randomized trial. *J Foot Ankle Surg* 2006;45:360–5.
212 Doherty C, Bleakley C, Delahunt E, *et al*. Treatment and prevention of acute and recurrent ankle sprain: an overview of systematic reviews with meta-analysis. *Br J Sports Med* 2017;51:113–25.
213 de Vries JS, Krips R, Blankevoort L, *et al*. Arthroscopic capsular shrinkage for chronic ankle instability with thermal radiofrequency: prospective multicenter trial. *Orthopedics* 2008;31:655–10.
214 Daş M, Temiz A, Çevik Y. Implementation of the Ottawa ankle rules by general practitioners in the emergency department of a Turkish district hospital. *Ulus Travma Acil Cerrahi Derg* 2016;22:361–4.
215 Kievit J, Verhoeff WWA, Dijkgraaf PB. *Rapport AZL-CBO: Sturing van Zorgverlening, Kwaliteit en Informatie. Budgettering op de Afdeling Algemene Heelkunde, Kostenonderzoek en Informatievoorziening. Utrecht*: The Netherlands: Nationaal Ziekenhuis Instituut, 1991:19–35.
216 van Riet Y, van der Schouw Y, van der Werken C. Minder rontgenfoto's en toch goede klinische zorg door geprotocolleerde fysische diagnostiek bij enkelletsels. *Ned Tijdschr Geneeskd* 2000;144:224–8.

CLINICAL PRACTICE GUIDELINES

ROBROY L. MARTIN, PT, PhD • **TODD E. DAVENPORT,** DPT • **JOHN J. FRASER,** DPT, PhD • **JENNA SAWDON-BEA,** PT, PhD
CHRISTOPHER R. CARCIA, PT, PhD • **LINDSAY A. CARROLL,** DPT • **BENJAMIN R. KIVLAN,** PT, PhD • **DOMINIC CARREIRA,** MD

Ankle Stability and Movement Coordination Impairments: Lateral Ankle Ligament Sprains Revision 2021

Clinical Practice Guidelines Linked to the International Classification of Functioning, Disability and Health From the Academy of Orthopaedic Physical Therapy of the American Physical Therapy Association

J Orthop Sports Phys Ther. 2021;51(4):CPG1-CPG80. doi:10.2519/jospt.2021.0302

REVIEWERS: Paul Beattie, PT, PhD • Jay Hertel, PhD, ATC • Jeff Houck, PT, PhD • Christopher Neville, PT, PhD
Stephen Paulseth, DPT, ATC • Karin Grävare Silbernagel, PT, PhD, ATC

Commander John J. Fraser is a military service member and this work was prepared as part of his official duties. Title 17, USC, §105 provides that "Copyright protection under this title is not available for any work of the U.S. Government." Title 17, USC, §101 defines a US Government work as a work prepared by a military service member or employee of the US Government as part of that person's official duties. The views expressed in this manuscript reflect the results of research conducted by the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, or the US Government. For author, coordinator, contributor, and reviewer affiliations, see end of text. Address correspondence to Clinical Practice Guidelines Managing Editor, Academy of Orthopaedic Physical Therapy, APTA, Inc, 2920 East Avenue South, Suite 200, La Crosse, WI 54601. E-mail: cpg@orthopt.org

Summary of Recommendations

CLINICAL COURSE – ACUTE LATERAL ANKLE SPRAIN

B Clinicians should include patient age, body mass index, pain coping strategies, report of instability, history of previous sprain, ability to bear weight, pain with weight bearing, ankle dorsiflexion range of motion (ROM), medial joint-line tenderness, balance, and ability to jump and land (as safely tolerated) in their initial assessment, because of their role in influencing the clinical course and estimation of time to accomplish the goals of an individual with an acute lateral ankle sprain (LAS).

CLINICAL COURSE – CHRONIC ANKLE INSTABILITY

C Clinicians may include previous treatment, number of sprains, pain level, and self-report of function in their evaluation, as well as an assessment of the sensorimotor movement systems of the foot, ankle, knee, and hip during dynamic postural control and functional movements, because of their role in influencing the clinical course and estimation of time to accomplish the goals of an individual with chronic ankle instability (CAI).

DIAGNOSIS/CLASSIFICATION – ACUTE LATERAL ANKLE SPRAIN

B Clinicians should use special tests, including the reverse anterolateral drawer test and anterolateral talar palpation in addition to the traditional anterior drawer test, and a thorough history and physical examination to aid in the diagnosis of a LAS.

DIAGNOSIS/CLASSIFICATION – CHRONIC ANKLE INSTABILITY

B When determining whether an individual has CAI, clinicians should use a reliable and valid discriminative instrument, such as the Cumberland Ankle Instability Tool or the Identification of Functional Ankle Instability, as well as a battery of functional performance tests that have established validity to differentiate between healthy controls and individuals with CAI.

EXAMINATION – OUTCOME MEASURES

A Clinicians should use validated patient-reported outcome measures, such as the Patient-Reported Outcomes Measurement Information System physical function and pain interference scales, the Foot and Ankle Ability Measure, and the Lower Extremity Functional Scale, as part of a standard clinical examination. Clinicians should utilize these before and 1 or more times after the application of interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with an acute LAS or CAI.

C Clinicians may use the Pain Self-Efficacy Questionnaire in the acute and postacute periods after a LAS to assess effective coping strategies for pain, and the 11-item Tampa Scale of Kinesiophobia and the Fear-Avoidance Beliefs Questionnaire to assess fear of movement and reinjury and fear-avoidance beliefs in those with CAI.

EXAMINATION – PHYSICAL IMPAIRMENT MEASURES

A Clinicians should assess and document ankle swelling, ROM, talar translation, talar inversion, and single-leg balance in patients with an acute LAS, postacute LAS, or CAI at baseline and 2 or more times over an episode of care. Clinicians should specifically include measures of dorsiflexion, using the weight-bearing lunge test, static single-limb balance on a firm surface with eyes closed, and dynamic balance with the Star Excursion Balance Test anterior, anteromedial, posteromedial, and posterolateral reach directions.

C In patients with CAI, clinicians may also assess and document hip abduction, extension, and external rotation strength 2 or more times over an episode of care.

EXAMINATION – ACTIVITY LIMITATION/PHYSICAL PERFORMANCE MEASURES

B Clinicians should assess and document objective and reliable measures of activity limitation, participation restriction, and symptom reproduction at baseline and 2 or more times over an episode of care when evaluating a patient with a LAS or CAI, and specifically include measures of single-limb hopping under timed conditions when appropriate.

INTERVENTIONS – PRIMARY PREVENTION OF FIRST-TIME LATERAL ANKLE SPRAIN

A Clinicians should recommend the use of prophylactic bracing to reduce the risk of a first-time LAS, particularly for those with risk factors for LAS.

C Clinicians may recommend the use of prophylactic balance training exercises to individuals who have not experienced a first-time LAS.

INTERVENTIONS – SECONDARY PREVENTION OF RECURRENT LATERAL ANKLE SPRAINS FOLLOWING AN INITIAL SPRAIN

A Clinicians should prescribe prophylactic bracing and use proprioceptive and balance-focused therapeutic exercise training programs to address impairments identified on physical examination to reduce the risk of a subsequent injury in patients with a first-time LAS.

INTERVENTIONS – ACUTE AND POSTACUTE LATERAL ANKLE SPRAINS: PROTECTION AND OPTIMAL LOADING

A Clinicians should advise patients with an acute LAS to use external supports, such as braces or taping, and to progressively bear weight on the affected limb. The type of external support and gait assistive device recommended should be based on the severity of the injury, phase of tissue healing, level of protection indicated, extent of pain, and patient preference.

A In more severe injuries, immobilization ranging from semi-rigid bracing to below-knee casting may be indicated for up to 10 days post injury.

INTERVENTIONS – ACUTE AND POSTACUTE LATERAL ANKLE SPRAINS: THERAPEUTIC EXERCISE

A Clinicians should implement rehabilitation programs with a structured therapeutic exercise component that can include protected active ROM, stretching exercises, neuromuscular training, postural re-education, and balance training, both in clinic and at home, as determined by injury severity, identified impairments, preferences, learning needs, and social barriers in those with a LAS.

D There is conflicting evidence as to the best way to augment the unsupervised components of a home program in those with a LAS, for example, by written instructions, exercise-based video games, or app-based instruction. Therefore, this can be determined by the individual's specific learning needs and access to relevant technology.

INTERVENTIONS – ACUTE AND POSTACUTE LATERAL ANKLE SPRAINS: OCCUPATIONAL AND SPORTS-RELATED TRAINING

B Clinicians should implement a return-to-work schedule and use a brace early in rehabilitation, occupational or sport-related training, and/or a work-hardening program to mitigate activity limitation and participation restriction following a LAS.

INTERVENTIONS – ACUTE AND POSTACUTE LATERAL ANKLE SPRAINS: MANUAL THERAPY

A Clinicians should use manual therapy procedures, such as lymphatic drainage, active and passive soft tissue and joint mobilization, and anterior-to-posterior talar mobilization procedures within pain-free movement, alongside therapeutic exercise to reduce swelling, improve pain-free ankle and foot mobility, and normalize gait parameters in individuals with a LAS.

INTERVENTIONS – ACUTE AND POSTACUTE LATERAL ANKLE SPRAINS: ACUPUNCTURE

D There is conflicting evidence regarding the use of acupuncture to reduce symptoms associated with an acute LAS.

INTERVENTIONS – ACUTE AND POSTACUTE LATERAL ANKLE SPRAINS: PHYSICAL AGENTS

Cryotherapy

C Clinicians may use repeated intermittent applications of ice in association with a therapeutic exercise program to address symptoms and functioning following an acute LAS.

Diathermy

C Clinicians can utilize pulsating shortwave diathermy for reducing edema and gait deviations associated with acute ankle sprains.

Electrotherapy

D There is moderate evidence both for and against the use of electrotherapy for the management of acute ankle sprains.

Low-Level Laser Therapy

C Clinicians may use low-level laser therapy to reduce pain in the initial phase of an acute LAS.

Ultrasound

A Clinicians should not use ultrasound for the management of acute ankle sprains.

INTERVENTIONS – ACUTE AND POSTACUTE LATERAL ANKLE SPRAINS: NONSTEROIDAL ANTI-INFLAMMATORY MEDICATION

C Clinicians may prescribe nonsteroidal anti-inflammatory medications (as physical therapy practice acts allow) to reduce pain and swelling in those with an acute LAS.

INTERVENTIONS – CHRONIC ANKLE INSTABILITY: EXTERNAL SUPPORT

B Clinicians should not use external support, including braces or taping, as a stand-alone intervention to improve balance and postural stability in individuals with CAI.

INTERVENTIONS – CHRONIC ANKLE INSTABILITY: THERAPEUTIC EXERCISE AND ACTIVITY

A Clinicians should prescribe proprioceptive and neuromuscular therapeutic exercise to improve dynamic postural stability and patient-perceived stability during function in individuals with CAI.

INTERVENTIONS – CHRONIC ANKLE INSTABILITY: MANUAL THERAPY

A Clinicians should use manual therapy procedures, such as graded joint mobilizations, manipulations, and non–weight-bearing and weight-bearing mobilization with movement, to improve weight-bearing ankle dorsiflexion and dynamic balance in the short term for individuals with CAI.

INTERVENTIONS – CHRONIC ANKLE INSTABILITY: DRY NEEDLING

C Clinicians may use dry needling of the fibularis muscle group, in conjunction with a proprioceptive training program, to reduce pain and improve function in individuals with CAI.

INTERVENTIONS – CHRONIC ANKLE INSTABILITY: COMBINED TREATMENTS

B Clinicians may use multiple interventions to supplement balance training over an episode of care for individuals with CAI, to include a combination of exercise and manual therapy procedures as guided by the patient's values and goals, the clinician's judgment, and evidence-based clinical recommendations.

INTERVENTIONS TO ADDRESS PSYCHOLOGICAL FACTORS DURING THE COURSE OF REHABILITATION

E Clinicians may use psychologically informed techniques, such as motivational interviewing, to maximize patients' self-efficacy and to address uncomplicated psychological correlates and mediators of injury adjustment and recovery in order to maximize the effects of treatment in a positive manner for individuals with a LAS and CAI.

List of Abbreviations

ACR: American College of Radiology
ADL: activities of daily living
ADT: anterior drawer test
AII: Ankle Instability Instrument
ALDT: anterolateral drawer test
AOFAS: American Orthopaedic Foot & Ankle Society
APTA: American Physical Therapy Association
ATFL: anterior talofibular ligament
BAR: Bernese ankle rules
BESS: Balance Error Scoring System
BMI: body mass index
CAI: chronic ankle instability
CAIT: Cumberland Ankle Instability Tool
CAT: computer adaptive test
CI: confidence interval
CPG: clinical practice guideline
CT: computed tomography
FAAM: Foot and Ankle Ability Measure
FABQ: Fear-Avoidance Beliefs Questionnaire
FADI: Foot and Ankle Disability Index
FAOS: Foot and Ankle Outcome Score
FFI: Foot Function Index
FPI: Foot Posture Index
HR: hazard ratio
ICD: International Statistical Classification of Diseases and Related Health Problems
ICF: International Classification of Functioning, Disability and Health
IdFAI: Identification of Functional Ankle Instability
***JOSPT*:** *Journal of Orthopaedic & Sports Physical Therapy*
LAS: lateral ankle sprain
LE-FMS: lower extremity Functional Movement Screen
LEFS: Lower Extremity Functional Scale
LRAR: low-risk ankle rules
MCID: minimal clinically important difference
MRI: magnetic resonance imaging
NSAID: nonsteroidal anti-inflammatory drug
OAR: Ottawa ankle rules
OR: odds ratio
PF: physical function
PI: pain interference
PROMIS: Patient-Reported Outcomes Measurement Information System
PSEQ: Pain Self-Efficacy Questionnaire
RALDT: reverse anterolateral drawer test
RCT: randomized clinical trial
ROM: range of motion
SAFAS: Sports Athlete Foot and Ankle Score
SEBT: Star Excursion Balance Test
TSK-11: 11-item Tampa Scale of Kinesiophobia
USI: ultrasound imaging

Introduction

AIM OF THE GUIDELINES

The Academy of Orthopaedic Physical Therapy of the American Physical Therapy Association (APTA) has an ongoing effort to create evidence-based clinical practice guidelines (CPGs) for orthopaedic physical therapy management of patients with musculoskeletal impairments described in the World Health Organization's International Classification of Functioning, Disability and Health (ICF).[476] The purposes of these clinical guidelines are to:

- Describe evidence-based physical therapy practice, including diagnosis, prognosis, intervention, and assessment of outcome, for musculoskeletal disorders commonly managed by orthopaedic physical therapists
- Classify and define common musculoskeletal conditions using the World Health Organization's terminology related to impairments of body function and body structure, activity limitations, and participation restrictions
- Identify interventions supported by current best evidence to address impairments of body function and structure, activity limitations, and participation restrictions associated with common musculoskeletal conditions
- Identify appropriate outcome measures to assess changes resulting from physical therapy interventions in body function and structure as well as in activity and participation of these individuals
- Provide a description to policy makers, using internationally accepted terminology, of the practice of orthopaedic physical therapists
- Provide information for payers and claims reviewers regarding the practice of orthopaedic physical therapy for common musculoskeletal conditions
- Create a reference publication for orthopaedic physical therapy clinicians, academic instructors, clinical instructors, students, interns, residents, and fellows regarding the best current practice of orthopaedic physical therapy

STATEMENT OF INTENT

These guidelines are not intended to be construed or to serve as a standard of medical care. Standards of care are determined on the basis of all clinical data available for an individual patient and are subject to change as scientific knowledge and technology advance and patterns of care evolve. These parameters of practice should be considered guidelines only. Adherence to them will not ensure a successful outcome in every patient, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results. The ultimate judgment regarding a particular clinical procedure or treatment plan must be made based on clinician experience and expertise in light of the clinical presentation of the patient, the available evidence, available diagnostic and treatment options, and the patient's values, expectations, and preferences. However, we suggest that significant departures from accepted guidelines should be documented in the patient's medical records at the time the relevant clinical decision is made.

SCOPE AND RATIONALE OF THE GUIDELINES

This guideline addresses the distinct but related lower extremity impairments of those with a first-time lateral ankle sprain (LAS) and those with chronic ankle instability (CAI). Studies generally categorize LAS based on chronicity, with the acute period occurring during the first 1 to 2 weeks following injury.[348] In the 2013 CPG,[298] the term "subacute" was used to characterize the time after the acute period and for up to 12 months post injury. In the current 2021 CPG, the term "subacute" was replaced with "postacute" to better characterize the time after the acute period to the 12-month point. Depending on many factors, impairments may continue following injury. While most individuals experience resolution of symptoms, complaints of instability may continue and are defined as CAI. The 2013 CPG[298] reported that the prevalence of CAI varied greatly, from 0% to 73%. A more recent longitudinal study[109] found that 60% of individuals achieve resolution of activity limitations and participation restrictions by the 12-month point, with 40% progressing to develop CAI. Those with CAI are characterized by perceived instability or episodic "giving way" of the ankle that persists for more than 12 months following the initial injury and results in activity limitation and participation restriction.[179] Individuals with CAI may have varying amounts of mechanical instability due to connective tissue impairment, functional instability resulting from sensorimotor impairment, or elements of both.[179] These impairments, which are mediated by intrinsic and extrinsic factors, contribute to activity limitation and restriction of participation. While the International Ankle Consortium has published criteria to identify patients with CAI,[159] these criteria were not consistently used in the literature. When summarizing the literature in this 2021 CPG, conditions described as "recurrent sprains," "ankle instability," "functional ankle instability," and "mechanical ankle instability" greater than 12 months following the first-time injury are categorized as CAI. Therefore, the term "LAS" when used in this CPG is meant to describe those with first-time ankle sprains less than 12 months after injury, and "CAI" is used to describe those with persistent symptoms for 12 months or more after injury. Additionally, the term "ankle sprain" is used in this CPG when specific studies applied that term to their participants. It was assumed that a vast majority of those with "ankle sprains" had a LAS, unless otherwise indicated in those studies. The criteria described above were applied as consistently as possible given the information provided by the studies summarized in this CPG.

Methods

Content experts were appointed by the Academy of Orthopaedic Physical Therapy, APTA, Inc to conduct a review of the literature and develop an updated CPG for ankle stability and movement coordination impairments: lateral ankle ligament sprains. The aims of the revision were to provide a concise summary of the contemporary evidence since publication of the original guideline and to develop new recommendations or revise previously published recommendations to support evidence-based practice. The authors of this guideline revision worked with the CPG editors and medical librarians for methodological guidance. The research librarians were chosen for their expertise in systematic review and rehabilitation literature search and to perform systematic searches for concepts associated with classification, examination, and intervention strategies for ankle stability and movement coordination impairments: lateral ankle ligament sprains. Briefly, the following databases were searched from April 2012 to June 2020: MEDLINE, CINAHL, Cochrane Library, and PEDro (see **APPENDIX A** for full search strategies and **APPENDIX B** for search dates and results, available at www.orthopt.org).

The authors declared relationships and developed a conflict management plan, which included submitting a conflict-of-interest form to the Academy of Orthopaedic Physical Therapy, APTA, Inc. Articles that were authored by a reviewer were assigned to an alternate reviewer. Funding was provided to the CPG development team for travel and expenses for CPG development training by the Academy of Orthopaedic Physical Therapy, APTA, Inc. The CPG development team maintained editorial independence.

Articles contributing to recommendations were reviewed based on specified inclusion and exclusion criteria, with the goal of identifying evidence relevant to physical therapist clinical decision making for adults with ankle stability and movement coordination impairments: lateral ankle ligament sprains. The title and abstract of each article were reviewed independently by 2 members of the CPG development team for inclusion (see **APPENDIX C** for inclusion and exclusion criteria, available at www.orthopt.org). Full-text review was then similarly conducted to obtain the final set of articles for contribution to recommendations. The team leader (R.L.M.) provided the final decision on discrepancies that were not resolved by the review team (see **APPENDIX D** for the flow chart of articles, available at www.orthopt.org). For selected relevant topics that were not appropriate for the development of recommendations, such as incidence and imaging, articles were not subject to the systematic review process and were not included in the flow chart. Evidence tables for this CPG are available on the Clinical Practice Guidelines page of the Academy of Orthopaedic Physical Therapy of the APTA website (www.orthopt.org).

This guideline was issued in 2021 based on the published literature through June 2020, and will be considered for review in 2025, or sooner if new evidence becomes available. Any updates to the guideline in the interim period will be noted on the Academy of Orthopaedic Physical Therapy of the APTA website (www.orthopt.org).

LEVELS OF EVIDENCE

Individual clinical research articles were graded according to criteria adapted from the Centre for Evidence-Based Medicine (Oxford, UK) for diagnostic, prospective, and therapeutic studies. In teams of 2, each reviewer independently assigned a level of evidence and evaluated the quality of each article using a critical appraisal tool (see **APPENDICES E** and **F** for the level-of-evidence table and details on procedures used for assigning levels of evidence, available at www.orthopt.org). The evidence update was organized from the highest level of evidence to the lowest level. An abbreviated version of the grading system is provided below.

I	Evidence obtained from high-quality diagnostic studies, prospective studies, randomized controlled trials, or systematic reviews
II	Evidence obtained from lesser-quality diagnostic studies, prospective studies, systematic reviews, or randomized controlled trials (eg, weaker diagnostic criteria and reference standards, improper randomization, no blinding, less than 80% follow-up)
III	Case-control studies or retrospective studies
IV	Case series
V	Expert opinion

STRENGTH OF EVIDENCE AND GRADES OF RECOMMENDATION

The strength of the evidence supporting the recommendations was graded according to the previously established methods for the original guideline and those provided below. Each team developed recommendations based on the strength of evidence, including how directly the studies addressed the question of ankle stability and movement coordination impairments: lateral ankle ligament sprains. In developing their recommendations, the authors considered the strengths and limitations of the body of evidence and the health benefits, side effects, and risks of tests and interventions.

GRADES OF RECOMMENDATION		STRENGTH OF EVIDENCE	LEVEL OF OBLIGATION
A	Strong evidence	A preponderance of level I and/or level II studies support the recommendation. This must include at least 1 level I study	Must or should
B	Moderate evidence	A single high-quality randomized controlled trial or a preponderance of level II studies support the recommendation	Should
C	Weak evidence	A single level II study or a preponderance of level III and IV studies, including statements of consensus by content experts, support the recommendation	May
D	Conflicting evidence	Higher-quality studies conducted on this topic disagree with respect to their conclusions. The recommendation is based on these conflicting studies	
E	Theoretical/foundational evidence	A preponderance of evidence from animal or cadaver studies, from conceptual models/principles, or from basic sciences/bench research support this conclusion	May
F	Expert opinion	Best practice based on the clinical experience of the guideline development team	May

GUIDELINE REVIEW PROCESS AND VALIDATION

Identified reviewers who are experts in ankle stability and movement coordination impairments and in the management and rehabilitation of ankle sprains reviewed the CPG draft for integrity, accuracy, and to ensure that it fully represented the current evidence for the condition. The guideline draft was also posted for public comment and review on www.orthopt.org, and a notification of this posting was sent to the members of the Academy of Orthopaedic Physical Therapy, APTA, Inc. In addition, a panel of consumer/patient representatives and external stakeholders, such as claims reviewers, medical coding experts, academic educators, clinical educators, physician specialists, and researchers, also reviewed the guideline. All comments, suggestions, and feedback from the expert reviewers, public, and consumer/patient representatives were provided to the authors and editors for consideration and revisions. Guideline development methods, policies, and implementation processes are reviewed at least yearly by the Academy of Orthopaedic Physical Therapy and by APTA's Clinical Practice Guideline Advisory Panel, including consumer/patient representatives, external stakeholders, and experts in physical therapy practice guideline methodology.

DISSEMINATION AND IMPLEMENTATION TOOLS

In addition to publishing these guidelines in the *Journal of Orthopaedic & Sports Physical Therapy* (*JOSPT*), these guidelines will be posted on CPG areas of both the JOSPT and the Academy of Orthopaedic Physical Therapy, APTA, Inc websites, which are free-access website areas, and submitted to be made available (free access) on the ECRI Guidelines Trust (guidelines.ecri.org) and the Physiotherapy Evidence Database (https://pedro.org.au/). The implementation tools planned to be made available for patients, clinicians, educators, payers, policy makers, and researchers, and the associated implementation strategies, are listed in **TABLE 1**.

CLASSIFICATION

The primary International Statistical Classification of Diseases and Related Health Problems (ICD)-10 codes associated with ankle stability and movement coordination impairments are **S93.4 sprain and strain of ankle** and **M24.27 disorder of ligament, ankle and foot**.

The corresponding ICD-9-Clinical Modification codes include **845.00 sprain of ankle, unspecified site**, **845.02 sprain of**

TABLE 1 Planned Strategies and Tools to Support the Dissemination and Implementation of This Clinical Practice Guideline

Tool	Strategy
JOSPT's "Perspectives for Patients" and/or "Perspectives for Practice" articles	Patient-oriented guideline summary available on www.jospt.org
Mobile app of guideline-based exercises for patient/clients and health care practitioners	Marketing and distribution of app using www.orthopt.org
Clinician's Quick-Reference Guide	Summary of guideline recommendations available on www.orthopt.org
JOSPT's Read for Credit℠ continuing education units	Continuing Education Units available for physical therapists and athletic trainers
Webinars and educational offerings for health care practitioners	Guideline-based instruction available for practitioners on www.orthopt.org
Mobile and web-based app of guideline for training of health care practitioners	Marketing and distribution of app using www.orthopt.org
Physical Therapy National Outcomes Data Registry	Support the ongoing usage of data registry for common musculoskeletal conditions (www.ptoutcomes.com)
Non-English versions of the guidelines and guideline implementation tools	Development and distribution of translated guidelines and tools to JOSPT's international partners and global audience
American Physical Therapy Association's CPG+	Dissemination and implementation aids

calcaneofibular (ligament) of ankle, **845.03 sprain of tibiofibular (ligament), distal of ankle**, and **718.87 other joint derangement, not elsewhere classified, ankle and foot**.

The primary ICF body function codes associated with ankle ligament sprain are **b7150 stability of a single joint** and **b7601 control of complex voluntary movements**.

The primary ICF body structures codes associated with ankle stability and movement coordination impairments are **s75023 ligaments and fasciae of ankle and foot**, **s75012 muscles of lower leg**, **s75002 muscles of thigh**, and **s7402 muscles of pelvic region**.

The primary ICF activities and participation codes associated with ankle stability and movement coordination impairments are **d450 walking**, **d4552 running**, **d4553 jumping**, **d4558 exercise tolerance functions, other specified**, and **d9201 sports**.

ORGANIZATION OF THE GUIDELINE

A summary of the updated literature is provided for incidence/prevalence, pathoanatomical features, and differential diagnosis. As described in the Scope and Rationale of the Guideline, the term "LAS" is used to describe those with first-time ankle sprains less than 12 months after injury, and "CAI" is used to describe those with persistent symptoms for 12 months or more after injury. For risk factors, clinical course, diagnosis, examination, and intervention, the summary recommendation and grade of evidence from the 2013 guideline are presented, followed by a synthesis of the recent literature with the corresponding evidence levels. Each of those 5 topics concludes with the 2021 summary recommendation and its updated grade of evidence.

CLINICAL PRACTICE GUIDELINES

Impairment/Function-Based Diagnosis

INCIDENCE/PREVALENCE UPDATE 2021

Acute Lateral Ankle Sprain

It is estimated that approximately 50% of individuals who sustain a LAS seek medical attention, so reports of incidence and prevalence of LAS are suspected to be lower than actual rates of occurrence.[451] Despite this, ankle sprains are still the most common foot-ankle and sports-related injury for which individuals seek medical care,[119,329] including emergency room visits.[213] Level I evidence from a 2014 systematic review with meta-analysis shows a pooled prevalence of 11.88% of individuals with LAS in the general population.[119] Of the patients who do seek care, only 6.8% to 11.0% are referred to a rehabilitation specialist within 30 days of the injury.[132,133]

The same meta-analysis found that the incidence and prevalence of ankle sprains were greatest in children 12 years of age or younger (incidence, 2.85 per 1000 exposures; 95% confidence interval [CI]: 2.51, 3.19; prevalence, 12.62% of injuries).[119] Adolescents (age, 13-17 years) sustained sprains at a rate of 1.94 per 1000 exposures (95% CI: 1.73, 2.14), while adults (18 years of age or older) had a lower rate of ankle sprains, with an incidence of 0.72 per 1000 exposures (95% CI: 0.67, 0.77).[119] The prevalence of ankle sprains in adolescents was reported to be 10.55% of all injuries, which was lower than the prevalence of LAS in adults (11.41% of all injuries).[119] A 2016 study of more than 225 000 individuals who presented to an emergency room with an ankle sprain showed a slightly different distribution of injuries across age levels.[387] This study found that 27% of sprains occurred in individuals under 18 years of age, 40% occurred in individuals who were between 18 and 35 years of age, 18% occurred in individuals aged 36 to 49 years, and 15% occurred in individuals who were older than 49 years old.[387] One study reported the median age of individuals sustaining ankle sprains to be 27 years, with the highest rate of injury occurring in males between the ages of 14 and 37 years.[9]

Females had an estimated incidence rate of 13.6 ankle sprains per 1000 exposures (95% CI: 13.25, 13.94), which is nearly double that of males (6.94 per 1000 exposures; 95% CI: 6.8, 7.09).[119] Prevalence rates between the sexes were similar: prevalence in females was 10.99% and in males was 10.55%.[119] A 2016 study supported the evidence that ankle sprains occur more often in females, reporting that 57% of recorded ankle sprains were sustained by females.[387] A second study with a much smaller sample size reported that the prevalence of LAS was similar between the sexes.[9]

Forty percent of LASs occur during sports.[451] A 2016 study by Halabchi et al[170] reported that 58.5% of professional basketball and football athletes had experienced an ankle sprain. In high school athletes in the United States, ankle sprains occur at a rate of 3.13 per 10 000 exposures.[416] Ankle sprains are the most common injury in amateur student-athletes in Brazil, making up 18.2% of all reported injuries during the 2013 sports seasons.[17] In the United States, ankle sprains accounted for 7.3% of all reported injuries in collegiate athletics between 2009 and 2015, occurring at a rate of 4.95 per 10 000 athlete exposures.[372] Although more than half (57.3%) of these injuries occurred during practice, there was a higher rate of ankle sprains per athletic exposure during competition.[372] Ankle sprains are most common in indoor/court sports such as volleyball and basketball, occurring at a rate of 7 ankle sprains per 1000 athlete exposures.[119] Field sports, such as soccer, football, and rugby, have a much lower pooled incidence, at only 1 ankle sprain per 1000 athlete exposures.[119] Sport-specific prevalence and incidence of LAS have been described for American football,[29,326,337] Australian rules football,[466] baseball,[291,381] basketball,[157,180,288,306,346,368,372,439] dancing,[361,445] fencing,[172] figure skating,[254] floorball,[345,346] futsal,[289] Gaelic football,[370] handball,[4,15,321,322] ice hockey,[72] in-line hockey,[324] lacrosse,[457] netball,[400] rugby,[142,143,362] soccer,[9,17,52,129,135,164,261,408,453,466] surfing,[190] ultimate Frisbee,[181] and volleyball.[17,77,215,322,363] The prevalence and incidence of LAS have also been reported for those in military service.[40,119,344,389,480]

Recurrent Injury and Chronic Ankle Instability

Reports of the prevalence of CAI vary, ranging from 0.7% to 1.1%[178] in young adults, to 20% in adolescent athletes,[123] to 23.4% in high school and collegiate athletes,[420] to 29% in high school students.[191] Recurrent ankle sprains and instability are common among athletes. Female high school and collegiate athletes had significantly higher prevalence of CAI than their male counterparts.[420] A 2014 level IV study found that the prevalence of instability was significantly higher in high school athletes than in collegiate athletes.[420] In collegiate athletes, nearly 12% of reported ankle sprains were recurrent.[372] These recurrent sprains were most often sustained in athletes participating in women's basketball, outdoor track, and field hockey and men's basketball.[372] At the elite and professional levels of competition, recurrent ankle sprains occur at a similar rate, with 14.2% of professional football and basketball players reporting a history of a recurrent sprain[170] and 13.7% of elite soccer players sustaining recurrent LAS.[129] In the only prospective study performed to date, Doherty et al[109] reported that the prevalence of CAI was 40% in individuals who sought care for a first-time LAS. The much higher estimate of CAI from this prospective study[109] compared to results from retrospective studies is likely related to care-seeking behaviors, with the true burden likely underrepresented in the studies that employed retrospective designs.

PATHOANATOMICAL FEATURES UPDATE 2021

Concomitant injuries commonly occur with an acute LAS,[84,310] with bone bruising on magnetic resonance imaging (MRI) being one of the most common findings.[54,216] The extent of ankle effusion present after injury may be associated with more severe associated injuries,[70] but does not necessarily indicate the presence or absence of a fracture.[10] Ankle impingement, which can cause pain and limited motion, was found in 25% of individuals after LAS[212] and potentially results from soft tissue injury and/or posttraumatic tibiotalar osteophytes.[262,313,411] There is also evidence that alterations in the mechanical stiffness of soft tissue around the ankle can lead to abnormal kinematics and symptoms after a LAS,[236,253] including increased talar inversion and rotation,[271,342] that may result from a lengthened anterior talofibular ligament (ATFL)[2,74,217,327] and/or increased ATFL-posterior talofibular ligament angle.[270] The abnormal kinematics that occur after a LAS may contribute to altered joint loading and explain findings of an increase in cartilage stress and degeneration in talocrural,[151,196,238,443,472] subtalar,[222] and talonavicular joints.[293,443] Signs of early arthritis have been related to painful end range of motion (ROM) in individuals with symptoms lasting 6 to 12 months after the initial injury.[443] Symptoms of pain and instability may continue after a LAS and result from coexisting pathologies, including os trigonum syndrome; osteochondral injury; syndesmotic, deltoid, or subtalar ligament injuries; talonavicular, calcaneonavicular, and calcaneocuboid joint injuries; fibularis muscle group injuries; and/or nerve pathologies.[13,56,98,199,210,282,285,340,411,483] In individuals with CAI, intra-articular pathologies may be associated with continued symptoms.[282,411] It should be noted that these coexisting pathologies are seen on diagnostic testing in those who sustain a LAS but do not have symptoms.[147,444] There may also be anatomical factors, such as distal tibiofibular joint variations,[18,237] a flatter subtalar joint,[438] and hindfoot varus alignment,[281] associated with chronic complaints of instability.

Sensorimotor and ROM deficits can occur after a LAS and may lead to movement system abnormalities. While findings may be dependent on measurement technique and subject selection, investigators have found altered movement strategies with balance activities,[28,103,108,112,113,118,154,225,228] gait,[107,136,359] and jumping.[11,110,114,117] These changes may not be limited to the ankle, but can occur proximally at the knee and hip[11,107,108,110,112-114,117,118] as well as in the uninvolved lower extremity.[108,118] Changes in movement strategies on the involved lower extremity may be protective in nature, to prevent reinjury, and include a reliance on the hip and knee to reduce forces at the ankle.[11,110,112,114,117] Specific sensorimotor and ROM deficits at the foot-ankle complex include decreased strength of leg/ankle muscles,[138,347] decreased fibularis muscle reaction time,[188] decreased ankle dorsiflexion and plantar flexion ROM,[1,138,432] increased ankle frontal plane ROM,[39,138] and increased forefoot and midfoot mobility.[138] Due to the heterogeneity of pathomechanics and tissues injured during an inversion sprain, the role of these sensorimotor ROM deficits and movement system abnormalities is debated, as they are not always present or are present to varying degrees, with symptoms frequently lasting from a few weeks to 12 months or longer.[11,24,78,80,85,94,99,204,224,255,320,334,354,413,427,434]

Individuals who recover from a LAS, as defined by returning to at least a moderate level of activity and having a near normal self-reported functional level of activity within 12 months, are identified as "copers," while those who continue to have complaints of instability are identified as having CAI.[468] Attempts to identify the sensorimotor ROM deficits in those with CAI have received considerable attention. While findings may be dependent on measurement technique and subject selection, investigators have generally identified the following sensorimotor ROM deficits at the foot, ankle, knee, and hip: (1) abnormal timing of muscle activation at the ankle, knee, and hip,[5,86,88,122,131,188,205,211,221,241,242,256,264,269,275,319,330,331,383,399,401,403,406,407,430,442,459,460] (2) decreased force output/strength at the ankle[3,59,60,138,235,249,333,343,352,473,481] and hip,[87,249,301,305,333] (3) impaired force and proprioception at the ankle,[22,59,169,219,296,379,404] (4) decreased ankle dorsiflexion ROM,[138,239,352] and (5) increased subtalar and midfoot motion.[138] Research has also found impaired central mediated processes, including spinal-level sensorimotor control/reflex inhibition[36,64,121,145,171,226,227,292,308,338,403,406,407,423,433] and supraspinal corticomotor abnormalities.[171,308,330,332,375,377,424,426,428,458] These impaired sensorimotor and central mediated processes may be evident in both the injured and uninjured limbs and impact the movement system, as seen with static and dynamic balance, walking, stepping, running, jumping, cutting, and kicking.[88,105,108,264,396,403-407]

RISK FACTORS

2013 Condensed Summary

The 2013 CPG[298] examined intrinsic and extrinsic factors of acute LAS and ankle instability. Evidence showed that there was an increased risk of acute LAS in individuals who have a history of LAS and loss of ankle dorsiflexion ROM, do not warm up properly, do not use an external support (bracing and taping), and do not participate in neuromuscular retraining. The risk factors for CAI were less clear than those for LAS in 2013. The authors suggested that, in addition to not using an external support and not participating in a balance program, anatomical factors, such as increased talar curvature, may increase risk for ankle instability.

EVIDENCE UPDATE

Acute Lateral Ankle Sprain: Nonmodifiable Intrinsic Risk Factors

Previous Injury

II There is conflicting evidence that a previous LAS elevates risk for a subsequent LAS. A meta-analysis by Vuurberg et al[451] of studies between 2009 and 2016 found that previous injury was not a significant risk factor for LAS (relative risk = 1.44; 95% CI: 0.96, 2.16). Results from 2 studies not included in this review were consistent with this finding.[20,174] However, 2 other studies reported that individuals with a history of LAS are at increased risk for a subsequent sprain, with a hazard ratio (HR) of 2.21 (95% CI: 1.07, 4.57) when the index sprain occurred within the previous 6 months.[92,355]

III A study of professional basketball players found that players with a history of LAS were 1.41 (95% CI: 1.13, 1.74) times more likely to sustain a subsequent ankle sprain than players who did not have a history of sprain within the previous year.[180] A similar study of professional soccer players also showed that history of LAS increased the risk of future ankle sprain.[57]

Sex

I A 2014 meta-analysis found that female sex was a risk factor for LAS, with a cumulative incidence rate for females of 13.6 per 1000 exposures (95% CI: 13.25, 13.94) versus a cumulative incidence rate for males of 6.94 per 1000 exposures (95% CI: 6.8, 7.09).[119]

II A study of high school lacrosse players showed that females were more likely to sustain a LAS, at a rate of 2.4 per 1000 exposures versus 1.6 per 1000 exposures for males.[457]

III Female sex as a risk factor for LAS was also identified in a meta-analysis by Vuurberg et al.[451] Female athletes with a history of concussion had 1.88 to 2.54 higher odds of also reporting a LAS or knee injury.[193] Conflicting results regarding sex as a risk factor for LAS were found in a case-control study of professional soccer players.[57]

Body Mass Index

II A meta-analysis identified lower body mass index (BMI) as a potential intrinsic risk factor for a LAS.[451] When data from studies published between 2009 and 2016 were pooled, individuals with a lower BMI trended toward a slightly higher rate of sprain (mean difference, –0.08; 95% CI: –0.14, 0.02).[451] Articles not included in this analysis both agreed[365,366] and disagreed with this finding.[92,174]

III A case-control study found that BMI was not a risk factor for LAS in those presenting to emergency departments.[484]

Age

II In elite football and basketball players (age range, 15-40 years), it was noted that each 5-year increase of age was found to increase the odds of sustaining a LAS by 1.51 times (odds ratio [OR] = 1.51; 95% CI: 1.02, 2.25).[353] In contrast, younger age was associated with increased risk of LAS in military recruits undergoing training.[365,366]

III In professional soccer players, it was found that age was not related to LAS injury risk.[57]

Other Nonmodifiable Intrinsic Risk Factors

II Among collegiate athletes, those with a navicular-medial malleolar distance greater than 4.65 cm, measured with a digital caliper in maximal dorsiflexion to represent external rotation of the talus, were 4.14 times more likely to sustain a LAS than athletes with a smaller navicular-medial malleolar distance.[240] Leg-heel angle and foot internal rotation angle in plantar flexion were not found to be associated with risk of a LAS.[240]

III Among soldiers, a Beighton score of 4[21] or greater and narrower bimalleolar width were associated with increased risk of a LAS.[366] Foot Posture Index (FPI) score and all 6 component scores[57] and the Q-angle[484] were not found to be associated with risk of a LAS. Two studies have potentially identified a genetic predisposition to LAS.[360,388]

Acute Lateral Ankle Sprain: Modifiable Intrinsic Risk Factors

Range of Motion

II Asymmetrical ankle dorsiflexion ROM greater than 2.5 cm between sides, as measured with the weight-bearing lunge test, was predictive of LAS in firefighters.[446] Conflicting findings were found in collegiate male athletes.[174] Non–weight-bearing measures of ankle dorsiflexion ROM and inversion/eversion motion were not found to be risk factors for a LAS.[20,92]

Strength

I Decreased hip abductor strength was found to increase the risk of LAS in male soccer players, with a reported OR of 1.10 (95% CI: 1.02, 1.18).[357] When hip abductor strength was less than 33.8% of body weight, the probability of LAS increased from 11.9% to 26.7%.[357]

II Decreased hip extensor strength was associated with a significant (P = .028) increased risk of LAS in youth soccer players.[95]

Functional Performance

II Risk of LAS is generally increased with worse performance on unilateral standing reach tests like the Star Excursion Balance Test (SEBT) and the Y Balance Test. Better performance on the SEBT (posterolateral direction) decreased the risk of LAS (HR = 0.96; 95% CI: 0.92, 0.99).[92] When netball players reached 77.5% or less of their leg length on the posteromedial direction of the SEBT, risk of LAS was increased by more than 4 times (OR = 4.04; 95% CI: 1.00, 16.35).[20] Worse performance on the anterior reach component of the Y Balance Test was associated with increased incidence of LAS in males (but not in females).[174] In adolescent soccer players, the inability to reach at least 76% and 70% of limb length in the posteromedial and posterolateral directions, respectively, during the SEBT represented significant cutoff points indicating increased risk of LAS in the subsequent 10 months.[233] Asymmetrical performance (greater than 2 cm in the anterior direction, greater than 3 cm in the posteromedial and posterolateral directions, right versus left lower extremity) on the Y Balance Test was predictive of LAS in firefighters.[446]

II Athletes who performed the multiple hop test with more than 12 "change-in-support errors" had a 4-fold increased risk of an index LAS.[128] These "change-in-support errors" include shuffling or jumping on the support foot, removing the hands from the iliac crests, and putting the nonsupport foot down.[128]

II A LAS was not associated with performance on the foot-lift test in active university students[92] or in netball players.[20] Single-leg stance quality graded using the Balance Error Scoring System (BESS)[174] and performance on the side recognition test[92] were also not found to be associated with increased risk of LAS. In netball players, vertical jump height and performance on the demi-pointe balance test were not associated with incidence of LAS.[20]

II Adolescent athletes who took greater than 15.4 seconds to complete the single-leg hop test, with 10 repetitions over a 30-cm distance, were at higher risk of sustaining a LAS in the following 10 months.[233]

II In elite soccer players, poor performance (mediolateral force more than 0-0.4 seconds and/or resultant horizontal ground reaction forces more than 3-5 seconds) on a single-leg drop-jump landing was predictive of a LAS within 3 years.[134] Gait abnormalities with earlier peak pressure on the lateral forefoot, higher peak pressure under the first metatarsal, higher peak metatarsal impulse, and more medial pressure at heel-off were associated with higher risk of a LAS in military recruits.[365,366]

II There is a slight increase in the odds of LAS for semiprofessional soccer players with worse performance on the single-leg hop for distance (OR = 1.10; 95% CI: 1.00, 1.23).[307] Composite score on the Soccer Injury Movement Screen (components include anterior reach, single-leg deadlift, in-line lunge, single-leg hop for distance, and tuck jump) does not predict LAS in semiprofessional soccer players.[307]

Acute Lateral Ankle Sprain: Extrinsic Risk Factors

Activity

I A meta-analysis found that risk of LAS was associated with type of sport played: the highest risk was in individuals playing court sports (cumulative incidence of 7 per 1000 exposures; 95% CI: 6.8, 7.2).[119] Another meta-analysis showed that a LAS is more likely to occur in the second half of games during soccer, rugby, futsal, American football, and Gaelic football.[93]

II Elite Gaelic football players are more likely to sustain a LAS during match play versus during training, with the likelihood during match play of 62.2% and during training of 32.4%.[370] In high school lacrosse players, competition, compared to practice, was more likely to elicit a LAS in both males (3.0 per 1000 competition exposures versus 1.0 per 1000 practice exposures) and females (3.8 per 1000 competition exposures versus 1.8 per 1000 practice exposures).[457]

Playing Surface

II There was no difference in LAS risk among Major League Soccer players playing on artificial turf versus natural grass.[47] There was no difference in the rate of ankle sprain in rugby players playing on artificial turf versus grass.[362]

Chronic Ankle Instability: Risk Factors

Physical Characteristics

II In a retrospective study of more than 800 000 young adults serving in the military, increased BMI was found to be associated with CAI in males (overweight: OR = 1.249, $P<.001$; obese: OR = 1.418, $P<.001$) and females (overweight: OR = 1.989, $P<.001$; obese: OR = 2.754, $P<.001$).[178]

II Among athletes returning to sport following a LAS, those whose height was more than 191 cm had 16 times greater odds of sustaining a recurrent sprain that same season. Athletes whose mass was more than 100 kg had 8 times greater odds of sustaining a recurrent sprain in the same season.[304]

III In a large study of 900 healthy individuals aged 8 to 101 years, Baldwin et al[23] found that, for every degree of decreased ankle dorsiflexion ROM, the odds of bilateral ankle instability (defined by a score on the Cumberland Ankle Instability Tool [CAIT] of 25 or less) increased by 3% (95% CI: 0%, 6%). Healthy females with a CAIT score of 25 or less were 2.6 times more likely to have bilateral ankle instability (95% CI: 1.7, 3.8), and the odds of having bilateral ankle instability (defined as a CAIT score of 25 or less) decreased by 2% (95% CI: 1%, 3%) for each year of increasing age. Additionally, the odds of having ankle instability (defined by a CAIT score of 25 or less) were increased by 4% for every centimeter of increased waist size (95% CI: 2%, 6%).[23]

Functional Performance

II Inability to complete jumping and landing tasks within 2 weeks of the initial injury, poorer dynamic postural control, and lower self-reported function at 6 months after the initial injury were predictors of CAI at 6 months.[109]

Other Risk Factors

I Not using prophylactic bracing and not participating in an exercise program that includes balance training are risk factors for a subsequent LAS following a first-time LAS.[33,43,102,336,356,451]

II Participating in sports increases the risk of recurrent ankle sprains, as the odds of sustaining a recurrent ankle sprain were 6.83 times higher (95% CI: 1.35, 34.56) in individuals who participated in sports than in those who did not participate in sports.[293]

2021 Risk Factor Evidence Summary

Female sex, hip abductor and extensor weakness, poor performance on balance and hopping tests, and participating in court sports are risk factors for an acute LAS. Not using prophylactic bracing, not participating in an exercise-balance program, poor functional performance after a LAS, participating in sports, and higher BMI are risk factors for CAI.

CLINICAL COURSE

2013 Condensed Summary Without Recommendation

Following a LAS, there is a rapid decrease in pain and improvement in function in the first 2 weeks after injury. However, 5% to 33% of patients continue to experience pain 1 year or more after the LAS, with 5% to 25% still experiencing pain after 3 years. Fifty percent to 85% of individuals with a LAS report full recovery at approximately 3 years after the injury, independent of sprain severity. When symptoms of instability continue beyond 1 year after a LAS, patients are commonly diagnosed as having CAI. In high-quality studies, continued reports of instability were noted in 0% to 33% of patients in follow-up periods of 3 years or less. Prognosis may also be related to not receiving appropriate treatment after injury, including bracing and rehabilitation. There is higher risk of ankle instability and reinjury in high- compared to low-activity groups.

ACUTE AND POSTACUTE LATERAL ANKLE SPRAIN

Evidence Update

The acute phase is operationally defined as 1 to 2 weeks or less after injury, while the postacute period may last up to 12 months following injury.

I For a faster return to sports, an evidence-based clinical guideline by Vuurberg et al[451] recommended a supervised exercise program to address the strength, coordination, proprioception, and functional deficits that occur after a LAS. This is consistent with a systematic review that found a shorter time to return to sports after an acute ankle sprain following functional treatment, the use of compression stockings, and anteroposterior talocrural joint mobilization.[8]

I An assessment of recovery time in high school athletes after a first-time ankle sprain found that there was a 75% chance of returning to sport within 3 days after the injury and a 95% chance of returning within 10 days, with no difference between new and recurrent ankle sprains.[309] Another study of high school athletes found that more severe injuries involving multiple ligaments resulted in a greater than 3-week loss of participation.[417] In college athletics, 44.4% of individuals returned to play in less than 24 hours after injury.[372] In soccer players, the average time lost after ankle sprain was 12 to 15 days,[129,466] while rugby players returned to participation on average 24 days after injury.[422]

I The Synthesizing a clinical Prognostic Rule for Ankle Injuries in the Emergency Department study, with 682 individuals evaluated within 7 days after an ankle sprain, found older age, higher BMI, higher pain level when resting, higher pain level when bearing weight, inability to bear weight, longer time (days) from injury to assessment, and prior recurrent sprain to be predictors of a poor outcome.[384]

II A systematic review and meta-analysis found that the addition of rehabilitation exercises to standard care significantly reduced reinjury in the 7 to 12 months following injury.[33] Another systematic review and meta-analysis found that bracing and neuromuscular training were not associated with reduced recurrence of ankle sprains at 12 months.[43]

II Despite significant improvements in self-reported function over a 6-week period after a LAS, ankle laxity did not significantly change as assessed with the anterior drawer test (ADT) (P>.05).[74]

II Those with a medial joint bone marrow contusion, on the tibia and/or talus, identified on MRI within 2 weeks after a LAS had a significantly longer recovery time to return to normal walking (25 versus 16 days, P = .0002) and sports (92 versus 56 days, P = .0001).[54] Those with simple or complex LAS, as determined by radiological imaging, did not have different outcomes at 6 months (P>.05).[41]

II At baseline, older age, more severe injury, and less than full weight-bearing status were correlated (adjusted R^2 = 0.341, P<.01), with worse functional status at week 4, while baseline older age, less than full weight-bearing status, and injury mechanism were correlated (adjusted R^2 = 0.20, P<.01) with worse functional status at 4 months.[335] Pain with weight-bearing dorsiflexion and medial joint-line tenderness at 4-week assessment were associated (adjusted R^2 = 0.49, P<.01) with lower function at 4 months.[335]

II Effective coping strategies for pain and lower age (P<.017), but not severity of injury (P>.68), were associated with fewer symptoms and limitations at 3-week follow-up after a LAS.[37] A recent LAS (OR = 8.23) and younger age (OR = 8.41) were independent predictors of a recurrent ankle sprain in a convenience sample (n = 100).[355]

II In a prospective cohort of 70 individuals who sustained a LAS, 60% (n = 42) were categorized as "copers" and recovered, while 40% (n = 28) went on to suffer CAI.[104,109] Inability to complete jumping and landing tasks within 2 weeks after a first-time LAS was predictive of CAI at 6 months (sensitivity, 83%; specificity, 55%; P = .004).[109] Clinical tests of ROM, swelling, ligament laxity, and posterior glide within 2 weeks after injury had limited predictive value (accuracy, 68.8%) in determining those who went on to develop CAI versus becoming a "coper" at 1 year.[104]

III A cohort study in the National Basketball Association found that 56% of those who sustained an ankle sprain did not miss any games. The incidence of ankle sprain among players with a history of prior ankle sprain in the past year was 1.41 times higher than those without a history of ankle sprain in the past year (P = .002).[180]

III Among 44 patients recruited from general practices and physical therapy clinics at 4-year follow-up from a LAS, 18% (n = 8) experienced a subsequent injury, 29.5% (n = 13) reported pain, 45.5% (n = 20) had tenderness on clinical examination, and 25% (n = 11) had limited ankle dorsiflexion ROM.[212] Almost 20% (n = 24) of individuals in another study continued to have ankle complaints of some kind at 5-year follow-up.[294]

III Obesity may influence outcome, as full recovery at 6 months was 65%, 59%, and 52% for those with a BMI of less than 25 kg/m^2, 25 to 30 kg/m^2, and greater than 30 kg/m^2, respectively.[32] In a study of anthropometric and clinical assessments, the highest correlation with a new ankle sprain was the history of a previous sprain (r = 0.265, P<.001).[484]

III A significant decrease in dorsiflexion, plantar flexion, and eversion ROM (26%-27%, P<.002) was found 4 weeks after LAS among 20 patients.[432] Fraser et al[138] found decreased ankle dorsiflexion ROM (P<.001), increased ankle frontal plane ROM (P<.001), and increased forefoot and midfoot mobility (P<.001) in individuals with a history of LAS.

III An assessment of the movement system using static and dynamic balance activities,[28,103,108,112,113,118,154,225,228,354] gait,[107,136,359] and jumping[11,110,114,115,117] can identify abnormal movement strategies at the ankle, knee, and hip caused by sensorimotor ROM deficits.

IV At a 1-year telephone follow-up of those seen in the emergency department after an ankle sprain, those with more severe injuries had more persistent complications (χ^2 = 3.636, P<.05).[163]

IV A case series found that greater severity of injury diagnosed using ultrasound imaging (USI) was predictive of 1-year self-reported outcome following LAS (P<.05).[63]

IV Another case series found that after a LAS, increasing height and weight were associated with a recurrent sprain within the same season.[304]

IV Fair to moderate correlations (r = −0.40 to −0.57, P<.05) were identified between pain levels and reported confidence with weight-bearing lunge and hopping tests.[68]

Evidence Synthesis and Rationale

A full return to participation can be expected from 1 day to a little more than 3 weeks after LAS, depending on the demands of the desired activity or sport. However, full recovery with no symptoms or limitations may take months or years to obtain, and cannot be expected in all patients. There is conflicting evidence for the role of injury severity in the clinical course after a LAS. The update of evidence since 2013 continues to support that a supervised impairment-driven exercise program can allow for a faster recovery and help prevent reinjury, with patient factors being able to help predict the clinical course after LAS.

2021 Recommendation

B Clinicians should include patient age, BMI, pain coping strategies, report of instability, history of previous sprain, ability to bear weight, pain with weight bearing, ankle dorsiflexion ROM, medial joint-line tenderness, balance, and ability to jump and land (as safely tolerated) in their initial assessment because of their role in influencing the clinical course and estimation of time to accomplish the goals of an individual with an acute LAS.

CHRONIC ANKLE INSTABILITY

Evidence Update

II A functional treatment program aimed to improve jumping and landing biomechanics increased self-reported functional status in the treatment group (n = 14) compared to the control group (n = 14). The estimate of effect size using the Foot and Ankle Ability Measure (FAAM) was 1.95 (95% CI: 1.03, 2.86).[14]

III Baseline self-reported functional limitations, decreased single-limb balance, and number of previous ankle sprains were predictive of treatment success in individuals with CAI, with the single-limb balance test being the single best predictor.[469,470] A single-limb balance test greater than or equal to 5 errors was predictive of success with ankle joint mobilizations (positive likelihood ratio = 33.3; 95% CI: 4.1, 274.4), and a test greater than or equal to 2 errors was predictive of success with plantar massage (positive likelihood ratio = 62.5; 95% CI: 8.3, 472.4).[470]

III A systematic review by Al Adal et al[7] reported the presence of pain in 50% to 79% of those with CAI. Pain was usually intermittent, mild, and occurred during vigorous activity.[7] A study not included in that review had similar findings, and also noted that those with more severe perceived ankle instability were more likely to have pain (OR = 5.38, P<.001).[6]

III Individuals with CAI have movement system abnormalities that have been identified during activity such as static and dynamic balance activities, walking,[140] stepping,[49,396] running, jumping, cutting,[139,230,247,248,398] and kicking.[124,367] A systematic review by Rosen et al[376] found deficits in static and dynamic postural control in those with CAI. Similar findings were noted by other studies not included in the review by Rosen et al.[22,89,105,116,138,167,205,239,250,258,260,352,376,392,405,485]

III A systematic review that evaluated the literature on walking and running biomechanics reported that those with CAI had increased ankle and rearfoot inversion, ankle plantar flexion, vertical forces on the lateral part of the foot, and fibularis longus muscle activity.[317] Similar findings were noted by others whose studies were not included in this review.[69,97,100,136,149,220,244,334,401,421,481] There have also been abnormalities noted at the knee and hip with less knee adduction, decreased gluteus medius muscle activity, and altered hip-ankle coordination.[88,89,276,318,401,481] These abnormalities may alter the timing of movements and cause the center of mass to laterally deviate and fall outside the base of support to potentially cause instability.[317]

III In the systematic review by Rosen et al,[376] it was identified that those with CAI had deficits with hopping and jumping activity. Another systematic review that evaluated the literature on landing biomechanics in those with CAI noted the following: (1) dynamic postural stability deficits with longer time to stabilization after landing, (2) altered ankle and knee kinematics while landing with greater knee extension and ankle dorsiflexion, (3) greater vertical and lateral loading rates, and (4) reduction in fibularis longus and brevis muscle activation prior to contact.[397] Similar findings were noted by studies not included in these reviews.[38,127,176,177,192,206,207,221,275,279,319,399,429,430,460] Studies investigating jumping have also found less hip flexion and hip adduction at initial contact, with decreased gluteus medius activity, in addition to a reduced jump height and flight distance.[192,256,305,319] A study by Liu et al[283] found that dynamic postural stability during multidirectional hopping could not accurately differentiate among healthy, coper, and unstable groups. Similar findings were noted by others.[173,301] However, in aggregate, findings suggest that those with CAI may use a landing strategy that relies on proximal joints to protect the ankle from reinjury.[397]

III Those that go on to develop CAI may be differentiated from copers based on their movement patterns, including dynamic balance,[105,116,205,250,352] walking,[50,106,136,456] stepping down,[49,125] running,[259] and landing from a jump,[111] with copers having biomechanics more similar to those of healthy individuals.[49,50,105,116,125,136,205,259,352] The neuromuscular ankle strategies adopted by copers may allow them to prevent recurrent symptoms.

III A decrease in activity and participation and overall health-related quality of life was found in those with CAI[123,138,183,251,297,471] compared to those without CAI and may result from the sensorimotor ROM deficits and altered movement control strategies.[198,395] However, this might not be true for younger individuals (age, 15-16 years), as their reported physical activity level did not seem to be affected by a history of ankle instability.[191]

III In individuals with CAI, significant ($P<.001$) predictors of a successful improvement with a balance training program were impaired dynamic balance with an SEBT posteromedial reach distance of 85.18% or less and a FAAM activities of daily living (ADL) score or Foot and Ankle Disability Index (FADI) score of 92.55% or less at baseline. For patients who met both criteria, there was a 70% probability of a successful outcome.[42]

III A systematic review–based consensus recommended nonsurgical treatment for 3 to 6 months prior to considering surgery for CAI.[402] A cross-sectional study found that those with CAI who did not seek medical treatment for their LAS had worse subjective function.[197]

III Radiographic measures of a cavus foot type did not discriminate between those with CAI and controls ($P>.05$).[263]

Evidence Synthesis and Rationale

Those who do not become "copers" after LAS and go on to develop CAI may have sensorimotor and ROM impairments at the trunk, hip, knee, ankle, and foot as well as impaired central mediated processes, as noted in the pathoanatomical section, that may put them at risk for further injury. The sensorimotor system may be assessed clinically with objective and reliable measures of impairments of body function and activity limitation and participation restriction, such as dynamic balance, hopping, running, and jumping. Because of the role of central mediated processes, evaluating the uninjured lower extremity for sensorimotor impairments may be appropriate. Patient factors can help to predict the clinical course in those with CAI.

2021 Recommendation

C Clinicians may include previous treatment, number of sprains, pain level, and self-report of function in their evaluation as well as an assessment of the sensorimotor movement systems of the foot, ankle, knee, and hip during dynamic postural control and functional movements, because of their role in influencing the clinical course and estimation of time to accomplish the goals of an individual with CAI.

DIAGNOSIS/CLASSIFICATION LATERAL ANKLE SPRAIN

2013 Recommendation

B Clinicians should use the clinical findings of level of function, ligamentous laxity, hemorrhaging, point tenderness, total ankle motion, swelling, and pain to classify a patient with acute LAS into the ICD category of sprain and strain of ankle (S93.4), and the associated ICF impairment-based category of ankle stability (b7150 stability of a single joint) and movement coordination impairments (b7601 control of complex voluntary movements).

Evidence Update

II In a prospective, double-blind trial, Li and colleagues[272] compared the diagnostic properties of the ADT, anterolateral drawer test (ALDT), and the reverse anterolateral drawer test (RALDT) between 2 raters in a mixed group of healthy individuals (n = 34) and those with confirmed ATFL injury (n = 38). The results indicated that the RALDT was superior to both the ADT and ALDT in nearly all categories for both raters. Mean sensitivity (averages of raters 1 and 2) was 0.224 for the ADT, 0.473 for the ALDT, and 0.894 for the RALDT. Specificity was at or near 1 for the ADT and ALDT, though only slightly less for the RALDT (0.897). Mean accuracy was 0.590 for the ADT, 0.715 for the ALDT, and 0.896 for the RALDT. Kappa values were also higher for the RALDT (0.639) compared to the ADT (0.196) and ALDT (0.528). The authors concluded that the RALDT was more sensitive and accurate when compared to the ADT and ALDT for diagnosis of ATFL injuries.[104,272]

II Croy et al[73] prospectively evaluated the diagnostic accuracy of the ADT in 66 individuals with a history of a LAS and 20 control individuals against digital USI during mechanical testing. The ADT uses a 5-point ordinal scale to classify degree of laxity (0, hypomobile; 1, normal; 2, mild increased laxity; 3, moderate increased laxity; 4, severe increased laxity). The diagnostic accuracy of the ADT was assessed for 2 thresholds: 2 or greater and 3 or greater. Two thresholds were used for the imaging reference standard: based on the literature (2.3 mm) and twice the standard deviation of the control group

(3.7 mm). Sensitivity of the ADT was 0.74 for the 2.3-mm cutoff and 0.83 for the 3.7-mm cutoff. Specificity of the ADT was 0.38 and 0.40 for the 2.3-mm and 3.7-mm cutoffs, respectively. The authors concluded that the ADT provides a limited ability to detect excessive anterior talocrural laxity. The authors, however, conceded that because a side-to-side comparison was not performed, as is typical in clinical practice, the ADT might provide useful information when used in this manner.[73]

III Wiebking et al[467] compared the diagnostic accuracy of the ADT, arthrometer assessment, and stress ultrasonography in 30 patients with lateral ankle trauma under anesthesia. The investigators were blinded to the diagnosis, and both ankles of all participants were examined. The ADT exhibited a sensitivity of 0.93 and a specificity of 0.67. The arthrometer displayed a sensitivity of 0.80 and a specificity of 0.40, while the stress ultrasonography demonstrated a sensitivity of 0.27 and a specificity of 0.87. The authors concluded that clinical examination with adequate analgesia was superior to both arthrometry and stress ultrasonography for diagnosing acute LAS.[467]

III Gomes et al,[153] in a cross-sectional study, looked at the efficacy of the anterolateral talar palpation test, using palpation to assess for anterior translation of the talus during a traditional ADT, to diagnose ankle instability. Two blinded investigators examined 24 participants (14 patients with confirmed anterior-lateral ligamentous injury and 10 controls). The first examiner performed the traditional ADT and the second examiner performed the anterolateral talar palpation test on all participants. Tests were categorized as positive or negative. The traditional ADT had a sensitivity of 0.50, a specificity of 1.0, a positive predictive value of 100%, a negative predictive value of 56.3%, and an overall accuracy of 69.6%. The anterolateral talar palpation test had a sensitivity of 1.0, a specificity of 0.77, a positive predictive value of 87.5%, a negative predictive value of 100%, and an overall accuracy of 91.3%. The authors concluded that while the results for the anterolateral talar palpation test were encouraging, it should be used as a complement to the traditional ADT to improve diagnostic accuracy in this patient population.[153]

Evidence Synthesis and Rationale

While the traditional ADT seems to have limited reliability and accuracy, it continues to be one of the most common tests used clinically. Adding palpation to assess for anterior translation of the talus during the traditional ADT improves the diagnostic accuracy of the ADT. Therefore, the anterolateral talar palpation test and the RALDT have stronger evidence than the traditional ADT to support their use in diagnosing ATFL injuries after LAS.

2021 Recommendation

B Clinicians should use special tests, including the RALDT and anterolateral talar palpation added to the traditional ADT, in addition to a thorough history and physical examination to aid in the diagnosis of a LAS.

CHRONIC ANKLE INSTABILITY

2013 Recommendation

B Clinicians may incorporate a discriminative instrument, such as the CAIT, to assist in identifying the presence and severity of ankle instability associated with the ICD category of instability secondary to old ligament injury, ankle and foot (M24.27), and the associated ICF impairment-based category of ankle stability (b7150 stability of a single joint) and movement coordination impairments (b7601 control of complex voluntary movements).

Evidence Update

I Rosen and colleagues[376] completed a systematic review with meta-analysis of 29 studies to determine whether functional performance tests could identify individuals with CAI. The authors found level B (moderate to strong) evidence for several functional performance tests. Specifically, the side hop (P = .009, n = 7), timed hop (P = .002, n = 9), multiple hop test (P<.001, n = 13), and the foot-lift test (P = .020, n = 3) were able to discriminate between individuals with CAI and healthy controls. Additionally, components of the SEBT (medial: P = .006, n = 7; anteromedial: P = .022, n = 7; posteromedial: P<.001, n = 13) were also capable of discriminating between the two groups.[376]

I To diagnose mechanical ankle instability and provide objective measures of laxity, arthrometers have been employed to quantify either anterior talocrural displacement and/or inversion ROM. A recent systematic review by Wenning and colleagues[465] identified that while most devices have good to excellent reliability (0.65-0.99), there were only 2 studies reporting the sensitivity and specificity of testing in individuals with CAI.

III In 2013, Donahue and colleagues[120] introduced a new discriminative instrument, the Identification of Functional Ankle Instability (IdFAI). The IdFAI, which consists of 10 questions, combined elements of both the CAIT and the Ankle Instability Instrument (AII). Scores can range from 0 to 37. A score of 11 or greater suggests that the individual is likely to have CAI. Unique to the IdFAI, the instrument has an operational definition of "giving way" at the top of the form. The IdFAI demonstrated an overall test-retest reliability of 0.92 and was significantly related to responses on the Lower Extremity Functional

Scale (LEFS) (Spearman $\rho = -0.38$, $P<.01$).[120] Subsequent investigation of 1127 college-aged individuals found that the IdFAI was able to predict 87.8% of cases in which a person met the minimum criteria for CAI, including a history of at least 1 ankle sprain and an episode of giving way.[394] This prediction percentage was greater than the combined use of the CAIT and AII.[394]

III In 2014, Wright and colleagues[478] revisited the cutoff score for the CAIT. This work was prompted by some investigators noting that individuals who indicated their ankle was relatively asymptomatic were classified as having CAI. Using 2 independent data sets, the authors identified a new cutoff score of 25 or less, down 2 points from what was previously established.[478] The recalibrated cutoff score exhibited a sensitivity of 96.6%, a specificity of 86.8%, a positive likelihood ratio of 7.31, and a negative likelihood ratio of 0.39. Additional work on the CAIT identified the minimal detectable change to be 3.08 and the minimal clinically important difference (MCID) to be 3 points or greater.[479]

III Given the usefulness of these questionnaires, several have been cross-culturally adapted and translated into other languages and formats. Evidence is available to support Arabic,[246] Dutch,[452] French,[148] Greek,[435] Japanese,[257] Persian,[168] Spanish,[75,369] and digital[374] versions of the CAIT. Similarly, evidence exists to support Chinese,[454] Korean,[232] Japanese,[311] Persian,[312,315] and Portuguese[299] versions of the IdFAI. Additionally, reliability of the IdFAI has been established across several adult age groups.[166] Likewise, the AII has been translated into Chinese,[273] French,[286] and Persian,[316] with evidence to support their use. One systematic review questioned the use of validated instruments translated and cross-culturally adapted for Brazilian Portuguese after critical analysis of their psychometric properties.[358]

V The International Ankle Consortium suggested the following criteria to identify individuals with CAI: history of at least 1 significant ankle sprain, subjective reports of the previously injured ankle "giving way," episodes of a subsequent sprain and/or perceptions of ankle instability, and diminished function as measured with the FAAM. Additionally, the consortium recommended confirmation of ankle instability by using a validated ankle-specific questionnaire with an appropriate cutoff score.[159]

Evidence Synthesis and Rationale

While discriminative self-report instruments continue to have the most evidence to support their use in diagnosing CAI, there is also evidence for use of functional performance tests, including hopping and dynamic balance tests. The criteria outlined by the International Ankle Consortium will hopefully unify how individuals with CAI are identified. However, further evidence is needed to support these criteria. The ability of arthrometers to diagnose mechanical ankle instability and provide objective measures of laxity is unclear, and their utility is limited by their lack of practicality in the majority of clinical settings.

2021 Recommendation

B When determining whether an individual has CAI, clinicians should use a reliable and valid discriminative instrument, such as the CAIT or the IdFAI, as well as a battery of functional performance tests that have established validity to differentiate between healthy controls and individuals with CAI.

DIFFERENTIAL DIAGNOSIS

ACUTE LATERAL ANKLE SPRAIN

2013 Recommendation

Clinicians should use diagnostic classifications other than an acute LAS when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline. Particularly, the Ottawa ankle rules (OAR) and Bernese ankle rules (BAR) should be used to determine whether a radiograph is required to rule out a fracture of the ankle and/or foot.

Evidence Update

The ankle has been cited as the most frequently misdiagnosed region for patients reporting to the emergency department.[323] An inadequate history and/or physical examination and failure to order or interpret radiographs have been identified as the most common reasons for misdiagnosis.[323] To decrease the likelihood of missing a fracture, application of the OAR has been deemed an integral part of the diagnostic process.[414,451]

A recent systematic review and meta-analysis concluded that the OAR are the gold standard of decision rules for excluding fractures after an acute ankle injury.[25] This includes fractures of the distal tibia, distal fibula, base of the fifth metatarsal, and navicular. Utilization of the OAR has been validated in different populations[455] across the lifespan.[130,328] Although some investigators are proponents of the low-risk ankle rules (LRAR) in the pediatric population,[34,35] others have shown that the sensitivity of the LRAR (85.7%) is inferior to that of the OAR (100%) in this demographic.[130] There is evidence that implementation of the OAR in the emergency department decreases costs,[278] patient wait time,[182] length of stay (median, 20 minutes),[182] and radiograph imaging,[182,431] without sacrificing outcomes.[81] Likewise, there is evidence that the OAR can be used during athletic events.[83,158] To improve dissemination and adherence, the use of technology, including apps[339] and electronic clinical decision support tools, has been recommended.[393,419] Collectively, investigators routinely report the OAR to have a high sensitivity (92%-100%), though low to moderate specificity (7.8%-68%).[30,81,209,351,431] Specificity may be improved with other tests such as the BAR.[209] However, the BAR alone have not been advocated for clinical use because of the lower-than-desirable sensitivity.[96] To maintain the level of OAR sensitivity, the OAR should be applied in their entirety. Amiri and colleagues[12] reported that sole utilization of the ability of a patient to bear weight and complete 4 steps in the emergency department, while omitting tenderness at the malleoli, resulted in a lower sensitivity (88%) compared to sensitivity values associated with full application of the OAR. Despite the amount of evidence that supports clinical use of the OAR, not all studies are in agreement,[71] possibly because clinical biases and concern of litigation remain.[16]

In addition to a fracture of the distal tibia, distal fibula, base of the fifth metatarsal, and navicular, soft tissue pathology must be considered when differentially diagnosing a patient who has sustained an acute ankle sprain. To optimize the differential diagnosis of soft tissue injury, the physical exam is most accurate when performed 4 to 5 days after injury.[451] Using MRI, copathologies have been confirmed in 92% of cases following an acute sprain.[84] Differential diagnosis and assessment for copathologies may include:

- Syndesmotic injury[45,162,371]
- Osteochondral lesions[84,371]
- Talar bone contusion[371]
- Deltoid ligament sprain[371]
- Tendinous injuries,[84] including Achilles tendon rupture and fibularis longus/brevis tendon and retinacular injury
- Symptomatic accessory ossicles, including os trigonum syndrome[210]
- Midfoot sprains (eg, talonavicular, calcaneocuboid, and calcaneonavicular ligaments)[10]
- Epiphyseal plate injuries[34,448]

2021 Summary

Clinicians should conduct a thorough patient history and examine the multiple segments of the ankle-foot complex to rule in or out the pathologies that may be present when differentially diagnosing an acute sprain, and utilize the OAR when determining whether a radiograph is necessary after an acute LAS.

CHRONIC ANKLE INSTABILITY

2013 Recommendation

Clinicians should use diagnostic classifications other than ankle instability when the patient's reported activity limitations or impairments of body function and structure are not consistent with those presented in the Diagnosis/Classification section of this guideline.

Evidence Update

While the majority of patients recover after an acute ankle sprain, around 40% may continue to exhibit symptoms consistent with CAI. Concurrent pathologies may explain why symptoms remain problematic for months or longer in some cases. Frequently, these copathologies are documented at the time of surgery following unsuccessful nonsurgical management.[13,282] Coexisting pathology accompanying CAI may include:

- Fibularis muscle pathology[13,199]
- Ankle impingement[13,262]
- Osteochondral lesions[13]
- Synovitis[282]
- Chondral lesions (superficial or deep)[196,265,282]
- Bony or avulsion fragments[282,364]
- Loose bodies[282]
- Syndesmotic injury[65,326]
- Arthritis[293]
- Bifurcate ligament injury[415]
- Symptomatic accessory ossicles,[364] including os trigonum syndrome[98]

2021 Recommendation

Clinicians should consider the presence of pathologies that may coexist or exist in isolation and refer to other appropriate professionals when symptoms and/or function do not fully recover after a LAS.

IMAGING

2013 Condensed Summary

Radiographs may be useful in acute cases when indicated by the OAR and BAR. Generally, patients with suspected ankle sprains are treated nonsurgically for 4 to 6 weeks. For patients with persistent symptoms, including symptoms consistent with ankle instability, radiographs, stress radiographs, MRI, arthrography, computed tomography (CT), USI, and/or bone scan/scintigraphy can be used to assess the integrity of the soft tissue and/or osseous anatomy.

2021 Evidence Update and Summary

The American College of Radiology (ACR) has produced the "ACR Appropriateness Criteria," an evidence-based guideline to assist providers in making the most appropriate imaging choices for specific clinical conditions, including those with acute and chronic ankle injuries (https://www.acr.org/). These ACR Appropriateness Criteria state that if the OAR are positive, an ankle radiograph is the first appropriate imaging study. If radiographs demonstrate potential osteochondral injury or there are persistent symptoms, an MRI or CT scan without contrast is usually appropriate. Leg radiographs, ankle stress radiographs, an MRI scan without contrast, or a CT scan without contrast are usually appropriate for those who have an alignment abnormality suggesting syndesmotic/ligamentous injury or dislocation. Ultrasound imaging is usually not the first imaging study after an acute trauma to the ankle, but may be an appropriate secondary evaluation modality to assess for underlying soft tissue injuries, chondral avulsion fractures in children, or abnormalities with dynamic imaging stress testing. Exclusion criteria from these recommendations include children younger than 5 years of age or those with altered leg sensation (ie, diabetic), altered mental capacity, and/or inability to communicate (https://www.acr.org/).

In those with symptoms that are present for more than 6 weeks, the Appropriateness Criteria note that ankle radiographs are usually appropriate. If ankle radiographs are negative but ankle instability, ankle impingement, osteochondral lesions, and/or tendon injuries are suspected, an MRI without contrast is usually appropriate. Ultrasound imaging may also be appropriate when a tendon injury is suspected, and contrast can be added to MRI when ankle instability is suspected (https://www.acr.org/).

Ultrasound imaging is a growing area of interest in physical therapy. Systematic reviews have found USI to be reliable and accurate in the diagnosis of ATFL and calcaneofibular ligament injuries.[48,266,385,386] Specific studies have supported USI with stress testing[150,314] to be useful to further assess the ATFL to identify the type of injury,[44] grade severity of injury,[63] and assess its thickness.[284] Another systematic review found USI to be accurate in identifying foot fractures,[53] and specifically fifth metatarsal, lateral malleolus, and medial malleolus fractures, in those with a foot and/or ankle sprain.[19] Ultrasound imaging was also found to be accurate and sensitive in detecting tendinous injuries,[380] as well as useful for visual biofeedback to target activation of specific muscles during rehabilitation.[243]

CLINICAL PRACTICE GUIDELINES

Examination

OUTCOME MEASURES

2013 Recommendation

A Clinicians should incorporate validated functional outcome measures, such as the FAAM and the LEFS, as part of a standard clinical examination. These should be utilized before and after interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with ankle sprain and instability.

Evidence Update

I The Patient-Reported Outcomes Measurement Information System (PROMIS) physical function (PF) computer adaptive test (CAT) performed as well as the FAAM ADL subscale and the 5-point Foot Function Index (FFI) in an assessment of content validity, convergent validity, and item reliability, with less response burden, in 60 (19.4%) individuals scheduled for CAI surgery.[200] In a general orthopaedic population (n = 3069), the MCID values varied depending on methods and were calculated for the PROMIS PF test (range, 3-30; median, 11.3), PROMIS pain interference (PI) test (range, 3-25; median, 8.9), and the FAAM sports subscale (range, 9-77; median, 32.5).[203]

II In a general orthopaedic foot population, the PROMIS PF test, PROMIS PI test, and FAAM sports subscale were sensitive and responsive to changes in patient-reported health, with effect sizes ranging from 0.95 to 1.31 across 4 time points (3, greater than 3, 6, and greater than 6 months).[202] In analyses that included Rasch modeling, the PROMIS PF, mobility, and PI scales were more normally distributed, with fewer floor and ceiling effects, than the Foot and Ankle Outcome Score (FAOS).[245] Additionally, the PROMIS CATs were more precise and had better test-retest reliability than both the FAOS and the Medical Outcomes Study 12-Item Short-Form Health Survey in 19 (6.2%) individuals scheduled for ankle instability surgery.[245]

II There was evidence of validity, reliability, and responsiveness for the Korean version of the American Academy of Orthopaedic Surgeons foot and ankle questionnaire in a study that included 11 (5.3%) individuals with ankle instability.[223]

II The score 5 to 7 days after a LAS on the Pain Self-Efficacy Questionnaire (PSEQ), which assesses a patient's confidence to accomplish activities despite pain, was significantly correlated with function (r = 0.26, P = .017) and pain level (r = 0.32, P<.01) 3 weeks after injury.[37]

III The PROMIS PF CAT was found to be efficient, reliable, valid, and precise, while adequately assessing function in 48 (15%) patients scheduled for ankle instability surgery.[201]

III A difference in FAAM sports subscale score (95 versus 84.8), but not in the ADL subscale score (99 versus 97.2), was noted between "copers" and those with chronic complaints of instability.[152] Slightly different results were noted by Wright et al,[477] as FAAM scores were different in those with chronic complaints of instability compared to "copers" and uninjured participants, with ADL subscale scores of 96.36, 99.54, and 99.79 and sports subscale scores of 89.76, 98.70, and 97.83, respectively.

III The Fear-Avoidance Beliefs Questionnaire (FABQ) correlated (R^2 = 0.18-0.35, P<.028) with measures of balance and joint laxity.[194]

III Evidence to support the use of the 11-item Tampa Scale of Kinesiophobia (TSK-11) to asses fear of movement and reinjury and the FABQ to assess fear-avoidance beliefs is available, as scores on these instruments differentiated those with CAI from healthy controls (P<.001).[195] Other studies have found the TSK-11 scores of controls and "copers" to be different from the scores of those with CAI (P<.001).[138] The TSK-11 scores were also correlated with ankle joint laxity in female athletes (r = 0.285, P = .013), but not in male athletes (r = –0.094, P = .46).[141]

III There is evidence to support the use of a 12-item shortened FAAM, with a combined ADL and sports subscale,[184,185] as well as evidence to support the use of Turkish,[51,441] German,[287] Japanese,[440] Chinese,[155] and Dutch[461] versions of the FAAM for those with a history of an ankle sprain and/or chronic complaints of instability. Evidence is also available to support the use of Chinese,[156] Brazilian Portuguese,[300] Thai,[410] and Italian[447] versions of the FFI in individuals with a history of an ankle sprain.

IV Preliminary research in 26 participants found evidence of validity of the Sports Athlete Foot and Ankle Score (SAFAS) for assessing sports-related ankle injuries in high-performing athletes.[325]

Evidence is available to support a Brazilian Portuguese version of the SAFAS.[79]

IV There is evidence to support a Persian version of the American Orthopaedic Foot & Ankle Society (AOFAS) ankle-hindfoot scale, a reliable and valid instrument for those with ankle ligament injuries.[450]

IV Greater kinesiophobia measured with TSK-11 scores was associated with less confidence on the SEBT (r = −0.46) and vertical jump (r = −0.45).[68]

Evidence Synthesis and Rationale

There continues to be strong evidence to support the use of patient-reported outcome measures over the course of treatment to assess for changes in impairments of body function and structure, activity limitations, and participation restrictions for those with an acute LAS or CAI. The PROMIS PF and PI scales, which can be delivered in a contemporary CAT format, have been supported since the 2013 recommendation. Additionally, there is recent evidence to support instruments to capture various aspects of the patient's psychological status, such as fear of reinjury, kinesiophobia, fear-avoidance beliefs, and reinjury anxiety.

2021 Recommendations

A Clinicians should use validated patient-reported outcome measures, such as the PROMIS PF and PI scales, the FAAM, and the LEFS, as part of a standard clinical examination. Clinicians should utilize these before and 1 or more times after the application of interventions intended to alleviate the impairments of body function and structure, activity limitations, and participation restrictions associated with an acute LAS or CAI.

C Clinicians may use the PSEQ in the acute and postacute periods after a LAS to assess effective coping strategies for pain and the TSK-11 and FABQ to assess fear of movement and reinjury and fear-avoidance beliefs in those with CAI.

PHYSICAL IMPAIRMENT MEASURES

2013 Recommendation

A When evaluating a patient with an acute or subacute LAS over an episode of care, assessment of impairment of body function should include objective and reproducible measures of ankle swelling, ankle ROM, talar translation and inversion, and single-leg balance.

LATERAL ANKLE SPRAIN

Evidence Update

II After an acute LAS, pain with dorsiflexion measured at 4 weeks using the weight-bearing lunge test was associated with a lower functional status at 4 months (unstandardized β = 6.8, P<.005).[335]

III In individuals with LAS symptoms lasting 6 to 12 months, multivariate analysis showed a significant (P<.05) positive association with swelling (OR = 3.58) and a difference in passive plantar flexion ROM (OR = 1.09) to bone edema in the talocrural joint. Differences in passive plantar flexion ROM (OR = 1.07) and pain at the end range of dorsiflexion and/or plantar flexion (OR = 5.23) were associated with osteophytes in the talonavicular joint.[443]

III Bilateral reductions in SEBT reach distances were identified in individuals assessed within 2 weeks after a LAS, with large effect sizes (η^2 = 0.27-0.29) for the involved and uninvolved lower extremities in the posterolateral and posteromedial reach directions, a medium effect size (η^2 = 0.18) for the involved lower extremity in the anterior direction, and a small effect size (η^2 = 0.06) for the uninvolved limbs in the anterior direction.[118] In those after LAS, the SEBT was found to be reliable in all 8 directions (intraclass correlation coefficient range, 0.72-0.93), with minimal clinical difference values of 8.56%, 13.36%, and 13.33% for the anterior, posteromedial, and posterolateral directions, respectively.[349]

III A combination of balance, proprioception, and motor control assessment could differentiate individuals 3.5 months after a LAS from healthy controls.[354] This assessment included clinical measures of dorsiflexion ROM measured with the weight-bearing lunge test, the SEBT, the number of touches or foot lifts in 30 seconds during single-leg balance with eyes closed (foot-lift test), and time to descend stairs. The association between sprain status was best between the SEBT in the anterior direction and single-leg balance with eyes closed (χ^2 = 15.2, P<.001).[354]

III Non–weight-bearing ROM (dorsiflexion, P = .452; plantar flexion, P = .436; inversion, P = .383; and eversion, P = .657), pain level (P = .822), and foot volume measures (P = .654) were not different between those with a first-time LAS and those with recurrent injuries when measured within 5 days after injury.[464]

CHRONIC ANKLE INSTABILITY

III Univariate comparison found that impairment measures of dorsiflexion ROM with the weight-bearing lunge test and number of errors with 20-second single-limb balance on a firm surface with eyes closed could be used to predict treatment success for patients with CAI ($P<.10$).[469,470]

III Dorsiflexion ROM measured in non–weight bearing with the knee flexed was associated with severity of CAI as assessed with the CAIT ($r = 0.22$, $P = .04$).[373]

III Those with CAI have decreased weight-bearing dorsiflexion ROM compared to healthy controls (inclinometer, 48.3° versus 43.3°; $P<.05$[239]; wall-toe distance, 8.3 versus 10.0 cm; $P = .013$[250]). Weight-bearing dorsiflexion ROM with the lunge test (measured with a digital inclinometer) was correlated ($r = -0.39$, $P = .002$) with lateral step-down performance, as those with poor movement quality had less ankle dorsiflexion ROM than those with good movement quality (36° versus 42°, $P = .01$).[161] Weight-bearing dorsiflexion ROM was also correlated with movement at the knee during single-leg landing ($r = 0.53$, $P = .04$).[186] Different findings were noted by Vomacka et al,[449] as no difference was found in dorsiflexion ROM between those with CAI, copers, and healthy controls ($P>.05$).

III Rosen et al[376] performed a systematic review with meta-analysis to evaluate balance tests to differentiate healthy individuals from those with CAI, and found the foot-lift test to be a useful static balance test (mean effect size, −0.76; $P = .020$) and the SEBT to be a useful dynamic balance test in the posteromedial (mean effect size, 0.37; $P<.001$), medial (mean effect size, 0.37; $P = .006$), and anteromedial (mean effect size, 0.33; $P = .022$) reach directions. Included in the review, Ko et al[231] found high intrarater reliability for the foot-lift test (standard error of measurement, 1.3 errors) and SEBT (standard error of measurement, 4.6 cm), while Linens et al[280] found the cutoff scores needed to identify those with CAI from healthy individuals to be 5 errors/touches on the foot-lift test and 91% reach distance on the SEBT in the posteromedial direction.

III Studies not included in the review by Rosen et al[376] found that all 8 directions of the SEBT differentiated between healthy subjects and those with CAI, with the posteromedial and posterolateral directions being the best predictors of CAIT score ($P\leq.001$ and $P<.05$, respectively).[239,392] Poor performance on the SEBT (less than 85.2% reach distance in the posteromedial direction) was found to be the best single predictor of a successful treatment (OR = 11.32).[42] Other studies support the anterior reach direction[89,208,234,250] as well as the posteromedial direction as being able to differentiate those with CAI from healthy controls.[234,250]

III The SEBT was found to be an accurate and valid measure of dynamic balance in those with CAI, as there was a large and significant correlation ($R^2 = 0.98$, $P<.001$) between visual estimation and motion analysis measures of maximum reach distance.[27] While variations in how the SEBT is administered can affect results, one method does not seem superior to another.[76]

III Associations have been identified between dorsiflexion ROM with the weight-bearing lunge test and the anterior reach direction ($r = 0.55$, $P<.001$), posterolateral reach direction ($r = 0.29$, $P = .03$), and the composite SEBT scores ($r = 0.30$, $P = .02$), while there was no association with the posteromedial reach direction ($r = 0.01$, $R^2 = 0.001$, $P = .47$).[26] Terada et al[425] also found a significant correlation between dorsiflexion ROM and SEBT anterior reach distance ($r = 0.410$, $P = .014$). Similar findings were found by Gabriner et al,[146] as dorsiflexion ROM measured with the weight-bearing lunge test and plantar cutaneous sensation explained a significant amount of the variance associated with SEBT anterior reach distance ($R^2 = 0.16$, $P = .041$), while eversion strength and time to medial-lateral boundary explained a significant amount of the variance associated with SEBT posteromedial reach distance ($R^2 = 0.28$, $P = .002$).[146] Weight-bearing dorsiflexion ROM was also correlated with sagittal knee ($r = -0.53$, $P = .04$) and frontal trunk ($r = 0.62$, $P = .01$) movements, as well as with SEBT anterior reach distance ($r = 0.51$, $P = .05$).[187]

III Some studies have found that the SEBT was able to differentiate "copers" from those with CAI,[138,205,250] while another did not.[152]

III A systematic review and meta-analysis found that individuals with CAI had decreased hip abduction, extension, and external rotation strength ($P<.001$; effect size range, 0.52-0.93), but no difference in knee kinematics, with dynamic balance activities ($P = .26$).[87] Studies included in this review also found that hip abduction and external rotation strength each explained a significant ($R^2 = 0.25$, $P = .01$) amount of the SEBT posteromedial and posterolateral reach directions.[302] Studies not in the review also support a decrease in hip strength in those with CAI.[249]

III The BESS with the eyes closed was significantly different ($P = .01$) and could distinguish copers (mean ± SD BESS score, 1.12 ± 0.85) from those with CAI (2.7 ± 1.87).[258]

III Foot posture, as measured with the FPI score, may affect static and dynamic postural control in individuals with CAI, as a neutral group had better dynamic postural control, while the pronator group had better static postural control ($P \leq .05$).[189] However, no significant differences in foot posture, arch height index, or foot mobility magnitude have been found in individuals with or without LAS or CAI.[138]

III In those with CAI, measures of static and dynamic postural control (eg, SEBT), dorsiflexion ROM, plantar cutaneous sensation, strength, and ankle-subtalar joint motion contributed significantly (R^2 = 0.18-0.35, P<.05) to multiple patient-reported outcome measure score variances.[194]

IV Significant correlations between isokinetic inversion muscle strength and the single-leg balance test, single heel-raise test, and sidestep test (r = 0.23-0.51, P<.009) were identified in those with CAI.[343] Postural control evaluation using the modified Romberg test could substitute for dynamometer testing of joint position sense, as these measures were correlated (r = −0.81, P<.001) in those with chronic complaints of instability.[59]

Evidence Synthesis and Rationale

A growing body of evidence supports assessing impairments of body function and structures before beginning treatment, and then 2 or more times over an episode of care, to identify limitations, predict treatment success, and define progress over the course of treatment for those with acute LAS or CAI. The role of bilateral lower extremity impairments that result from central mediated processes needs further investigation and may affect how test results comparing injured to uninjured sides are interpreted.

2021 Recommendations

A Clinicians should assess and document ankle swelling, ROM, talar translation, talar inversion, and single-leg balance in patients with an acute LAS, postacute LAS, or CAI at baseline and 2 or more times over an episode of care. Clinicians should specifically include measures of dorsiflexion as measured with the weight-bearing lunge test, static balance with a single limb on a firm surface with eyes closed, and dynamic balance with the SEBT anterior, anteromedial, posteromedial, and posterolateral reach directions.

C In those with CAI, clinicians may also assess and document hip abduction, extension, and external rotation strength 2 or more times over an episode of care.

ACTIVITY LIMITATION – PHYSICAL PERFORMANCE MEASURES

2013 Recommendation

B When evaluating a patient in the postacute period following a recent or recurring LAS, physical therapists/clinicians should assess and document activity limitation, participation restriction, and symptom reproduction using objective and reproducible measures that assess performance with lateral movements, diagonal movements, and directional changes, such as single-limb hop tests.

Evidence Update

III The systematic review and meta-analysis by Rosen et al[376] assessed functional performance tests and found that the timed hop (mean effect size, −1.056; P = .009), side hop (mean effect size, −2.314; P = .001), and multiple hop tests (mean effect size, 1.399; P<.001) were able to differentiate healthy individuals from those with CAI. Included in the review by Rosen et al,[376] Ko et al[231] found the single-leg hop test (standard error of measurement, 0.6 seconds) to have high intrarater reliability, with Linens et al[280] identifying a cutoff score of 12.88 seconds as being able to differentiate those with CAI from healthy individuals.

III The lower extremity Functional Movement Screen (LE-FMS) scores differentiated healthy individuals from those with CAI (8.2 versus 6.9, P<.05). Both inline lunge (affected side and nonaffected side) and hurdle step (affected side and nonaffected side) were different (P<.05), while there was no difference between the two groups in the deep squat (P>.05). Also in those with CAI, the total LE-FMS score and inline lunge test correlated to the FADI ADL and sports scores (r = 0.807-0.896, P<.01).[62]

III The timed dynamic leap and balance test was able to differentiate those with CAI from controls (51.85 seconds versus 41.12 seconds, P<.001).[206]

IV Those with ankle laxity, as assessed with the ADT, had lower hopping for distance (percent body height, 95.03% versus 105.26%; P<.05) and performed poorer on a hexagon hopping course (count, 13.21 versus 14.52; P<.05) when compared to those with stable ankles.[474]

IV One-leg hopping for distance demonstrated significant side-to-side differences compared with the unaffected ankle (P = .035) and was correlated with joint position sense (r = −0.38 to 0.66, P<.05) in those with chronic complaints of instability.[59]

Evidence Synthesis and Rationale

There continues to be strong evidence to support the use of single-limb hopping under timed conditions to assess activity limitation and participation restrictions. Hopping should be performed under safe conditions, and only after a patient has appropriately been progressed along a continuum of activity. Further studies are needed to define the usefulness of more comprehensive movement screens.

2021 Recommendation

B Clinicians should assess and document objective and reliable measures of activity limitation, participation restriction, and symptom reproduction at baseline and 2 or more times during an episode of care when evaluating a patient with a LAS or CAI, and specifically include measures of single-limb hopping under timed conditions when appropriate.

TECHNOLOGY AND INSTRUMENTATION

2021 Evidence Summary

The use of technology (eg, computerized measurement devices) to assess physical impairment as well as activity and functional performance in those with a history of LAS and chronic complaints of ankle instability has been supported.[1,5,58,61,144,252,260,277,392,413,475,482] Research studies have also used motion analysis and a force plate to assess static and dynamic balance, gait, and jumping,[49,50,55,69,85,90,101,103,107,108,110,112-114,116-118,126,136,139,140,167,173,175,176,192,205,218,225,228,256,259,274,276,279,318,350,379,396,398,399,401,409,421,429,430,481] as well as an isokinetic dynamometer to assess strength, joint reposition, and movement detection.[59,60,78,82,264,333,343,347,379,392,404,473]

CLINICAL PRACTICE GUIDELINES

Interventions

Interventions for acute and subacute LAS and CAI were presented in the 2013 CPG[298] using the context of acute and progressive loading/sensorimotor training phases of treatment. Since that time, study samples have become more consistent, using language that is different from that in the initial CPG. The major distinction between the two phases of treatment as described in the 2013 CPG was a time threshold of 72 hours post injury.[1] For the 2021 CPG update, intervention guidelines are presented using a consensus framework that reflects how research evidence has developed since the initial CPG (**TABLE 2**). It uses the terms "acute LAS" and "CAI."[159,160] This evidence update identified specific neuromusculoskeletal impairments, activity limitations, participation restrictions, treatment response, and the mediating intrinsic factors that exist along a spectrum of acute LAS, postacute LAS, and CAI (**FIGURE 1**).

Clinicians should consider the updated evidence-based recommendations provided in this guideline in the appropriate context of clinical experience and patient preference when determining the nature and timing of interventions during the course of rehabilitation for an individual with LAS. Due to heterogeneity of impairment and activity limitation experienced by individuals with LAS and CAI, interventions should be tailored to the specific needs of the patient. Furthermore, intrinsic and environmental factors that mediate outcomes should also be addressed when prescribing interventions for individuals with LAS and CAI. Physical therapists and other rehabilitation specialists are members of larger, multidisciplinary teams while treating patients with LAS and CAI. Engaging other physical therapists, athletic trainers, physicians, surgeons, mental and behavioral health care providers, nurses, strength and conditioning specialists, vocational specialists, and other health disciplines may be warranted for optimal transition to work or sport. Patient-reported and objective clinical and instrumented measures that can capture resolution of ankle-foot impairment, return to activity, and resumption of social participation are paramount to managing the intensity and dose of interventions.

PREVENTION OF LATERAL ANKLE SPRAINS

PRIMARY PREVENTION OF A FIRST-TIME LATERAL ANKLE SPRAIN

2013 Recommendation

None.

Evidence Update

I Leppänen and colleagues[268] conducted a systematic review and meta-analysis to examine the effects of any primary prevention interventions in sports injuries. Ten trials addressing prevention of ankle injuries with external ankle joint supports were included. Pooled results showed a significant reduction in the frequency of ankle injuries compared to no ankle supports (pooled OR = 0.40; 95% CI: 0.30, 0.53). Subjects in these trials (n = 6662) were young male and female athletes in basketball, male athletes in soccer and American football, and military paratroopers. The external ankle supports used were different kinds of stabilizing devices, such as orthoses and braces. Ankle taping was not studied in these randomized clinical trials (RCTs).

TABLE 2 Treatment-Based Classification of LAS: Operational Definitions to Guide Intervention for LAS, Based on History and Physical Examination Findings

	Classification 1	Classification 2
2013 CPG	Acute/protected motion • Within 72 h following inversion mechanism injury • Individuals who demonstrated significant swelling, pain, limited weight bearing, and overt gait deviations (ie, limited stance time, abbreviated/omitted terminal stance phase)	Sensorimotor training • Postacute period • Primary concerns of instability, weakness, limited balance responses, and intermittent swelling
2021 CPG	Acute LAS • Within 72 h following inversion mechanism injury • Individuals who demonstrated significant swelling, pain, limited weight bearing, and overt gait deviations (ie, limited stance time, abbreviated/omitted terminal stance phase)	Chronic ankle instability • History of at least 1 significant ankle sprain within the past 12 mo • A history of the previously injured ankle joint "giving way" and/or recurrent sprain and/or "feelings of instability"

Abbreviations: CPG, clinical practice guideline; LAS, lateral ankle sprain.

I Vuurberg and colleagues[451] reported that the use of an ankle brace or tape reduces the risk of first-time LAS (relative risk = 0.69; 95% CI: 0.49, 0.96), especially in those who participate in sports. When compared to bracing, taping has been suggested to be less advantageous from a cost-benefit perspective.[336] The choice between brace and tape should depend on patient/client preference, the clinician's judgment, and the cost-effectiveness of the interventions. The review of 3 RCTs (n = 3410) assessing the prophylactic effects of low-fitted or high-fitted footwear found that this intervention yielded no significant reduction in ankle sprain risk.

I Bellows and Wong[31] found 3 trials (n = 3581), in a systematic review and meta-analysis, that demonstrated a statistically significant 4.2% absolute risk reduction of ankle sprains with the use of a brace compared to no treatment, corresponding to a 64% reduction of relative risk.

I The Bellows and Wong[31] review also identified 6 trials (n = 3577) that demonstrated a statistically significant 6.5% absolute risk reduction of ankle sprains with a balance training program compared to no treatment, corresponding to a 46% relative risk reduction. The specific nature and level of supervision for balance training exercises demonstrated high variability among the included studies. This review and meta-analysis included studies of individuals with and without a history of prior LAS.

I Vuurberg and colleagues[451] reported that while there is evidence to support the use of exercise for prevention of recurrent sprains, there is a lack of evidence to support the use of prophylactic exercises for the prevention of first-time ankle sprains.

Evidence Synthesis and Rationale

There is strong evidence to support the use of prophylactic bracing and taping for the prevention of first-time ankle sprains. While bracing appears to be more cost-effective than taping, clinician experience and patient preference should be considered when deciding which intervention to employ. There is strong evidence for the use of balance exercise for the prevention of recurrent ankle sprains, yet there is a lack of evidence for the use of these interventions for the primary prevention of first-time ankle sprains at present. However, clinicians may recommend exercise as part of a comprehensive fitness program due to the potential prophylactic benefits and relatively low associated risks. More research is needed to clarify the specific mode and volume of exercise necessary to produce preventive effects. Based on the frequency of injury and morbidity associated with

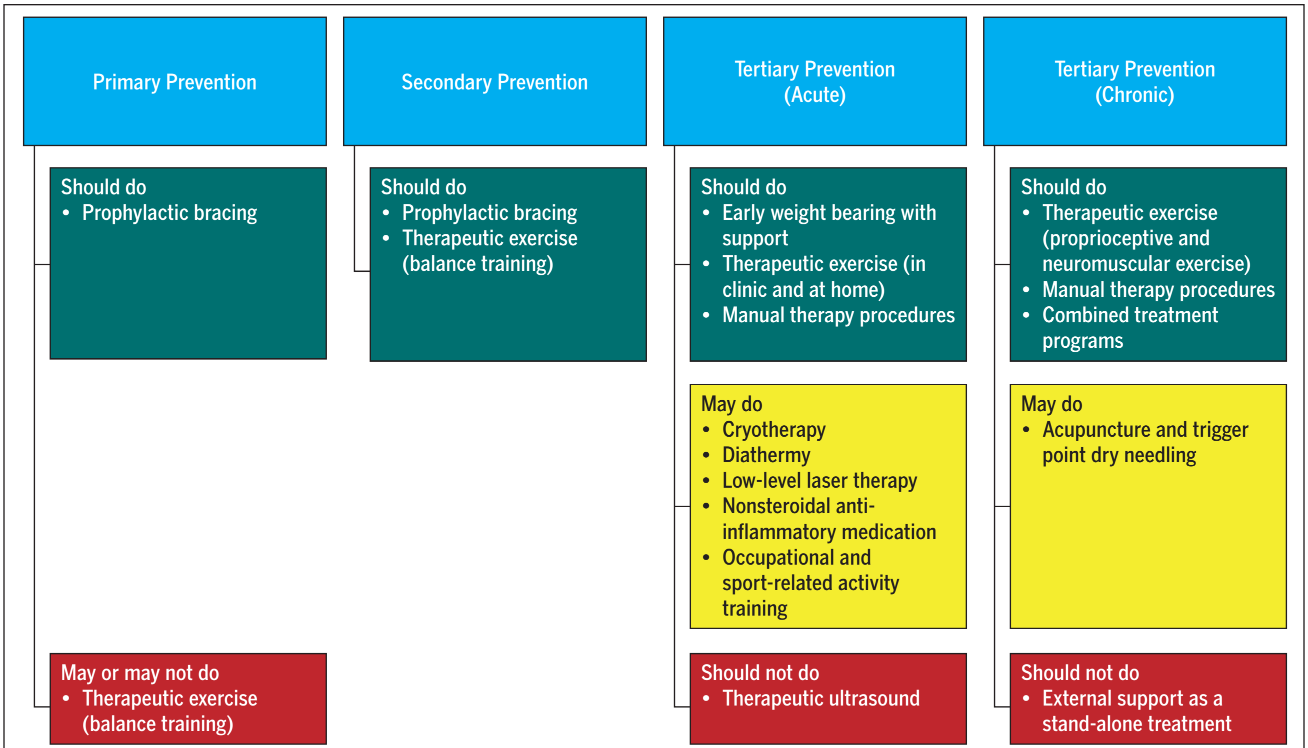


FIGURE 1. Evidence-based interventions by level of prevention. Primary prevention refers to interventions to reduce the risk of a first-time LAS in people exposed to risk factors, secondary prevention refers to interventions to reduce the risk for recurrent LAS after a first-time LAS, and tertiary prevention refers to interventions to reduce the effects and progression of a LAS. Abbreviation: LAS, lateral ankle sprain.

LAS and CAI, prophylactic bracing and taping should be routinely employed in individuals with intrinsic risk factors or those who engage in high-risk activities such as court sports. Further investigation may be needed to define the necessary components of a brace, as well as specific taping techniques that best provide protection.

2021 Recommendations

A Clinicians should recommend the use of prophylactic bracing to reduce the risk of a first-time LAS, particularly for those with risk factors for LAS.

C Clinicians may recommend the use of prophylactic balance training exercises to individuals who have not experienced a first-time LAS.

SECONDARY PREVENTION OF RECURRENT LATERAL ANKLE SPRAIN FOLLOWING AN INITIAL SPRAIN

2013 Recommendation

C Clinicians can implement balance and sport-related activity training to reduce the risk of recurrent ankle sprains in athletes.

Evidence Update

I In a meta-analysis of 3 systematic reviews investigating the effectiveness of exercise interventions for secondary prevention of LAS, Doherty and colleagues[102] found a significantly decreased risk of sustaining a recurrent ankle sprain in the intervention group compared to controls (OR = 0.59; 95% CI: 0.51, 0.68).

I Doherty and colleagues[102] also found consistency among 5 included systematic reviews that bracing was effective at preventing a recurrence of an ankle sprain (OR = 0.40; 95% CI: 0.29, 0.56), especially if the individual engaged in high-risk activity such as indoor court- or field-based athletics.

I Doherty and colleagues[102] concluded from data in 2 systematic reviews that bracing was superior to taping, though 3 systematic reviews advocated for the value of taping. There is limited evidence on mechanisms that lead to these beneficial effects. When compared to bracing, taping has been suggested to be less advantageous from a cost-benefit perspective.[336]

I There is inconclusive evidence from systematic reviews for footwear modification or foot orthoses to prevent a recurrent ankle sprain after an initial LAS among evaluated systematic reviews.[102,356] Furthermore, there is a lack of evidence pertaining to orthotic use in the treatment of CAI or the prevention of ankle sprain recurrence.[102,356]

I Therapeutic exercise involving proprioceptive and balance retraining is associated with reduced frequency of recurrent LAS, based on data from 10 trials (n = 1284), and reduced prevalence of functional ankle instability, based on data from 3 trials (n = 174).[451]

I Based on data from 7 trials (n = 1417), Bleakley and colleagues[33] found a significant reduction in recurrent injury following exercise-based intervention in people with an existing LAS, compared to usual care, at 7 to 12 months post injury (OR = 0.53; 95% CI: 0.38, 0.73). Usual care consisted of 1 or more of protection, rest, ice, and elevation. Although most programs in the included studies emphasized strength and balance training, the specific nature and volume of exercises demonstrated substantial variability.

I Burger and colleagues[43] found a statistically similar rate of recurrence in people with a prior LAS who received neuromuscular exercise compared to bracing, based on a systematic review and meta-analysis (3 trials, n = 144).

Evidence Synthesis and Rationale

There is strong evidence to support the use of prophylactic bracing, taping, and balance training exercises for the prevention of subsequent ankle sprains. While bracing appears to be more cost-effective than taping, clinician experience and patient preference should be considered when deciding which intervention to employ. Footwear modification and orthotic prescription have been shown to be ineffective for general prophylaxis of subsequent ankle sprain; however, the utility of these interventions for addressing specific ankle-foot impairments that contribute to activity limitation following LAS and CAI has yet to be elucidated. The necessary components of a brace, taping technique, footwear, and orthosis that best provide protection may need further investigation.

2021 Recommendation

A Clinicians should prescribe prophylactic bracing and use proprioceptive and balance-focused therapeutic exercise training programs to address impairments identified on physical examination to reduce the risk of a subsequent injury in patients with a first-time LAS.

INTERVENTIONS FOR ACUTE AND POSTACUTE LATERAL ANKLE SPRAINS

PROTECTION AND OPTIMAL LOADING

2013 Recommendation

A Clinicians should advise patients with an acute LAS to use external supports (taping and bracing) and to progressively bear weight on the affected limb. The type of external support and gait assistive device recommended should be based on the severity of the injury, phase of tissue healing, level of protection indicated, extent of pain, and patient preference. In more severe injuries, immobilization, ranging from semi-rigid bracing to below-knee casting, may be indicated.

Evidence Update

I Petersen and colleagues[348] performed a systematic review and meta-analysis of treatment of acute ankle ligament injuries. The authors included a review by Kerkhoffs and colleagues,[214] who compared studies (21 trials, n = 2184 participants) regarding functional treatment and immobilization. Functional treatment promoted significant improvements in return-to-sports rate, time to return to sports, return-to-work rate, time to return to work, swelling, and satisfaction with treatment compared to immobilization. Vuurberg and colleagues[451] also found that a functional approach involving early weight bearing with the ankle braced or taped and inclusion of neuromuscular and proprioceptive exercises led to the fastest resumption of work and ADL compared to immobilization.

I In the review conducted by Vuurberg and colleagues,[451] the authors concluded, based on 3 RCTs (n = 694), that a short period of immobilization of 10 days or less with a plaster cast or rigid support can be of added value in the treatment of grade III sprains, resulting in decreased pain and edema and improved functional outcomes.

I A period of 4 weeks in a lower-leg cast following an acute LAS results in a longer time required, and a lower proportion of patients able, to return to work and sport 4 to 6 weeks after injury compared to individuals treated with functional support and exercise strategies (22 RCTs, n = 2304).[214]

Evidence Synthesis and Rationale

Based on strong evidence, optimized loading should begin in the acute phase and continue into the postacute phase following a LAS. The duration and extent of loading should be dictated by the physical examination and should consider comorbidities, clinician experience, and patient preference when planning care. Treatment with early neuromuscular and proprioceptive exercises in the postacute period appears to be superior to immobilization in optimizing functional outcomes. A period of immobilization may be considered for severe sprains. If immobilization is employed post injury, a period of no more than 10 days is suggested.

2021 Recommendations

A Clinicians should advise patients with an acute LAS to use external supports, such as braces or taping, and to progressively bear weight on the affected limb. The type of external support and gait assistive device recommended should be based on the severity of the injury, phase of tissue healing, level of protection indicated, extent of pain, and patient preference.

A In more severe injuries, immobilization, ranging from semi-rigid bracing to below-knee casting, may be indicated for up to 10 days post injury.

THERAPEUTIC EXERCISE

Therapeutic exercise as described in the literature generally consists of a structured program, with varying components that can include protected active ROM, stretching exercises, neuromuscular training, postural re-education, and balance training.

2013 Recommendation

A Clinicians should implement rehabilitation programs that include therapeutic exercises for patients with severe LAS.

Evidence Update

I In a systematic review and meta-analysis, Vuurberg and colleagues[451] found that exercise therapy programs, initiated early following an acute LAS injury, promoted faster time to recovery with improved objective instability (relative risk = 0.68; 95% CI: 0.49, 0.95) and subjective instability (relative risk = 0.80; 95% CI: 0.64, 1.00). Exercise programs generally consisted of balance retraining, postural re-education, and neuromuscular training, with varying and diverse modes and volumes of exercises.

I Feger and colleagues[133] included 4 trials in a systematic review and meta-analysis. Compared to independent exercise, supervised exercise was associated with less pain and subjective instability at intermediate follow-up (8 weeks after injury), but there were no differences in self-reported outcomes at longer follow-up periods (3 and 12 months after injury); with greater gains in ankle strength and joint position sense but worse postural control at 4-month follow-up; and there were inconclusive results regarding prevention of recurrent ankle sprains at 12 months after injury. The authors concluded that supervised exercise may promote additional clinical benefit in patients with severe LAS compared to mild LAS and to a home exercise program.

I There is conflicting evidence for improved balance responses after virtual reality training in individuals with LAS. Gumaa and Rehan Youssef[165] identified 4 trials through a systematic review that assessed the clinical effectiveness of virtual reality for individuals with LAS (n = 273), which involved a variety of different virtual environments and video games. In 2 of the included RCTs, significant improvements were noted in measures of dynamic balance and postural sway, and no significant differences were noted in the other 2 trials.

Evidence Synthesis and Rationale

Therapeutic exercise consisting of neuromuscular training, postural re-education, and balance training appears to improve subjective and objective talocrural stability, as well as reduce time to return to preinjury activity. Compositions of exercise programs in the literature are diverse, so specific recommendations regarding mode and volume are unfeasible. Clinicians should customize exercise programs to findings from the physical examination and analysis of the task to which the individual will return. There appears to be clinical benefit for exercise to be supervised in individuals with more severe LAS compared to mild LAS. Virtual environments and computerized game applications have mixed effects on measurements of body structures and functions in people with LAS, but may be useful in an adjunctive role for skilled exercise prescription.

2021 Recommendations

A Clinicians should implement rehabilitation programs with a structured therapeutic exercise program, which can include protected active ROM, stretching exercises, neuromuscular training, postural re-education, and balance training, both in clinic and at home, as determined by injury severity, identified impairments, preferences, learning needs, and social barriers in those with a LAS.

D There is conflicting evidence as to the best way to augment the unsupervised components of a home program in those with a LAS: by written instructions, exercise-based video games, or app-based instruction. Therefore, augmentation can be determined by the individual's specific learning needs and access to relevant technology.

OCCUPATIONAL AND SPORT-RELATED ACTIVITY TRAINING

2013 Recommendation

C Clinicians may implement balance and sport-related activity training to reduce the risk of recurrent LAS in athletes.

Evidence Update

I In the systematic review and evidence-based multidisciplinary guidelines developed by Vuurberg and colleagues,[451] the authors recommended that return to sedentary work should occur 2 to 6 weeks following injury, and at 6 to 8 weeks for more physical occupations and sports activities, as outlined in **FIGURE 2**. These specific guidelines should be considered with the contextual factors of in-

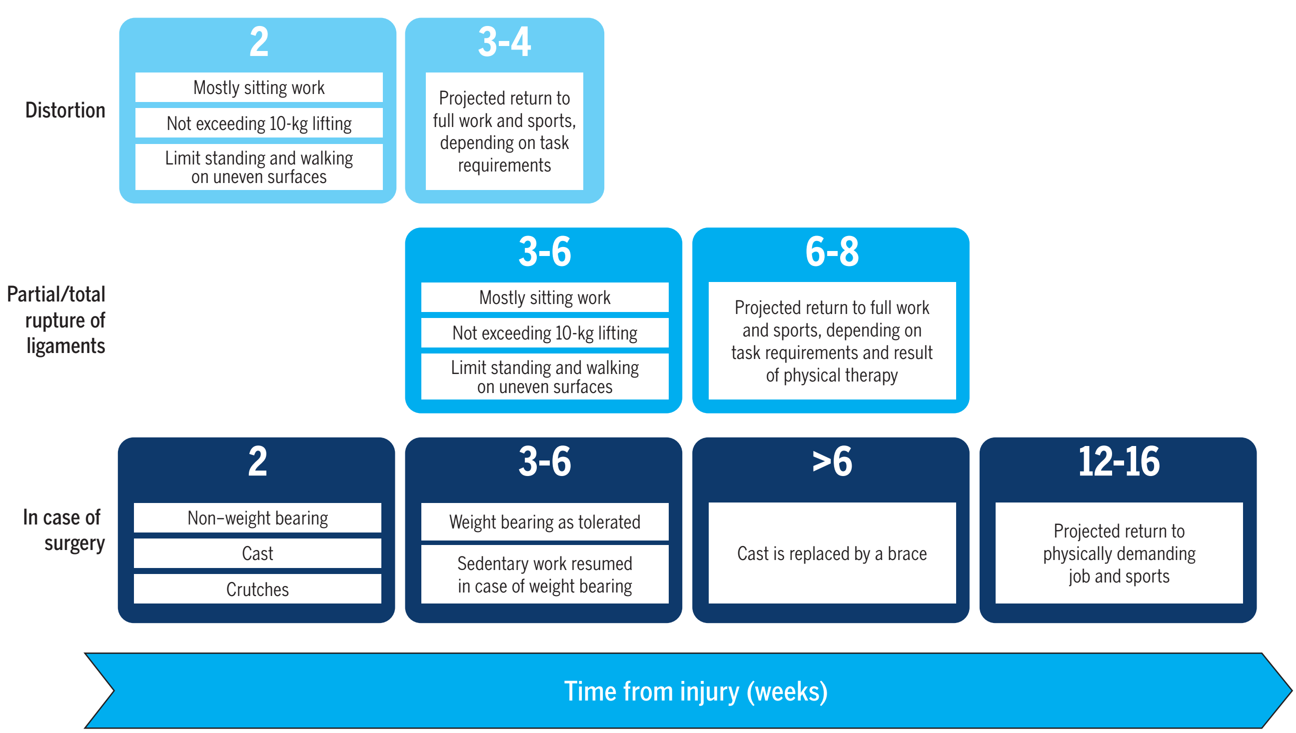


FIGURE 2. Evidence-based guidelines for return to physical occupations and sports activities as outlined by Vuurberg et al.[451]

jury severity, access and response to rehabilitation care, and task requirements.

Evidence Synthesis and Rationale

While the previous literature focused on primary injury prevention, the bulk of the current literature focuses on prevention of recurrent injuries. While further research is needed for specific occupations and sports, return to work and sports can be facilitated with functional treatment earlier in the rehabilitation course, use of a brace, and by employing a return-to-work/sports schedule.

2021 Recommendation

B Clinicians should implement a return-to-work schedule and use a brace early in the rehabilitation, occupational or sport-related training, and/or work-hardening program to mitigate activity limitation and participation restriction following LAS.

MANUAL THERAPY

2013 Recommendation

B Clinicians should use manual therapy procedures, such as lymphatic drainage, active and passive soft tissue and joint mobilization, and anterior-to-posterior talar mobilization procedures, within pain-free movement to reduce swelling, improve pain-free ankle and foot mobility, and normalize gait parameters in individuals with an acute LAS.

Evidence Update

I Vuurberg and colleagues[451] concluded that manual joint mobilization can provide a short-term increase in ankle joint dorsiflexion ROM following acute LAS, based on data from 12 trials (n = 427). Ankle joint mobilization has been reported to decrease pain,[290] and when combined with exercise has resulted in better outcomes compared to exercise therapy alone in 1 well-designed RCT.[67]

I Clar and colleagues[66] reviewed 1 high-, 10 moderate-, and 2 low-quality trials concerning manual therapy after LAS. The authors concluded that there was moderate evidence in favor of manual therapy (mobilization/manipulation) of the knee and/or full kinetic chain and of the ankle and/or foot, combined with multimodal or exercise therapy, for LAS. Data from 12 trials (n = 687) in the review by Doherty and colleagues[102] indicated that manual therapy resulted in equivocal outcomes for self-reported function and injury recurrence.

Evidence Synthesis and Rationale

Additional evidence in favor of manual therapy has emerged that highlights the importance of hands-on treatments to reduce pain and increase short-term ankle dorsiflexion ROM in those with a LAS. Manual therapy combined with exercise appears to stimulate optimal effects on short-term treatment outcomes. Although the effects of manual therapy after LAS are most prominent in the short term, use of manual therapy appears to add value for pain control and movement in the acute period compared to exercise alone or no treatment. Selection of manual therapy techniques should be based on the clinical examination and analysis of the movement requirements of the function to which the individual will return. The clinician should favor slow-velocity techniques that do not provoke symptoms in the acute phase.

2021 Recommendation

A Clinicians should use manual therapy procedures, such as lymphatic drainage, active and passive soft tissue and joint mobilization, and anterior-to-posterior talar mobilization procedures within pain-free movement, alongside therapeutic exercise to reduce swelling, improve pain-free ankle and foot mobility, and normalize gait parameters in individuals with a LAS.

ACUPUNCTURE

2013 Recommendation

None.

Evidence Update

I Doherty and colleagues[102] evaluated 3 systematic reviews involving acupuncture for the treatment of acute LAS. Two of the reviews reported insufficient data to determine the relative effectiveness of complementary medicine in the treatment of acute LAS for self-reported function or injury recurrence. The third review concluded that acupuncture was likely to have a therapeutic effect on improving acute symptoms, yet it acknowledged that the magnitude of the effect was likely to be overestimated due to the low quality of the included studies. Included in the review by Doherty and colleagues,[102] a systematic review and meta-analysis by Park and colleagues[341] included 17 trials (n = 1820). Trial quality was generally poor, with high heterogeneity and risk of bias. Three trials reported adequate methods of randomization and only 1 reported a method of allocation concealment. The benefit of acupuncture remained significant when the analysis was limited to studies with the lowest risk of bias. Specifically, acupuncture was more effective than conventional treatment in relieving pain, facilitating return to normal activity, and promoting quality of life.

Evidence Synthesis and Rationale

There is a paucity of high-quality studies that report complete data on the clinical application of acupuncture in individuals with acute LAS. On this basis, the evidence for the efficacy of acupuncture in the treatment of acute LAS for the primary outcomes of injury recurrence/self-reported function is inconclusive. Observations of clinical benefit were based on only a small number of well-designed studies and require additional replication before a recommendation can be made for this intervention.

2021 Recommendation

D There is conflicting evidence regarding the use of acupuncture to reduce symptoms associated with acute LAS.

PHYSICAL AGENTS: CRYOTHERAPY

2013 Recommendation

A Clinicians should use repeated intermittent applications of ice to reduce pain, decrease the need for pain medication, and improve weight bearing following an acute ankle sprain.

Evidence Update

I Doherty and colleagues[102] concluded that ice, compression, and elevation alone are not effective for improving the primary outcomes of self-reported function or recurrence following acute ankle sprain compared with no treatment. Three systematic reviews included by Doherty and colleagues[102] concluded that treatment success was achieved with exercise therapy combined with rest, ice, compression, and elevation.

I Vuurberg and colleagues[451] reviewed 27 trials (n = 1670) and concluded that there was no evidence to support the isolated use of ice to increase function and decrease swelling and pain at rest in individuals with LAS. The combination of ice and exercise results in significant improvements in ankle function in the short term, allowing patients to increase loading during weight bearing compared with standard functional treatment (1 RCT, n = 101). In combination with exercise therapy, ice has a greater effect on reducing swelling compared with heat application in individuals with LAS (1 trial, n = 30).

Evidence Synthesis and Rationale

Since the initial CPG, strong evidence has emerged that rest, ice, compression, and elevation are insufficient to improve self-reported function and injury recurrence in people with an acute LAS. Use of ice in a combined approach to intervention that involves exercise may improve load tolerance during weight bearing, which can improve the ability of individuals to bear weight on the affected limb. Clinicians should consider individual effects of ice on weight bearing and patient preference to decide whether the application of ice may be warranted.

2021 Recommendation

C Clinicians may use repeated intermittent applications of ice in association with a therapeutic exercise program to address symptoms and functioning following an acute LAS.

PHYSICAL AGENTS: DIATHERMY

2013 Recommendation

C Clinicians can utilize pulsating shortwave diathermy for reducing edema and gait deviations associated with acute ankle sprains.

Evidence Update

None.

2021 Recommendation

No change.

PHYSICAL AGENTS: ELECTROTHERAPY

2013 Recommendation

D There is moderate evidence both for and against the use of electrotherapy for the management of acute ankle sprains.

Evidence Update

None.

2021 Recommendation

No change.

PHYSICAL AGENTS: LOW-LEVEL LASER THERAPY

2013 Recommendation

D There is moderate evidence both for and against the use of low-level laser therapy for the management of acute ankle sprains.

Evidence Update

I In an RCT (n = 40), de Moraes Prianti and colleagues[91] observed significant reductions in pain and swelling in the first 6 days following acute LAS in response to treatment with light-emitting diodes ($\lambda 627 \pm 10$ nm) with an energy density of 10 J/cm^2 combined with a standardized cryotherapy protocol.

III In another RCT (n = 19), Calin and colleagues[46] measured significant improvements in ankle pain and function at 10 days following the initiation of a fractionated irradiation photobiomodulation therapy protocol (635 nm, 15 mW), consisting of 2 sessions (4.5 and 9 J/cm²) separated by a 30-minute time interval. No significant differences in ankle pain and function were observed at 6-week follow-up.

Evidence Synthesis and Rationale

There remains a paucity of high-quality trials to support the use of low-level laser therapy, including the range of intervention parameters available.

2021 Recommendation

C Clinicians may use low-level laser therapy to reduce pain in the initial phase of an acute LAS.

PHYSICAL AGENTS: ULTRASOUND

2013 Recommendation

A Clinicians should not use ultrasound for the management of acute ankle sprains.

Evidence Update

I Doherty and colleagues[102] concluded from their systematic review and meta-analysis that none of the included studies demonstrated any beneficial effect of ultrasound therapy in the treatment of acute LAS.

Evidence Synthesis and Rationale

There are very few trials evaluating the effectiveness of ultrasound therapy for acute LAS, and even fewer have considered the range of parameters available.

2021 Recommendation

A Clinicians should not use ultrasound for the management of acute ankle sprains.

NONSTEROIDAL ANTI-INFLAMMATORY MEDICATION

2013 Recommendation

None.

Evidence Update

I Vuurberg and colleagues[451] concluded that the use of oral or topical nonsteroidal anti-inflammatory drugs (NSAIDs) results in less pain fewer than 14 days after LAS, without significantly increasing the risk of adverse events, compared with placebo (26 trials, n = 4225). Doherty and colleagues[102] established an equivocal effect of pharmacological agents, typically NSAIDs, on function and recurrent injury in individuals with LAS, based on data from 13 trials (n = 2423).

I Selective NSAIDs (celecoxib 200 mg, 2 times daily) are noninferior to nonselective NSAIDs (eg, ibuprofen, naproxen, or diclofenac) to reduce pain after an acute LAS (4 trials, n = 1490).[451] Diclofenac showed superior results at days 1 and 2 compared with piroxicam (2 trials, n = 201) and ibuprofen (1 trial, n = 60) for reducing pain during motion in patients with mild to severe acute ankle sprains and demonstrated equal adverse event rates.[451] Despite dose differences, the clinical benefit of acetaminophen (paracetamol) is equivalent to NSAIDs for pain, swelling, and ROM after LAS.[451]

Evidence Synthesis and Rationale

Based on available evidence, NSAIDs may be expected to reduce pain in individuals with acute LAS, but are not expected to improve ankle ROM and reduce the likelihood of recurrent injury. Nonsteroidal anti-inflammatory medications may confer benefit over risk within the first 14 days following injury. The observed short-term pain reduction may be important for early weight bearing. Selective NSAIDs, nonselective NSAIDs, and acetaminophen/paracetamol may be considered based on individual needs, given their similar clinical effects.

2021 Recommendation

C Clinicians may prescribe NSAIDs (as physical therapy practice acts allow) to reduce pain and swelling in those with an acute LAS.

INTERVENTIONS FOR CHRONIC ANKLE INSTABILITY EXTERNAL SUPPORT

2013 Recommendation

None.

Evidence

I In a systematic review and network meta-analysis (21 trials, n = 469), Tsikopoulos and colleagues[437] identified moderate evidence that external support of any type, including insoles plus bracing, bracing, insoles, and taping, was no more effective than controls in providing clinical benefit for postural stability and balance performance.

Evidence Synthesis and Rationale

While external supports are recommended for prevention of reinjury, the use of external support as a sole treatment intervention is insufficient to promote sustained improvements in balance and postural stability in people with CAI. The clinician may consider whether the use of external supports, such as taping and bracing, would assist the individual with CAI to achieve short-term goals of rehabilitation through the improved ability to engage in interventions that can promote long-term clinical benefit.

2021 Recommendation

B Clinicians should not use external support, including braces or taping, as a stand-alone intervention to improve balance and postural stability in individuals with CAI.

THERAPEUTIC EXERCISE AND ACTIVITIES

2013 Recommendation

C Clinicians may include therapeutic exercises and activities, such as weight-bearing functional exercises and single-limb balance activities using unstable surfaces, to improve mobility, strength, coordination, and postural control in the postacute period of rehabilitation for ankle sprains.

Evidence Update

I Doherty and colleagues[102] assessed 22 systematic reviews that evaluated exercise therapy for treatment of CAI or recurrent ankle sprain. Therapeutic exercises that have been studied include balance retraining, postural re-education, neuromuscular training, and strengthening of ankle and lower-quarter kinetic-chain muscles using isolated exercises and movement patterns. The authors concluded that exercise therapy is generally considered effective in the treatment of CAI for the outcomes of self-reported function and reinjury incidence.[102]

I In the meta-analysis of 8 RCTs conducted by Powden and colleagues,[356] rehabilitation protocols that focused on balance training effectively improved health-related quality of life, as measured by patient-oriented outcomes, in individuals with CAI.

Evidence Synthesis and Rationale

There is consensus across the literature that therapeutic exercises demonstrate a strong positive clinical benefit in those with CAI. Exercise protocols across studies are substantially heterogeneous and comparisons across studies are infeasible, so specific recommendations currently are not possible for the best mode and volume of exercise to promote clinical benefit.

2021 Recommendation

A Clinicians should prescribe proprioceptive and neuromuscular therapeutic exercise to improve dynamic postural stability and patient-perceived stability during function in individuals with CAI.

MANUAL THERAPY

2013 Recommendation

A Clinicians should include manual therapy procedures, such as graded joint mobilizations, manipulations, and non–weight-bearing and weight-bearing mobilization with movement, to improve ankle dorsiflexion, proprioception, and weight-bearing tolerance in patients recovering from chronic LAS symptoms.

Evidence Update

I In the systematic review and multidisciplinary guideline conducted by Vuurberg and colleagues,[451] a combination of manual therapy interventions with other treatment modalities, such as exercise therapy, enhanced the effectiveness of manual joint mobilization and was recommended in the treatment of CAI.

I Five systematic reviews that investigated manual therapy for the treatment of CAI were included in the study conducted by Doherty and colleagues.[102] Each of these reviews identified that manual mobilization likely has a short-term positive effect on ankle dorsiflexion ROM.

I In the meta-analysis of studies that encompassed manual therapy–focused treatment programs, Powden and colleagues[356] found that interventions such as anterior-to-posterior Maitland grade III joint mobilizations, Mulligan talocrural mobilizations with movement, tibiofibular manipulations, and plantar massage had large, significant pre-to-post treatment effects in improving patient-oriented outcomes in individuals with CAI.

I In the systematic review and meta-analysis conducted by Weerasekara and colleagues,[463] joint mobilization demonstrated clinical benefit in individuals with CAI through immediate improvements in dynamic balance and weight-bearing dorsiflexion ROM in the short term. Joint mobilization did not have an immediate effect on static balance or pain intensity, nor did it affect weight-bearing ankle dorsiflexion ROM in the long term.

I Based on a systematic review and meta-analysis including 4 trials of people with CAI (n = 208), Shi and colleagues[390] found that 6 sessions of manual therapy promoted significant improvements in ankle strength, balance, and functional tests, while a single session of manual therapy did not promote significant improvements in these measurements.

I Stathopoulos and colleagues[412] identified 2 trials (n = 93) involving individuals with CAI who received Mulligan-based mobilization with movement. The trials were characterized by high statistical heterogeneity, and meta-analysis was not undertaken. Qualitative synthesis suggested significant improvement of ankle dorsiflexion ROM after intervention in the included trials. Weerasekara and colleagues[462] identified evidence from 4 trials (n = 201) suggesting significant improvement of weight-bearing ankle dorsiflexion ROM after mobilization with movement compared to sham and no intervention in people with CAI. However, there was insufficient evidence to draw conclusions about long-term effects (6 months or greater) and other outcome measures.

Evidence Synthesis and Rationale

Manual therapy procedures appear effective in improving outcomes in people with CAI, including increased short-term ankle dorsiflexion ROM, ankle strength, balance, and functional test performance. Although these effects are not observed in the long term, short-term effects of intervention may be important to help people with CAI to meet short-term activity participation and rehabilitation goals.

2021 Recommendation

A Clinicians should use manual therapy procedures, such as graded joint mobilizations, manipulations, and non–weight-bearing and weight-bearing mobilization with movement, to improve weight-bearing ankle dorsiflexion and dynamic balance in the short term for individuals with CAI.

DRY NEEDLING

2013 Recommendation

None.

Evidence Update

I The results of a single-blinded RCT (n = 20) assessing trigger point dry needling of the fibularis muscles in individuals with a history of ankle sprain suggest that the intervention may provide some short-term improvements in strength and unilateral balance.[378]

II In an RCT assessing the inclusion of fibularis muscle trigger point dry needling as part of a proprioceptive and strengthening exercise program for individuals with CAI, the treatment group demonstrated better outcomes in pain and function at 1 month following treatment.[382]

III Data from a small cohort study by Rossi and colleagues (n = 20),[378] included in the systematic review and meta-analysis by Mansfield et al,[295] indicated that the addition of lumbar multifidus dry needling in individuals with CAI resulted in no significant differences in ankle plantar flexor-evertor strength, balance, and hop test performance compared to people with CAI who received fibularis muscle trigger point dry needling alone.

Evidence Synthesis and Rationale

Few studies currently exist to support the use of dry needling in people with CAI. Results reported by the included small RCTs and cohort studies were generally favorable for pain, function, strength, and balance.

2021 Recommendation

C Clinicians may use dry needling of the fibularis muscle group in conjunction with a proprioceptive training program to reduce pain and improve function in individuals with CAI.

COMBINED TREATMENTS

Combined treatments include intervention plans that use at least 2 or more types of interventions.

2013 Recommendation

None.

Evidence Update

I In the systematic review and meta-analysis conducted by Powden and colleagues,[356] which synthesized 7 RCTs that employed 2 or more targeted interventions, including stretching, strength training, balance training, vestibular-ocular reflex training, soft tissue mobilization, dry needling, and strain/counterstrain techniques, it was found that combined treatment led to large, statistically significant improvements in patient-reported function in individuals with CAI (summary effect size, 1.14). Combined intervention resulted in slightly improved functional outcomes that were not statistically significant when compared to balance training alone.

I A systematic review and network meta-analysis by Tsikopoulos and colleagues[436] identified that a 4-week supervised rehabilitation program consisting of balance training, strengthening, functional tasks, and ROM exercises resulted in statistically and clinically significant benefit compared to control interventions in people with CAI.

Evidence Synthesis and Rationale

Research evidence supports the clinical benefit of interventions that combine 2 or more treatments, selected based on patient-centered factors, to supplement a balance training program. While these approaches appear to only slightly improve functional outcomes when compared to balance training alone, the adverse events associated with combined approaches were infrequent, transient, and mild. This literature may indicate the potential presence of treatment interactions and caution against one-size-fits-all approaches to clinical management.

2021 Recommendation

B Clinicians may use multiple interventions to supplement balance training over an episode of care for individuals with CAI, to include a combination of exercise and manual therapy procedures as guided by the patient's values and goals, the clinician's judgment, and evidence-based clinical recommendations.

INTERVENTIONS TO ADDRESS PSYCHOLOGICAL FACTORS DURING THE COURSE OF REHABILITATION

2013 Recommendation

None.

Evidence Update

I

In the systematic review of studies assessing the effects of the therapeutic alliance on pain conducted by Taccolini Manzoni and colleagues,[418] a lack of evidence pertaining to the therapeutic alliance in rehabilitation of musculoskeletal conditions was found. The authors of this review, which encompassed studies of mixed methodology, concluded that there is a lack of evidence to support the effect of the therapeutic alliance on pain relief.

I

In a systematic review studying the effects of the therapeutic alliance in the treatment of patients with persistent pain syndromes, 3 studies suggested that a strong therapeutic alliance between the patient and treating physical therapist may improve outcomes in individuals with chronic musculoskeletal conditions.[137,229] To facilitate a strong therapeutic alliance, physical therapists must understand factors that positively and negatively influence the relationship.[137,229] These may include trust, communication, shared goal setting, identification and mitigation of barriers to care seeking and compliance, individualized and flexible care, respect of persons, and other factors that influence the patient's knowledge, skills, beliefs, and attitudes toward treatment.[137,229]

II

In a retrospective case-control study, athletes with a history of recurrent ankle sprains were found to have the highest levels of fear avoidance compared to patients with a first-time ankle sprain or healthy controls.[195] To improve the quality of patient care, Houston and colleagues[195] recommended that clinicians use global, regional, and psychological measures to better evaluate patient status and treatment response, while considering functional deficits and psychological barriers during the rehabilitation course.

III

McCann and Gribble[303] detailed how self-efficacy and resiliency can influence outcomes in CAI and proposed a theoretical model of how both intrinsic and extrinsic psychological factors can influence functional outcomes following LAS. In the conceptual model, perceptions of LAS as a benign injury may limit care seeking and negatively influence outcomes.[303] A consequence of nonresolving impairment and activity limitation following injury may contribute to lower self-efficacy and resiliency, further contributing to functional decline.[303] The authors advocate that patients struggling to adhere to rehabilitation may benefit from a repeated evaluation of self-efficacy, or an assessment of other personal and environmental factors.[303]

III

Patients who go on to develop chronic ankle-foot disability have been found to have higher levels of neuroticism,[391] anxiety,[391] depression,[391] and kinesiophobia.[267] Fraser and Hertel[137] outlined the importance for physical therapists to evaluate and employ mitigating strategies to address negative psychoemotional factors during rehabilitation of individuals with LAS and CAI.

Evidence Synthesis and Rationale

Clinicians may take purposeful steps to build an effective therapeutic relationship with patients and use psychologically informed elements in the plan of care. These include mutual trust, communication, shared goal setting, identification and mitigation of barriers to care seeking and compliance, individualized and flexible care, respect of persons, and other factors that influence the patient's knowledge, skills, beliefs, and attitudes toward treatment. Global, regional, and psychological measures are recommended to comprehensively evaluate the patient status and treatment response. Targeted interventions, such as education, encouragement, goal setting, and fear mitigation, may help to improve these intrinsic factors and facilitate return to function in this patient population.

2021 Recommendation

E

Clinicians may use psychologically informed techniques, such as motivational interviewing, to maximize patients' self-efficacy and address uncomplicated psychological correlates and mediators of injury adjustment and recovery, to maximize the effects of treatment in a positive manner for individuals with LAS and CAI.

Component 1: Medical Screening

↓

Component 2: Classify Condition

Patient examination: acute lateral ankle sprain (LAS)
- Sudden onset with an ankle inversion–related injury
- Negative Ottawa ankle rules
- Positive reverse anterolateral drawer ligamentous test
- Positive anterolateral talar palpation test
- Positive anterior drawer test

Patient examination: chronic ankle instability (CAI)
- History of at least 1 significant ankle sprain
- Reports of "giving way"
- Episode of a subsequent sprain and/or perceptions of ankle instability
- Decreased performance on functional performance tests
- Discriminative instrument scores: Identification of Functional Ankle Instability (IdFAI) score of 11 or greater; Cumberland Ankle Instability Tool (CAIT) score of 25 or less; 4 or more answers of "yes" on the Ankle Instability Instrument (AII)

↓

Component 3: Irritability

↓

Acute LAS: identify level of tissue irritability

↓

Component 4: Outcome Measures

↓

LAS and CAI
- Patient-Reported Outcomes Measurement Information System (PROMIS) physical function computer adaptive test (CAT), Foot and Ankle Ability Measure (FAAM), and/or Lower Extremity Functional Scale (LEFS) as a measure of self-reported activity limitation and participation restriction (A)
- 11-item Tampa Scale of Kinesiophobia (TSK-11) and Fear-Avoidance Beliefs Questionnaire (FABQ) as measures of fear of movement and reinjury and fear-avoidance beliefs (C)
- Pain visual analog scale (VAS) (F)
- Dorsiflexion range of motion (ROM) with the weight-bearing lunge test (A)
- Total ankle ROM (A)
- Talar translation (A)
- Static balance with the single-leg balance test on a firm surface with eyes closed (A)
- Dynamic balance with the Star Excursion Balance Test (SEBT) anterior, anteromedial, posteromedial, and posterolateral reach directions (A)
- Clinical performance assessment with measures of single-limb hopping under timed conditions (A)

Acute LAS
- Ankle swelling (A)

CAI
- Hip strength (C)

↓

Figure continues on page CPG38.

FIGURE 3. Decision tree. Letters in parentheses reflect the grade of evidence on which the recommendation for each item is based: (A) strong evidence, (B) moderate evidence, (C) weak evidence, (D) conflicting evidence, (E) theoretical/foundational evidence, and (F) expert opinion.

Component 5: Intervention Strategies

LAS
- Progressively bear weight with bracing external supports (A)
- Structured rehabilitation programs that include therapeutic exercises, both in clinic and at home, to include protected active ROM, stretching exercises, and neuromuscular training (A)
- Manual therapy procedures, such as lymphatic drainage, active and passive soft tissue and joint mobilization, and anterior-to-posterior talar mobilization procedures, within pain-free movement to reduce swelling, improve pain-free ankle and foot mobility, and normalize gait (A)
- Occupational and sport-related training and work hardening to mitigate activity limitation and participation restriction (B)
- Low-level laser therapy to reduce pain in those with acute symptoms (C)
- Pulsating shortwave diathermy for reducing edema and gait deviations (C)
- Nonsteroidal anti-inflammatory medications to reduce pain and swelling in those with acute symptoms (C)
- Psychologically informed techniques, such as motivational interviewing, to maximize patients' self-efficacy, address uncomplicated psychological correlates, and identify mediators of injury adjustment (E)

CAI
- Proprioceptive and neuromuscular therapeutic exercise to improve dynamic postural stability and patient-perceived stability (A)
- Manual therapy procedures, such as graded joint mobilizations, manipulations, and non–weight-bearing and weight-bearing mobilization with movement, to improve ankle dorsiflexion, proprioception, and weight-bearing tolerance (A)
- Trigger point dry needling of the fibularis (peroneal) muscle group in conjunction with a proprioceptive training program to reduce pain and improve function (C)
- Psychologically informed techniques, such as motivational interviewing, to maximize patients' self-efficacy, address uncomplicated psychological correlates, and identiy mediators of injury adjustment (E)

FIGURE 3 (continued). Decision tree. Letters in parentheses reflect the grade of evidence on which the recommendation for each item is based: (A) strong evidence, (B) moderate evidence, (C) weak evidence, (D) conflicting evidence, (E) theoretical/foundational evidence, and (F) expert opinion.

AFFILIATIONS AND CONTACTS

AUTHORS

RobRoy L. Martin, PT, PhD
Professor
Department of Physical Therapy
Duquesne University
Pittsburgh, PA
and
Staff Physical Therapist
Center for Sports Medicine
University of Pittsburgh Medical Center
Pittsburgh, PA
martinr280@duq.edu

Todd E. Davenport, DPT
Professor and Vice Chair
Department of Physical Therapy
University of the Pacific
Stockton, CA
tdavenport@pacific.edu

John J. Fraser, DPT, PhD
Deputy Director for Operational Readiness & Health
Warfighter Performance Department Head
Naval Health Research Center
San Diego, CA
John.j.fraser8.mil@mail.mil

Jenna Sawdon-Bea, PT, PhD
Chair/Associate Professor
Department of Physical Therapy
California State University, Fresno
Fresno, CA
jsbea@csufresno.edu

Christopher R. Carcia, PT, PhD
Physical Therapy Program Director and Associate Professor
Department of Kinesiology
Colorado Mesa University
Grand Junction, CO
ccarcia@coloaradomesa.edu

Lindsay A. Carroll, DPT
Department of Rehabilitation Science
Duquesne University
Pittsburgh, PA
carrolll1@duq.edu

Benjamin R. Kivlan, PT, PhD
Associate Professor and Chair
Department of Physical Therapy
Duquesne University
Pittsburgh, PA
kivlanb@duq.edu

Dominic Carreira, MD
Orthopaedic Surgeon
Peachtree Orthopedics
Atlanta, GA
and
Clinical Instructor
Department of Orthopedics
Atlanta Medical Center
Atlanta, GA
dcarreira@gmail.com

REVIEWERS

Paul Beattie, PT, PhD
Distinguished Clinical Professor Emeritus
Department of Exercise Science
Arnold School of Public Health
University of South Carolina
Columbia, SC
pbeattie@mailbox.sc.edu

Jay Hertel, PhD, ATC
Joe H. Gieck Professor of Sports Medicine
Departments of Kinesiology and Orthopaedic Surgery
University of Virginia
Charlottesville, VA
Jhertel@virginia.edu

Jeff Houck, PT, PhD
Director of Research and Professor
School of Physical Therapy
George Fox University
Newberg, OR
jhouck@georgefox.edu

Christopher Neville, PT, PhD
Professor
Department of Physical Therapy Education
Upstate Medical University
Syracuse, NY
nevillec@upstate.edu

Stephen Paulseth, DPT, ATC
Clinical Specialist
Paulseth & Associates Physical Therapy, Inc
Los Angeles, CA
paulsethpt@yahoo.com

Karin Grävare Silbernagel, PT, PhD, ATC
Associate Professor and Associate Chair
Department of Physical Therapy
University of Delaware
Newark, DE
kgs@udel.edu

REFERENCES

1. Abassi M, Bleakley C, Whiteley R. Athletes at late stage rehabilitation have persisting deficits in plantar- and dorsiflexion, and inversion (but not eversion) after ankle sprain. *Phys Ther Sport*. 2019;38:30-35. https://doi.org/10.1016/j.ptsp.2019.04.015
2. Abdeen R, Comfort P, Starbuck C, Nester C. Ultrasound characteristics of foot and ankle structures in healthy, coper, and chronically unstable ankles. *J Ultrasound Med*. 2019;38:917-926. https://doi.org/10.1002/jum.14770
3. Abdel-aziem AA, Draz AH. Chronic ankle instability alters eccentric eversion/inversion and dorsiflexion/plantarflexion ratio. *J Back Musculoskelet Rehabil*. 2014;27:47-53. https://doi.org/10.3233/BMR-130418
4. Achenbach L, Loose O, Laver L, et al. Beach handball is safer than indoor team handball: injury rates during the 2017 European Beach Handball Championships. *Knee Surg Sports Traumatol Arthrosc*. 2018;26:1909-1915. https://doi.org/10.1007/s00167-018-4907-5
5. Ahn SH, Hwang UJ, Gwak GT, Yoo HI, Kwon OY. Comparison of the strength and electromyography of the evertor muscles with and without toe flexion in patients with chronic ankle instability. *Foot Ankle Int*. 2020;41:479-485. https://doi.org/10.1177/1071100719898464
6. Al Adal S, Mackey M, Pourkazemi F, Hiller CE. The relationship between pain and associated characteristics of chronic ankle instability: a retrospective study. *J Sport Health Sci*. 2020;9:96-101. https://doi.org/10.1016/j.jshs.2019.07.009
7. Al Adal S, Pourkazemi F, Mackey M, Hiller CE. The prevalence of pain in people with chronic ankle instability: a systematic review. *J Athl Train*. 2019;54:662-670. https://doi.org/10.4085/1062-6050-531-17
8. Al Bimani SA, Gates LS, Warner M, Bowen C. Factors influencing return to play following conservatively treated ankle sprain: a systematic review. *Phys Sportsmed*. 2019;47:31-46. https://doi.org/10.1080/00913847.2018.1533392
9. Al Bimani SA, Gates LS, Warner M, Ewings S, Crouch R, Bowen C. Characteristics of patients with ankle sprain presenting to an emergency department in the south of England (UK): a seven-month review. *Int Emerg Nurs*. 2018;41:38-44. https://doi.org/10.1016/j.ienj.2018.05.008
10. Allen GM, Wilson DJ, Bullock SA, Watson M. Extremity CT and ultrasound in the assessment of ankle injuries: occult fractures and ligament injuries. *Br J Radiol*. 2020;93:20180989. https://doi.org/10.1259/bjr.20180989
11. Allet L, Zumstein F, Eichelberger P, Armand S, Punt IM. Neuromuscular control mechanisms during single-leg jump landing in subacute ankle sprain patients: a case control study. *PM R*. 2017;9:241-250. https://doi.org/10.1016/j.pmrj.2016.07.006
12. Amiri H, Vahdati SS, Gharehkhani M, Maheronnaghsh R, Shokoohi H, Rahimi-Movaghar V. Does the normal four steps weight-bearing rule predict the need for radiography in cases of blunt ankle trauma? *Med J Islam Repub Iran*. 2017;31:32. https://doi.org/10.14196/mjiri.31.32
13. Araoye I, Pinter Z, Lee S, Netto CC, Hudson P, Shah A. Revisiting the prevalence of associated copathologies in chronic lateral ankle instability: are there any predictors of outcome? *Foot Ankle Spec*. 2019;12:311-315. https://doi.org/10.1177/1938640018793513
14. Ardakani MK, Wikstrom EA, Minoonejad H, Rajabi R, Sharifnezhad A. Hop-stabilization training and landing biomechanics in athletes with chronic ankle instability: a randomized controlled trial. *J Athl Train*. 2019;54:1296-1303. https://doi.org/10.4085/1062-6050-550-17
15. Asai K, Nakase J, Shimozaki K, Toyooka K, Kitaoka K, Tsuchiya H. Incidence of injury in young handball players during national competition: a 6-year survey. *J Orthop Sci*. 2020;25:677-681. https://doi.org/10.1016/j.jos.2019.06.011
16. Ashurst JV, Nappe T, Digiambattista S, et al. Effect of triage-based use of the Ottawa foot and ankle rules on the number of orders for radiographic imaging. *J Am Osteopath Assoc*. 2014;114:890-897. https://doi.org/10.7556/jaoa.2014.176
17. Asperti AM, Fernandes TL, Pedrinelli A, Hernandez AJ. Sports injuries among amateur athletes at a Brazilian university. *Acta Ortop Bras*. 2017;25:93-98. https://doi.org/10.1590/1413-785220172502165651
18. Ataoğlu MB, Tokgöz MA, Köktürk A, Ergişi Y, Hatipoğlu MY, Kanatlı U. Radiologic evaluation of the effect of distal tibiofibular joint anatomy on arthroscopically proven ankle instability. *Foot Ankle Int*. 2020;41:223-228. https://doi.org/10.1177/1071100719884555
19. Atilla OD, Yesilaras M, Kilic TY, et al. The accuracy of bedside ultrasonography as a diagnostic tool for fractures in the ankle and foot. *Acad Emerg Med*. 2014;21:1058-1061. https://doi.org/10.1111/acem.12467
20. Attenborough AS, Sinclair PJ, Sharp T, et al. The identification of risk factors for ankle sprains sustained during netball participation. *Phys Ther Sport*. 2017;23:31-36. https://doi.org/10.1016/j.ptsp.2016.06.009
21. Azma K, Mottaghi P, Hosseini A, Abadi HH, Nouraei MH. Benign joint hypermobility syndrome in soldiers; what is the effect of military training courses on associated joint instabilities? *J Res Med Sci*. 2014;19:639-643.
22. Bączkowicz D, Falkowski K, Majorczyk E. Assessment of relationships between joint motion quality and postural control in patients with chronic ankle joint instability. *J Orthop Sports Phys Ther*. 2017;47:570-577. https://doi.org/10.2519/jospt.2017.6836
23. Baldwin JN, McKay MJ, Hiller CE, et al. Correlates of perceived ankle instability in healthy individuals aged 8 to 101 years. *Arch Phys Med Rehabil*. 2017;98:72-79. https://doi.org/10.1016/j.apmr.2016.08.474
24. Bansbach HM, Lovalekar MT, Abt JP, Rafferty D, Yount D, Sell TC. Military personnel with self-reported ankle injuries do not demonstrate deficits in dynamic postural stability or landing kinematics. *Clin Biomech (Bristol, Avon)*. 2017;47:27-32. https://doi.org/10.1016/j.clinbiomech.2017.05.008
25. Barelds I, Krijnen WP, van de Leur JP, van der Schans CP, Goddard RJ. Diagnostic accuracy of clinical decision rules to exclude fractures in acute ankle injuries: systematic review and meta-analysis. *J Emerg Med*. 2017;53:353-368. https://doi.org/10.1016/j.jemermed.2017.04.035
26. Basnett CR, Hanish MJ, Wheeler TJ, et al. Ankle dorsiflexion range of motion influences dynamic balance in individuals with chronic ankle instability. *Int J Sports Phys Ther*. 2013;8:121-128.
27. Bastien M, Moffet H, Bouyer L, Perron M, Hébert LJ, Leblond J. Concurrent and discriminant validity of the Star Excursion Balance Test for military personnel with lateral ankle sprain. *J Sport Rehabil*. 2014;23:44-55. https://doi.org/10.1123/jsr.2012-0132
28. Bastien M, Moffet H, Bouyer LJ, Perron M, Hébert LJ, Leblond J. Alteration in global motor strategy following lateral ankle sprain. *BMC Musculoskelet Disord*. 2014;15:436. https://doi.org/10.1186/1471-2474-15-436
29. Beaulieu-Jones BR, Rossy WH, Sanchez G, et al. Epidemiology of injuries identified at the NFL Scouting Combine and their impact on performance in the National Football League: evaluation of 2203 athletes from 2009 to 2015. *Orthop J Sports Med*. 2017;5:2325967117708744. https://doi.org/10.1177/2325967117708744
30. Beceren GN, Yolcu S, Tomruk O, Atay T, Baykal YB. Ottawa versus Bernese: which is better? *Eur J Trauma Emerg Surg*. 2013;39:147-150. https://doi.org/10.1007/s00068-012-0249-z
31. Bellows R, Wong CK. The effect of bracing and balance training on ankle sprain incidence among athletes: a systematic review with meta-analysis. *Int J Sports Phys Ther*. 2018;13:379-388.
32. Bielska IA, Brison R, Brouwer B, et al. Is recovery from ankle sprains negatively affected by obesity? *Ann Phys Rehabil Med*. 2019;62:8-13. https://doi.org/10.1016/j.rehab.2018.08.006
33. Bleakley CM, Taylor JB, Dischiavi SL, Doherty C, Delahunt E. Rehabilitation exercises reduce reinjury post ankle sprain, but the content and parameters of an optimal exercise program have yet to be established: a systematic review and meta-analysis. *Arch Phys Med Rehabil*. 2019;100:1367-1375. https://doi.org/10.1016/j.apmr.2018.10.005
34. Boutis K, Grootendorst P, Willan A, et al. Effect of the Low Risk Ankle Rule on the frequency of radiography in children with ankle injuries. *CMAJ*. 2013;185:E731-E738. https://doi.org/10.1503/cmaj.122050
35. Boutis K, von Keyserlingk C, Willan A, et al. Cost consequence analysis of implementing the Low Risk Ankle Rule in emergency departments. *Ann Emerg Med*. 2015;66:455-463.e4. https://doi.org/10.1016/j.annemergmed.2015.05.027

36. Bowker S, Terada M, Thomas AC, Pietrosimone BG, Hiller CE, Gribble PA. Neural excitability and joint laxity in chronic ankle instability, coper, and control groups. *J Athl Train*. 2016;51:336-343. https://doi.org/10.4085/1062-6050-51.5.05

37. Briet JP, Houwert RM, Hageman M, Hietbrink F, Ring DC, Verleisdonk E. Factors associated with pain intensity and physical limitations after lateral ankle sprains. *Injury*. 2016;47:2565-2569. https://doi.org/10.1016/j.injury.2016.09.016

38. Brown CN, Ko J, Rosen AB, Hsieh K. Individuals with both perceived ankle instability and mechanical laxity demonstrate dynamic postural stability deficits. *Clin Biomech (Bristol, Avon)*. 2015;30:1170-1174. https://doi.org/10.1016/j.clinbiomech.2015.08.008

39. Brown CN, Rosen AB, Ko J. Ankle ligament laxity and stiffness in chronic ankle instability. *Foot Ankle Int*. 2015;36:565-572. https://doi.org/10.1177/1071100714561057

40. Bulathsinhala L, Hill OT, Scofield DE, Haley TF, Kardouni JR. Epidemiology of ankle sprains and the risk of separation from service in US Army soldiers. *J Orthop Sports Phys Ther*. 2015;45:477-484. https://doi.org/10.2519/jospt.2015.5733

41. Bullock SA, Allen GM, Watson MS, Wilson DJ. Predicting poor outcome from simple ankle injuries: a prospective cohort study. *Br J Radiol*. 2018;91:20170213. https://doi.org/10.1259/bjr.20170213

42. Burcal CJ, Sandrey MA, Hubbard-Turner T, McKeon PO, Wikstrom EA. Predicting dynamic balance improvements following 4-weeks of balance training in chronic ankle instability patients. *J Sci Med Sport*. 2019;22:538-543. https://doi.org/10.1016/j.jsams.2018.11.001

43. Burger M, Dreyer D, Fisher RL, et al. The effectiveness of proprioceptive and neuromuscular training compared to bracing in reducing the recurrence rate of ankle sprains in athletes: a systematic review and meta-analysis. *J Back Musculoskelet Rehabil*. 2018;31:221-229. https://doi.org/10.3233/BMR-170804

44. Cai Y, Li S, Chen S, Hua Y, Shan J. An ultrasound classification of anterior talofibular ligament (ATFL) injury. *Open Orthop J*. 2017;11:610-616. https://doi.org/10.2174/1874325001711010610

45. Calder J, Mitchell A, Lomax A, et al. The broken "ring of fire": a new radiological sign as predictor of syndesmosis injury? *Orthop J Sports Med*. 2017;5:2325967117695064. https://doi.org/10.1177/2325967117695064

46. Calin MA, Badila A, Hristea A, Manea D, Savastru R, Nica AS. Fractionated irradiation in photobiomodulation therapy of ankle sprain. *Am J Phys Med Rehabil*. 2019;98:692-698. https://doi.org/10.1097/PHM.0000000000001178

47. Calloway SP, Hardin DM, Crawford MD, et al. Injury surveillance in Major League Soccer: a 4-year comparison of injury on natural grass versus artificial turf field. *Am J Sports Med*. 2019;47:2279-2286. https://doi.org/10.1177/0363546519860522

48. Cao S, Wang C, Ma X, Wang X, Huang J, Zhang C. Imaging diagnosis for chronic lateral ankle ligament injury: a systemic review with meta-analysis. *J Orthop Surg Res*. 2018;13:122. https://doi.org/10.1186/s13018-018-0811-4

49. Cao S, Wang C, Ma X, et al. In vivo kinematics of functional ankle instability patients and lateral ankle sprain copers during stair descent. *J Orthop Res*. 2019;37:1860-1867. https://doi.org/10.1002/jor.24303

50. Cao S, Wang C, Zhang G, et al. In vivo kinematics of functional ankle instability patients during the stance phase of walking. *Gait Posture*. 2019;73:262-268. https://doi.org/10.1016/j.gaitpost.2019.07.377

51. Çelik D, Malkoç M, Martin R. Evidence for reliability, validity and responsiveness of Turkish Foot and Ankle Ability Measure (FAAM). *Rheumatol Int*. 2016;36:1469-1476. https://doi.org/10.1007/s00296-016-3485-4

52. Cezarino LG, da Silva Grüninger BL, Scattone Silva R. Injury profile in a Brazilian first-division youth soccer team: a prospective study. *J Athl Train*. 2020;55:295-302. https://doi.org/10.4085/1062-6050-449-18

53. Champagne N, Eadie L, Regan L, Wilson P. The effectiveness of ultrasound in the detection of fractures in adults with suspected upper or lower limb injury: a systematic review and subgroup meta-analysis. *BMC Emerg Med*. 2019;19:17. https://doi.org/10.1186/s12873-019-0226-5

54. Chan VO, Moran DE, Shine S, Eustace SJ. Medial joint line bone bruising at MRI complicating acute ankle inversion injury: what is its clinical significance? *Clin Radiol*. 2013;68:e519-e523. https://doi.org/10.1016/j.crad.2013.05.093

55. Chen H, Li HY, Zhang J, Hua YH, Chen SY. Difference in postural control between patients with functional and mechanical ankle instability. *Foot Ankle Int*. 2014;35:1068-1074. https://doi.org/10.1177/1071100714539657

56. Chen L, Wang X, Huang J, et al. Outcome comparison between functional ankle instability cases with and without anterior ankle impingement: a retrospective cohort study. *J Foot Ankle Surg*. 2019;58:52-56. https://doi.org/10.1053/j.jfas.2018.07.015

57. Cherati AS, Dousti M, Younespour S. Association between foot posture index and ankle sprain in indoor football players. *Glob J Health Sci*. 2016;8:51426. https://doi.org/10.5539/gjhs.v8n10p160

58. Chiu YL, Tsai YJ, Lin CH, Hou YR, Sung WH. Evaluation of a smartphone-based assessment system in subjects with chronic ankle instability. *Comput Methods Programs Biomed*. 2017;139:191-195. https://doi.org/10.1016/j.cmpb.2016.11.005

59. Cho BK, Park JK. Correlation between joint-position sense, peroneal strength, postural control, and functional performance ability in patients with chronic lateral ankle instability. *Foot Ankle Int*. 2019;40:961-968. https://doi.org/10.1177/1071100719846114

60. Cho BK, Park JK, Choi SM, Kang SW, SooHoo NF. The peroneal strength deficits in patients with chronic ankle instability compared to ankle sprain copers and normal individuals. *Foot Ankle Surg*. 2019;25:231-236. https://doi.org/10.1016/j.fas.2017.10.017

61. Choi HS, Shin WS. Postural control systems in two different functional movements: a comparison of subjects with and without chronic ankle instability. *J Phys Ther Sci*. 2016;28:102-106. https://doi.org/10.1589/jpts.28.102

62. Choi HS, Shin WS. Validity of the lower extremity functional movement screen in patients with chronic ankle instability. *J Phys Ther Sci*. 2015;27:1923-1927. https://doi.org/10.1589/jpts.27.1923

63. Choi WS, Cho JH, Lee DH, Chung JY, Lim SM, Park YU. Prognostic factors of acute ankle sprain: need for ultrasonography to predict prognosis. *J Orthop Sci*. 2020;25:303-309. https://doi.org/10.1016/j.jos.2019.04.012

64. Chou E, Kim KM, Baker AG, Hertel J, Hart JM. Lower leg neuromuscular changes following fibular reposition taping in individuals with chronic ankle instability. *Man Ther*. 2013;18:316-320. https://doi.org/10.1016/j.math.2012.11.004

65. Chun KY, Choi YS, Lee SH, et al. Deltoid ligament and tibiofibular syndesmosis injury in chronic lateral ankle instability: magnetic resonance imaging evaluation at 3T and comparison with arthroscopy. *Korean J Radiol*. 2015;16:1096-1103. https://doi.org/10.3348/kjr.2015.16.5.1096

66. Clar C, Tsertsvadze A, Court R, Hundt GL, Clarke A, Sutcliffe P. Clinical effectiveness of manual therapy for the management of musculoskeletal and non-musculoskeletal conditions: systematic review and update of UK evidence report. *Chiropr Man Therap*. 2014;22:12. https://doi.org/10.1186/2045-709X-22-12

67. Cleland JA, Mintken PE, McDevitt A, et al. Manual physical therapy and exercise versus supervised home exercise in the management of patients with inversion ankle sprain: a multicenter randomized clinical trial. *J Orthop Sports Phys Ther*. 2013;43:443-455. https://doi.org/10.2519/jospt.2013.4792

68. Corbett RO, Keith TR, Hertel J. Patient-reported outcomes and perceived confidence measures in athletes with a history of ankle sprain. *J Sport Rehabil*. 2020;29:795-800. https://doi.org/10.1123/jsr.2018-0310

69. Cornwall MW, Jain T, Hagel T. Tibial and calcaneal coupling during walking in those with chronic ankle instability. *Gait Posture*. 2019;70:130-135. https://doi.org/10.1016/j.gaitpost.2019.02.021

70. Crema MD, Krivokapic B, Guermazi A, et al. MRI of ankle sprain: the association between joint effusion and structural injury severity in a large cohort of athletes. *Eur Radiol*. 2019;29:6336-6344. https://doi.org/10.1007/s00330-019-06156-1

71. Crosswell S, Leaman A, Phung W. Minimising negative ankle and foot

X-rays in the Emergency Department—are the Ottawa ankle rules good enough? *Injury*. 2014;45:2002-2004. https://doi.org/10.1016/j.injury.2014.09.001

72. Crowley SG, Trofa DP, Vosseller JT, et al. Epidemiology of foot and ankle injuries in National Collegiate Athletic Association men's and women's ice hockey. *Orthop J Sports Med*. 2019;7:2325967119865908. https://doi.org/10.1177/2325967119865908

73. Croy T, Koppenhaver S, Saliba S, Hertel J. Anterior talocrural joint laxity: diagnostic accuracy of the anterior drawer test of the ankle. *J Orthop Sports Phys Ther*. 2013;43:911-919. https://doi.org/10.2519/jospt.2013.4679

74. Croy T, Saliba S, Saliba E, Anderson MW, Hertel J. Talofibular interval changes after acute ankle sprain: a stress ultrasonography study of ankle laxity. *J Sport Rehabil*. 2013;22:257-263. https://doi.org/10.1123/jsr.22.4.257

75. Cruz-Díaz D, Hita-Contreras F, Lomas-Vega R, Osuna-Pérez MC, Martínez-Amat A. Cross-cultural adaptation and validation of the Spanish version of the Cumberland Ankle Instability Tool (CAIT): an instrument to assess unilateral chronic ankle instability. *Clin Rheumatol*. 2013;32:91-98. https://doi.org/10.1007/s10067-012-2095-0

76. Cuğ M. Stance foot alignment and hand positioning alter Star Excursion Balance Test scores in those with chronic ankle instability: what are we really assessing? *Physiother Theory Pract*. 2017;33:316-322. https://doi.org/10.1080/09593985.2017.1302028

77. Cuñado-González Á, Martín-Pintado-Zugasti A, Rodríguez-Fernández ÁL. Prevalence and factors associated with injuries in elite Spanish volleyball. *J Sport Rehabil*. 2019;28:796-802. https://doi.org/10.1123/jsr.2018-0044

78. Czamara A, Emilianowicz M, Markowska I, et al. Biomechanics assessment of long term consequences of talocrural joint sprain in conservatively treated males. *Acta Bioeng Biomech*. 2013;15:73-81. https://doi.org/10.5277/abb130410

79. da Cunha RA, Hazime FA, da Silva Martins MC, Ferreira M, de Castro Pochini A, Ejnisman B. Translation, cross-cultural adaptation, and clinimetric testing of instruments used to assess patients with ankle sprain in the Brazilian population. *J Orthop Sports Phys Ther*. 2016;46:1042-1050. https://doi.org/10.2519/jospt.2016.6218

80. Dallinga JM, van der Does HT, Benjaminse A, Lemmink KA. Dynamic postural stability differences between male and female players with and without ankle sprain. *Phys Ther Sport*. 2016;17:69-75. https://doi.org/10.1016/j.ptsp.2015.05.002

81. Daş M, Temiz A, Çevik Y. Implementation of the Ottawa ankle rules by general practitioners in the emergency department of a Turkish district hospital. *Ulus Travma Acil Cerrahi Derg*. 2016;22:361-364. https://doi.org/10.5505/tjtes.2016.72662

82. David P, Halimi M, Mora I, Doutrellot PL, Petitjean M. Isokinetic testing of evertor and invertor muscles in patients with chronic ankle instability. *J Appl Biomech*. 2013;29:696-704. https://doi.org/10.1123/jab.29.6.696

83. David S, Gray K, Russell JA, Starkey C. Validation of the Ottawa Ankle Rules for acute foot and ankle injuries. *J Sport Rehabil*. 2016;25:48-51. https://doi.org/10.1123/jsr.2014-0253

84. Debieux P, Wajnsztejn A, Mansur NSB. Epidemiology of injuries due to ankle sprain diagnosed in an orthopedic emergency room. *Einstein (São Paulo)*. 2020;18:eAO4739. https://doi.org/10.31744/einstein_journal/2020AO4739

85. Dedieu P, Chamoun R, Lacaud G, Moulinat T, Queron M, Zanone PG. Does a not-so-recent ankle sprain influence interjoint coordination during walking? *Clin Biomech (Bristol, Avon)*. 2017;50:114-121. https://doi.org/10.1016/j.clinbiomech.2017.10.016

86. DeJong AF, Koldenhoven RM, Hart JM, Hertel J. Gluteus medius dysfunction in females with chronic ankle instability is consistent at different walking speeds. *Clin Biomech (Bristol, Avon)*. 2020;73:140-148. https://doi.org/10.1016/j.clinbiomech.2020.01.013

87. DeJong AF, Koldenhoven RM, Hertel J. Proximal adaptations in chronic ankle instability: systematic review and meta-analysis. *Med Sci Sports Exerc*. 2020;52:1563-1575. https://doi.org/10.1249/MSS.0000000000002282

88. DeJong AF, Mangum LC, Hertel J. Gluteus medius activity during gait is altered in individuals with chronic ankle instability: an ultrasound imaging study. *Gait Posture*. 2019;71:7-13. https://doi.org/10.1016/j.gaitpost.2019.04.007

89. DeJong AF, Mangum LC, Hertel J. Ultrasound imaging of the gluteal muscles during the Y-Balance Test in individuals with or without chronic ankle instability. *J Athl Train*. 2020;55:49-57. https://doi.org/10.4085/1062-6050-363-18

90. de la Motte S, Arnold BL, Ross SE. Trunk-rotation differences at maximal reach of the Star Excursion Balance Test in participants with chronic ankle instability. *J Athl Train*. 2015;50:358-365. https://doi.org/10.4085/1062-6050-49.3.74

91. de Moraes Prianti B, Novello GF, de Souza Moreira Prianti T, Costa DR, Pessoa DR, Nicolau RA. Evaluation of the therapeutic effects of LED (λ627 ± 10 nm) on the initial phase of ankle sprain treatment: a randomised placebo-controlled clinical trial. *Lasers Med Sci*. 2018;33:1031-1038. https://doi.org/10.1007/s10103-018-2460-6

92. de Noronha M, França LC, Haupenthal A, Nunes GS. Intrinsic predictive factors for ankle sprain in active university students: a prospective study. *Scand J Med Sci Sports*. 2013;23:541-547. https://doi.org/10.1111/j.1600-0838.2011.01434.x

93. de Noronha M, Lay EK, McPhee MR, Mnatzaganian G, Nunes GS. Ankle sprain has higher occurrence during the latter parts of matches: systematic review with meta-analysis. *J Sport Rehabil*. 2019;28:373-380. https://doi.org/10.1123/jsr.2017-0279

94. De Ridder R, Willems T, Vanrenterghem J, Robinson MA, Roosen P. Lower limb landing biomechanics in subjects with chronic ankle instability. *Med Sci Sports Exerc*. 2015;47:1225-1231. https://doi.org/10.1249/MSS.0000000000000525

95. De Ridder R, Witvrouw E, Dolphens M, Roosen P, Van Ginckel A. Hip strength as an intrinsic risk factor for lateral ankle sprains in youth soccer players: a 3-season prospective study. *Am J Sports Med*. 2017;45:410-416. https://doi.org/10.1177/0363546516672650

96. Derksen RJ, Knijnenberg LM, Fransen G, Breederveld RS, Heymans MW, Schipper IB. Diagnostic performance of the Bernese versus Ottawa ankle rules: results of a randomised controlled trial. *Injury*. 2015;46:1645-1649. https://doi.org/10.1016/j.injury.2015.03.038

97. Deschamps K, Matricali GA, Dingenen B, De Boeck J, Bronselaer S, Staes F. Foot and ankle kinematics in chronic ankle instability subjects using a midfoot strike pattern when running, including influence of taping. *Clin Biomech (Bristol, Avon)*. 2018;54:1-7. https://doi.org/10.1016/j.clinbiomech.2018.02.016

98. D'Hooghe P, Alkhelaifi K, Almusa E, Tabben M, Wilson MG, Kaux JF. Chronic lateral ankle instability increases the likelihood for surgery in athletes with os trigonum syndrome. *Knee Surg Sports Traumatol Arthrosc*. 2019;27:2813-2817. https://doi.org/10.1007/s00167-018-5183-0

99. Dickson TJ, Waddington G, Terwiel FA. Snowsport experience, expertise, lower limb injury and somatosensory ability. *J Sci Med Sport*. 2019;22 suppl 1:S17-S21. https://doi.org/10.1016/j.jsams.2018.08.005

100. Dingenen B, Deschamps K, Delchambre F, Van Peer E, Staes FF, Matricali GA. Effect of taping on multi-segmental foot kinematic patterns during walking in persons with chronic ankle instability. *J Sci Med Sport*. 2017;20:835-840. https://doi.org/10.1016/j.jsams.2017.04.004

101. Dingenen B, Staes FF, Janssens L. A new method to analyze postural stability during a transition task from double-leg stance to single-leg stance. *J Biomech*. 2013;46:2213-2219. https://doi.org/10.1016/j.jbiomech.2013.06.026

102. Doherty C, Bleakley C, Delahunt E, Holden S. Treatment and prevention of acute and recurrent ankle sprain: an overview of systematic reviews with meta-analysis. *Br J Sports Med*. 2017;51:113-125. https://doi.org/10.1136/bjsports-2016-096178

103. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Balance failure in single limb stance due to ankle sprain injury: an analysis of center of pressure using the fractal dimension method. *Gait Posture*. 2014;40:172-176. https://doi.org/10.1016/j.gaitpost.2014.03.180

104. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Clinical tests have limited predictive value for chronic ankle instability when conducted in the acute phase of a first-time lateral ankle sprain injury. *Arch Phys Med Rehabil*. 2018;99:720-725.e1. https://doi.org/10.1016/j.apmr.2017.11.008

105. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Dynamic balance deficits in individuals with chronic ankle instability compared to ankle sprain copers 1 year after a first-time lateral ankle sprain injury. *Knee Surg Sports Traumatol Arthrosc*. 2016;24:1086-1095. https://doi.org/10.1007/s00167-015-3744-z

106. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Locomotive biomechanics in persons with chronic ankle instability and lateral ankle sprain copers. *J Sci Med Sport*. 2016;19:524-530. https://doi.org/10.1016/j.jsams.2015.07.010

107. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Lower extremity function during gait in participants with first time acute lateral ankle sprain compared to controls. *J Electromyogr Kinesiol*. 2015;25:182-192. https://doi.org/10.1016/j.jelekin.2014.09.004

108. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Postural control strategies during single limb stance following acute lateral ankle sprain. *Clin Biomech (Bristol, Avon)*. 2014;29:643-649. https://doi.org/10.1016/j.clinbiomech.2014.04.012

109. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Recovery from a first-time lateral ankle sprain and the predictors of chronic ankle instability: a prospective cohort analysis. *Am J Sports Med*. 2016;44:995-1003. https://doi.org/10.1177/0363546516628870

110. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Single-leg drop landing movement strategies 6 months following first-time acute lateral ankle sprain injury. *Scand J Med Sci Sports*. 2015;25:806-817. https://doi.org/10.1111/sms.12390

111. Doherty C, Bleakley C, Hertel J, Caulfield B, Ryan J, Delahunt E. Single-leg drop landing movement strategies in participants with chronic ankle instability compared with lateral ankle sprain 'copers'. *Knee Surg Sports Traumatol Arthrosc*. 2016;24:1049-1059. https://doi.org/10.1007/s00167-015-3852-9

112. Doherty C, Bleakley C, Hertel J, et al. Inter-joint coordination strategies during unilateral stance 6-months following first-time lateral ankle sprain. *Clin Biomech (Bristol, Avon)*. 2015;30:129-135. https://doi.org/10.1016/j.clinbiomech.2014.12.011

113. Doherty C, Bleakley C, Hertel J, et al. Inter-joint coordination strategies during unilateral stance following first-time, acute lateral ankle sprain: a brief report. *Clin Biomech (Bristol, Avon)*. 2015;30:636-639. https://doi.org/10.1016/j.clinbiomech.2015.04.012

114. Doherty C, Bleakley C, Hertel J, et al. Coordination and symmetry patterns during the drop vertical jump, 6-months after first-time lateral ankle sprain. *J Orthop Res*. 2015;33:1537-1544. https://doi.org/10.1002/jor.22915

115. Doherty C, Bleakley C, Hertel J, et al. Coordination and symmetry patterns during the drop vertical jump in people with chronic ankle instability and lateral ankle sprain copers. *Phys Ther*. 2016;96:1152-1161. https://doi.org/10.2522/ptj.20150160

116. Doherty C, Bleakley C, Hertel J, et al. Lower limb interjoint postural coordination one year after first-time lateral ankle sprain. *Med Sci Sports Exerc*. 2015;47:2398-2405. https://doi.org/10.1249/MSS.0000000000000673

117. Doherty C, Bleakley C, Hertel J, et al. Lower extremity coordination and symmetry patterns during a drop vertical jump task following acute ankle sprain. *Hum Mov Sci*. 2014;38:34-46. https://doi.org/10.1016/j.humov.2014.08.002

118. Doherty C, Bleakley CM, Hertel J, Caulfield B, Ryan J, Delahunt E. Laboratory measures of postural control during the Star Excursion Balance Test after acute first-time lateral ankle sprain. *J Athl Train*. 2015;50:651-664. https://doi.org/10.4085/1062-6050-50.1.09

119. Doherty C, Delahunt E, Caulfield B, Hertel J, Ryan J, Bleakley C. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. *Sports Med*. 2014;44:123-140. https://doi.org/10.1007/s40279-013-0102-5

120. Donahue M, Simon J, Docherty CL. Reliability and validity of a new questionnaire created to establish the presence of functional ankle instability: the IdFAI. *Athl Train Sports Health Care*. 2013;5:38-43. https://doi.org/10.3928/19425864-20121212-02

121. Donahue MS, Docherty CL, Riley ZA. Decreased fibularis reflex response during inversion perturbations in FAI subjects. *J Electromyogr Kinesiol*. 2014;24:84-89. https://doi.org/10.1016/j.jelekin.2013.08.012

122. Donnelly L, Donovan L, Hart JM, Hertel J. Eversion strength and surface electromyography measures with and without chronic ankle instability measured in 2 positions. *Foot Ankle Int*. 2017;38:769-778. https://doi.org/10.1177/1071100717701231

123. Donovan L, Hetzel S, Laufenberg CR, McGuine TA. Prevalence and impact of chronic ankle instability in adolescent athletes. *Orthop J Sports Med*. 2020;8:2325967119900962. https://doi.org/10.1177/2325967119900962

124. dos Santos MJ, Gorges AL, Rios JL. Individuals with chronic ankle instability exhibit decreased postural sway while kicking in a single-leg stance. *Gait Posture*. 2014;40:231-236. https://doi.org/10.1016/j.gaitpost.2014.04.002

125. Dundas MA, Gutierrez GM, Pozzi F. Neuromuscular control during stepping down in continuous gait in individuals with and without ankle instability. *J Sports Sci*. 2014;32:926-933. https://doi.org/10.1080/02640414.2013.868917

126. Ebrahimabadi Z, Naimi SS, Rahimi A, et al. Investigating the anticipatory postural adjustment phase of gait initiation in different directions in chronic ankle instability patients. *J Bodyw Mov Ther*. 2018;22:40-45. https://doi.org/10.1016/j.jbmt.2017.03.016

127. Eechaute C, De Ridder R, Maes T, et al. Evidence of a different landing strategy in subjects with chronic ankle instability. *Gait Posture*. 2017;52:62-67. https://doi.org/10.1016/j.gaitpost.2016.11.002

128. Eechaute C, Leemans L, De Mesmaeker M, et al. The predictive value of the multiple hop test for first-time noncontact lateral ankle sprains. *J Sports Sci*. 2020;38:86-93. https://doi.org/10.1080/02640414.2019.1682891

129. Ekstrand J, Krutsch W, Spreco A, et al. Time before return to play for the most common injuries in professional football: a 16-year follow-up of the UEFA Elite Club Injury Study. *Br J Sports Med*. 2020;54:421-426. https://doi.org/10.1136/bjsports-2019-100666

130. Ellenbogen AL, Rice AL, Vyas P. Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in a pediatric population. *Am J Emerg Med*. 2017;35:1262-1265. https://doi.org/10.1016/j.ajem.2017.03.058

131. Feger MA, Donovan L, Hart JM, Hertel J. Lower extremity muscle activation during functional exercises in patients with and without chronic ankle instability. *PM R*. 2014;6:602-611; quiz 611. https://doi.org/10.1016/j.pmrj.2013.12.013

132. Feger MA, Glaviano NR, Donovan L, et al. Current trends in the management of lateral ankle sprain in the United States. *Clin J Sport Med*. 2017;27:145-152. https://doi.org/10.1097/JSM.0000000000000321

133. Feger MA, Herb CC, Fraser JJ, Glaviano N, Hertel J. Supervised rehabilitation versus home exercise in the treatment of acute ankle sprains: a systematic review. *Clin Sports Med*. 2015;34:329-346. https://doi.org/10.1016/j.csm.2014.12.001

134. Fransz DP, Huurnink A, Kingma I, de Boode VA, Heyligers IC, van Dieën JH. Performance on a single-legged drop-jump landing test is related to increased risk of lateral ankle sprains among male elite soccer players: a 3-year prospective cohort study. *Am J Sports Med*. 2018;46:3454-3462. https://doi.org/10.1177/0363546518808027

135. Fransz DP, Huurnink A, Kingma I, Verhagen EA, van Dieën JH. A systematic review and meta-analysis of dynamic tests and related force plate parameters used to evaluate neuromusculoskeletal function in foot and ankle pathology. *Clin Biomech (Bristol, Avon)*. 2013;28:591-601. https://doi.org/10.1016/j.clinbiomech.2013.06.002

136. Fraser JJ, Hart JM, Saliba SF, Park JS, Tumperi M, Hertel J. Multisegmented ankle-foot kinematics during gait initiation in ankle sprains and chronic ankle instability. *Clin Biomech (Bristol, Avon)*. 2019;68:80-88. https://doi.org/10.1016/j.clinbiomech.2019.05.017

137. Fraser JJ, Hertel J. Joint mobility and stability strategies for the ankle. In: *Independent Study Course 29.2: Neurology in Orthopaedics*. La Crosse, WI: Academy of Orthopaedic Physical Therapy; 2019.

138. Fraser JJ, Koldenhoven RM, Jaffri AH, et al. Foot impairments contribute to functional limitation in individuals with ankle sprain and chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc*. 2020;28:1600-1610. https://doi.org/10.1007/s00167-018-5028-x

139. Fuerst P, Gollhofer A, Lohrer H, Gehring D. Ankle joint control in people with chronic ankle instability during run-and-cut movements. *Int J Sports Med*. 2018;39:853-859. https://doi.org/10.1055/s-0044-100792

140. Fukano M, Fukubayashi T, Kumai T. In vivo talocrural and subtalar kinematics during the stance phase of walking in individuals with repetitive ankle sprains. *J Biomech*. 2020;101:109651. https://doi.org/10.1016/j.jbiomech.2020.109651

141. Fukano M, Mineta S, Hirose N. Fear avoidance beliefs in college athletes with a history of ankle sprain. *Int J Sports Med*. 2020;41:128-133. https://doi.org/10.1055/a-1065-1940

142. Fuller CW, Taylor A. Ten-season epidemiological study of match injuries in men's international rugby sevens. *J Sports Sci*. 2020;38:1595-1604. https://doi.org/10.1080/02640414.2020.1752059

143. Fuller CW, Taylor A, Raftery M. Eight-season epidemiological study of injuries in men's international Under-20 rugby tournaments. *J Sports Sci*. 2018;36:1776-1783. https://doi.org/10.1080/02640414.2017.1418193

144. Fusco A, Giancotti GF, Fuchs PX, Wagner H, Varalda C, Cortis C. Wobble board balance assessment in subjects with chronic ankle instability. *Gait Posture*. 2019;68:352-356. https://doi.org/10.1016/j.gaitpost.2018.12.017

145. Futatsubashi G, Sasada S, Tazoe T, Komiyama T. Gain modulation of the middle latency cutaneous reflex in patients with chronic joint instability after ankle sprain. *Clin Neurophysiol*. 2013;124:1406-1413. https://doi.org/10.1016/j.clinph.2013.01.029

146. Gabriner ML, Houston MN, Kirby JL, Hoch MC. Contributing factors to Star Excursion Balance Test performance in individuals with chronic ankle instability. *Gait Posture*. 2015;41:912-916. https://doi.org/10.1016/j.gaitpost.2015.03.013

147. Galli MM, Protzman NM, Mandelker EM, Malhotra AD, Schwartz E, Brigido SA. An examination of anatomic variants and incidental peroneal tendon pathologic features: a comprehensive MRI review of asymptomatic lateral ankles. *J Foot Ankle Surg*. 2015;54:164-172. https://doi.org/10.1053/j.jfas.2014.11.005

148. Geerinck A, Beaudart C, Salvan Q, et al. French translation and validation of the Cumberland Ankle Instability Tool, an instrument for measuring functional ankle instability. *Foot Ankle Surg*. 2020;26:391-397. https://doi.org/10.1016/j.fas.2019.05.002

149. Gehring D, Faschian K, Lauber B, Lohrer H, Nauck T, Gollhofer A. Mechanical instability destabilises the ankle joint directly in the ankle-sprain mechanism. *Br J Sports Med*. 2014;48:377-382. https://doi.org/10.1136/bjsports-2013-092626

150. George J, Jaafar Z, Hairi IR, Hussein KH. The correlation between clinical and ultrasound evaluation of anterior talofibular ligament and calcaneofibular ligament tears in athletes. *J Sports Med Phys Fitness*. 2020;60:749-757. https://doi.org/10.23736/S0022-4707.20.10050-1

151. Golditz T, Steib S, Pfeifer K, et al. Functional ankle instability as a risk factor for osteoarthritis: using T2-mapping to analyze early cartilage degeneration in the ankle joint of young athletes. *Osteoarthritis Cartilage*. 2014;22:1377-1385. https://doi.org/10.1016/j.joca.2014.04.029

152. Golditz T, Welsch GH, Pachowsky M, Hennig FF, Pfeifer K, Steib S. A multimodal approach to ankle instability: interrelations between subjective and objective assessments of ankle status in athletes. *J Orthop Res*. 2016;34:525-532. https://doi.org/10.1002/jor.23039

153. Gomes JLE, Soares AF, Bastiani CE, de Castro JV. Anterolateral talar palpation: a complementary test for ankle instability. *Foot Ankle Surg*. 2018;24:486-489. https://doi.org/10.1016/j.fas.2017.05.006

154. González-Iñigo S, Munuera-Martínez PV, Lafuente-Sotillos G, Castillo-López JM, Ramos-Ortega J, Domínguez-Maldonado G. Ankle sprain as a work-related accident: status of proprioception after 2 weeks. *PeerJ*. 2017;5:e4163. https://doi.org/10.7717/peerj.4163

155. González-Sánchez M, Li GZ, Ruiz Muñoz M, Cuesta-Vargas AI. Foot and ankle ability measure to measure functional limitations in patients with foot and ankle disorders: a Chinese cross-cultural adaptation and validation. *Disabil Rehabil*. 2017;39:2182-2189. https://doi.org/10.1080/09638288.2016.1219772

156. González-Sánchez M, Ruiz-Muñoz M, Li GZ, Cuesta-Vargas AI. Chinese cross-cultural adaptation and validation of the Foot Function Index as tool to measure patients with foot and ankle functional limitations. *Disabil Rehabil*. 2018;40:2056-2061. https://doi.org/10.1080/09638288.2017.1325944

157. Gordon AI, DiStefano LJ, Denegar CR, Ragle RB, Norman JR. College and professional women's basketball players' lower extremity injuries: a survey of career incidence. *Int J Athl Ther Train*. 2014;19:25-33. https://doi.org/10.1123/ijatt.2014-0020

158. Gould SJ, Cardone DA, Munyak J, Underwood PJ, Gould SA. Sideline coverage: when to get radiographs? A review of clinical decision tools. *Sports Health*. 2014;6:274-278. https://doi.org/10.1177/1941738114529701

159. Gribble PA, Delahunt E, Bleakley C, et al. Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the International Ankle Consortium. *Br J Sports Med*. 2014;48:1014-1018. https://doi.org/10.1136/bjsports-2013-093175

160. Gribble PA, Delahunt E, Bleakley CM, et al. Selection criteria for patients with chronic ankle instability in controlled research: a position statement of the International Ankle Consortium. *J Athl Train*. 2014;49:121-127. https://doi.org/10.4085/1062-6050-49.1.14

161. Grindstaff TL, Dolan N, Morton SK. Ankle dorsiflexion range of motion influences Lateral Step Down Test scores in individuals with chronic ankle instability. *Phys Ther Sport*. 2017;23:75-81. https://doi.org/10.1016/j.ptsp.2016.07.008

162. Großterlinden LG, Hartel M, Yamamura J, et al. Isolated syndesmotic injuries in acute ankle sprains: diagnostic significance of clinical examination and MRI. *Knee Surg Sports Traumatol Arthrosc*. 2016;24:1180-1186. https://doi.org/10.1007/s00167-015-3604-x

163. Guillodo Y, Simon T, Le Goff A, Saraux A. Interest of rehabilitation in healing and preventing recurrence of ankle sprains. *Ann Phys Rehabil Med*. 2013;56:503-514. https://doi.org/10.1016/j.rehab.2013.06.007

164. Gulbrandsen M, Hartigan DE, Patel KA, Makovicka JL, Tummala SV, Chhabra A. Ten-year epidemiology of ankle injuries in men's and women's collegiate soccer players. *J Athl Train*. 2019;54:881-888. https://doi.org/10.4085/1062-6050-144-18

165. Gumaa M, Rehan Youssef A. Is virtual reality effective in orthopedic rehabilitation? A systematic review and meta-analysis. *Phys Ther*. 2019;99:1304-1325. https://doi.org/10.1093/ptj/pzz093

166. Gurav RS, Ganu SS, Panhale VP. Reliability of the Identification of Functional Ankle Instability (IdFAI) scale across different age groups in adults. *N Am J Med Sci*. 2014;6:516-518. https://doi.org/10.4103/1947-2714.143283

167. Hadadi M, Abbasi F. Comparison of the effect of the combined mechanism ankle support on static and dynamic postural control of chronic ankle instability patients. *Foot Ankle Int*. 2019;40:702-709. https://doi.org/10.1177/1071100719833993

168. Hadadi M, Ebrahimi Takamjani I, Ebrahim Mosavi M, Aminian G, Fardipour S, Abbasi F. Cross-cultural adaptation, reliability, and validity of the Persian version of the Cumberland Ankle Instability Tool. *Disabil Rehabil*. 2017;39:1644-1649. https://doi.org/10.1080/09638288.2016.1207105

169. Hagen M, Lemke M, Lahner M. Deficits in subtalar pronation and supination proprioception in subjects with chronic ankle instability. *Hum Mov Sci*. 2018;57:324-331. https://doi.org/10.1016/j.humov.2017.09.010

170. Halabchi F, Angoorani H, Mirshahi M, Pourgharib Shahi MH, Mansournia MA. The prevalence of selected intrinsic risk factors for ankle sprain among elite football and basketball players. *Asian J Sports Med*. 2016;7:e35287. https://doi.org/10.5812/asjsm.35287

171. Harkey M, McLeod MM, Terada M, Gribble PA, Pietrosimone BG. Quadratic association between corticomotor and spinal-reflexive excitability and self-reported disability in participants with chronic ankle instability. *J Sport Rehabil*. 2016;25:137-145. https://doi.org/10-1123/jsr.2014-0282

172. Harmer PA. Epidemiology of time-loss injuries in international fencing: a prospective, 5-year analysis of Fédération Internationale d'Escrime competitions. *Br J Sports Med*. 2019;53:442-448. https://doi.org/10.1136/bjsports-2018-100002

173. Harriss J, Khan A, Song K, Register-Mihalik JK, Wikstrom EA. Clinical movement assessments do not differ between collegiate athletes with and without chronic ankle instability. *Phys Ther Sport*. 2019;36:22-27. https://doi.org/10.1016/j.ptsp.2018.12.009

174. Hartley EM, Hoch MC, Boling MC. Y-Balance Test performance and BMI are associated with ankle sprain injury in collegiate male athletes. *J Sci Med Sport*. 2018;21:676-680. https://doi.org/10.1016/j.jsams.2017.10.014

175. Hartley EM, Hoch MC, McKeon PO. Reliability and responsiveness of gait initiation profiles in those with chronic ankle instability. *Gait Posture*. 2016;49:86-89. https://doi.org/10.1016/j.gaitpost.2016.06.022

176. Herb CC, Blemker S, Saliba S, Hart J, Hertel J. Chronic ankle instability patients exhibit higher variability in lower extremity joint-coupling variability during drop vertical jumps. *J Biomech*. 2020;99:109479. https://doi.org/10.1016/j.jbiomech.2019.109479

177. Herb CC, Grossman K, Feger MA, Donovan L, Hertel J. Lower extremity biomechanics during a drop-vertical jump in participants with or without chronic ankle instability. *J Athl Train*. 2018;53:364-371. https://doi.org/10.4085/1062-6050-481-15

178. Hershkovich O, Tenenbaum S, Gordon B, et al. A large-scale study on epidemiology and risk factors for chronic ankle instability in young adults. *J Foot Ankle Surg*. 2015;54:183-187. https://doi.org/10.1053/j.jfas.2014.06.001

179. Hertel J, Corbett RO. An updated model of chronic ankle instability. *J Athl Train*. 2019;54:572-588. https://doi.org/10.4085/1062-6050-344-18

180. Herzog MM, Mack CD, Dreyer NA, et al. Ankle sprains in the National Basketball Association, 2013-2014 through 2016-2017. *Am J Sports Med*. 2019;47:2651-2658. https://doi.org/10.1177/0363546519864678

181. Hess MC, Swedler DI, Collins CS, Ponce BA, Brabston EW. Descriptive epidemiology of injuries in professional ultimate Frisbee athletes. *J Athl Train*. 2020;55:195-204. https://doi.org/10.4085/1062-6050-269-18

182. Ho JK, Chau JP, Chan JT, Yau CH. Nurse-initiated radiographic-test protocol for ankle injuries: a randomized controlled trial. *Int Emerg Nurs*. 2018;41:1-6. https://doi.org/10.1016/j.ienj.2018.04.001

183. Hoch JM, Baez SE, Cramer RJ, Hoch MC. Differences in the modified Disablement in the Physically Active scale in those with and without chronic ankle instability. *J Sport Rehabil*. 2019;28:476-480. https://doi.org/10.1123/jsr.2017-0295

184. Hoch JM, Hartzell J, Kosik KB, Cramer RJ, Gribble PA, Hoch MC. Continued validation and known groups validity of the Quick-FAAM: inclusion of participants with chronic ankle instability and ankle sprain copers. *Phys Ther Sport*. 2020;43:84-88. https://doi.org/10.1016/j.ptsp.2020.02.012

185. Hoch JM, Powden CJ, Hoch MC. Reliability, minimal detectable change, and responsiveness of the Quick-FAAM. *Phys Ther Sport*. 2018;32:269-272. https://doi.org/10.1016/j.ptsp.2018.04.004

186. Hoch MC, Farwell KE, Gaven SL, Weinhandl JT. Weight-bearing dorsiflexion range of motion and landing biomechanics in individuals with chronic ankle instability. *J Athl Train*. 2015;50:833-839. https://doi.org/10.4085/1062-6050-50.5.07

187. Hoch MC, Gaven SL, Weinhandl JT. Kinematic predictors of Star Excursion Balance Test performance in individuals with chronic ankle instability. *Clin Biomech (Bristol, Avon)*. 2016;35:37-41. https://doi.org/10.1016/j.clinbiomech.2016.04.008

188. Hoch MC, McKeon PO. Peroneal reaction time after ankle sprain: a systematic review and meta-analysis. *Med Sci Sports Exerc*. 2014;46:546-556. https://doi.org/10.1249/MSS.0b013e3182a6a93b

189. Hogan KK, Powden CJ, Hoch MC. The influence of foot posture on dorsiflexion range of motion and postural control in those with chronic ankle instability. *Clin Biomech (Bristol, Avon)*. 2016;38:63-67. https://doi.org/10.1016/j.clinbiomech.2016.08.010

190. Hohn E, Robinson S, Merriman J, Parrish R, Kramer W. Orthopedic injuries in professional surfers: a retrospective study at a single orthopedic center. *Clin J Sport Med*. 2020;30:378-382.

191. Holland B, Needle AR, Battista RA, West ST, Christiana RW. Physical activity levels among rural adolescents with a history of ankle sprain and chronic ankle instability. *PLoS One*. 2019;14:e0216243. https://doi.org/10.1371/journal.pone.0216243

192. Hopkins JT, Son SJ, Kim H, Page G, Seeley MK. Characterization of multiple movement strategies in participants with chronic ankle instability. *J Athl Train*. 2019;54:698-707. https://doi.org/10.4085/1062-6050-480-17

193. Houston MN, Hoch JM, Cameron KL, Abt JP, Peck KY, Hoch MC. Sex and number of concussions influence the association between concussion and musculoskeletal injury history in collegiate athletes. *Brain Inj*. 2018;32:1353-1358. https://doi.org/10.1080/02699052.2018.1512718

194. Houston MN, Hoch JM, Gabriner ML, Kirby JL, Hoch MC. Clinical and laboratory measures associated with health-related quality of life in individuals with chronic ankle instability. *Phys Ther Sport*. 2015;16:169-175. https://doi.org/10.1016/j.ptsp.2014.10.006

195. Houston MN, Van Lunen BL, Hoch MC. Health-related quality of life in individuals with chronic ankle instability. *J Athl Train*. 2014;49:758-763. https://doi.org/10.4085/1062-6050-49.3.54

196. Hu Y, Tao H, Qiao Y, et al. Evaluation of the talar cartilage in chronic lateral ankle instability with lateral ligament injury using biochemical T2* mapping: correlation with clinical symptoms. *Acad Radiol*. 2018;25:1415-1421. https://doi.org/10.1016/j.acra.2018.01.021

197. Hubbard-Turner T. Lack of medical treatment from a medical professional after an ankle sprain. *J Athl Train*. 2019;54:671-675. https://doi.org/10.4085/1062-6050-428-17

198. Hubbard-Turner T, Turner MJ. Physical activity levels in college students with chronic ankle instability. *J Athl Train*. 2015;50:742-747. https://doi.org/10.4085/1062-6050-50.3.05

199. Hudson PW, de Cesar Netto C, Araoye IB, Jones CW, Bergstresser SL, Shah A. Preoperative assessment of the peroneal tendons in lateral ankle instability: examining clinical factors, magnetic resonance imaging sensitivity, and their relationship. *J Foot Ankle Surg*. 2019;58:208-212. https://doi.org/10.1053/j.jfas.2018.07.008

200. Hung M, Baumhauer JF, Brodsky JW, et al. Psychometric comparison of the PROMIS Physical Function CAT with the FAAM and FFI for measuring patient-reported outcomes. *Foot Ankle Int*. 2014;35:592-599. https://doi.org/10.1177/1071100714528492

201. Hung M, Baumhauer JF, Latt LD, et al. Validation of PROMIS® Physical Function computerized adaptive tests for orthopaedic foot and ankle outcome research. *Clin Orthop Relat Res*. 2013;471:3466-3474. https://doi.org/10.1007/s11999-013-3097-1

202. Hung M, Baumhauer JF, Licari FW, Bounsanga J, Voss MW, Saltzman CL. Responsiveness of the PROMIS and FAAM instruments in foot and ankle orthopedic population. *Foot Ankle Int*. 2019;40:56-64. https://doi.org/10.1177/1071100718799758

203. Hung M, Baumhauer JF, Licari FW, Voss MW, Bounsanga J, Saltzman CL. PROMIS and FAAM minimal clinically important differences in foot and ankle orthopedics. *Foot Ankle Int*. 2019;40:65-73. https://doi.org/10.1177/1071100718800304

204. Huurnink A, Fransz DP, Kingma I, Verhagen EA, van Dieën JH. Postural stability and ankle sprain history in athletes compared to uninjured controls. *Clin Biomech (Bristol, Avon)*. 2014;29:183-188. https://doi.org/10.1016/j.clinbiomech.2013.11.014

205. Jaber H, Lohman E, Daher N, et al. Neuromuscular control of ankle and hip during performance of the Star Excursion Balance Test in subjects with and without chronic ankle instability. *PLoS One*. 2018;13:e0201479. https://doi.org/10.1371/journal.pone.0201479

206. Jaffri AH, Newman TM, Smith BI, et al. Dynamic leap and balance test: ability to discriminate balance deficits in individuals with chronic ankle instability. *J Sport Rehabil*. 2020;29:263-270. https://doi.org/10.1123/jsr.2018-0380

207. Jeon K, Kim K, Kang N. Leg stiffness control during drop landing movement in individuals with mechanical and functional ankle disabilities. *Sports Biomech*. 2020:1-14. https://doi.org/10.1080/14763141.2020.1726997

208. John C, Stotz A, Gmachowski J, et al. Is an elastic ankle support effective in improving jump landing performance, and static and dynamic balance in young adults with and without chronic ankle instability? *J Sport Rehabil*. 2020;29:789-794. https://doi.org/10.1123/jsr.2019-0147

209. Jonckheer P, Willems T, De Ridder R, et al. Evaluating fracture risk in acute ankle sprains: any news since the Ottawa ankle rules? A systematic review. *Eur J Gen Pract*. 2016;22:31-41. https://doi.org/10.3109/13814788.2015.1102881

210. Kalbouneh HM, Alajoulin O, Alsalem M, et al. Incidence of symptomatic os trigonum among nonathletic patients with ankle sprain. *Surg Radiol Anat*. 2019;41:1433-1439. https://doi.org/10.1007/s00276-019-02354-0

211. Kazemi K, Arab AM, Abdollahi I, López-López D, Calvo-Lobo C. Electromiography [sic] comparison of distal and proximal lower limb muscle activity patterns during external perturbation in subjects with and without functional ankle instability. *Hum Mov Sci*. 2017;55:211-220. https://doi.org/10.1016/j.humov.2017.08.013

212. Kemler E, Thijs KM, Badenbroek I, van de Port IG, Hoes AW, Backx FJ. Long-term prognosis of acute lateral ankle ligamentous sprains: high incidence of recurrences and residual symptoms. *Fam Pract*. 2016;33:596-600. https://doi.org/10.1093/fampra/cmw076

213. Kemler E, van de Port I, Valkenberg H, Hoes AW, Backx FJ. Ankle injuries in the Netherlands: trends over 10-25 years. *Scand J Med Sci Sports*. 2015;25:331-337. https://doi.org/10.1111/sms.12248

214. Kerkhoffs GM, Rowe BH, Assendelft WJ, Kelly K, Struijs PA, van Dijk CN. Immobilisation and functional treatment for acute lateral ankle ligament injuries in adults. *Cochrane Database Syst Rev*. 2002:CD003762. https://doi.org/10.1002/14651858.CD003762

215. Kerr ZY, Gregory AJ, Wosmek J, et al. The first decade of web-based sports injury surveillance: descriptive epidemiology of injuries in US high school girls' volleyball (2005-2006 through 2013-2014) and National Collegiate Athletic Association women's volleyball (2004-2005 through 2013-2014). *J Athl Train*. 2018;53:926-937. https://doi.org/10.4085/1062-6050-162-17

216. Khor YP, Tan KJ. The anatomic pattern of injuries in acute inversion ankle sprains: a magnetic resonance imaging study. *Orthop J Sports Med*. 2013;1:2325967113517078. https://doi.org/10.1177/2325967113517078

217. Kikumoto T, Akatsuka K, Nakamura E, Ito W, Hirabayashi R, Edama M. Quantitative evaluation method for clarifying ankle plantar flexion angles using anterior drawer and inversion stress tests: a cross-sectional study. *J Foot Ankle Res*. 2019;12:27. https://doi.org/10.1186/s13047-019-0337-y

218. Kim CY, Choi JD. Comparison between ankle proprioception measurements and postural sway test for evaluating ankle instability in subjects with functional ankle instability. *J Back Musculoskelet Rehabil*. 2016;29:97-107. https://doi.org/10.3233/BMR-150603

219. Kim CY, Choi JD, Kim HD. No correlation between joint position sense and force sense for measuring ankle proprioception in subjects with healthy and functional ankle instability. *Clin Biomech (Bristol, Avon)*. 2014;29:977-983. https://doi.org/10.1016/j.clinbiomech.2014.08.017

220. Kim E, Choi H, Cha JH, Park JC, Kim T. Effects of neuromuscular training on the rear-foot angle kinematics in elite women field hockey players with chronic ankle instability. *J Sports Sci Med*. 2017;16:137-146.

221. Kim H, Son SJ, Seeley MK, Hopkins JT. Altered movement strategies during jump landing/cutting in patients with chronic ankle instability. *Scand J Med Sci Sports*. 2019;29:1130-1140. https://doi.org/10.1111/sms.13445

222. Kim HS, Yoon YC, Sung KS, Kim MJ, Ahn S. Comparison of T2 relaxation values in subtalar cartilage between patients with lateral instability of the ankle joint and healthy volunteers. *Eur Radiol*. 2018;28:4151-4162. https://doi.org/10.1007/s00330-018-5390-6

223. Kim JB, Kim JK, Seo SG, Lee DY. Validity, reliability, and responsiveness of the Korean version of American Academy of Orthopaedic Surgeons Foot and Ankle Questionnaire. *J Foot Ankle Surg*. 2015;54:46-50. https://doi.org/10.1053/j.jfas.2014.08.011

224. Kim JH, Sung ES. Differences in ankle ROM between young men and women with a history of ankle sprain. *Sportverletz Sportschaden*. 2019;33:82-86. https://doi.org/10.1055/a-0753-7953

225. Kim KM. Higher visual reliance during single-leg balance bilaterally occurring following acute lateral ankle sprain: a potential central mechanism of bilateral sensorimotor deficits. *Gait Posture*. 2020;78:26-29. https://doi.org/10.1016/j.gaitpost.2020.03.003

226. Kim KM, Hart JM, Saliba SA, Hertel J. Modulation of the fibularis longus Hoffmann reflex and postural instability associated with chronic ankle instability. *J Athl Train*. 2016;51:637-643. https://doi.org/10.4085/1062-6050-51.10.05

227. Kim KM, Hart JM, Saliba SA, Hertel J. Relationships between self-reported ankle function and modulation of Hoffmann reflex in patients with chronic ankle instability. *Phys Ther Sport*. 2016;17:63-68. https://doi.org/10.1016/j.ptsp.2015.05.003

228. Kim KM, Kim JS, Oh J, Lee SY. Time-to-boundary analysis of postural control following acute lateral ankle sprain. *Gait Posture*. 2019;67:151-153. https://doi.org/10.1016/j.gaitpost.2018.10.002

229. Kinney M, Seider J, Beaty AF, Coughlin K, Dyal M, Clewley D. The impact of therapeutic alliance in physical therapy for chronic musculoskeletal pain: a systematic review of the literature. *Physiother Theory Pract*. 2020;36:886-898. https://doi.org/10.1080/09593985.2018.1516015

230. Kipp K, Palmieri-Smith RM. Differences in kinematic control of ankle joint motions in people with chronic ankle instability. *Clin Biomech (Bristol, Avon)*. 2013;28:562-567. https://doi.org/10.1016/j.clinbiomech.2013.03.008

231. Ko J, Rosen AB, Brown CN. Comparison between single and combined clinical postural stability tests in individuals with and without chronic ankle instability. *Clin J Sport Med*. 2017;27:394-399. https://doi.org/10.1097/JSM.0000000000000354

232. Ko J, Rosen AB, Brown CN. Cross-cultural adaptation, reliability, and validation of the Korean version of the Identification Functional Ankle Instability (IdFAI). *Disabil Rehabil*. 2018;40:3185-3190. https://doi.org/10.1080/09638288.2017.1375032

233. Ko J, Rosen AB, Brown CN. Functional performance tests identify lateral ankle sprain risk: a prospective pilot study in adolescent soccer players. *Scand J Med Sci Sports*. 2018;28:2611-2616. https://doi.org/10.1111/sms.13279

234. Ko J, Wikstrom E, Li Y, Weber M, Brown CN. Performance differences between the modified Star Excursion Balance Test and the Y-Balance Test in individuals with chronic ankle instability. *J Sport Rehabil*. 2020;29:748-753. https://doi.org/10.1123/jsr.2018-0078

235. Ko KR, Lee H, Lee WY, Sung KS. Ankle strength is not strongly associated with postural stability in patients awaiting surgery for chronic lateral ankle instability. *Knee Surg Sports Traumatol Arthrosc*. 2020;28:326-333. https://doi.org/10.1007/s00167-018-4960-0

236. Kobayashi T, Saka M, Suzuki E, et al. In vivo kinematics of the talocrural and subtalar joints during weightbearing ankle rotation in chronic ankle instability. *Foot Ankle Spec*. 2014;7:13-19. https://doi.org/10.1177/1938640013514269

237. Kobayashi T, Suzuki E, Yamazaki N, et al. Fibular malalignment in individuals with chronic ankle instability. *J Orthop Sports Phys Ther*. 2014;44:872-878. https://doi.org/10.2519/jospt.2014.5217

238. Kobayashi T, Suzuki E, Yamazaki N, et al. In vivo talocrural joint contact mechanics with functional ankle instability. *Foot Ankle Spec*. 2015;8:445-453. https://doi.org/10.1177/1938640015585967

239. Kobayashi T, Watanabe K, Ito T, et al. The effect of novel ankle-realigning socks on dynamic postural stability in individuals with chronic ankle instability. *Int J Sports Phys Ther*. 2019;14:264-272.

240. Kobayashi T, Yoshida M, Yoshida M, Gamada K. Intrinsic predictive factors of noncontact lateral ankle sprain in collegiate athletes: a case-control study. *Orthop J Sports Med*. 2013;1:2325967113518163. https://doi.org/10.1177/2325967113518163

241. Koldenhoven RM, Feger MA, Fraser JJ, Hertel J. Variability in center of pressure position and muscle activation during walking with chronic ankle instability. *J Electromyogr Kinesiol*. 2018;38:155-161. https://doi.

org/10.1016/j.jelekin.2017.12.003

242. Koldenhoven RM, Feger MA, Fraser JJ, Saliba S, Hertel J. Surface electromyography and plantar pressure during walking in young adults with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc*. 2016;24:1060-1070. https://doi.org/10.1007/s00167-016-4015-3

243. Koldenhoven RM, Fraser JJ, Saliba SA, Hertel J. Ultrasonography of gluteal and fibularis muscles during exercises in individuals with a history of lateral ankle sprain. *J Athl Train*. 2019;54:1287-1295. https://doi.org/10.4085/1062-6050-406-18

244. Koldenhoven RM, Hart J, Saliba S, Abel MF, Hertel J. Gait kinematics & kinetics at three walking speeds in individuals with chronic ankle instability and ankle sprain copers. *Gait Posture*. 2019;74:169-175. https://doi.org/10.1016/j.gaitpost.2019.09.010

245. Koltsov JCB, Greenfield ST, Soukup D, Do HT, Ellis SJ. Validation of Patient-Reported Outcomes Measurement Information System computerized adaptive tests against the Foot and Ankle Outcome Score for 6 common foot and ankle pathologies. *Foot Ankle Int*. 2017;38:870-878. https://doi.org/10.1177/1071100717709573

246. Korakakis V, Abassi M, Kotsifak A, Manai H, AbuEsba A. Cross-cultural adaptation and psychometric properties' evaluation of the modern standard Arabic version of Cumberland Ankle Instability Tool (CAIT) in professional athletes. *PLoS One*. 2019;14:e0217987. https://doi.org/10.1371/journal.pone.0217987

247. Koshino Y, Ishida T, Yamanaka M, et al. Kinematics and muscle activities of the lower limb during a side-cutting task in subjects with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc*. 2016;24:1071-1080. https://doi.org/10.1007/s00167-015-3745-y

248. Koshino Y, Yamanaka M, Ezawa Y, et al. Lower limb joint motion during a cross cutting movement differs in individuals with and without chronic ankle instability. *Phys Ther Sport*. 2014;15:242-248. https://doi.org/10.1016/j.ptsp.2013.12.001

249. Kosik KB, Johnson NF, Terada M, Thomas AC, Mattacola CG, Gribble PA. Decreased ankle and hip isometric peak torque in young and middle-aged adults with chronic ankle instability. *Phys Ther Sport*. 2020;43:127-133. https://doi.org/10.1016/j.ptsp.2020.02.014

250. Kosik KB, Johnson NF, Terada M, Thomas AC, Mattacola CG, Gribble PA. Decreased dynamic balance and dorsiflexion range of motion in young and middle-aged adults with chronic ankle instability. *J Sci Med Sport*. 2019;22:976-980. https://doi.org/10.1016/j.jsams.2019.05.005

251. Kosik KB, Johnson NF, Terada M, Thomas-Fenwick AC, Mattacola CG, Gribble PA. Health-related quality of life among middle-aged adults with chronic ankle instability, copers, and uninjured controls. *J Athl Train*. 2020;55:733-738. https://doi.org/10.4085/1062-6050-190-19

252. Kosik KB, Terada M, McCann R, Thomas A, Johnson N, Gribble P. Differences in temporal gait mechanics are associated with decreased perceived ankle joint health in individuals with chronic ankle instability. *Gait Posture*. 2019;70:403-407. https://doi.org/10.1016/j.gaitpost.2019.03.032

253. Kovaleski JE, Heitman RJ, Gurchiek LR, Hollis JM, Liu W, Pearsall AW, 4th. Joint stability characteristics of the ankle complex in female athletes with histories of lateral ankle sprain, part II: clinical experience using arthrometric measurement. *J Athl Train*. 2014;49:198-203. https://doi.org/10.4085/1062-6050-49.2.08

254. Kowalczyk AD, Geminiani ET, Dahlberg BW, Micheli LJ, Sugimoto D. Pediatric and adolescent figure skating injuries: a 15-year retrospective review. *Clin J Sport Med*. In press. https://doi.org/10.1097/JSM.0000000000000743

255. Kros W, Keijsers NLW, van Ochten JM, Bierma-Zeinstra SMA, van Middelkoop M. Center of pressure during stance and gait in subjects with or without persistent complaints after a lateral ankle sprain. *Gait Posture*. 2016;48:24-29. https://doi.org/10.1016/j.gaitpost.2016.04.022

256. Kunugi S, Masunari A, Koumura T, Fujimoto A, Yoshida N, Miyakawa S. Altered lower limb kinematics and muscle activities in soccer players with chronic ankle instability. *Phys Ther Sport*. 2018;34:28-35. https://doi.org/10.1016/j.ptsp.2018.08.003

257. Kunugi S, Masunari A, Yoshida N, Miyakawa S. Association between Cumberland Ankle Instability Tool score and postural stability in collegiate soccer players with and without functional ankle instability. *Phys Ther Sport*. 2018;32:29-33. https://doi.org/10.1016/j.ptsp.2018.03.002

258. Kwon YU. Static postural stability in chronic ankle instability, an ankle sprain and healthy ankles. *Int J Sports Med*. 2018;39:625-629. https://doi.org/10.1055/a-0608-4552

259. Kwon YU, Harrison K, Kweon SJ, Williams DSB, 3rd. Ankle coordination in chronic ankle instability, coper, and control groups in running. *Med Sci Sports Exerc*. 2020;52:663-672. https://doi.org/10.1249/MSS.0000000000002170

260. Laessoe U, Svendsen AW, Christensen MN, Rasmussen JR, Gaml AS. Evaluation of functional ankle instability assessed by an instrumented wobble board. *Phys Ther Sport*. 2019;35:133-138. https://doi.org/10.1016/j.ptsp.2018.12.002

261. Larruskain J, Lekue JA, Diaz N, Odriozola A, Gil SM. A comparison of injuries in elite male and female football players: a five-season prospective study. *Scand J Med Sci Sports*. 2018;28:237-245. https://doi.org/10.1111/sms.12860

262. Lee DJ, Shin HS, Lee JH, Kyung MG, Lee KM, Lee DY. Morphological characteristics of os subfibulare related to failure of conservative treatment of chronic lateral ankle instability. *Foot Ankle Int*. 2020;41:216-222. https://doi.org/10.1177/1071100719884056

263. Lee DO, Kim JH, Song SH, Cho HI, Lee J. Is subtle cavus foot a risk factor for chronic ankle instability? Comparison of prevalence of subtle cavus foot between chronic ankle instability and control group on the standing lateral radiograph. *Foot Ankle Surg*. 2020;26:907-910. https://doi.org/10.1016/j.fas.2019.12.001

264. Lee JH, Lee SH, Choi GW, Jung HW, Jang WY. Individuals with recurrent ankle sprain demonstrate postural instability and neuromuscular control deficits in unaffected side. *Knee Surg Sports Traumatol Arthrosc*. 2020;28:184-192. https://doi.org/10.1007/s00167-018-5190-1

265. Lee S, Yoon YC, Kim JH. T2 mapping of the articular cartilage in the ankle: correlation to the status of anterior talofibular ligament. *Clin Radiol*. 2013;68:e355-e361. https://doi.org/10.1016/j.crad.2013.01.023

266. Lee SH, Yun SJ. Ankle ultrasound for detecting anterior talofibular ligament tear using operative finding as reference standard: a systematic review and meta-analysis. *Eur J Trauma Emerg Surg*. 2020;46:73-81. https://doi.org/10.1007/s00068-019-01169-3

267. Lentz TA, Sutton Z, Greenberg S, Bishop MD. Pain-related fear contributes to self-reported disability in patients with foot and ankle pathology. *Arch Phys Med Rehabil*. 2010;91:557-561. https://doi.org/10.1016/j.apmr.2009.12.010

268. Leppänen M, Aaltonen S, Parkkari J, Heinonen A, Kujala UM. Interventions to prevent sports related injuries: a systematic review and meta-analysis of randomised controlled trials. *Sports Med*. 2014;44:473-486. https://doi.org/10.1007/s40279-013-0136-8

269. Levin O, Vanwanseele B, Thijsen JR, Helsen WF, Staes FF, Duysens J. Proactive and reactive neuromuscular control in subjects with chronic ankle instability: evidence from a pilot study on landing. *Gait Posture*. 2015;41:106-111. https://doi.org/10.1016/j.gaitpost.2014.09.005

270. Li HY, Li WL, Chen SY, Hua YH. Increased ATFL–PTFL angle could be an indirect MRI sign in diagnosis of chronic ATFL injury. *Knee Surg Sports Traumatol Arthrosc*. 2020;28:208-212. https://doi.org/10.1007/s00167-018-5252-4

271. Li HY, Zhou RS, Hua YH, Chen SY. MRI identification of the fibular and talus position in patients with mechanical ankle instability. *Int J Sports Med*. 2017;38:546-550. https://doi.org/10.1055/s-0043-106741

272. Li Q, Tu Y, Chen J, et al. Reverse anterolateral drawer test is more sensitive and accurate for diagnosing chronic anterior talofibular ligament injury. *Knee Surg Sports Traumatol Arthrosc*. 2020;28:55-62. https://doi.org/10.1007/s00167-019-05705-x

273. Li Y, Guan L, Ko J, Zhang S, Brown CN, Simpson KJ. Cross-cultural adaptation and validation of an ankle instability questionnaire for use in Chinese-speaking population. *J Sport Health Sci*. 2019;8:555-560. https://doi.org/10.1016/j.jshs.2017.04.003

274. Li Y, Ko J, Walker M, et al. Does chronic ankle instability influence knee biomechanics of females during inverted surface landings? *Int J Sports Med*. 2018;39:1009-1017. https://doi.org/10.1055/s-0044-102130
275. Li Y, Ko J, Walker MA, et al. Does chronic ankle instability influence lower extremity muscle activation of females during landing? *J Electromyogr Kinesiol*. 2018;38:81-87. https://doi.org/10.1016/j.jelekin.2017.11.009
276. Lilley T, Herb CC, Hart J, Hertel J. Lower extremity joint coupling variability during gait in young adults with and without chronic ankle instability. *Sports Biomech*. 2018;17:261-272. https://doi.org/10.1080/14763141.2017.1287215
277. Lin CH, Chiang SL, Lu LH, Wei SH, Sung WH. Validity of an ankle joint motion and position sense measurement system and its application in healthy subjects and patients with ankle sprain. *Comput Methods Programs Biomed*. 2016;131:89-96. https://doi.org/10.1016/j.cmpb.2016.03.026
278. Lin CW, Uegaki K, Coupé VM, Kerkhoffs GM, van Tulder MW. Economic evaluations of diagnostic tests, treatment and prevention for lateral ankle sprains: a systematic review. *Br J Sports Med*. 2013;47:1144-1149. https://doi.org/10.1136/bjsports-2012-090319
279. Lin JZ, Lin YA, Lee HJ. Are landing biomechanics altered in elite athletes with chronic ankle instability. *J Sports Sci Med*. 2019;18:653-662.
280. Linens SW, Ross SE, Arnold BL, Gayle R, Pidcoe P. Postural-stability tests that identify individuals with chronic ankle instability. *J Athl Train*. 2014;49:15-23. https://doi.org/10.4085/1062-6050-48.6.09
281. Lintz F, Bernasconi A, Baschet L, et al. Relationship between chronic lateral ankle instability and hindfoot varus using weight-bearing cone beam computed tomography. *Foot Ankle Int*. 2019;40:1175-1181. https://doi.org/10.1177/1071100719858309
282. Liszka H, Depukat P, Gądek A. Intra-articular pathologies associated with chronic ankle instability. *Folia Med Cracov*. 2016;56:95-100.
283. Liu K, Glutting J, Wikstrom E, Gustavsen G, Royer T, Kaminski TW. Examining the diagnostic accuracy of dynamic postural stability measures in differentiating among ankle instability status. *Clin Biomech (Bristol, Avon)*. 2013;28:211-217. https://doi.org/10.1016/j.clinbiomech.2012.11.003
284. Liu K, Gustavsen G, Royer T, Wikstrom EA, Glutting J, Kaminski TW. Increased ligament thickness in previously sprained ankles as measured by musculoskeletal ultrasound. *J Athl Train*. 2015;50:193-198. https://doi.org/10.4085/1062-6050-49.3.77
285. Lobo CC, Morales CR, Sanz DR, Corbalán IS, Marín AG, López DL. Ultrasonography comparison of peroneus muscle cross-sectional area in subjects with or without lateral ankle sprains. *J Manipulative Physiol Ther*. 2016;39:635-644. https://doi.org/10.1016/j.jmpt.2016.09.001
286. Locquet M, Benhotman B, Bornheim S, et al. The "Ankle Instability Instrument": cross-cultural adaptation and validation in French. *Foot Ankle Surg*. 2021;27:70-76. https://doi.org/10.1016/j.fas.2020.02.006
287. Lohrer H, Nauck T, Gehring D, Wissler S, Braag B, Gollhofer A. Differences between mechanically stable and unstable chronic ankle instability subgroups when examined by arthrometer and FAAM-G. *J Orthop Surg Res*. 2015;10:32. https://doi.org/10.1186/s13018-015-0171-2
288. Lopezosa-Reca E, Gijon-Nogueron G, Morales-Asencio JM, Cervera-Marin JA, Luque-Suarez A. Is there any association between foot posture and lower limb–related injuries in professional male basketball players? A cross-sectional study. *Clin J Sport Med*. 2020;30:46-51.
289. López-Segovia M, Vivo Fernández I, Herrero Carrasco R, Pareja Blanco F. Preseason injury characteristics in Spanish professional futsal players: the LNFS project. *J Strength Cond Res*. In press. https://doi.org/10.1519/JSC.0000000000003419
290. Loudon JK, Reiman MP, Sylvain J. The efficacy of manual joint mobilisation/manipulation in treatment of lateral ankle sprains: a systematic review. *Br J Sports Med*. 2014;48:365-370. https://doi.org/10.1136/bjsports-2013-092763
291. Lucasti CJ, Dworkin M, Warrender WJ, et al. Ankle and lower leg injuries in professional baseball players. *Am J Sports Med*. 2020;48:908-915. https://doi.org/10.1177/0363546520902135
292. Madsen LP, Kitano K, Koceja DM, Zehr EP, Docherty CL. Effects of chronic ankle instability on cutaneous reflex modulation during walking. *Exp Brain Res*. 2019;237:1959-1971. https://doi.org/10.1007/s00221-019-05565-4
293. Mailuhu AKE, Oei EHG, van Ochten JM, Bindels PJE, Bierma-Zeinstra SMA, van Middelkoop M. Subgroup characteristics of patients with chronic ankle instability in primary care. *J Sci Med Sport*. 2019;22:866-870. https://doi.org/10.1016/j.jsams.2019.02.009
294. Mailuhu AKE, Oei EHG, van Putte-Katier N, et al. Clinical and radiological predictors for persistent complaints five years after a lateral ankle sprain: a long-term follow-up study in primary care. *J Sci Med Sport*. 2018;21:250-256. https://doi.org/10.1016/j.jsams.2017.07.005
295. Mansfield CJ, Vanetten L, Willy R, Di Stasi S, Magnussen R, Briggs M. The effects of needling therapies on muscle force production: a systematic review and meta-analysis. *J Orthop Sports Phys Ther*. 2019;49:154-170. https://doi.org/10.2519/jospt.2019.8270
296. Marinho HVR, Amaral GM, de Souza Moreira B, et al. Influence of passive joint stiffness on proprioceptive acuity in individuals with functional instability of the ankle. *J Orthop Sports Phys Ther*. 2017;47:899-905. https://doi.org/10.2519/jospt.2017.7030
297. Marshall AN, Snyder Valier AR, Yanda A, Lam KC. The impact of a previous ankle injury on current health-related quality of life in college athletes. *J Sport Rehabil*. 2020;29:43-50. https://doi.org/10.1123/jsr.2018-0249
298. Martin RL, Davenport TE, Paulseth S, Wukich DK, Godges JJ. Ankle stability and movement coordination impairments: ankle ligament sprains. *J Orthop Sports Phys Ther*. 2013;43:A1-A40. https://doi.org/10.2519/jospt.2013.0305
299. Martinez BR, Lopes Sauers AD, Ferreira CL, et al. Translation, cross-cultural adaptation, and measurement properties of the Brazilian version of the Identification of Functional Ankle Instability (IdFAI) questionnaire. *Phys Ther Sport*. 2018;29:1-8. https://doi.org/10.1016/j.ptsp.2017.09.004
300. Martinez BR, Staboli IM, Kamonseki DH, Budiman-Mak E, Yi LC. Validity and reliability of the Foot Function Index (FFI) questionnaire Brazilian-Portuguese version. *Springerplus*. 2016;5:1810. https://doi.org/10.1186/s40064-016-3507-4
301. McCann RS, Bolding BA, Terada M, Kosik KB, Crossett ID, Gribble PA. Isometric hip strength and dynamic stability of individuals with chronic ankle instability. *J Athl Train*. 2018;53:672-678. https://doi.org/10.4085/1062-6050-238-17
302. McCann RS, Crossett ID, Terada M, Kosik KB, Bolding BA, Gribble PA. Hip strength and Star Excursion Balance Test deficits of patients with chronic ankle instability. *J Sci Med Sport*. 2017;20:992-996. https://doi.org/10.1016/j.jsams.2017.05.005
303. McCann RS, Gribble PA. Resilience and self-efficacy: a theory-based model of chronic ankle instability. *Int J Athl Ther Train*. 2016;21:32-37. https://doi.org/10.1123/ijatt.2015-0032
304. McCann RS, Kosik KB, Terada M, Gribble PA. Prediction of recurrent injury in the same competitive sport season following return-to-play from an ankle sprain. *Int J Athl Ther Train*. 2019;24:78-84. https://doi.org/10.1123/ijatt.2018-0006
305. McCann RS, Terada M, Kosik KB, Gribble PA. Landing kinematics and isometric hip strength of individuals with chronic ankle instability. *Foot Ankle Int*. 2019;40:969-977. https://doi.org/10.1177/1071100719846085
306. McCarthy MM, Voos JE, Nguyen JT, Callahan L, Hannafin JA. Injury profile in elite female basketball athletes at the Women's National Basketball Association combine. *Am J Sports Med*. 2013;41:645-651. https://doi.org/10.1177/0363546512474223
307. McCunn R, aus der Fünten K, Whalan M, Sampson JA, Meyer T. Soccer Injury Movement Screen (SIMS) composite score is not associated with injury among semiprofessional soccer players. *J Orthop Sports Phys Ther*. 2018;48:630-636. https://doi.org/10.2519/jospt.2018.8037
308. McLeod MM, Gribble PA, Pietrosimone BG. Chronic ankle instability and neural excitability of the lower extremity. *J Athl Train*. 2015;50:847-853. https://doi.org/10.4085/1062-6050-50.4.06
309. Medina McKeon JM, Bush HM, Reed A, Whittington A, Uhl TL, McKeon PO. Return-to-play probabilities following new versus recurrent ankle sprains in high school athletes. *J Sci Med Sport*. 2014;17:23-28. https://doi.org/10.1016/j.jsams.2013.04.006

310. Miller JR, Dunn KW, Ciliberti LJ, Jr., Eldridge SW, Reed LD. Diagnostic value of early magnetic resonance imaging after acute lateral ankle injury. *J Foot Ankle Surg*. 2017;56:1143-1146. https://doi.org/10.1053/j.jfas.2017.05.011
311. Mineta S, Inami T, Fukano M, et al. The reliability, and discriminative ability of the Identification of Functional Ankle Instability questionnaire, Japanese version. *Phys Ther Sport*. 2019;35:1-6. https://doi.org/10.1016/j.ptsp.2018.10.013
312. Mirshahi M, Halabchi F, Golbakhsh M, Saadat S. Reliability and recalibration of the Persian version of Cumberland Ankle Instability Tool cut-off score in athletes with functional ankle instability. *Adv J Emerg Med*. 2019;3:e26.
313. Miyamoto W, Takao M, Matsushita T. Anterior fibrous bundle: a cause of residual pain and restrictive plantar flexion following ankle sprain. *Knee Surg Sports Traumatol Arthrosc*. 2013;21:1385-1389. https://doi.org/10.1007/s00167-012-2053-z
314. Mizrahi DJ, Nazarian LN, Parker L. Evaluation of the anterior talofibular ligament via stress sonography in asymptomatic and symptomatic populations. *J Ultrasound Med*. 2018;37:1957-1963. https://doi.org/10.1002/jum.14542
315. Mohamadi S, Dadgoo M, Ebrahimi I, Salavati M, Saeedi A, Valiollahi B. Translation, cross-cultural adaptation, reliability, and validity of the Identification of Functional Ankle Instability questionnaire in Persian speaking participants with a history of ankle sprain. *Disabil Rehabil*. 2019;41:1931-1936. https://doi.org/10.1080/09638288.2018.1452053
316. Mohamadi S, Ebrahimi I, Dadgoo M, Salavati M, Saeedi A, Valiollahi B. Translation, cross-cultural adaptation and factor analysis of the Persian version of Ankle Instability Instrument. *Med J Islam Repub Iran*. 2018;32:79. https://doi.org/10.14196/mjiri.32.79
317. Moisan G, Descarreaux M, Cantin V. Effects of chronic ankle instability on kinetics, kinematics and muscle activity during walking and running: a systematic review. *Gait Posture*. 2017;52:381-399. https://doi.org/10.1016/j.gaitpost.2016.11.037
318. Moisan G, Mainville C, Descarreaux M, Cantin V. Kinematic, kinetic and electromyographic differences between young adults with and without chronic ankle instability during walking. *J Electromyogr Kinesiol*. 2020;51:102399. https://doi.org/10.1016/j.jelekin.2020.102399
319. Moisan G, Mainville C, Descarreaux M, Cantin V. Unilateral jump landing neuromechanics of individuals with chronic ankle instability. *J Sci Med Sport*. 2020;23:430-436. https://doi.org/10.1016/j.jsams.2019.11.003
320. Mojza K, Krzak K, Bączkowicz D. Subjective and objective evaluation of the functional condition after a single lateral sprain of the ankle in athletes. *Ortop Traumatol Rehabil*. 2018;20:455-463. https://doi.org/10.5604/01.3001.0012.8392
321. Mónaco M, Rincón JAG, Ronsano BJM, Whiteley R, Sanz-Lopez F, Rodas G. Injury incidence and injury patterns by category, player position, and maturation in elite male handball elite players. *Biol Sport*. 2019;36:67-74. https://doi.org/10.5114/biolsport.2018.78908
322. Mońka M, Jagintowicz M, Chudzik W. Types and incidences of sport injuries in male volleyball and handball players. *Fizjoterapia*. 2015;23:3-16.
323. Moonen PJ, Mercelina L, Boer W, Fret T. Diagnostic error in the Emergency Department: follow up of patients with minor trauma in the outpatient clinic. *Scand J Trauma Resusc Emerg Med*. 2017;25:13. https://doi.org/10.1186/s13049-017-0361-5
324. Moreno-Alcaraz VJ, Cejudo A, Sainz de Baranda P. Injury types and frequency in Spanish inline hockey players. *Phys Ther Sport*. 2020;42:91-99. https://doi.org/10.1016/j.ptsp.2020.01.003
325. Morssinkhof ML, Wang O, James L, van der Heide HJ, Winson IG. Development and validation of the Sports Athlete Foot and Ankle Score: an instrument for sports-related ankle injuries. *Foot Ankle Surg*. 2013;19:162-167. https://doi.org/10.1016/j.fas.2013.02.001
326. Mulcahey MK, Bernhardson AS, Murphy CP, et al. The epidemiology of ankle injuries identified at the National Football League Combine, 2009-2015. *Orthop J Sports Med*. 2018;6:2325967118786227. https://doi.org/10.1177/2325967118786227
327. Mun JU, Cho HR, Sung YJ, et al. The role of the anterior talofibular ligament area as a morphological parameter of the chronic ankle sprain. *J Orthop Sci*. 2020;25:297-302. https://doi.org/10.1016/j.jos.2019.05.001
328. Murphy J, Weiner DA, Kotler J, et al. Utility of Ottawa ankle rules in an aging population: evidence for addition of an age criterion. *J Foot Ankle Surg*. 2020;59:286-290. https://doi.org/10.1053/j.jfas.2019.04.017
329. Nabian MH, Zadegan SA, Zanjani LO, Mehrpour SR. Epidemiology of joint dislocations and ligamentous/tendinous injuries among 2,700 patients: five-year trend of a tertiary center in Iran. *Arch Bone Jt Surg*. 2017;5:426-434. https://doi.org/10.22038/abjs.2017.18370.1470
330. Nanbancha A, Tretriluxana J, Limroongreungrat W, Sinsurin K. Decreased supraspinal control and neuromuscular function controlling the ankle joint in athletes with chronic ankle instability. *Eur J Appl Physiol*. 2019;119:2041-2052. https://doi.org/10.1007/s00421-019-04191-w
331. Needle AR, Kaminski TW, Baumeister J, Higginson JS, Farquhar WB, Swanik CB. The relationship between joint stiffness and muscle activity in unstable ankles and copers. *J Sport Rehabil*. 2017;26:15-25. https://doi.org/10.1123/jsr.2015-0061
332. Needle AR, Palmer JA, Kesar TM, Binder-Macleod SA, Swanik CB. Brain regulation of muscle tone in healthy and functionally unstable ankles. *J Sport Rehabil*. 2013;22:202-211. https://doi.org/10.1123/jsr.22.3.202
333. Negahban H, Moradi-Bousari A, Naghibi S, et al. The eccentric torque production capacity of the ankle, knee, and hip muscle groups in patients with unilateral chronic ankle instability. *Asian J Sports Med*. 2013;4:144-152. https://doi.org/10.5812/asjsm.34515
334. Northeast L, Gautrey CN, Bottoms L, Hughes G, Mitchell ACS, Greenhalgh A. Full gait cycle analysis of lower limb and trunk kinematics and muscle activations during walking in participants with and without ankle instability. *Gait Posture*. 2018;64:114-118. https://doi.org/10.1016/j.gaitpost.2018.06.001
335. O'Connor SR, Bleakley CM, Tully MA, McDonough SM. Predicting functional recovery after acute ankle sprain. *PLoS One*. 2013;8:e72124. https://doi.org/10.1371/journal.pone.0072124
336. Olmsted LC, Vela LI, Denegar CR, Hertel J. Prophylactic ankle taping and bracing: a numbers-needed-to-treat and cost-benefit analysis. *J Athl Train*. 2004;39:95-100.
337. Osbahr DC, Drakos MC, Lyman S, Barnes RP, Kennedy JG, Warren RF. Syndesmosis and lateral ankle sprains in the National Football League. *Orthopedics*. 2013;36:e1378-e1384. https://doi.org/10.3928/01477447-20131021-18
338. Otzel DM, Hass CJ, Wikstrom EA, Bishop MD, Borsa PA, Tillman MD. Motoneuron function does not change following whole-body vibration in individuals with chronic ankle instability. *J Sport Rehabil*. 2019;28:614-622. https://doi.org/10.1123/jsr.2017-0364
339. Paradis M, Stiell I, Atkinson KM, et al. Acceptability of a mobile clinical decision tool among emergency department clinicians: development and evaluation of the Ottawa Rules app. *JMIR Mhealth Uhealth*. 2018;6:e10263. https://doi.org/10.2196/10263
340. Park BS, Chung CY, Park MS, et al. Inverse relationship between radiographic lateral ankle instability and osteochondral lesions of the talus in patients with ankle inversion injuries. *Foot Ankle Int*. 2019;40:1368-1374. https://doi.org/10.1177/1071100719868476
341. Park J, Hahn S, Park JY, Park HJ, Lee H. Acupuncture for ankle sprain: systematic review and meta-analysis. *BMC Complement Altern Med*. 2013;13:55. https://doi.org/10.1186/1472-6882-13-55
342. Park SJ, Jeong HJ, Shin HK, et al. Rotational and varus instability in chronic lateral ankle instability: in vivo 3D biomechanical analysis. *Acta Med Okayama*. 2018;72:583-589. https://doi.org/10.18926/AMO/56376
343. Park YH, Park SH, Kim SH, Choi GW, Kim HJ. Relationship between isokinetic muscle strength and functional tests in chronic ankle instability. *J Foot Ankle Surg*. 2019;58:1187-1191. https://doi.org/10.1053/j.jfas.2019.04.005
344. Parviainen M, Pihlajamäki H, Kautiainen H, Kiviranta I. Incidence and risk factors of foot and ankle disorders in male Finnish conscripts. *Mil Med*. 2019;184:e352-e358. https://doi.org/10.1093/milmed/usy297
345. Pasanen K, Bruun M, Vasankari T, Nurminen M, Frey WO. Injuries during the international floorball tournaments from 2012 to 2015.

BMJ Open Sport Exerc Med. 2016;2:e000217. https://doi.org/10.1136/bmjsem-2016-000217

346. Pasanen K, Ekola T, Vasankari T, et al. High ankle injury rate in adolescent basketball: a 3-year prospective follow-up study. *Scand J Med Sci Sports*. 2017;27:643-649. https://doi.org/10.1111/sms.12818
347. Perron M, Moffet H, Nadeau S, Hébert LJ, Belzile S. Persistence of long term isokinetic strength deficits in subjects with lateral ankle sprain as measured with a protocol including maximal preloading. *Clin Biomech (Bristol, Avon)*. 2014;29:1151-1157. https://doi.org/10.1016/j.clinbiomech.2014.09.010
348. Petersen W, Rembitzki IV, Koppenburg AG, et al. Treatment of acute ankle ligament injuries: a systematic review. *Arch Orthop Trauma Surg*. 2013;133:1129-1141. https://doi.org/10.1007/s00402-013-1742-5
349. Pierobon A, Raguzzi I, Soliño S, et al. Minimal detectable change and reliability of the Star Excursion Balance Test in patients with lateral ankle sprain. *Physiother Res Int*. 2020;25:e1850. https://doi.org/10.1002/pri.1850
350. Pionnier R, Découfour N, Barbier F, Popineau C, Simoneau-Buessinger E. Unipodal landing in individuals with unilateral chronic ankle instability [abstract]. *Comput Methods Biomech Biomed Engin*. 2014;17 suppl 1:100-101. https://doi.org/10.1080/10255842.2014.931334
351. Pires R, Pereira A, Abreu ESG, et al. Ottawa ankle rules and subjective surgeon perception to evaluate radiograph necessity following foot and ankle sprain. *Ann Med Health Sci Res*. 2014;4:432-435.
352. Plante JE, Wikstrom EA. Differences in clinician-oriented outcomes among controls, copers, and chronic ankle instability groups. *Phys Ther Sport*. 2013;14:221-226. https://doi.org/10.1016/j.ptsp.2012.09.005
353. Pourgharib Shahi MH, Selk Ghaffari M, Mansournia MA, Halabchi F. Risk factors influencing the incidence of ankle sprain among elite football and basketball players: a prospective study. *Foot Ankle Spec*. 2020:1938640020921251. https://doi.org/10.1177/1938640020921251
354. Pourkazemi F, Hiller C, Raymond J, Black D, Nightingale E, Refshauge K. Using balance tests to discriminate between participants with a recent index lateral ankle sprain and healthy control participants: a cross-sectional study. *J Athl Train*. 2016;51:213-222. https://doi.org/10.4085/1062-6050-51.4.11
355. Pourkazemi F, Hiller CE, Raymond J, Black D, Nightingale EJ, Refshauge KM. Predictors of recurrent sprains after an index lateral ankle sprain: a longitudinal study. *Physiotherapy*. 2018;104:430-437. https://doi.org/10.1016/j.physio.2017.10.004
356. Powden CJ, Hoch JM, Hoch MC. Rehabilitation and improvement of health-related quality-of-life detriments in individuals with chronic ankle instability: a meta-analysis. *J Athl Train*. 2017;52:753-765. https://doi.org/10.4085/1062-6050-52.5.01
357. Powers CM, Ghoddosi N, Straub RK, Khayambashi K. Hip strength as a predictor of ankle sprains in male soccer players: a prospective study. *J Athl Train*. 2017;52:1048-1055. https://doi.org/10.4085/1062-6050-52.11.18
358. Prudêncio DA, Serafim TT, Marinho Mateus Lopes A, Maffulli N, Okubo R. Questionnaires and scales for assessment of ankle function: a systematic review of instruments translated and validated for Brazilian Portuguese. *Disabil Rehabil*. 2021;43:309-316. https://doi.org/10.1080/09638288.2019.1626917
359. Punt IM, Ziltener JL, Laidet M, Armand S, Allet L. Gait and physical impairments in patients with acute ankle sprains who did not receive physical therapy. *PM R*. 2015;7:34-41. https://doi.org/10.1016/j.pmrj.2014.06.014
360. Qi B, Liu JQ, Liu GL. Genetic association between *ACTN3* polymorphism and risk of non-acute ankle sprain. *Genet Mol Res*. 2016;15:gmr15048962. https://doi.org/10.4238/gmr15048962
361. Ramkumar PN, Farber J, Arnouk J, Varner KE, McCulloch PC. Injuries in a professional ballet dance company: a 10-year retrospective study. *J Dance Med Sci*. 2016;20:30-37. https://doi.org/10.12678/1089-313X.20.1.30
362. Ranson C, George J, Rafferty J, Miles J, Moore I. Playing surface and UK professional rugby union injury risk. *J Sports Sci*. 2018;36:2393-2398. https://doi.org/10.1080/02640414.2018.1458588
363. Reeser JC, Gregory A, Berg RL, Comstock RD. A comparison of women's collegiate and girls' high school volleyball injury data collected prospectively over a 4-year period. *Sports Health*. 2015;7:504-510. https://doi.org/10.1177/1941738115600143
364. Reiner MM, Sharpe JJ. The role of the accessory malleolar ossicles and malleolar avulsion fractures in lateral ankle ligament reconstruction. *Foot Ankle Spec*. 2018;11:308-314. https://doi.org/10.1177/1938640017729498
365. Rice H, Nunns M, House C, Fallowfield J, Allsopp A, Dixon S. High medial plantar pressures during barefoot running are associated with increased risk of ankle inversion injury in Royal Marine recruits. *Gait Posture*. 2013;38:614-618. https://doi.org/10.1016/j.gaitpost.2013.02.001
366. Rice H, Nunns M, House C, Fallowfield J, Allsopp A, Dixon S. A narrow bimalleolar width is a risk factor for ankle inversion injury in male military recruits: a prospective study. *Clin Biomech (Bristol, Avon)*. 2017;41:14-19. https://doi.org/10.1016/j.clinbiomech.2016.11.001
367. Rios JL, Gorges AL, dos Santos MJ. Individuals with chronic ankle instability compensate for their ankle deficits using proximal musculature to maintain reduced postural sway while kicking a ball. *Hum Mov Sci*. 2015;43:33-44. https://doi.org/10.1016/j.humov.2015.07.001
368. Rodas G, Bove T, Caparrós T, et al. Ankle sprain versus muscle strain injury in professional men's basketball: a 9-year prospective follow-up study. *Orthop J Sports Med*. 2019;7:2325967119849035. https://doi.org/10.1177/2325967119849035
369. Rodríguez-Fernández ÁL, Rebollo-Roldán J, Jiménez-Rejano JJ, Güeita-Rodríguez J. Psychometric properties of the Spanish version of the Cumberland Ankle Instability Tool. *Disabil Rehabil*. 2015;37:1888-1894. https://doi.org/10.3109/09638288.2014.984879
370. Roe M, Murphy JC, Gissane C, Blake C. Time to get our four priorities right: an 8-year prospective investigation of 1326 player-seasons to identify the frequency, nature, and burden of time-loss injuries in elite Gaelic football. *PeerJ*. 2018;6:e4895. https://doi.org/10.7717/peerj.4895
371. Roemer FW, Jomaah N, Niu J, et al. Ligamentous injuries and the risk of associated tissue damage in acute ankle sprains in athletes: a cross-sectional MRI study. *Am J Sports Med*. 2014;42:1549-1557. https://doi.org/10.1177/0363546514529643
372. Roos KG, Kerr ZY, Mauntel TC, Djoko A, Dompier TP, Wikstrom EA. The epidemiology of lateral ligament complex ankle sprains in National Collegiate Athletic Association sports. *Am J Sports Med*. 2017;45:201-209. https://doi.org/10.1177/0363546516660980
373. Rosen A, Ko J, Brown C. A multivariate assessment of clinical contributions to the severity of perceived dysfunction measured by the Cumberland Ankle Instability Tool. *Int J Sports Med*. 2016;37:1154-1158. https://doi.org/10.1055/s-0042-113464
374. Rosen AB, Johnston M, Chung S, Burcal CJ. The reliability and validity of a digital version of the Cumberland Ankle Instability Tool. *Disabil Rehabil*. In press. https://doi.org/10.1080/09638288.2019.1671504
375. Rosen AB, McGrath ML, Maerlender AL. Males with chronic ankle instability demonstrate deficits in neurocognitive function compared to control and copers. *Res Sports Med*. 2021;29:116-128. https://doi.org/10.1080/15438627.2020.1723099
376. Rosen AB, Needle AR, Ko J. Ability of functional performance tests to identify individuals with chronic ankle instability: a systematic review with meta-analysis. *Clin J Sport Med*. 2019;29:509-522.
377. Rosen AB, Yentes JM, McGrath ML, Maerlender AC, Myers SA, Mukherjee M. Alterations in cortical activation among individuals with chronic ankle instability during single-limb postural control. *J Athl Train*. 2019;54:718-726. https://doi.org/10.4085/1062-6050-448-17
378. Rossi A, Blaustein S, Brown J, et al. Spinal and peripheral dry needling versus peripheral dry needling alone among individuals with a history of lateral ankle sprain: a randomized controlled trial. *Int J Sports Phys Ther*. 2017;12:1034-1047.
379. Saavedra-Miranda M, Mendez-Rebolledo G. Measurement and relationships of proprioceptive isokinetic repositioning, postural control, and a self-reported questionnaire in patients with chronic ankle instability. *Isokinet Exerc Sci*. 2017;25:33-39. https://doi.org/10.3233/IES-160642
380. Sakai S, Urabe Y, Morikawa M, et al. Quantity and quality of the pero-

neus longus assessed using ultrasonography in leg with chronic ankle instability. *J Phys Ther Sci*. 2018;30:1396-1400. https://doi.org/10.1589/jpts.30.1396

381. Salhab HA, Fares MY, Khachfe HH, Fares J. Musculoskeletal lower limb injuries in Major League Baseball. *Phys Ther Sport*. 2019;39:38-43. https://doi.org/10.1016/j.ptsp.2019.06.007

382. Salom-Moreno J, Ayuso-Casado B, Tamaral-Costa B, Sánchez-Milá Z, Fernández-de-las-Peñas C, Alburquerque-Sendín F. Trigger point dry needling and proprioceptive exercises for the management of chronic ankle instability: a randomized clinical trial. *Evid Based Complement Alternat Med*. 2015;2015:790209. https://doi.org/10.1155/2015/790209

383. Samadi H, Rajabi R. Comparing the onset of pre-activity of leg muscles between athletes with functional ankle instability and healthy athletes during landing from a jump. *J Babol Univ Med Sci*. 2017;19:7-13.

384. Schlussel MM, Keene DJ, Collins GS, et al. Development and prospective external validation of a tool to predict poor recovery at 9 months after acute ankle sprain in UK emergency departments: the SPRAINED prognostic model. *BMJ Open*. 2018;8:e022802. https://doi.org/10.1136/bmjopen-2018-022802

385. Sconfienza LM, Albano D, Allen G, et al. Clinical indications for musculoskeletal ultrasound updated in 2017 by European Society of Musculoskeletal Radiology (ESSR) consensus. *Eur Radiol*. 2018;28:5338-5351. https://doi.org/10.1007/s00330-018-5474-3

386. Seok H, Lee SH, Yun SJ. Diagnostic performance of ankle ultrasound for diagnosing anterior talofibular and calcaneofibular ligament injuries: a meta-analysis. *Acta Radiol*. 2020;61:651-661. https://doi.org/10.1177/0284185119873119

387. Shah S, Thomas AC, Noone JM, Blanchette CM, Wikstrom EA. Incidence and cost of ankle sprains in United States emergency departments. *Sports Health*. 2016;8:547-552. https://doi.org/10.1177/1941738116659639

388. Shang X, Li Z, Cao X, et al. The association between the *ACTN3* R577X polymorphism and noncontact acute ankle sprains. *J Sports Sci*. 2015;33:1775-1779. https://doi.org/10.1080/02640414.2015.1012098

389. Sharma J, Greeves JP, Byers M, Bennett AN, Spears IR. Musculoskeletal injuries in British Army recruits: a prospective study of diagnosis-specific incidence and rehabilitation times. *BMC Musculoskelet Disord*. 2015;16:106. https://doi.org/10.1186/s12891-015-0558-6

390. Shi X, Han J, Witchalls J, Waddington G, Adams R. Does treatment duration of manual therapy influence functional outcomes for individuals with chronic ankle instability: a systematic review with meta-analysis? *Musculoskelet Sci Pract*. 2019;40:87-95. https://doi.org/10.1016/j.msksp.2019.01.015

391. Shivarathre DG, Howard N, Krishna S, Cowan C, Platt SR. Psychological factors and personality traits associated with patients in chronic foot and ankle pain. *Foot Ankle Int*. 2014;35:1103-1107. https://doi.org/10.1177/1071100714550648

392. Sierra-Guzmán R, Jiménez F, Abián-Vicén J. Predictors of chronic ankle instability: analysis of peroneal reaction time, dynamic balance and isokinetic strength. *Clin Biomech (Bristol, Avon)*. 2018;54:28-33. https://doi.org/10.1016/j.clinbiomech.2018.03.001

393. Silveira PC, Ip IK, Sumption S, Raja AS, Tajmir S, Khorasani R. Impact of a clinical decision support tool on adherence to the Ottawa Ankle Rules. *Am J Emerg Med*. 2016;34:412-418. https://doi.org/10.1016/j.ajem.2015.11.028

394. Simon J, Donahue M, Docherty CL. Critical review of self-reported functional ankle instability measures: a follow up. *Phys Ther Sport*. 2014;15:97-100. https://doi.org/10.1016/j.ptsp.2013.03.005

395. Simon JE, Docherty CL. Health-related quality of life is decreased in middle-aged adults with chronic ankle instability. *J Sci Med Sport*. 2018;21:1206-1209. https://doi.org/10.1016/j.jsams.2018.05.008

396. Simpson JD, Rendos NK, Stewart EM, et al. Bilateral spatiotemporal postural control impairments are present in participants with chronic ankle instability. *Phys Ther Sport*. 2019;39:1-7. https://doi.org/10.1016/j.ptsp.2019.06.002

397. Simpson JD, Stewart EM, Macias DM, Chander H, Knight AC. Individuals with chronic ankle instability exhibit dynamic postural stability deficits and altered unilateral landing biomechanics: a systematic review. *Phys Ther Sport*. 2019;37:210-219. https://doi.org/10.1016/j.ptsp.2018.06.003

398. Simpson JD, Stewart EM, Turner AJ, Macias DM, Chander H, Knight AC. Lower limb joint kinetics during a side-cutting task in participants with or without chronic ankle instability. *J Athl Train*. 2020;55:169-175. https://doi.org/10.4085/1062-6050-334-18

399. Simpson JD, Stewart EM, Turner AJ, et al. Neuromuscular control in individuals with chronic ankle instability: a comparison of unexpected and expected ankle inversion perturbations during a single leg drop-landing. *Hum Mov Sci*. 2019;64:133-141. https://doi.org/10.1016/j.humov.2019.01.013

400. Smyth EA, Piromalli L, Antcliff A, et al. A prospective study of health problems at the 2018 17/U and 19/U Australian National Netball Championships with comparison of surveillance methodology. *J Sci Med Sport*. 2020;23:215-221. https://doi.org/10.1016/j.jsams.2019.10.004

401. Son SJ, Kim H, Seeley MK, Hopkins JT. Altered walking neuromechanics in patients with chronic ankle instability. *J Athl Train*. 2019;54:684-697. https://doi.org/10.4085/1062-6050-478-17

402. Song Y, Li H, Sun C, et al. Clinical guidelines for the surgical management of chronic lateral ankle instability: a consensus reached by systematic review of the available data. *Orthop J Sports Med*. 2019;7:2325967119873852. https://doi.org/10.1177/2325967119873852

403. Sousa ASP. Antagonist co-activation during short and medium latency responses in subjects with chronic ankle instability. *J Electromyogr Kinesiol*. 2018;43:168-173. https://doi.org/10.1016/j.jelekin.2018.10.006

404. Sousa ASP, Leite J, Costa B, Santos R. Bilateral proprioceptive evaluation in individuals with unilateral chronic ankle instability. *J Athl Train*. 2017;52:360-367. https://doi.org/10.4085/1062-6050-52.2.08

405. Sousa ASP, Silva M, Gonzalez S, Santos R. Bilateral compensatory postural adjustments to a unilateral perturbation in subjects with chronic ankle instability. *Clin Biomech (Bristol, Avon)*. 2018;57:99-106. https://doi.org/10.1016/j.clinbiomech.2018.06.015

406. Sousa ASP, Valente I, Pinto A, Santos R. Reliability of two methods for identifying the timing of medium latency responses in subjects with and without chronic ankle instability. *Sci Rep*. 2019;9:3115. https://doi.org/10.1038/s41598-019-40073-z

407. Sousa ASP, Valente I, Pinto A, Soutelo T, Silva M. Short and medium latency responses in participants with chronic ankle instability. *J Athl Train*. 2018;53:679-686. https://doi.org/10.4085/1062-6050-120-17

408. Sousa P, Rebelo A, Brito J. Injuries in amateur soccer players on artificial turf: a one-season prospective study. *Phys Ther Sport*. 2013;14:146-151. https://doi.org/10.1016/j.ptsp.2012.05.003

409. Springer S, Gottlieb U. Effects of dual-task and walking speed on gait variability in people with chronic ankle instability: a cross-sectional study. *BMC Musculoskelet Disord*. 2017;18:316. https://doi.org/10.1186/s12891-017-1675-1

410. Srimakarat P, Jaroenarpornwatana A, Janchai S, Tantisiriwat N. Reliability and validity of Foot Function Index Thai version [FFI-TH]. *J Med Assoc Thai*. 2018;101:253-260.

411. Staats K, Sabeti-Aschraf M, Apprich S, et al. Preoperative MRI is helpful but not sufficient to detect associated lesions in patients with chronic ankle instability. *Knee Surg Sports Traumatol Arthrosc*. 2018;26:2103-2109. https://doi.org/10.1007/s00167-017-4567-x

412. Stathopoulos N, Dimitriadis Z, Koumantakis GA. Effectiveness of Mulligan's mobilization with movement techniques on range of motion in peripheral joint pathologies: a systematic review with meta-analysis between 2008 and 2018. *J Manipulative Physiol Ther*. 2019;42:439-449. https://doi.org/10.1016/j.jmpt.2019.04.001

413. Steinberg N, Adams R, Ayalon M, Dotan N, Bretter S, Waddington G. Recent ankle injury, sport participation level, and tests of proprioception. *J Sport Rehabil*. 2019;28:824-830. https://doi.org/10.1123/jsr.2018-0164

414. Strudwick K, McPhee M, Bell A, Martin-Khan M, Russell T. Review article: best practice management of common ankle and foot injuries in the emergency department (part 2 of the musculoskeletal injuries rapid review series). *Emerg Med Australas*. 2018;30:152-180. https://doi.

org/10.1111/1742-6723.12904

415. Sun Y, Wang H, Tang Y, Qin S, Zhao M, Zhang F. Diagnosis and treatment of chronic lateral ankle instability with ligamentum bifurcatum injury: an observational study. *Medicine (Baltimore)*. 2018;97:e0028. https://doi.org/10.1097/MD.0000000000010028

416. Swenson DM, Collins CL, Best TM, Flanigan DC, Fields SK, Comstock RD. Epidemiology of knee injuries among U.S. high school athletes, 2005/2006-2010/2011. *Med Sci Sports Exerc*. 2013;45:462-469. https://doi.org/10.1249/MSS.0b013e318277acca

417. Swenson DM, Collins CL, Fields SK, Comstock RD. Epidemiology of U.S. high school sports-related ligamentous ankle injuries, 2005/06-2010/11. *Clin J Sport Med*. 2013;23:190-196. https://doi.org/10.1097/JSM.0b013e31827d21fe

418. Taccolini Manzoni AC, Bastos de Oliveira NT, Nunes Cabral CM, Aquaroni Ricci N. The role of the therapeutic alliance on pain relief in musculoskeletal rehabilitation: a systematic review. *Physiother Theory Pract*. 2018;34:901-915. https://doi.org/10.1080/09593985.2018.1431343

419. Tajmir S, Raja AS, Ip IK, et al. Impact of clinical decision support on radiography for acute ankle injuries: a randomized trial. *West J Emerg Med*. 2017;18:487-495. https://doi.org/10.5811/westjem.2017.1.33053

420. Tanen L, Docherty CL, Van Der Pol B, Simon J, Schrader J. Prevalence of chronic ankle instability in high school and Division I athletes. *Foot Ankle Spec*. 2014;7:37-44. https://doi.org/10.1177/1938640013509670

421. Tavakoli S, Forghany S, Nester C. The effect of dual tasking on foot kinematics in people with functional ankle instability. *Gait Posture*. 2016;49:364-370. https://doi.org/10.1016/j.gaitpost.2016.07.302

422. Tee JC, Till K, Jones B. Incidence and characteristics of injury in under-19 academy level rugby league match play: a single season prospective cohort study. *J Sports Sci*. 2019;37:1181-1188. https://doi.org/10.1080/02640414.2018.1547100

423. Terada M, Bowker S, Thomas AC, Pietrosimone B, Hiller CE, Gribble PA. Corticospinal excitability and inhibition of the soleus in individuals with chronic ankle instability. *PM R*. 2016;8:1090-1096. https://doi.org/10.1016/j.pmrj.2016.04.006

424. Terada M, Bowker S, Thomas AC, et al. Alterations in stride-to-stride variability during walking in individuals with chronic ankle instability. *Hum Mov Sci*. 2015;40:154-162. https://doi.org/10.1016/j.humov.2014.12.004

425. Terada M, Harkey MS, Wells AM, Pietrosimone BG, Gribble PA. The influence of ankle dorsiflexion and self-reported patient outcomes on dynamic postural control in participants with chronic ankle instability. *Gait Posture*. 2014;40:193-197. https://doi.org/10.1016/j.gaitpost.2014.03.186

426. Terada M, Johnson N, Kosik K, Gribble P. Quantifying brain white matter microstructure of people with lateral ankle sprain. *Med Sci Sports Exerc*. 2019;51:640-646. https://doi.org/10.1249/MSS.0000000000001848

427. Terada M, Kosik K, Johnson N, Gribble P. Altered postural control variability in older-aged individuals with a history of lateral ankle sprain. *Gait Posture*. 2018;60:88-92. https://doi.org/10.1016/j.gaitpost.2017.11.009

428. Terada M, Kosik KB, McCann RS, Gribble PA. Diaphragm contractility in individuals with chronic ankle instability. *Med Sci Sports Exerc*. 2016;48:2040-2045. https://doi.org/10.1249/MSS.0000000000000994

429. Terada M, Pietrosimone B, Gribble PA. Individuals with chronic ankle instability exhibit altered landing knee kinematics: potential link with the mechanism of loading for the anterior cruciate ligament. *Clin Biomech (Bristol, Avon)*. 2014;29:1125-1130. https://doi.org/10.1016/j.clinbiomech.2014.09.014

430. Terada M, Pietrosimone BG, Gribble PA. Alterations in neuromuscular control at the knee in individuals with chronic ankle instability. *J Athl Train*. 2014;49:599-607. https://doi.org/10.4085/1062-6050-49.3.28

431. Tharao MK, Oroko P, Abdulkarim A, Saidi H. Validation of the Ottawa ankle rules at a tertiary teaching hospital. *Ann Afr Surg*. 2015;12:77-80.

432. Theurillat C, Punt I, Armand S, Bonnefoy-Mazure A, Allet L. Active ankle circumduction to identify mobility deficits in subacute ankle sprain patients. *J Appl Biomech*. 2018;34:1-6. https://doi.org/10.1123/jab.2016-0321

433. Thompson CS, Hiller CE, Schabrun SM. Altered spinal-level sensorimotor control related to pain and perceived instability in people with chronic ankle instability. *J Sci Med Sport*. 2019;22:425-429. https://doi.org/10.1016/j.jsams.2018.10.009

434. Toyooka T, Urabe Y, Sugiura S, et al. Does the single-limb stance reflect chronic ankle instability in an athlete? *Gait Posture*. 2018;66:242-246. https://doi.org/10.1016/j.gaitpost.2018.08.023

435. Tsekoura M, Billis E, Fousekis K, Christakou A, Tsepis E. Cross cultural adaptation, reliability, and validity of the Greek version of the Cumberland Ankle Instability Tool. *Physiother Theory Pract*. In press. https://doi.org/10.1080/09593985.2019.1652944

436. Tsikopoulos K, Mavridis D, Georgiannos D, Vasiliadis HS. Does multimodal rehabilitation for ankle instability improve patients' self-assessed functional outcomes? A network meta-analysis. *Clin Orthop Relat Res*. 2018;476:1295-1310. https://doi.org/10.1097/01.blo.0000534691.24149.a2

437. Tsikopoulos K, Sidiropoulos K, Kitridis D, Cain SM, Metaxiotis D, Ali A. Do external supports improve dynamic balance in patients with chronic ankle instability? A network meta-analysis. *Clin Orthop Relat Res*. 2020;478:359-377. https://doi.org/10.1097/CORR.0000000000000946

438. Tümer N, Vuurberg G, Blankevoort L, Kerkhoffs G, Tuijthof GJM, Zadpoor AA. Typical shape differences in the subtalar joint bones between subjects with chronic ankle instability and controls. *J Orthop Res*. 2019;37:1892-1902. https://doi.org/10.1002/jor.24336

439. Tummala SV, Hartigan DE, Makovicka JL, Patel KA, Chhabra A. 10-year epidemiology of ankle injuries in men's and women's collegiate basketball. *Orthop J Sports Med*. 2018;6:2325967118805400. https://doi.org/10.1177/2325967118805400

440. Uematsu D, Suzuki H, Sasaki S, et al. Evidence of validity for the Japanese version of the Foot and Ankle Ability Measure. *J Athl Train*. 2015;50:65-70. https://doi.org/10.4085/1062-6050-49.3.42

441. Usgu S, Usgu G, Uygur F, Yakut Y. Validity and reliability of the Foot and Ankle Ability Measure Turkish version for athletes. *Int J Athl Ther Train*. 2019;24:263-269. https://doi.org/10.1123/ijatt.2017-0095

442. Váczi M, Ambrus M. Chronic ankle instability impairs quadriceps femoris contractility and it is associated with reduced stretch-shortening cycle function. *Isokinet Exerc Sci*. 2014;22:99-106. https://doi.org/10.3233/IES-130525

443. van Ochten JM, de Vries AD, van Putte N, et al. Association between patient history and physical examination and osteoarthritis after ankle sprain. *Int J Sports Med*. 2017;38:717-724. https://doi.org/10.1055/s-0043-109554

444. van Ochten JM, Mos MC, van Putte-Katier N, et al. Structural abnormalities and persistent complaints after an ankle sprain are not associated: an observational case control study in primary care. *Br J Gen Pract*. 2014;64:e545-e553. https://doi.org/10.3399/bjgp14X681349

445. Vassallo AJ, Hiller C, Stamatakis E, Pappas E. Epidemiology of dance-related injuries presenting to emergency departments in the United States, 2000-2013. *Med Probl Perform Art*. 2017;32:170-175. https://doi.org/10.21091/mppa.2017.3028

446. Vaulerin J, Chorin F, Emile M, d'Arripe-Longueville F, Colson SS. Ankle sprains risk factors in a sample of French firefighters: a preliminary prospective study. *J Sport Rehabil*. 2020;29:608-615. https://doi.org/10.1123/jsr.2018-0284

447. Venditto T, Tognolo L, Rizzo RS, et al. 17-Italian Foot Function Index with numerical rating scale: development, reliability, and validity of a modified version of the original Foot Function Index. *Foot (Edinb)*. 2015;25:12-18. https://doi.org/10.1016/j.foot.2014.09.004

448. Voizard P, Moore J, Leduc S, Nault ML. The heterogeneous management of pediatric ankle traumas: a retrospective descriptive study. *Medicine (Baltimore)*. 2018;97:e11020. https://doi.org/10.1097/MD.0000000000011020

449. Vomacka MM, Calhoun MR, Lininger MR, Ko J. Dorsiflexion range of motion in copers and those with chronic ankle instability. *Int J Exerc Sci*. 2019;12:614-622.

450. Vosoughi AR, Roustaei N, Mahdaviazad H. American Orthopaedic Foot and Ankle Society ankle–hindfoot scale: a cross-cultural adaptation and validation study from Iran. *Foot Ankle Surg*. 2018;24:219-223. https://doi.org/

10.1016/j.fas.2017.02.007

451. Vuurberg G, Hoorntje A, Wink LM, et al. Diagnosis, treatment and prevention of ankle sprains: update of an evidence-based clinical guideline. *Br J Sports Med*. 2018;52:956. https://doi.org/10.1136/bjsports-2017-098106

452. Vuurberg G, Kluit L, van Dijk CN. The Cumberland Ankle Instability Tool (CAIT) in the Dutch population with and without complaints of ankle instability. *Knee Surg Sports Traumatol Arthrosc*. 2018;26:882-891. https://doi.org/10.1007/s00167-016-4350-4

453. Waldén M, Hägglund M, Ekstrand J. Time-trends and circumstances surrounding ankle injuries in men's professional football: an 11-year follow-up of the UEFA Champions League injury study. *Br J Sports Med*. 2013;47:748-753. https://doi.org/10.1136/bjsports-2013-092223

454. Wang W, Sheng J, Tang Y, et al. Adaptation and psychometric evaluation of the simplified Chinese version of the Identification of Functional Ankle Instability questionnaire in Chinese-speaking patients with chronic ankle instability disorders. *BMC Musculoskelet Disord*. 2020;21:325. https://doi.org/10.1186/s12891-020-03314-1

455. Wang X, Chang SM, Yu GR, Rao ZT. Clinical value of the Ottawa ankle rules for diagnosis of fractures in acute ankle injuries. *PLoS One*. 2013;8:e63228. https://doi.org/10.1371/journal.pone.0063228

456. Wanner P, Schmautz T, Kluge F, Eskofier B, Pfeifer K, Steib S. Ankle angle variability during running in athletes with chronic ankle instability and copers. *Gait Posture*. 2019;68:329-334. https://doi.org/10.1016/j.gaitpost.2018.11.038

457. Warner K, Savage J, Kuenze CM, Erkenbeck A, Comstock RD, Covassin T. A comparison of high school boys' and girls' lacrosse injuries: academic years 2008-2009 through 2015-2016. *J Athl Train*. 2018;53:1049-1055. https://doi.org/10.4085/1062-6050-312-17. 2018;53:1049-1055

458. Watson EL, Bearden AC, Doughton JH, Needle AR. The effects of multiple modalities of cognitive loading on dynamic postural control in individuals with chronic ankle instability. *Gait Posture*. 2020;79:10-15. https://doi.org/10.1016/j.gaitpost.2020.03.019

459. Webster KA, Gribble PA. A comparison of electromyography of gluteus medius and maximus in subjects with and without chronic ankle instability during two functional exercises. *Phys Ther Sport*. 2013;14:17-22. https://doi.org/10.1016/j.ptsp.2012.02.002

460. Webster KA, Pietrosimone BG, Gribble PA. Muscle activation during landing before and after fatigue in individuals with or without chronic ankle instability. *J Athl Train*. 2016;51:629-636. https://doi.org/10.4085/1062-6050-51.10.01

461. Weel H, Zwiers R, Azim D, et al. Validity and reliability of a Dutch version of the Foot and Ankle Ability Measure. *Knee Surg Sports Traumatol Arthrosc*. 2016;24:1348-1354. https://doi.org/10.1007/s00167-014-3480-9

462. Weerasekara I, Deam H, Bamborough N, et al. Effect of Mobilisation with Movement (MWM) on clinical outcomes in lateral ankle sprains: a systematic review and meta-analysis. *Foot (Edinb)*. 2020;43:101657. https://doi.org/10.1016/j.foot.2019.101657

463. Weerasekara I, Osmotherly P, Snodgrass S, Marquez J, de Zoete R, Rivett DA. Clinical benefits of joint mobilization on ankle sprains: a systematic review and meta-analysis. *Arch Phys Med Rehabil*. 2018;99:1395-1412.e5. https://doi.org/10.1016/j.apmr.2017.07.019

464. Weerasekara I, Tennakoon SUB, Suraweera HJ. Pain level, range of motion, and foot volume do not differ in recurrent and first-time ankle sprains. *Foot Ankle Spec*. 2020;13:116-122. https://doi.org/10.1177/1938640019843331

465. Wenning M, Lohrer H, Gollhofer A, Gehring D. In vivo arthrometer measurements of mechanical ankle instability—a systematic review. *J Orthop Res*. 2019;37:1133-1142. https://doi.org/10.1002/jor.24280

466. Whalan M, Lovell R, McCunn R, Sampson JA. The incidence and burden of time loss injury in Australian men's sub-elite football (soccer): a single season prospective cohort study. *J Sci Med Sport*. 2019;22:42-47. https://doi.org/10.1016/j.jsams.2018.05.024

467. Wiebking U, Pacha TO, Jagodzinski M. An accuracy evaluation of clinical, arthrometric, and stress-sonographic acute ankle instability examinations. *Foot Ankle Surg*. 2015;21:42-48. https://doi.org/10.1016/j.fas.2014.09.006

468. Wikstrom EA, Brown CN. Minimum reporting standards for copers in chronic ankle instability research. *Sports Med*. 2014;44:251-268. https://doi.org/10.1007/s40279-013-0111-4

469. Wikstrom EA, McKeon PO. Predicting balance improvements following STARS treatments in chronic ankle instability participants. *J Sci Med Sport*. 2017;20:356-361. https://doi.org/10.1016/j.jsams.2016.09.003

470. Wikstrom EA, McKeon PO. Predicting manual therapy treatment success in patients with chronic ankle instability: improving self-reported function. *J Athl Train*. 2017;52:325-331. https://doi.org/10.4085/1062-6050-52.2.07

471. Wikstrom EA, Song K. Generic and psychological patient-reported deficits in those with chronic ankle instability: a cross sectional study. *Phys Ther Sport*. 2019;40:137-142. https://doi.org/10.1016/j.ptsp.2019.09.004

472. Wikstrom EA, Song K, Tennant JN, Dederer KM, Paranjape C, Pietrosimone B. T1ρ MRI of the talar articular cartilage is increased in those with chronic ankle instability. *Osteoarthritis Cartilage*. 2019;27:646-649. https://doi.org/10.1016/j.joca.2018.12.019

473. Wisthoff B, Matheny S, Struminger A, et al. Ankle strength deficits in a cohort of college athletes with chronic ankle instability. *J Sport Rehabil*. 2019;28:752-757. https://doi.org/10.1123/jsr.2018-0092

474. Witchalls JB, Newman P, Waddington G, Adams R, Blanch P. Functional performance deficits associated with ligamentous instability at the ankle. *J Sci Med Sport*. 2013;16:89-93. https://doi.org/10.1016/j.jsams.2012.05.018

475. Witchalls JB, Waddington G, Adams R, Blanch P. Chronic ankle instability affects learning rate during repeated proprioception testing. *Phys Ther Sport*. 2014;15:106-111. https://doi.org/10.1016/j.ptsp.2013.04.002

476. World Health Organization. *International Classification of Functioning, Disability and Health: ICF*. Geneva, Switzerland: World Health Organization; 2001.

477. Wright CJ, Arnold BL, Ross SE, Ketchum J, Ericksen J, Pidcoe P. Clinical examination results in individuals with functional ankle instability and ankle-sprain copers. *J Athl Train*. 2013;48:581-589. https://doi.org/10.4085/1062-6050-48.3.15

478. Wright CJ, Arnold BL, Ross SE, Linens SW. Recalibration and validation of the Cumberland Ankle Instability Tool cutoff score for individuals with chronic ankle instability. *Arch Phys Med Rehabil*. 2014;95:1853-1859. https://doi.org/10.1016/j.apmr.2014.04.017

479. Wright CJ, Linens SW, Cain MS. Establishing the minimal clinical important difference and minimal detectable change for the Cumberland Ankle Instability Tool. *Arch Phys Med Rehabil*. 2017;98:1806-1811. https://doi.org/10.1016/j.apmr.2017.01.003

480. Yavnai N, Bar-Sela S, Pantanowitz M, et al. Incidence of injuries and factors related to injuries in combat soldiers. *BMJ Mil Health*. In press. https://doi.org/10.1136/jramc-2019-001312

481. Yen SC, Chui KK, Corkery MB, Allen EA, Cloonan CM. Hip-ankle coordination during gait in individuals with chronic ankle instability. *Gait Posture*. 2017;53:193-200. https://doi.org/10.1016/j.gaitpost.2017.02.001

482. Yen SC, Chui KK, Wang YC, Corkery MB, Nabian M, Farjadian AB. An examination of muscle force control in individuals with a functionally unstable ankle. *Hum Mov Sci*. 2019;64:221-229. https://doi.org/10.1016/j.humov.2019.02.005

483. Yoon DY, Moon SG, Jung HG, Kim NR. Differences between subtalar instability and lateral ankle instability focusing on subtalar ligaments based on three dimensional isotropic magnetic resonance imaging. *J Comput Assist Tomogr*. 2018;42:566-573. https://doi.org/10.1097/RCT.0000000000000717

484. Zamani Moghadam H, Hoseini ST, Hashemian AM, Sharifi MD. The relation of Q angle and anthropometric measures with ankle sprain; a case-control study. *Arch Acad Emerg Med*. 2017;5:e9. https://doi.org/10.22037/aaem.v5i1.112

485. Zhang L, Lu J, Cai B, Fan S, Jiang X. Quantitative assessments of static and dynamic balance performance in patients with chronic ankle instability. *Medicine (Baltimore)*. 2020;99:e19775. https://doi.org/10.1097/MD.0000000000019775

APPENDIX A

SEARCH STRATEGIES FOR ALL DATABASES SEARCHED

Limits: 2013 to present (June 1, 2020), human, English, research articles, nonfracture/osteoarthritis studies
Run on June 26, 2018 and updated on June 1, 2020

PubMed

History: June 26, 2018

Search	Query	Items Found, n
#18	#13 AND #8	7264
#17	#9 AND #7 AND #6 AND #1	2230
#16	#13 AND #5	5081
#15	#13 AND #4	1858
#14	#13 AND #3	6093
#13	#1 AND #9 AND #12	12346
#12	#10 OR #11	2483065
#11	((#2 NOT (fracture[tw] NOT (sprains[tw] OR sprain[tw] OR sprained[tw] OR strains[tw] OR strain[tw] OR strained[tw] OR swelling[tw] OR swollen[tw] OR swell[tw] OR "Joint Instability"[Mesh] OR instability[tw] OR instabilities[tw] OR unstable[tw] OR joint effusion[tw] oR "Proprioception"[Mesh] OR proprioception deficit[tw] OR proprioception deficits[tw] OR proprioception deficiency[tw] OR proprioception deficiencies[tw] OR "Postural Balance"[Mesh] OR balance[tw] OR unbalanced[tw] OR musculoskeletal equilibrium[tw] OR postural equilibrium[tw] OR hypermobility[tw] OR hypermobilities[tw] OR laxity[tw] OR laxities[tw] OR tear[tw] OR torn[tw] OR external rotation[tw] OR eversion[tw] OR inversion[tw]))	2424755
#10	((#2 NOT (osteoarthritis[tw] NOT (sprains[tw] OR sprain[tw] OR sprained[tw] OR strains[tw] OR strain[tw] OR strained[tw] OR swelling[tw] OR swollen[tw] OR swell[tw] OR "Joint Instability"[Mesh] OR instability[tw] OR instabilities[tw] OR unstable[tw] OR joint effusion[tw] oR "Proprioception"[Mesh] OR proprioception deficit[tw] OR proprioception deficits[tw] OR proprioception deficiency[tw] OR proprioception deficiencies[tw] OR "Postural Balance"[Mesh] OR balance[tw] OR unbalanced[tw] OR musculoskeletal equilibrium[tw] OR postural equilibrium[tw] OR hypermobility[tw] OR hypermobilities[tw] OR laxity[tw] OR laxities[tw] OR tear[tw] OR torn[tw] OR external rotation[tw] OR eversion[tw] OR inversion[tw]))	2477326
#9	("2013"[Date - Publication]: "3000"[Date - Publication]) NOT (animals[mh] NOT humans[mh]) NOT ("Book Reviews" [Publication Type] OR "Comment" [Publication Type] OR "Editorial" [Publication Type] OR "Letter" [Publication Type] OR "Review" [Publication Type] OR "Meeting Abstracts" [Publication Type] OR "Public Service Announcements" [Publication Type] OR "News" [Publication Type] OR "Newspaper Article" [Publication Type] OR "Case Reports" [Publication Type] OR "Academic Dissertations" [Publication Type] OR "Retracted Publication" [Publication Type]) AND "English"[Language]	4076704
#8	("Diagnosis"[Mesh] OR "diagnosis" [Subheading] OR "Delayed Diagnosis"[Mesh] OR "Early Diagnosis"[Mesh] OR "Diagnosis, Differential"[Mesh] OR "Diagnosis, Computer-Assisted"[Mesh] OR "Diagnostic Techniques and Procedures"[Mesh] OR diagnosis[tw] OR diagnose[tw] OR diagnoses[tw] OR diagnostic[tw] OR "Clinical Decision-Making"[Mesh] OR clinical decision-making[tw] OR clinical decision making[tw] OR medical decision-making[tw] OR medical decision making[tw] OR "Decision Making"[Mesh:NoExp] OR "Diagnostic Imaging"[Mesh] OR diagnostic imaging[tw] OR medical imaging[tw] OR "Radiography"[Mesh] OR radiography[tw] OR diagnostic x-ray[tw] OR diagnostic x ray[tw] OR diagnostic x-rays[tw] OR "Magnetic Resonance Imaging"[Mesh] OR magnetic resonance imaging[tw] OR MRI[tw] OR fMRI[tw] OR NMR imaging[tw] OR MR tomography[tw] OR "Ultrasonography"[Mesh] OR ultrasonography[tw] OR ultrasound[tw] OR ultrasounds[tw] OR ultrasonic[tw] OR "Electromyography"[Mesh] OR electromyography[tw] OR electromyographies[tw] OR electromyogram[tw] OR electromyograms[tw] OR electrophysiologic test[tw] OR electrophysiologic tests[tw] OR electrophysiologic testing[tw] OR "Neural Conduction"[Mesh] OR neural conduction[tw] OR neural conductions[tw] OR nerve conduction[tw] OR nerve conductions[tw] OR "Actigraphy"[Mesh] OR actigraphy[tw])	9523683
#7	("Sensitivity and Specificity"[Mesh] OR sensitivity[tw] OR specificity[tw] OR "Evaluation Studies as Topic"[Mesh] OR evaluation indexes[tw] OR evaluation report[tw] OR evaluation reports[tw] OR evaluation research[tw] OR use-effectiveness[tw] OR use effectiveness[tw] OR prepost tests[tw] OR pre post tests[tw] OR prepost test[tw] OR qualitative evaluation[tw] OR qualitative evaluations[tw] OR quantitative evaluation[tw] OR quantitative evaluations[tw] OR theoretical effectiveness[tw] OR critique[tw] OR critiques[tw] OR evaluation methodology[tw] OR evaluation methodologies[tw] OR "Validation Studies as Topic"[Mesh] OR "Reproducibility of Results"[Mesh] OR reproducibility[tw] OR validity[tw] OR reliability[tw] OR "Data Accuracy"[Mesh] OR data accuracy[tw] OR data accuracies[tw] OR data quality[tw] OR data qualities[tw] OR precision[tw] OR responsiveness[tw] OR consistency[tw] OR consistencies[tw] OR consistent[tw] OR log-likelihood ratio[tw] OR likelihood-ratio[tw] OR likelihood ratio[tw] OR LR test[tiab] OR "Epidemiologic Research Design"[Mesh] OR "Research Design"[Mesh] OR research design[tw] OR research designs[tw] OR research strategy[tw] OR research strategies[tw] OR research techniques[tw] OR research technique[tw] OR research methodology[tw] OR research methodologies[tw] OR experimental design[tw] OR experimental designs[tw])	3694180

Table continues on page CPG55.

APPENDIX A

Search	Query	Items Found, n
#6	(Cumberland ankle instability tool[tw] OR Chronic Ankle Instability Scale[tw] OR Sports Ankle Rating System[tw] OR Ankle Joint Functional Assessment Tool[tw] OR Foot Function Index[tw] OR Foot and Ankle Outcome Score[tw] OR Karlsson Ankle Function Score[tw] OR OR Karlsson Score[tw] OR Kaikkonen scale[tw] OR Kaikkonen score[tw] OR Ottawa ankle rules[tw] OR Buffalo modification[tiab] OR foot and ankle ability measure[tw] OR foot ability measure[tw] OR ankle ability measure[tw] OR foot and ankle disability index[tw] OR lower extremity function scale[tw] OR lower extremity functional scale[tw] OR ankle instability scale[tw] OR sports ankle rating system[tw] OR ankle joint function assessment[tw] OR ankle instability index[tw] OR ankle instability instrument[tw] OR identification of functional ankle instability[tw] OR Tampa scale of kinesiophobia[tw] OR sway index[tw] OR functional reach test[tw] OR Patient Reported Outcome Measurement Information System[tw] OR PROMIS[tiab] OR Health Utilities Index[tw] OR HUI[tiab] OR HUI-III[tiab] OR HUI-3[tiab] OR HUI3[tiab] OR HUI-II[tiab] OR HUI-2[tiab] OR HUI2[tiab] OR HUI-I[tiab] OR HUI-1[tiab] OR HUI1[tiab] OR Visual Analogue Scale[tw] OR European Quality of life 5 Dimensions[tw] OR EuroQol*[tiab] OR EQ-5D[tiab] OR EQ5D*[tiab] OR EQ 5D[tiab] OR EORTC[tiab] OR Rosser[tiab] OR short form health survey[tw] OR short-form health survey[tw] OR SF36[tiab] OR SF-36[tiab] OR SF 36[tiab] OR short form 36[tiab] OR shortform 36[tiab] OR shortform36[tiab] OR 36 item short form[tiab] OR 36-item short form[tiab] OR SF20[tiab] OR SF-20[tiab] OR SF 20[tiab] OR short form 20[tiab] OR shortform 20[tiab] OR shortform20[tiab] OR 20 item short form[tiab] OR 20-item short form[tiab] OR SF12[tiab] OR SF-12[tiab] OR SF 12[tiab] OR short form 12[tiab] OR shortform 12[tiab] OR shortform12[tiab] OR 12 item short form[tiab] OR 12-item short form[tiab] OR SF8[tiab] OR SF-8[tiab] OR SF 8[tiab] OR short form 8[tiab] OR shortform 8[tiab] OR shortform8[tiab] OR 8 item short form[tiab] OR 8-item short form[tiab] OR SF6[tiab] OR SF-6[tiab] OR SF 6[tiab] OR short form 6[tiab] OR shortform 6[tiab] OR shortform6[tiab] OR 6 item short form[tiab] OR 6-item short form[tiab] OR QoL Questionnaire[tw] OR QLQ[tiab] OR health questionnaire[tw] OR Godin leisure time[tw] OR Numeric Pain Scale[tw] OR lateral hopping for distance[tw] OR 6-m crossover hop[tw] OR side hop[tw] OR hopping course[tw] OR square hop[tw] OR cross hop[tw] OR hop test[tw] OR hopping test[tw] OR 40-m walk time[tw] OR 40-m run time[tw] OR figureof-eight run[tw] OR single-limb forward hop[tw] OR single limb forward hop[tw] OR stair hop[tw] OR shuttle run[tw] OR up/down hop[tw] OR hop up[tw] OR hopping up[tw] OR hop down[tw] OR hopping down[tw] OR triple crossover hop[tw] OR single-limb hurdle[tw] OR single limb hurdle[tw] OR single-limb 6-m hop[tw] OR single-limb 30-m hop[tw] OR figureof-eight hop[tw] OR figure of eight hop[tw] OR figure eight hop[tw] OR drop landing[tw] OR vertical jump[tw] OR "Walking Speed"[Mesh] OR "Gait"[Mesh] OR walking speed[tw] OR walking speeds[tw] OR walking gait[tw] OR gait speed[tw] OR gait speeds[tw] OR walking pace[tw] OR walking paces[tw] OR running gait[tw] OR running speed[tw] OR running speeds[tw] OR running pace[tw] OR running paces[tw] OR figure of 8 circumferential measure[tw] OR volumetric measure[tw] OR "Range of Motion, Articular"[Mesh] OR range of motion[tw] OR joint flexibility[tw] OR "Arthrometry, Articular"[Mesh] OR articular arthometry[tw] OR articular goniometry[tw] OR "Supination"[Mesh] OR supination[tw] OR supinations[tw] OR "Pronation"[Mesh] OR pronation[tw] OR pronations[tw] OR tibiopedal dorsiflexion[tw] OR weight-bearing lunge[tw] OR weight bearing lunge[tw] OR algometry[tw] OR "Pain Threshold"[Mesh] OR pain threshold[tw] OR pain thresholds[tw] OR pressurepain threshold[tw] OR pressurepain thresholds[tw] OR cutaneous sensation[tw] OR "Hypesthesia"[Mesh] OR hypesthesia[tw] OR "Hyperesthesia"[Mesh] OR hyperethesia[tw] OR joint position sense[tw] OR "Kinesthesis"[Mesh] OR kinesthesis[tw] OR kinesthesia[tw] OR kinesthesias[tw] OR kinesthetic[tw] OR movement sensation[tw] OR movement sensations[tw] OR isokinetic muscle strength[tw] OR isokinetic test[tw] OR isokinetic tests[tw] OR single-limb balance[tw] OR single limb balance[tw] OR Romberg test[tw] OR balance test[tw] OR balancing test[tw] OR Y balance[tiab] OR Balance Error Scoring System[tw] OR step-down test[tw] OR step down test[tw] OR single leg squat test[tw] OR functional movement screen[tw] OR functional movement screening[tw] OR functional movement screens[tw] OR joint accessory mobility[tw] OR joint play mobility[tw] OR anterior drawer[tw] OR talar tilt inversion[tw] OR talar tilt eversion[tw] OR talar rotation[tw] OR talofibular interval[tw] OR tibiofibular interval[tw] OR distal fibula interval[tw] OR Foot posture Index[tw] OR squeeze test[tiab] OR Cotton test[tiab] OR dorsiflexion maneuver[tw] OR dorsiflexion maneuvers[tw] OR dorsiflexion compression test[tw] OR crossed leg test[tw] OR heel thump test[tw] OR Kleiger dorsiflexion external rotation test[tiab] OR external rotation test[tw] OR Thompson test[tiab] OR function and prognostic score[tw] OR function and prognostic scores[tw] OR ankle function score[tw] OR ankle scoring system[tw] OR de Bie[tiab] OR multisegmented foot[tw] OR ankle-foot complex[tw] OR foot morphology[tw] OR intrinsic foot muscles[tw] OR ankle assessment[tw] OR ankle assessments[tw] OR foot assessment[tw] OR foot assessments[tw] OR feet assessment[tw] OR feet assessments[tw] OR biomechanical assessment[tw] OR biomechanical assessments[tw] OR foot root model[tw] OR ankle root model[tw])	208194
#5	("Risk"[Mesh] OR "Risk Assessment"[Mesh] OR "Risk Factors"[Mesh] OR "Health Risk Behaviors"[Mesh] OR risk[tw] OR risks[tw] OR risk-benefit[tw] OR "Probability"[Mesh] OR probability[tw] OR probabilities[tw] OR likelihood[tw] OR propensity[tw] OR "Logistic Models"[Mesh] OR logistic model[tw] OR logistic models[tw] OR logistic modeling[tw] OR logistic regression[tw] OR logistic regressions[tw] OR "Protective Factors"[Mesh] OR protective factor[tw] OR protective factors[tw] OR "Bayes Theorem"[Mesh] OR Bayes theorem[tw] OR Bayesian[tw] OR "Causality"[Mesh] OR causality[tw] OR causalities[tw] OR causation[tw] OR causations[tw] OR cause[tw] OR causes[tw] OR enabling factor[tw] OR enabling factors[tw] OR reinforcing factor[tw] OR reinforcing factors[tw] OR predisposing factor[tw] OR predisposing factors[tw] OR predisposition[tw] OR "Precipitating Factors"[Mesh] OR precipitating factors[tw] OR precipitating factor[tw] OR predictor[tw] OR predictors[tw] OR odds ratio[tw] OR odds ratios[tw] OR predict[tw] OR prediction[tw] OR predictions[tw] OR predictabilities[tw] OR predictability[tw] OR predicted[tw] OR predictor[tw] OR predictors[tw] OR predictive[tw] OR etiology[tw] OR etiologies[tw] OR etiological[tw] OR etiologic[tw] OR aetiology[tw] OR origin[tw] OR origination[tw] OR originating[tw] OR interact[tw] OR interaction[tw] OR interactions[tw] OR interacting[tw])	7760905
#4	("Incidence"[Mesh] OR incidence[tw] OR incidences[tw] OR "Morbidity"[Mesh] OR morbidity[tw] OR morbidities[tw] OR "Epidemiology"[Mesh] OR epidemiology[tw] OR "epidemiology" [Subheading] OR "Prevalence"[Mesh] OR prevalence[tw] OR prevalent[tw] OR prevalencies[tw])	2968951

Table continues on page CPG56.

APPENDIX A

Search	Query	Items Found, n
#3	("Physical Therapy Modalities"[Mesh] OR physical therapy[tw] OR physical therapies[tw] OR physiotherapy[tw] OR physiotherapies[tw] OR "Recovery of Function"[Mesh] OR recovery[tw] OR restoration[tw] OR reeducation[tw] OR "Rehabilitation"[Mesh] OR "rehabilitation" [Subheading] OR rehabilitation[tw] OR rehab[tw] OR "Early Ambulation"[Mesh] OR early ambulation[tw] OR accelerated ambulation[tw] OR early mobilization[tw] OR therapeutic modality[tw] OR therapeutic modalities[tw] OR "Exercise Therapy"[Mesh] OR exercise therapy[tw] OR therapeutic exercise[tw] OR therapeutic exercises[tw] OR stretching[tw] OR exercise movement[tw] OR strengthen[tw] OR strengthening[tw] OR "Resistance Training"[Mesh] OR resistance training[tw] OR strength training[tw] OR weight-bearing[tw] OR weight-lifting[tw] OR resistance methods[tw] OR training program[tw] OR "Biofeedback, Psychology"[Mesh] OR biofeedback[tw] OR psychophysiologic feedback[tw] OR neuromuscular electrical stimulation[tw] OR neuromuscular reeducation[tw] OR "Pain Management"[Mesh] OR "Pain Measurement"[Mesh] OR pain management[tw] OR pain measurement[tw] OR mobilization[tw] OR mobilizations[tw] OR "Musculoskeletal Manipulations"[Mesh] OR manipulation[tw] OR manipulations[tw] OR ultrasonography[tw] OR ultrasound[tw] OR acupuncture[tw] OR "Patient Education as Topic"[Mesh] OR patient education[tw] OR education of patients[tw] OR iontophoresis[tw] OR "Electric Stimulation"[Mesh] OR "Electric Stimulation Therapy"[Mesh] OR "Transcutaneous Electric Nerve Stimulation"[Mesh] OR electric stimulation[tw] OR nerve stimulation[tw] OR taping[tw] OR tape[tw] OR bracing[tw] OR brace[tw] OR braces[tw] OR orthoses[tw] OR immobilization[tw] OR immobilize[tw] OR orthotic[tw] OR orthotics[tw] OR thermal agent[tw] OR thermal agents[tw] OR diathermy[tw] OR "Range of Motion, Articular"[Mesh] OR range of motion[tw] OR joint flexibility[tw] OR joint movement[tw] OR manual therapy[tw] OR massage[tw] OR massages[tw] OR "Treatment Outcome"[Mesh] OR treatment outcome[tw] OR clinical effectiveness[tw] OR treatment effectiveness[tw] OR treatment efficacy[tw] OR patient outcome[tw] OR patient outcomes[tw])	2846636
#2	("Ankle Injuries"[Mesh] OR "Athletic Injuries"[Mesh] OR "Foot Injuries"[Mesh] OR injuries[tw] OR injury[tw] OR injured[tw] OR "Sprains and Strains"[Mesh] OR sprains[tw] OR sprain[tw] OR sprained[tw] OR strains[tw] OR strain[tw] OR strained[tw] OR swelling[tw] OR swollen[tw] OR swell[tw] OR "Joint Instability"[Mesh] OR instability[tw] OR instabilities[tw] OR unstable[tw] OR joint effusion[tw] OR "Proprioception"[Mesh] OR proprioception deficit[tw] OR proprioception deficits[tw] OR proprioception deficiency[tw] OR proprioception deficiencies[tw] OR "Postural Balance"[Mesh] OR balance[tw] OR unbalanced[tw] OR musculoskeletal equilibrium[tw] OR postural equilibrium[tw] OR hypermobility[tw] OR hypermobilities[tw] OR laxity[tw] OR laxities[tw] OR tear[tw] OR torn[tw] OR external rotation[tw] OR eversion[tw] OR inversion[tw] OR "Injury Severity Score"[Mesh] OR "Abbreviated Injury Scale"[Mesh])	2484080
#1	("Ankle"[Mesh] OR ankle[tw] OR ankles[tw] OR regio tarsalis[tw] OR talus[tw] OR tarsus[tw] OR "Metatarsus"[Mesh] OR metatarsus[tw] OR metatarsal[tw] OR "Ankle Joint"[Mesh] OR "Subtalar Joint"[Mesh] OR subtalar joint[tw] OR talocalcaneal joint[tw] OR talonavicular joint[tw] OR talocrural[tw] OR articulatio talocruralis[tw] OR "Tarsal Joints"[Mesh] OR tarsal joints[tw] OR tarsal joint[tw] OR midtarsal joint[tw] OR midtarsal joints[tw] OR intertarsal joint[tw] OR intertarsal joints[tw] OR intertarsal articulation[tw] OR articulationes intertarseae[tw]OR articulationes intertarsales[tw] OR "Lateral Ligament, Ankle"[Mesh] OR "Ligaments, Articular"[Mesh] OR "Collateral Ligaments"[Mesh] OR ankle lateral ligament[tw] OR ligamentum laterale articulationis talocruralis[tw] OR calcaneofibular[tw] OR tibiofibular[tw] OR tibiotalar[tw] OR tibionavicular[tw] OR tibiocalcaneal[tw] OR talofibular[tw] OR talonavicula[tw] OR calcaneocuboid[tw] OR bifurcate* ligament*[tw] OR inferior transverse ligament*[tw] OR deltoid ligament*[tw] OR medial ligament*[tw] OR interosseous ligament*[tw] OR dorsal interossei[tw] OR plantar interossei[tw] OR "Tibial Nerve"[Mesh] OR tibial nerve[tw] OR peroneal nerve[tw] OR peroneus nerve[tw] OR saphenous nerve[tw] OR medial plantar nerve[tw] OR lateral plantar nerve[tw] OR fibular nerve[tw] OR fibularis tertius[tw] OR "Achilles Tendon"[Mesh] OR achilles tendon[tw] OR calcaneal[tw] OR calcaneus[tw] OR interosseous membrane[tw] OR interosseous membranes[tw] OR syndesmosis[tw] OR syndesmoses[tw] OR syndesmotic[tw] OR tibialis anterior[tw] OR fibularis longus[tw] OR fibularis brevis[tw] OR peroneus tertius[tw] OR peroneus longus[tw] OR peroneus brevis[tw] OR flexor hallucis longus[tw] OR flexor digitorum longus[tw] OR extensor digitorum longus[tw] OR tibialis posterior[tw] OR soleus[tw] OR peroneal[tw] OR gastrocnemius[tw] OR abductor halluces[tw] OR adductor halluces[tw] OR flexor hallucis brevis[tw] OR abductor digiti minimi [tw]OR flexor digiti minimi[tw] OR lumbricals[tw] OR quadratus plantae[tw] OR flexor digitorum brevis[tw] OR gluteus medius[tw] OR gluteus maximus[tw] OR gluteal[tw] OR hip abductor[tw] OR hip rotator[tw]) OR ("Foot"[Mesh] OR foot[tw] OR feet[tw] OR articulationes pedis[tw] OR "Foot Joints"[Mesh] OR "Metatarsophalangeal Joint"[Mesh] OR metatarsophalangeal[tw] OR "Heel"[Mesh] OR heel[tw] OR heels[tw] OR sinus tarsi[tw] OR sinus tarsus[tw] OR rearfoot[tw] OR midfoot[tw])	253599

Embase

History: June 26, 2018

Search	Query	Items Found, n
#18	#13 AND #8	6182
#17	#9 AND #7 AND #6 AND #1	1931
#16	#13 AND #5	4759
#15	#13 AND #4	2211
#14	#13 AND #3	6959
#13	#1 AND #9 AND #12	10741
#12	#10 OR #11	2420321

Table continues on page CPG57.

APPENDIX A

Search	Query	Items Found, n
#11	#2 NOT (fracture NOT ('sprain'/exp OR sprains OR sprain OR sprained OR 'strain'/exp OR strains OR strains OR strain OR strained OR 'swelling'/exp OR swelling OR swollen OR swell OR 'instability'/exp OR instability OR instabilities OR unstable OR 'joint effusion'/exp OR 'joint effusion' OR 'proprioception deficit' OR 'proprioception deficits' OR 'proprioception deficiency' OR 'proprioception deficiencies' OR 'balance'/exp OR balance OR unbalanced OR 'musculoskeletal equilibrium'/exp OR 'musculoskeletal equilibrium' OR 'postural equilibrium'/exp OR 'postural equilibrium' OR 'hypermobility'/exp OR hypermobility OR hypermobilities OR laxity OR laxities OR 'tear'/exp OR tear OR torn OR 'external rotation'/exp OR 'external rotation' OR 'eversion'/exp OR 'inversion'/exp OR eversion OR inversion)) AND [embase]/lim	2350966
#10	#2 NOT (osteoarthritis NOT ('sprain'/exp OR sprains OR sprain OR sprained OR 'strain'/exp OR strains OR strains OR strain OR strained OR 'swelling'/exp OR swelling OR swollen OR swell OR 'instability'/exp OR instability OR instabilities OR unstable OR 'joint effusion'/exp OR 'joint effusion' OR 'proprioception deficit' OR 'proprioception deficits' OR 'proprioception deficiency' OR 'proprioception deficiencies' OR 'balance'/exp OR balance OR unbalanced OR 'musculoskeletal equilibrium'/exp OR 'musculoskeletal equilibrium' OR 'postural equilibrium'/exp OR 'postural equilibrium' OR 'hypermobility'/exp OR hypermobility OR hypermobilities OR laxity OR laxities OR 'tear'/exp OR tear OR torn OR 'external rotation'/exp OR 'external rotation' OR 'eversion'/exp OR 'inversion'/exp OR eversion OR inversion)) AND [embase]/lim	2411921
#9	(2013:py OR 2014:py OR 2015:py OR 2016:py OR 2017:py OR 2018:py) NOT ([animals]/lim NOT [humans]/lim) NOT ('book'/it OR 'chapter'/it OR 'conference abstract'/it OR 'conference paper'/it OR 'conference review'/it OR 'editorial'/it OR 'letter'/it OR 'note'/it OR 'press release'/it OR 'short survey'/it) AND [embase]/lim AND [english]/lim	3288905
#8	('diagnosis'/exp OR diagnosis OR diagnose OR diagnoses OR 'diagnostic'/exp OR diagnostic OR 'clinical decision-making'/exp OR 'clinical decision-making' OR 'clinical decision making'/exp OR 'clinical decision making' OR 'medical decision-making'/exp OR 'medical decision-making' OR 'medical decision making'/exp OR 'medical decision making' OR 'diagnostic imaging'/exp OR 'diagnostic imaging' OR 'medical imaging'/exp OR 'medical imaging' OR 'radiography'/exp OR radiography OR 'diagnostic x-ray' OR 'diagnostic x ray' OR 'diagnostic x-rays' OR 'magnetic resonance imaging'/exp OR 'magnetic resonance imaging' OR 'mri'/exp OR mri:ti,ab OR 'fmri'/exp OR fmri:ti,ab OR 'nmr imaging'/exp OR 'nmr imaging' OR 'mr tomography' OR 'ultrasonography'/exp OR ultrasonography OR 'ultrasound'/exp OR ultrasound OR ultrasounds OR 'ultrasonic'/exp OR ultrasonic OR 'electromyography'/exp OR electromyography OR electromyographies OR 'electromyogram'/exp OR electromyogram OR electromyograms OR 'electrophysiologic test' OR 'electrophysiologic tests' OR 'electrophysiologic testing' OR 'neural conduction'/exp OR 'neural conduction' OR 'neural conductions' OR 'nerve conduction'/exp OR 'nerve conduction' OR 'nerve conductions' OR 'actigraphy'/exp OR actigraphy) AND [embase]/lim	6600819
#7	('sensitivity'/exp OR sensitivity OR 'specificity'/exp OR specificity OR 'evaluation indexes'/exp OR 'evaluation indexes' OR 'evaluation report'/exp OR 'evaluation report' OR 'evaluation reports' OR 'evaluation research'/exp OR 'evaluation research' OR 'use effectiveness'/exp OR 'use effectiveness' OR prepost tests' OR 'pre post tests'/exp OR 'pre post tests' OR 'prepost test' OR 'qualitative evaluation'/exp OR 'qualitative evaluation' OR 'qualitative evaluations' OR 'quantitative evaluation'/exp OR 'quantitative evaluation' OR 'quantitative evaluations' OR 'theoretical effectiveness'/exp OR 'theoretical effectiveness' OR 'critique'/exp OR critique OR critiques OR 'evaluation methodology'/exp OR 'evaluation methodology' OR 'evaluation methodologies' OR 'reproducibility'/exp OR reproducibility OR 'validity'/exp OR validity OR 'reliability'/exp OR reliability OR 'data accuracy'/exp OR 'data accuracy' OR 'data accuracies' OR 'data quality'/exp OR 'data quality' OR 'data qualities' OR 'precision'/exp OR precision OR 'responsiveness'/exp OR responsiveness OR 'consistency'/exp OR consistency OR consistencies OR consistent OR 'log-likelihood ratio' OR 'likelihood-ratio' OR 'likelihood ratio'/exp OR 'likelihood ratio' OR 'research design'/exp OR 'research design' OR 'research designs' OR 'research strategy' OR 'research strategies' OR 'research techniques' OR 'research technique' OR 'research methodology'/exp OR 'research methodology' OR 'research methodologies' OR 'experimental design'/exp OR 'experimental design' OR 'experimental designs') AND [embase]/lim	5719204

Table continues on page CPG58.

APPENDIX A

Search	Query	Items Found, n
#6	('cumberland ankle instability tool'/exp OR 'cumberland ankle instability tool' OR 'chronic ankle instability scale' OR 'ankle joint functional assessment tool' OR 'foot function index'/exp OR 'foot function index' OR 'foot and ankle outcome score' OR 'karlsson ankle function score' OR 'karlsson score' OR 'kaikkonen scale' OR 'kaikkonen score' OR 'ottawa ankle rules'/exp OR 'ottawa ankle rules' OR 'buffalo modification' OR 'foot and ankle ability measure'/exp OR 'foot and ankle ability measure' OR 'foot ability measure' OR 'ankle ability measure' OR 'foot and ankle disability index'/exp OR 'foot and ankle disability index' OR 'lower extremity function scale'/exp OR 'lower extremity function scale' OR 'lower extremity functional scale' OR 'ankle instability scale' OR 'sports ankle rating system' OR 'ankle joint function assessment' OR 'ankle instability index' OR 'ankle instability instrument' OR 'identification of functional ankle instability' OR 'tampa scale of kinesiophobia'/exp OR 'tampa scale of kinesiophobia' OR 'sway index' OR 'functional reach test'/exp OR 'functional reach test' OR 'patient reported outcome measurement information system'/exp OR 'patient reported outcome measurement information system' OR 'short form health survey' OR 'short-form health survey' OR 'Short Form 36'/exp OR 'Short Form 12'/exp OR 'Short Form 20'/exp OR 'Short Form 8'/exp OR 'short form health survey' OR 'short-form health survey' OR 'Visual Analogue Scale' OR 'health utilities index'/exp OR 'health utilities index' OR HUI:ti,ab OR HUI-III:ti,ab OR HUI-3:ti,ab OR HUI3:ti,ab OR HUI-II:ti,ab OR HUI-2:ti,ab OR HUI2:ti,ab OR HUI-I:ti,ab OR HUI-1:ti,ab OR HUI1:ti,ab OR 'european quality of life 5 dimensions'/exp OR 'European Quality of life 5 Dimensions' OR EuroQol*:ti,ab OR EQ-5D:ti,ab OR EQ5D*:ti,ab OR EQ 5D:ti,ab OR EORTC:ti,ab OR Rosser:ti,ab OR SF36:ti,ab OR SF-36:ti,ab OR 'SF 36':ti,ab OR 'short form 36':ti,ab OR 'shortform 36':ti,ab OR shortform36:ti,ab OR '36 item short form':ti,ab OR '36-item short form':ti,ab OR SF20:ti,ab OR SF-20:ti,ab OR 'SF 20':ti,ab OR 'short form 20':ti,ab OR 'shortform 20':ti,ab OR shortform20:ti,ab OR '20 item short form':ti,ab OR '20-item short form':ti,ab OR SF12:ti,ab OR SF-12:ti,ab OR 'SF 12':ti,ab OR 'short form 12':ti,ab OR 'shortform 12':ti,ab OR shortform12:ti,ab OR '12 item short form':ti,ab OR '12-item short form':ti,ab OR SF8:ti,ab OR SF-8:ti,ab OR 'SF 8':ti,ab OR 'short form 8':ti,ab OR 'shortform 8':ti,ab OR shortform8:ti,ab OR '8 item short form':ti,ab OR '8-item short form':ti,ab OR SF6:ti,ab OR SF-6:ti,ab OR 'SF 6':ti,ab OR 'short form 6':ti,ab OR 'shortform 6':ti,ab OR shortform6:ti,ab OR '6 item short form':ti,ab OR '6-item short form':ti,ab OR 'QoL Questionnaire' OR QLQ:ti,ab OR 'health questionnaire' OR 'godin leisure time' OR 'numeric pain scale'/exp OR 'numeric pain scale' OR 'lateral hopping for distance' OR '6-m crossover hop' OR 'side hop' OR 'hopping course' OR 'square hop' OR 'cross hop' OR 'hop test' OR 'hopping test' OR '40-m walk time' OR '40-m run time' OR 'figureof-eight run' OR 'single-limb forward hop' OR 'single limb forward hop' OR 'stair hop' OR 'shuttle run' OR 'up/down hop' OR 'hop up' OR 'hopping up' OR 'hop down' OR 'hopping down' OR 'triple crossover hop' OR 'single-limb hurdle' OR 'single limb hurdle' OR 'single-limb 6-m hop' OR 'single-limb 30-m hop' OR 'figureof-eight hop' OR 'figure of eight hop' OR 'figure eight hop' OR 'drop landing' OR 'vertical jump'/exp OR 'vertical jump' OR 'walking speed'/exp OR 'walking speed' OR 'walking speeds' OR 'walking gait' OR 'gait speed'/exp OR 'gait speed' OR 'gait speeds' OR 'walking pace' OR 'walking paces' OR 'running gait' OR 'running speed'/exp OR 'running speed' OR 'running speeds' OR 'running pace' OR 'running paces' OR 'figure of 8 circumferential measure' OR 'volumetric measure' OR 'range of motion'/exp OR 'range of motion' OR 'joint flexibility'/exp OR 'joint flexibility' OR 'articular arthometry' OR 'articular goniometry' OR 'supination'/exp OR supination OR supinations OR 'pronation'/exp OR pronation OR pronations OR 'tibiopedal dorsiflexion' OR 'weight-bearing lunge' OR 'weight bearing lunge' OR 'algometry'/exp OR algometry OR 'pain threshold'/exp OR 'pain threshold' OR 'pain thresholds' OR 'pressurepain threshold'/exp OR 'pressurepain threshold' OR 'pressurepain thresholds' OR 'cutaneous sensation'/exp OR 'cutaneous sensation' OR 'hypesthesia'/exp OR hypesthesia OR hyperethesia OR 'joint position sense'/exp OR 'joint position sense' OR 'kinesthesis'/exp OR kinesthesis OR 'kinesthesia'/exp OR kinesthesia OR kinesthesias OR kinesthetic OR 'movement sensation' OR 'movement sensations' OR 'isokinetic muscle strength' OR 'isokinetic test' OR 'isokinetic tests' OR 'single-limb balance' OR 'single limb balance' OR 'romberg test'/exp OR 'romberg test' OR 'balance test'/exp OR 'balance test' OR 'balancing test' OR 'y balance' OR 'balance error scoring system'/exp OR 'balance error scoring system' OR 'step-down test' OR 'step down test'/exp OR 'step down test' OR 'single leg squat test' OR 'functional movement screen'/exp OR 'functional movement screen' OR 'functional movement screening' OR 'functional movement screens' OR 'joint accessory mobility' OR 'joint play mobility' OR 'anterior drawer' OR 'talar tilt inversion' OR 'talar tilt eversion' OR 'talar rotation' OR 'talofibular interval' OR 'tibiofibular interval' OR 'distal fibula interval' OR 'foot posture index'/exp OR 'foot posture index' OR 'squeeze test'/exp OR 'squeeze test' OR 'cotton test' OR 'dorsiflexion maneuver' OR 'dorsiflexion maneuvers' OR 'dorsiflexion compression test' OR 'crossed leg test' OR 'heel thump test' OR 'kleiger dorsiflexion external rotation test' OR 'external rotation test' OR 'thompson test' OR 'function and prognostic score' OR 'function and prognostic scores' OR 'ankle function score' OR 'ankle scoring system' OR 'multisegmented foot' OR 'ankle-foot complex' OR 'foot morphology' OR 'intrinsic foot muscles' OR 'ankle assessment' OR 'ankle assessments' OR 'foot assessment' OR 'foot assessments' OR 'feet assessment' OR 'feet assessments' OR 'biomechanical assessment' OR 'biomechanical assessments' OR 'foot root model' OR 'ankle root model') AND [embase]/lim	188148
#5	('risk'/exp OR risk OR risks OR 'risk benefit' OR 'probability'/exp OR probability OR probabilities OR likelihood OR propensity OR 'logistic model'/exp OR 'logistic model' OR 'logistic models' OR 'logistic modeling' OR 'logistic regression'/exp OR 'logistic regression' OR 'logistic regressions' OR 'protective factor' OR 'protective factors'/exp OR 'protective factors' OR 'bayes theorem'/exp OR 'bayes theorem' OR bayesian OR 'causality'/exp OR causality OR causalities OR causation OR causations OR cause OR causes OR 'enabling factor' OR 'enabling factors' OR 'reinforcing factor' OR 'reinforcing factors' OR 'predisposing factor'/exp OR 'predisposing factor' OR 'predisposing factors' OR 'predisposition'/exp OR predisposition OR 'precipitating factors'/exp OR 'precipitating factors' OR 'precipitating factor' OR 'odds ratio'/exp OR 'odds ratio' OR 'odds ratios' OR predict OR 'prediction'/exp OR prediction OR predictions OR predictabilities OR 'predictability'/exp OR predictability OR predicted OR predictor OR 'predictors'/exp OR predictors OR predictive OR 'etiology'/de OR etiology OR etiologies OR etiological OR etiologic OR aetiology OR 'origin'/exp OR origin OR origination OR originating OR interact OR interaction OR interactions OR interacting) AND [embase]/lim	9316738
#4	('incidence'/exp OR incidence OR incidences OR morbidity OR morbidities OR 'epidemiology'/exp OR epidemiology OR 'prevalence'/exp OR prevalence OR prevalent OR prevalencies) AND [embase]/lim	3694481

Table continues on page CPG59.

APPENDIX A

Search	Query	Items Found, n
#3	('physical therapy'/exp OR 'physical therapy' OR 'physical therapies' OR 'physiotherapy'/exp OR physiotherapy OR physiotherapies OR 'recovery'/exp OR recovery OR restoration OR reeducation OR 'rehabilitation'/exp OR rehabilitation OR rehab OR 'early ambulation'/exp OR 'early ambulation' OR 'accelerated ambulation' OR 'early mobilization'/exp OR 'early mobilization' OR 'exercise therapy'/exp OR 'exercise therapy' OR 'therapeutic exercise'/exp OR 'therapeutic exercise' OR 'therapeutic exercises' OR 'therapeutic modality' OR 'therapeutic modalities' OR 'stretching'/exp OR stretching OR 'exercise movement' OR strengthen OR strengthening OR 'resistance training'/exp OR 'resistance training' OR 'strength training'/exp OR 'strength training' OR 'weight bearing'/exp OR weight-bearing OR 'weight lifting'/exp OR weight-lifting OR 'resistance methods' OR 'training program'/exp OR 'training program' OR 'biofeedback'/exp OR biofeedback OR 'psychophysiologic feedback' OR 'neuromuscular electrical stimulation'/exp OR 'neuromuscular electrical stimulation' OR 'neuromuscular reeducation' OR 'pain management'/exp OR 'pain management' OR 'pain measurement'/exp OR 'pain measurement' OR 'mobilization'/exp OR mobilization OR mobilizations OR 'manipulation'/exp OR manipulation OR manipulations OR 'ultrasonography'/exp OR ultrasonography OR ultrasound OR 'acupuncture'/exp OR acupuncture OR 'patient education'/exp OR 'patient education' OR 'education of patients' OR 'iontophoresis'/exp OR iontophoresis OR 'electric stimulation'/exp OR 'electric stimulation' OR 'nerve stimulation'/exp OR 'nerve stimulation' OR 'tape'/exp OR taping OR tape OR 'bracing'/exp OR 'brace'/exp OR bracing OR brace OR braces OR orthoses OR 'immobilization'/exp OR immobilization OR immobilize OR 'orthotics'/exp OR orthotic OR orthotics OR 'thermal agent' OR 'thermal agents' OR 'diathermy'/exp OR diathermy OR 'range of motion'/exp OR 'range of motion' OR 'joint flexibility'/exp OR 'joint flexibility' OR 'joint movement'/exp OR 'joint movement' OR 'manual therapy'/exp OR 'manual therapy' OR 'massage'/exp OR massage OR massages OR 'treatment outcome'/exp OR 'treatment outcome' OR 'clinical effectiveness'/exp OR 'clinical effectiveness' OR 'treatment effectiveness' OR 'treatment efficacy' OR 'patient outcome'/exp OR 'patient outcome' OR 'patient outcomes') AND [embase]/lim	3750588
#2	('injury'/de OR injuries OR injury OR injured OR 'sprain'/exp OR sprains OR sprain OR sprained OR 'strain'/exp OR strains OR strains OR strain OR strained OR 'swelling'/exp OR swelling OR swollen OR swell OR 'instability'/exp OR instability OR instabilities OR unstable OR 'joint effusion'/exp OR 'joint effusion' OR 'proprioception deficit' OR 'proprioception deficits' OR 'proprioception deficiency' OR 'proprioception deficiencies' OR 'balance'/exp OR balance OR unbalanced OR 'musculoskeletal equilibrium'/exp OR 'musculoskeletal equilibrium' OR 'postural equilibrium'/exp OR 'postural equilibrium' OR 'hypermobility'/exp OR hypermobility OR hypermobilities OR laxity OR laxities OR 'tear'/exp OR tear OR torn OR 'external rotation'/exp OR 'external rotation' OR 'eversion'/exp OR 'inversion'/exp OR eversion OR inversion) AND [embase]/lim	2422429
#1	('ankle'/exp OR ankle OR ankles OR 'regio tarsalis' OR 'tarsus'/exp OR talus OR tarsus OR 'metatarsus'/exp OR metatarsus OR metatarsal OR 'subtalar joint'/exp OR 'subtalar joint' OR 'talonavicular joint'/exp OR 'talocalcaneal joint'/exp OR 'talocalcaneal joint' OR talocrural OR 'articulatio talocruralis' OR 'tarsal joint'/exp OR 'tarsal joints' OR 'tarsal joint' OR 'midtarsal joint'/exp OR 'midtarsal joint' OR 'midtarsal joints' OR 'intertarsal joint'/exp OR 'intertarsal joint' OR 'intertarsal joints' OR 'intertarsal articulation'/exp OR 'intertarsal articulation' OR 'articulationes intertarseae' OR 'articulationes intertarsales' OR 'ligamentum laterale articulationis talocruralis' OR calcaneofibular OR tibiofibular OR tibiotalar OR tibionavicular OR tibiocalcaneal OR talofibular OR talonavicula OR calcaneocuboid OR 'ankle lateral ligament'/exp OR 'ankle lateral ligament' OR 'bifurcate* ligament*' OR 'inferior transverse ligament*' OR 'deltoid ligament*' OR 'medial ligament*' OR 'interosseous ligament*' OR 'peroneus nerve'/exp OR 'tibial nerve'/exp OR 'tibial nerve' OR 'peroneal nerve' OR 'peroneus nerve' OR 'saphenous nerve'/exp OR 'saphenous nerve' OR 'medial plantar nerve'/exp OR 'medial plantar nerve' OR 'lateral plantar nerve'/exp OR 'lateral plantar nerve' OR 'fibular nerve'/exp OR 'fibular nerve' OR 'fibularis tertius' OR 'achilles tendon'/exp OR 'achilles tendon' OR calcaneal OR calcaneus OR 'interosseous membrane'/exp OR 'interosseous membrane' OR 'interosseous membranes' OR 'dorsal interossei' OR 'plantar interossei' OR syndesmosis OR syndesmoses OR syndesmotic OR 'tibialis anterior' OR 'fibularis longus' OR 'fibularis brevis' OR 'peroneus tertius' OR 'peroneus longus'/exp OR 'peroneus longus' OR 'peroneus brevis'/exp OR 'peroneus brevis' OR 'flexor hallucis longus'/exp OR 'flexor hallucis longus' OR 'flexor digitorum longus'/exp OR 'flexor digitorum longus' OR 'extensor digitorum longus' OR 'tibialis posterior' OR 'soleus'/exp OR soleus OR peroneal OR 'gastrocnemius'/exp OR gastrocnemius OR 'abductor hallucis'/exp OR 'abductor hallucis' OR 'adductor hallucis' OR 'flexor hallucis brevis'/exp OR 'flexor hallucis brevis' OR 'abductor digiti minimi'/exp OR 'abductor digiti minimi' OR 'flexor digiti minimi' OR 'lumbricals' OR 'quadratus plantae' OR 'flexor digitorum brevis' OR 'gluteus muscle'/exp OR 'gluteus medius' OR 'gluteus maximus' OR 'gluteal' OR 'hip abductor' OR 'hip rotator') OR ('foot'/exp foot OR feet OR 'foot muscle'/exp OR 'flexor digitorum brevis'/exp OR 'flexor digitorum brevis muscle'/exp OR 'plantaris muscle'/exp OR 'plantaris muscle' OR 'articulationes pedis' OR metatarsophalangeal OR 'heel'/exp OR heel OR heels OR 'sinus tarsi' OR 'sinus tarsus' OR 'rearfoot'/exp OR rearfoot OR 'midfoot'/exp OR midfoot) AND [embase]/lim	208854

CINAHL

History: June 26, 2018

Search	Query	Items Found, n
#14	#9 AND #8 AND [Published Date: 20130101-20181231, Source Types: Academic Journals, Language: English]	1991
#13	#7 AND #6 AND #1 AND [Published Date: 20130101-20181231, Source Types: Academic Journals, Language: English]	582
#12	#9 AND #5 AND [Published Date: 20130101-20181231, Source Types: Academic Journals, Language: English]	2066
#11	#9 AND #4 AND [Published Date: 20130101-20181231, Source Types: Academic Journals, Language: English]	179
#10	#9 AND #3 AND [Published Date: 20130101-20181231, Source Types: Academic Journals, Language: English]	2238
#9	#1 AND #2 AND [Published Date: 20130101-20181231, Source Types: Academic Journals, Language: English]	5128

Table continues on page CPG60.

APPENDIX A

Search	Query	Items Found, n
#8	(MH "Diagnosis" OR MH "Diagnosis, Computer Assisted" OR MH "Diagnosis, Delayed" OR MH "Diagnosis, Differential" OR MH "Early Diagnosis" OR MM "Diagnosis, Musculoskeletal" OR MH "Diagnostic Imaging" OR diagnosis OR diagnose OR diagnoses OR diagnostic OR "clinical decision-making" OR "clinical decision making" OR "medical decision-making" OR "medical decision making" OR "diagnostic imaging" OR "medical imaging" OR MH "Magnetic Resonance Imaging" OR MH "Ultrasonography" OR MH "Tomography, X-Ray" OR MH "Radiography" OR radiography OR "diagnostic x-ray" OR "diagnostic x ray" OR "diagnostic x-rays" OR "magnetic resonance imaging" OR MRI OR fMRI OR "NMR imaging" OR "MR tomography" OR ultrasonography OR ultrasound OR ultrasounds OR ultrasonic OR MH "Electromyography" OR electromyography OR electromyographies OR electromyogram OR electromyograms OR "electrophysiologic test" OR "electrophysiologic tests" OR "electrophysiologic testing" OR "neural conduction" OR "neural conductions" OR "nerve conduction" OR "nerve conductions" OR MH "Actigraphy" OR actigraphy OR MH "Physical Therapy Assessment")	934241
#7	(MH "Sensitivity and Specificity" OR sensitivity OR specificity OR MH "Evaluation Research" OR "evaluation indexes" OR "evaluation report" OR "evaluation reports" OR "evaluation research" OR use-effectiveness OR "use effectiveness" OR "prepost tests" OR "pre post tests" OR "prepost test" OR "qualitative evaluation" OR "qualitative evaluations" OR "quantitative evaluation" OR "quantitative evaluations" OR "theoretical effectiveness" OR critique OR critiques OR "evaluation methodology" OR "evaluation methodologies" OR MH "Reproducibility of Results" OR reproducibility OR MH "Validity+" OR validity OR MH "Reliability" OR reliability OR MH "Reliability and Validity" OR "data accuracy" OR "data accuracies" OR "data quality" OR "data qualities" OR MH "Precision" OR precision OR responsiveness OR consistency OR consistencies OR consistent OR "log-likelihood ratio" OR "likelihood-ratio" OR "likelihood ratio" OR MH "Study Design" OR "research design" OR "research designs" OR "research strategy" OR "research strategies" OR "research techniques" OR "research technique" OR MH "Research Methodology" OR "research methodology" OR "research methodologies" OR "experimental design" OR "experimental designs")	524735
#6	(ZQ "cumberland ankle instability tool" OR ZQ "cumberland ankle instability tool (cait)" OR "Cumberland ankle instability tool" OR ZQ "chronic ankle instability scale (cais)" OR "Chronic Ankle Instability Scale" OR ZQ "sports ankle rating system" OR "Sports Ankle Rating System" OR ZQ "ankle joint functional assessment tool" OR "Ankle Joint Functional Assessment Tool" OR ZQ "foot function index" OR ZQ "foot function index (ffi)" OR "Foot Function Index" OR ZQ "foot and ankle outcome score" OR ZQ "foot and ankle outcome score (faos)" OR ZQ "foot and ankle outcome scores (faos)" OR "Foot and Ankle Outcome Score" OR ZQ "karlsson score" OR "Karlsson Ankle Function Score" OR "Karlsson Score" OR ZQ "kaikkonen scale" OR "Kaikkonen scale" OR "Kaikkonen score" OR ZQ "ottawa ankle rules" OR ZQ "ottawa ankle rules (oar)" OR "Ottawa ankle rules" OR "Buffalo modification" OR ZQ "foot and ankle ability measure (faam)" OR "foot and ankle ability measure" OR "foot ability measure" OR "ankle ability measure" OR ZQ "foot and ankle disability index (fadi)" OR "foot and ankle disability index" OR ZQ "lower extremity functional scale (lefs)" OR "lower extremity functional scale" OR "ankle instability scale" OR "sports ankle rating system" OR ZQ "ankle joint functional assessment tool (ajfat)" OR "ankle joint function assessment" OR ZQ "ankle instability index" OR "ankle instability index" OR ZQ "ankle instability instrument" OR "ankle instability instrument" OR "identification of functional ankle instability" OR ZQ "tampa scale for kinesiophobia (tsk)" OR "Tampa scale of kinesiophobia" OR "sway index" OR ZQ "functional reach test" OR ZQ "functional reach test (frt)" OR "functional reach test" OR ZQ "patient reported outcomes measurement information system (promis)" OR "Patient Reported Outcome Measurement Information System" OR MH "Short Form-36 Health Survey (SF-36)" OR ZQ "short form health survey (sf-36)" OR ZQ "short form health survey" OR "short form health survey" OR "short-form health survey" OR ZQ "visual analogue scale" OR ZQ "visual analogue scale (vas)" OR "Visual Analogue Scale" OR ZQ "health utilities index (hui)" OR "health utilities index" OR "European Quality of life 5 Dimensions" OR EuroQol OR "short form 36" OR "shortform 36" OR shortform36 OR "36 item short form" OR "36-item short form" OR "short form 20" OR "shortform 20" OR shortform20 OR "20 item short form" OR "20-item short form" OR "short form 12" OR "shortform 12" OR shortform12 OR "12 item short form" OR "12-item short form" OR "short form 8" OR "shortform 8" OR shortform8 OR "8 item short form" OR "8-item short form" OR "short form 6" OR "shortform 6" OR shortform6 OR "6 item short form" OR "6-item short form" OR "QoL Questionnaire" OR "health questionnaire" OR ZQ "godin leisure time exercise questionnaire" OR ZQ "godin leisure time exercise questionnaire (glteq)" OR "Godin leisure time" OR ZQ "numeric pain scale" OR "Numeric Pain Scale" OR ZQ "hop test" OR "lateral hopping for distance" OR "6-m crossover hop" OR "side hop" OR "hopping course" OR "square hop" OR "cross hop" OR "hop test" OR "hopping test" OR "40-m walk time" OR "40-m run time" OR "figure-of-eight run" OR "single-limb forward hop" OR "single limb forward hop" OR "stair hop" OR "shuttle run" OR "up/down hop" OR "hop up" OR "hopping up" OR "hop down" OR "hopping down" OR "triple crossover hop" OR "single-limb hurdle" OR "single limb hurdle" OR "single-limb 6-m hop" OR "single-limb 30-m hop" OR "figureof-eight hop" OR "figure of eight hop" OR "figure eight hop" OR "drop landing" OR "vertical jump" OR "walking speed" OR "walking speeds" OR "walking gait" OR "gait speed" OR "gait speeds" OR "walking pace" OR "walking paces" OR "running gait" OR "running speed" OR "running speeds" OR "running pace" OR "running paces" OR "figure of 8 circumferential measure" OR "volumetric measure" OR MH "Range of Motion" OR "range of motion" OR "joint flexibility" OR "articular arthometry" OR "articular goniometry" OR MH "Supination" OR supination OR supinations OR MH "Pronation" OR pronation OR pronations OR "tibiopedal dorsiflexion" OR "weight-bearing lunge" OR "weight bearing lunge" OR MH "Algometry" OR algometry OR MH "Pain Threshold" OR "pain threshold" OR "pain thresholds" OR "pressurepain threshold" OR "pressurepain thresholds" OR "cutaneous sensation" OR MH "Hypesthesia" OR hypesthesia OR hyperethesia OR "joint position sense" OR MH "Kinesthesis" OR kinesthesis OR kinesthesia OR kinesthesias OR kinesthetic OR "movement sensation" OR "movement sensations" OR "isokinetic muscle strength" OR "isokinetic test" OR "isokinetic tests" OR "single-limb balance" OR "single limb balance" OR ZQ "romberg test" OR ZQ "romberg's test" OR "Romberg test" OR ZQ "balance test" OR "balance test" OR "balancing test" OR ZQ "y balance test" OR "Y balance" OR ZQ "balance error scoring system (bess)" OR "Balance Error Scoring System" OR ZQ "step-down test"OR "step-down test" OR "step down test" OR "single leg squat test" OR ZQ "functional movement screen" OR ZQ "functional movement screen (fms)" OR "functional movement screen" OR "functional movement screening" OR "functional movement screens" OR "joint accessory mobility" OR "joint play mobility" OR ZQ "anterior drawer test" OR "anterior drawer" OR "talar tilt inversion" OR "talar tilt eversion" OR "talar rotation" OR "talofibular interval" OR "tibiofibular interval" OR "distal fibula interval" OR ZQ "foot posture index" OR ZQ "foot posture index (fpi)"OR "foot posture index" OR "squeeze test" OR "Cotton test" OR "dorsiflexion maneuver" OR "dorsiflexion maneuvers" OR "dorsiflexion compression test" OR "crossed leg test" OR "heel thump test" OR "Kleiger dorsiflexion external rotation test" OR "external rotation test" OR ZQ "thompson test" OR "Thompson test" OR "function and prognostic score" OR "function and prognostic scores" OR ZQ "ankle function score" OR "ankle function score" OR "ankle scoring system" OR "multisegmented foot" OR "ankle-foot complex" OR "foot morphology" OR "intrinsic foot muscles" OR "ankle assessment" OR "ankle assessments" OR "foot assessment" OR "foot assessments" OR "feet assessment" OR "feet assessments" OR "biomechanical assessment" OR "biomechanical assessments" OR "foot root model" OR "ankle root model")	67776

Table continues on page CPG61.

APPENDIX A

Search	Query	Items Found, n
#5	(MH "Risk Assessment" OR MH "Risk Factors" OR risk OR risks OR risk-benefit OR MH "Probability" OR probability OR probabilities OR likelihood OR propensity OR MH "Multiple Logistic Regression" OR "logistic model" OR "logistic models" OR "logistic modeling" OR "logistic regression" OR "logistic regressions" OR "protective factor" OR "protective factors" OR "Bayes theorem" OR Bayesian OR MH "Causal Attribution" OR causality OR causalities OR causation OR causations OR cause OR causes OR "enabling factor" OR "enabling factors" OR "reinforcing factor" OR "reinforcing factors" OR "predisposing factor" OR "predisposing factors" OR predisposition OR "precipitating factors" OR "precipitating factor" OR predictor OR predictors OR MH "Odds Ratio" OR "odds ratio" OR "odds ratios" OR predict OR prediction OR predictions OR predictabilities OR predictability OR predicted OR predictor OR predictors OR predictive OR etiology OR etiologies OR etiological OR etiologic OR aetiology OR origin OR origination OR originating OR MH "Interaction (Research)" OR interact OR interaction OR interactions OR interacting)	1409663
#4	(MH "Incidence" OR incidence OR incidences OR MH "Morbidity" OR morbidity OR morbidities OR MH "Epidemiology" OR epidemiology OR MH "Prevalence" OR prevalence OR prevalent OR prevalencies)	178273
#3	(MH "Physical Therapy" OR "physical therapy" OR "physical therapies" OR physiotherapy OR physiotherapies OR MH "Recovery" OR MH "Recovery, Exercise" OR recovery OR restoration OR reeducation OR MH "Rehabilitation" OR rehabilitation OR rehab OR MH "Early Ambulation" OR "early ambulation" OR "accelerated ambulation" OR "early mobilization" OR MH "Therapeutic Exercise OR "exercise therapy" OR "therapeutic exercise" OR "therapeutic exercises" OR "therapeutic modality" OR "therapeutic modalities" OR stretching OR "exercise movement" OR MH "Gait Training" OR strengthen OR strengthening OR MH "Resistance Training" OR MH "Muscle Strengthening" OR "resistance training" OR "strength training" OR weight-bearing OR weight-lifting OR "resistance methods" OR "training program" OR MH "Biofeedback" OR biofeedback OR "psychophysiologic feedback" OR "neuromuscular electrical stimulation" OR "neuromuscular reeducation" OR MH "Pain Management" OR MH "Pain Measurement" OR "pain management" OR "pain measurement" OR MH "Joint Mobilization" OR mobilization OR mobilizations OR manipulation OR manipulations OR MH "Ultrasonography" OR ultrasonography OR ultrasound OR MH "Acupuncture" OR acupuncture OR MH "Patient Education"OR "patient education" OR "education of patients" OR MH "Iontophoresis" OR iontophoresis OR MH "Electrotherapy" OR "electric stimulation" OR "nerve stimulation" OR MH "Taping and Strapping" OR taping OR tape OR MH "Orthoses" OR orthoses OR bracing OR brace OR braces OR immobilization OR immobilize OR orthotic OR orthotics OR "thermal agent" OR "thermal agents" OR diathermy OR "range of motion" OR "joint flexibility" OR "joint movement" OR MH "Manual Therapy" OR "manual therapy" OR MH "Massage" OR massage OR massages OR MH "Treatment Outcomes" OR "treatment outcome" OR "clinical effectiveness" OR "treatment effectiveness" OR "treatment efficacy"OR MH "Outcomes (Health Care)"OR "patient outcome" OR "patient outcomes")	640059
#2	(MH "Wounds and Injuries" OR MH "Athletic Injuries+" OR MH "Leg Injuries" OR MH "Ligament Injuries" OR MH "Ankle Injuries+" OR MH "Foot Injuries+" OR MH "Tendon Injuries+"OR injuries OR injury OR injured OR MH "Ankle Sprain, Syndesmosis" OR MH "Sprains and Strains+" OR MH "Calf Strain" OR sprains OR sprain OR sprained OR strains OR strain OR strained OR swelling OR swollen OR swell MH "Joint Instability+" OR instability OR instabilities OR unstable OR "joint effusion" OR "proprioception deficit" OR "proprioception deficits" OR "proprioception deficiency" OR "proprioception deficiencies" OR MH "Balance, Postural" OR balance OR unbalanced OR "musculoskeletal equilibrium" OR "postural equilibrium" OR hypermobility OR hypermobilities OR laxity OR laxities OR MH "Tears and Lacerations+" OR tear OR torn OR "external rotation" OR MH "Eversion" OR MH "Inversion" OR eversion OR inversion)	352935
#1	(MH "Ankle"OR ankle OR ankles OR regio tarsalis OR MH "Talus" OR talus OR tarsus OR metatarsus OR metatarsal OR MH "Ankle Joint" OR "subtalar joint" OR "talocalcaneal joint" OR talocrural OR "articulatio talocruralis" OR "tarsal joints" OR "tarsal joint" OR "midtarsal joint" OR "midtarsal joints" OR "intertarsal joint" OR "intertarsal joints" OR "intertarsal articulation" OR "articulationes intertarseae" OR "articulationes intertarsales" OR "ligamentum laterale articulationis talocruralis" OR calcaneofibular OR tibiofibular OR tibiotalar OR tibionavicular OR tibiocalcaneal OR talofibular OR talonavicula OR calcaneocuboid OR MH "Lateral Ligament, Ankle" OR "ankle lateral ligament" OR "bifurcate* ligament*" OR "inferior transverse ligament*" OR "deltoid ligament*" OR "medial ligament*" OR "interosseous ligament*" OR MH "Tibial Nerve" OR "tibial nerve" OR MH "Peroneal Nerve" OR "peroneal nerve" OR "saphenous nerve" OR "medial plantar nerve" OR "lateral plantar nerve" OR "fibular nerve" OR "fibularis tertius" OR MH "Achilles Tendon" OR "achilles tendon" OR calcaneal OR calcaneus OR "interosseous membrane" OR "interosseous membranes" OR "dorsal interossei" OR "plantar interossei" OR syndesmosis OR syndesmoses OR syndesmotic OR "tibialis anterior" OR "fibularis longus" OR "fibularis brevis" OR "peroneus tertius" OR "peroneus longus" OR "peroneus brevis" OR "flexor hallucis longus" OR "flexor digitorum longus" OR "extensor digitorum longus" OR "tibialis posterior" OR MH "Soleus Muscles" OR soleus OR peroneal OR MH "Gastrocnemius Muscle" OR gastrocnemius OR "abductor hallucis" OR "adductor hallucis" OR "flexor hallucis brevis" OR "abductor digiti minimi" OR "flexor digiti minimi" OR "lumbricals" OR "quadratus plantae" OR "flexor digitorum brevis" OR MH "Gluteal Muscles" OR "gluteus medius" OR "gluteus maximus" OR "gluteal" OR "hip abductor" OR "hip rotator") OR (foot OR MH "Foot" OR feet OR "articulationes pedis" OR metatarsophalangeal OR MH "Heel" OR heel OR heels OR "sinus tarsi" OR "sinus tarsus" OR rearfoot OR midfoot)	68058

Cochrane Library

History: June 26, 2018

Search	Query	Items Found, n
#14	#9 AND #8 AND [Publication Year from 2013 to 2018]	538
#13	#7 AND #6 AND #1 AND [Publication Year from 2013 to 2018]	183
#12	#9 AND #5 AND [Publication Year from 2013 to 2018]	754
#11	#9 AND #4 AND [Publication Year from 2013 to 2018]	250
#10	#9 AND #3 AND [Publication Year from 2013 to 2018]	1299
#9	#1 AND #2 AND [Publication Year from 2013 to 2018]	1980

Table continues on page CPG62.

APPENDIX A

Search	Query	Items Found, n
#8	(diagnosis OR diagnose OR diagnoses OR diagnostic OR "clinical decision-making" OR "clinical decision making" OR "medical decision-making" OR "medical decision making" OR "diagnostic imaging" OR "medical imaging" OR radiography OR "diagnostic x-ray" OR "diagnostic x ray" OR "diagnostic x-rays" OR "magnetic resonance imaging" OR MRI OR fMRI OR "NMR imaging" OR "MR tomography" OR ultrasonography OR ultrasound OR ultrasounds OR ultrasonic OR electromyography OR electromyographies OR electromyogram OR electromyograms OR "electrophysiologic test" OR "electrophysiologic tests" OR "electrophysiologic testing" OR "neural conduction" OR "neural conductions" OR "nerve conduction" OR "nerve conductions" OR actigraphy)	158649
#7	(sensitivity OR specificity OR "evaluation indexes" OR "evaluation report" OR "evaluation reports" OR "evaluation research" OR use-effectiveness OR "use effectiveness" OR "prepost tests" OR "pre post tests" OR "prepost test" OR "qualitative evaluation" OR "qualitative evaluations" OR "quantitative evaluation" OR "quantitative evaluations" OR "theoretical effectiveness" OR critique OR critiques OR "evaluation methodology" OR "evaluation methodologies" OR reproducibility OR validity OR reliability OR "data accuracy" OR "data accuracies" OR "data quality" OR "data qualities" OR precision OR responsiveness OR consistency OR consistencies OR consistent OR "log-likelihood ratio" OR "likelihood-ratio" OR "likelihood ratio" OR "research design" OR "research designs" OR "research strategy" OR "research strategies" OR "research techniques" OR "research technique" OR "research methodology" OR "research methodologies" OR "experimental design" OR "experimental designs")	127277
#6	("Cumberland ankle instability tool" OR "Chronic Ankle Instability Scale" OR "Sports Ankle Rating System" OR "Ankle Joint Functional Assessment Tool" OR "Foot Function Index" OR "Foot and Ankle Outcome Score" OR "Karlsson Ankle Function Score" OR "Karlsson Score" OR "Kaikkonen scale" OR "Kaikkonen score" OR "Ottawa ankle rules" OR "Buffalo modification" OR "foot and ankle ability measure" OR "foot ability measure" OR "ankle ability measure" OR "foot and ankle disability index" OR "lower extremity functional scale" OR "ankle instability scale" OR "sports ankle rating system" OR "ankle joint function assessment" OR "ankle instability index" OR "ankle instability instrument" OR "identification of functional ankle instability" OR "Tampa scale of kinesiophobia" OR "sway index" OR "functional reach test" OR "Patient Reported Outcome Measurement Information System" OR "short form health survey" OR "short-form health survey" OR "Visual Analogue Scale" OR "health utilities index" OR "European Quality of life 5 Dimensions" OR EuroQol OR "short form 36" OR "shortform 36" OR shortform36 OR "36 item short form" OR "36-item short form" OR "short form 20" OR "shortform 20" OR shortform20 OR "20 item short form" OR "20-item short form" OR "short form 12" OR "shortform 12" OR shortform12 OR "12 item short form" OR "12-item short form" OR "short form 8" OR "shortform 8" OR shortform8 OR "8 item short form" OR "8-item short form" OR "short form 6" OR "shortform 6" OR shortform6 OR "6 item short form" OR "6-item short form" OR "QoL Questionnaire" OR "health questionnaire" OR "Godin leisure time" OR "Numeric Pain Scale" OR "lateral hopping for distance" OR "6-m crossover hop" OR "side hop" OR "hopping course" OR "square hop" OR "cross hop" OR "hop test" OR "hopping test" OR "40-m walk time" OR "40-m run time" OR "figureof-eight run" OR "single-limb forward hop" OR "single limb forward hop" OR "stair hop" OR "shuttle run" OR "up/down hop" OR "hop up" OR "hopping up" OR "hop down" OR "hopping down" OR "triple crossover hop" OR "single-limb hurdle" OR "single limb hurdle" OR "single-limb 6-m hop" OR "single-limb 30-m hop" OR "figureof-eight hop" OR "figure of eight hop" OR "figure eight hop" OR "drop landing" OR "vertical jump" OR "walking speed" OR "walking speeds" OR "walking gait" OR "gait speed" OR "gait speeds" OR "walking pace" OR "walking paces" OR "running gait" OR "running speed" OR "running speeds" OR "running pace" OR "running paces" OR "figure of 8 circumferential measure" OR "volumetric measure" OR "range of motion" OR "joint flexibility" OR "articular arthometry" OR "articular goniometry" OR supination OR supinations OR pronation OR pronations OR "tibiopedal dorsiflexion" OR "weight-bearing lunge" OR "weight bearing lunge" OR algometry OR "pain threshold" OR "pain thresholds" OR "pressurepain threshold" OR "pressurepain thresholds" OR "cutaneous sensation" OR hypesthesia OR hyperethesia OR "joint position sense" OR kinesthesis OR kinesthesia OR kinesthesias OR kinesthetic OR "movement sensation" OR "movement sensations" OR "isokinetic muscle strength" OR "isokinetic test" OR "isokinetic tests" OR "single-limb balance" OR "single limb balance" OR "Romberg test" OR "balance test" OR "balancing test" OR "Y balance" OR "Balance Error Scoring System" OR "step-down test" OR "step down test" OR "single leg squat test" OR "functional movement screen" OR "functional movement screening" OR "functional movement screens" OR "joint accessory mobility" OR "joint play mobility" OR "anterior drawer" OR "talar tilt inversion" OR "talar tilt eversion" OR "talar rotation" OR "talofibular interval" OR "tibiofibular interval" OR "distal fibula interval" OR "foot posture index" OR "squeeze test" OR "Cotton test" OR "dorsiflexion maneuver" OR "dorsiflexion maneuvers" OR "dorsiflexion compression test" OR "crossed leg test" OR "heel thump test" OR "Kleiger dorsiflexion external rotation test" OR "external rotation test" OR "Thompson test" OR "function and prognostic score" OR "function and prognostic scores" OR "ankle function score" OR "ankle scoring system" OR "multisegmented foot" OR "ankle-foot complex" OR "foot morphology" OR "intrinsic foot muscles" OR "ankle assessment" OR "ankle assessments" OR "foot assessment" OR "foot assessments" OR "feet assessment" OR "feet assessments" OR "biomechanical assessment" OR "biomechanical assessments" OR "foot root model" OR "ankle root model")	50924
#5	(risk OR risks OR risk-benefit OR probability OR probabilities OR likelihood OR propensity OR "logistic model" OR "logistic models" OR "logistic modeling" OR "logistic regression" OR "logistic regressions" OR "protective factor" OR "protective factors" OR "Bayes theorem" OR Bayesian OR causality OR causalities OR causation OR causations OR cause OR causes OR "enabling factor" OR "enabling factors" OR "reinforcing factor" OR "reinforcing factors" OR "predisposing factor" OR "predisposing factors" OR predisposition OR "precipitating factors" OR "precipitating factor" OR predictor OR predictors OR "odds ratio" OR "odds ratios" OR predict OR prediction OR predictions OR predictabilities OR predictability OR predicted OR predictor OR predictors OR predictive OR etiology OR etiologies OR etiological OR etiologic OR aetiology OR origin OR origination OR originating OR interact OR interaction OR interactions OR interacting)	355072
#4	(incidence OR incidences OR morbidity OR morbidities OR epidemiology OR prevalence OR prevalent OR prevalencies)	144274

Table continues on page CPG63.

APPENDIX A

Search	Query	Items Found, n
#3	("physical therapy" OR "physical therapies" OR physiotherapy OR physiotherapies OR recovery OR restoration OR reeducation OR rehabilitation OR rehab OR "early ambulation" OR "accelerated ambulation" OR "early mobilization" OR "exercise therapy" OR "therapeutic exercise" OR "therapeutic exercises" OR "therapeutic modality" OR "therapeutic modalities" OR stretching OR "exercise movement" OR strengthen OR strengthening OR "resistance training" OR "strength training" OR weight-bearing OR weight-lifting OR "resistance methods" OR "training program" OR biofeedback OR "psychophysiologic feedback" OR "neuromuscular electrical stimulation" OR "neuromuscular reeducation" OR "pain management" OR "pain measurement" OR mobilization OR mobilizations OR manipulation OR manipulations OR ultrasonography OR ultrasound OR acupuncture OR "patient education" OR "education of patients" OR iontophoresis OR "electric stimulation" OR "nerve stimulation" OR taping OR tape OR bracing OR brace OR braces OR immobilization OR immobilize OR orthotic OR orthotics OR "thermal agent" OR "thermal agents" OR diathermy OR "range of motion" OR "joint flexibility" OR "joint movement" OR "manual therapy" OR massage OR massages OR "treatment outcome" OR "clinical effectiveness" OR "treatment effectiveness" OR "treatment efficacy" OR "patient outcome" OR "patient outcomes")	312688
#2	(injuries OR injury OR injured OR sprains OR sprain OR sprained OR strains OR strain OR strained OR swelling OR swollen OR swell OR instability OR instabilities OR unstable OR "joint effusion" OR "proprioception deficit" OR "proprioception deficits" OR "proprioception deficiency" OR "proprioception deficiencies" OR balance OR unbalanced OR "musculoskeletal equilibrium" OR "postural equilibrium" OR hypermobility OR hypermobilities OR laxity OR laxities OR tear OR torn OR "external rotation" OR eversion OR inversion)	92252
#1	(ankle OR ankles OR regio tarsalis OR talar OR tarsus OR metatarsus OR metatarsal OR "subtalar joint" OR "talocalcaneal joint" OR talocrural OR "articulatio talocruralis" OR "tarsal joints" OR "tarsal joint" OR "midtarsal joint" OR "midtarsal joints" OR "intertarsal joint" OR "intertarsal joints" OR "intertarsal articulation" OR "articulationes intertarseae" OR "articulationes intertarsales" OR "ligamentum laterale articulationis talocruralis" OR calcaneofibular OR tibiofibular OR tibiotalar OR tibionavicular OR tibiocalcaneal OR talofibular OR talonavicula OR calcaneocuboid OR "bifurcate* ligament*" OR "inferior transverse ligament*" OR "deltoid ligament*" OR "medial ligament*" OR "interosseous ligament*" OR "tibial nerve" OR "peroneal nerve" OR "saphenous nerve" OR "medial plantar nerve" OR "lateral plantar nerve" OR "fibular nerve" OR "fibularis tertius" OR "achilles tendon" OR calcaneal OR calcaneus OR "interosseous membrane" OR "interosseous membranes" OR "dorsal interossei" OR "plantar interossei" OR syndesmosis OR syndesmoses OR syndesmotic OR "tibialis anterior" OR "fibularis longus" OR "fibularis brevis" OR "peroneus tertius" OR "peroneus longus" OR "peroneus brevis" OR "flexor hallucis longus" OR "flexor digitorum longus" OR "extensor digitorum longus" OR "tibialis posterior" OR soleus OR peroneal OR gastrocnemius OR "abductor hallucis" OR "adductor hallucis" OR "flexor hallucis brevis" OR "abductor digiti minimi" OR "flexor digiti minimi" OR "lumbricals" OR "quadratus plantae" OR "flexor digitorum brevis" OR "gluteus medius" OR "gluteus maximus" OR "gluteal" OR "hip abductor" OR "hip rotator") OR (foot OR feet OR "articulationes pedis" OR metatarsophalangeal OR heel OR heels OR "sinus tarsi" OR "sinus tarsus" OR rearfoot OR midfoot)	18648

PEDro Advanced Search

History: June 26, 2018

Search	Query	Items Found, n
#14	Abstract & Title: diagnos* Body Part: Foot OR Ankle Published Since: 2013	41
#13	Abstract & Title: inversion Body Part: Foot OR Ankle Published Since: 2013	10
#12	Abstract & Title: eversion Body Part: Foot OR Ankle Published Since: 2013	8
#11	Abstract & Title: external rotation Body Part: Foot OR Ankle Published Since: 2013	1
#10	Abstract & Title: tear Body Part: Foot OR Ankle Published Since: 2013	2
#9	Abstract & Title: equilibrium Body Part: Foot OR Ankle Published Since: 2013	3
#8	Abstract & Title: balance Body Part: Foot OR Ankle Published Since: 2013	109
#7	Abstract & Title: proprioception Body Part: Foot OR Ankle Published Since: 2013	12

Table continues on page CPG64.

APPENDIX A

Search	Query	Items Found, n
#6	Abstract & Title: swell* Body Part: Foot OR Ankle Published Since: 2013	11
#5	Abstract & Title: injury Body Part: Foot OR Ankle Published Since: 2013	70
#4	Abstract & Title: strain* Body Part: Foot OR Ankle Published Since: 2013	3
#3	Abstract & Title: sprain* Body Part: Foot OR Ankle Published Since: 2013	51
#2	Abstract & Title: unstable Body Part: Foot OR Ankle Published Since: 2013	6
#1	Abstract & Title: instability Body Part: Foot OR Ankle Published Since: 2013	50

PubMed Update

Updated Searches From June 26, 2018 to June 1, 2020

Search	Query	Items Found, n
#14	#1 AND #9 AND #12 AND #13	5070
#13	#3 OR #4 OR #5 OR (#6 AND #7) OR #8	16889026
#12	#10 OR #11	2724576
#11	(#2 NOT (fracture[tw] NOT (sprains[tw] OR sprain[tw] OR sprained[tw] OR strains[tw] OR strain[tw] OR strained[tw] OR swelling[tw] OR swollen[tw] OR swell[tw] OR "Joint Instability"[Mesh] OR instability[tw] OR instabilities[tw] OR unstable[tw] OR joint effusion[tw] OR "Proprioception"[Mesh] OR proprioception deficit[tw] OR proprioception deficits[tw] OR proprioception deficiency[tw] OR proprioception deficiencies[tw] OR "Postural Balance"[Mesh] OR balance[tw] OR unbalanced[tw] OR musculoskeletal equilibrium[tw] OR postural equilibrium[tw] OR hypermobility[tw] OR hypermobilities[tw] OR laxity[tw] OR laxities[tw] OR tear[tw] OR torn[tw] OR external rotation[tw] OR eversion[tw] OR inversion[tw]))	2660096
#10	(#2 NOT (osteoarthritis[tw] NOT (sprains[tw] OR sprain[tw] OR sprained[tw] OR strains[tw] OR strain[tw] OR strained[tw] OR swelling[tw] OR swollen[tw] OR swell[tw] OR "Joint Instability"[Mesh] OR instability[tw] OR instabilities[tw] OR unstable[tw] OR joint effusion[tw] OR "Proprioception"[Mesh] OR proprioception deficit[tw] OR proprioception deficits[tw] OR proprioception deficiency[tw] OR proprioception deficiencies[tw] OR "Postural Balance"[Mesh] OR balance[tw] OR unbalanced[tw] OR musculoskeletal equilibrium[tw] OR postural equilibrium[tw] OR hypermobility[tw] OR hypermobilities[tw] OR laxity[tw] OR laxities[tw] OR tear[tw] OR torn[tw] OR external rotation[tw] OR eversion[tw] OR inversion[tw]))	2717587
#9	("2018/06/01"[Date - Publication]: "3000"[Date - Publication]) NOT (animals[mh] NOT humans[mh]) NOT ("Book Reviews"[Publication Type] OR "Comment"[Publication Type] OR "Editorial"[Publication Type] OR "Letter"[Publication Type] OR "Review"[Publication Type] OR "Meeting Abstracts"[Publication Type] OR "Public Service Announcements"[Publication Type] OR "News"[Publication Type] OR "Newspaper Article"[Publication Type] OR "Case Reports"[Publication Type] OR "Academic Dissertations"[Publication Type] OR "Retracted Publication"[Publication Type]) AND "English"[Language]	1896226
#8	("Diagnosis"[Mesh] OR "diagnosis"[Subheading] OR "Delayed Diagnosis"[Mesh] OR "Early Diagnosis"[Mesh] OR "Diagnosis, Differential"[Mesh] OR "Diagnosis, Computer-Assisted"[Mesh] OR "Diagnostic Techniques and Procedures"[Mesh] OR diagnosis[tw] OR diagnose[tw] OR diagnoses[tw] OR diagnostic[tw] OR "Clinical Decision-Making"[Mesh] OR clinical decision-making[tw] OR clinical decision making[tw] OR medical decision-making[tw] OR medical decision making[tw] OR "Decision Making"[Mesh:NoExp] OR "Diagnostic Imaging"[Mesh] OR diagnostic imaging[tw] OR medical imaging[tw] OR "Radiography"[Mesh] OR radiography[tw] OR diagnostic x-ray[tw] OR diagnostic x ray[tw] OR diagnostic x-rays[tw] OR "Magnetic Resonance Imaging"[Mesh] OR magnetic resonance imaging[tw] OR MRI[tw] OR fMRI[tw] OR NMR imaging[tw] OR MR tomography[tw] OR "Ultrasonography"[Mesh] OR ultrasonography[tw] OR ultrasound[tw] OR ultrasounds[tw] OR ultrasonic[tw] OR "Electromyography"[Mesh] OR electromyography[tw] OR electromyographies[tw] OR electromyogram[tw] OR electromyograms[tw] OR electrophysiologic test[tw] OR electrophysiologic tests[tw] OR electrophysiologic testing[tw] OR "Neural Conduction"[Mesh] OR neural conduction[tw] OR neural conductions[tw] OR nerve conduction[tw] OR nerve conductions[tw] OR "Actigraphy"[Mesh] OR actigraphy[tw])	10339439

Table continues on page CPG65.

APPENDIX A

Search	Query	Items Found, n
#7	("Sensitivity and Specificity"[Mesh] OR sensitivity[tw] OR specificity[tw] OR "Evaluation Studies as Topic"[Mesh] OR evaluation indexes[tw] OR evaluation report[tw] OR evaluation reports[tw] OR evaluation research[tw] OR use-effectiveness[tw] OR use effectiveness[tw] OR prepost tests[tw] OR pre post tests[tw] OR prepost test[tw] OR qualitative evaluation[tw] OR qualitative evaluations[tw] OR quantitative evaluation[tw] OR quantitative evaluations[tw] OR theoretical effectiveness[tw] OR critique[tw] OR critiques[tw] OR evaluation methodology[tw] OR evaluation methodologies[tw] OR "Validation Studies as Topic"[Mesh] OR "Reproducibility of Results"[Mesh] OR reproducibility[tw] OR validity[tw] OR reliability[tw] OR "Data Accuracy"[Mesh] OR data accuracy[tw] OR data accuracies[tw] OR data quality[tw] OR data qualities[tw] OR precision[tw] OR responsiveness[tw] OR consistency[tw] OR consistencies[tw] OR consistent[tw] OR log-likelihood ratio[tw] OR likelihood-ratio[tw] OR likelihood ratio[tw] OR LR test[tiab] OR "Epidemiologic Research Design"[Mesh] OR "Research Design"[Mesh] OR research design[tw] OR research designs[tw] OR research strategy[tw] OR research strategies[tw] OR research techniques[tw] OR research technique[tw] OR research methodology[tw] OR research methodologies[tw] OR experimental design[tw] OR experimental designs[tw])	4082712
#6	(Cumberland ankle instability tool[tw] OR Chronic Ankle Instability Scale[tw] OR Sports Ankle Rating System[tw] OR Ankle Joint Functional Assessment Tool[tw] OR Foot Function Index[tw] OR Foot and Ankle Outcome Score[tw] OR Karlsson Ankle Function Score[tw] OR Karlsson Score[tw] OR Kaikkonen scale[tw] OR Kaikkonen score[tw] OR Ottawa ankle rules[tw] OR Buffalo modification[tiab] OR foot and ankle ability measure[tw] OR foot ability measure[tw] OR ankle ability measure[tw] OR foot and ankle disability index[tw] OR lower extremity function scale[tw] OR lower extremity functional scale[tw] OR ankle instability scale[tw] OR sports ankle rating system[tw] OR ankle joint function assessment[tw] OR ankle instability index[tw] OR ankle instability instrument[tw] OR identification of functional ankle instability[tw] OR Tampa scale of kinesiophobia[tw] OR sway index[tw] OR functional reach test[tw] OR Patient Reported Outcome Measurement Information System[tw] OR PROMIS[tiab] OR Health Utilities Index[tw] OR HUI[tiab] OR HUI-III[tiab] OR HUI-3[tiab] OR HUI3[tiab] OR HUI-II[tiab] OR HUI-2[tiab] OR HUI2[tiab] OR HUI-I[tiab] OR HUI-1[tiab] OR HUI1[tiab] OR Visual Analogue Scale[tw] OR European Quality of life 5 Dimensions[tw] OR EuroQol*[tiab] OR EQ-5D[tiab] OR EQ5D*[tiab] OR EQ 5D[tiab] OR EORTC[tiab] OR Rosser[tiab] OR short form health survey[tw] OR short-form health survey[tw] OR SF36[tiab] OR SF-36[tiab] OR SF 36[tiab] OR short form 36[tiab] OR shortform 36[tiab] OR shortform36[tiab] OR 36 item short form[tiab] OR 36-item short form[tiab] OR SF20[tiab] OR SF-20[tiab] OR SF 20[tiab] OR short form 20[tiab] OR shortform 20[tiab] OR shortform20[tiab] OR 20 item short form[tiab] OR 20-item short form[tiab] OR SF12[tiab] OR SF-12[tiab] OR SF 12[tiab] OR short form 12[tiab] OR shortform 12[tiab] OR shortform12[tiab] OR 12 item short form[tiab] OR 12-item short form[tiab] OR SF8[tiab] OR SF-8[tiab] OR SF 8[tiab] OR short form 8[tiab] OR shortform 8[tiab] OR shortform8[tiab] OR 8 item short form[tiab] OR 8-item short form[tiab] OR SF6[tiab] OR SF-6[tiab] OR SF 6[tiab] OR short form 6[tiab] OR shortform 6[tiab] OR shortform6[tiab] OR 6 item short form[tiab] OR 6-item short form[tiab] OR QoL Questionnaire[tw] OR QLQ[tiab] OR health questionnaire[tw] OR Godin leisure time[tw] OR Numeric Pain Scale[tw] OR lateral hopping for distance[tw] OR 6-m crossover hop[tw] OR side hop[tw] OR hopping course[tw] OR square hop[tw] OR cross hop[tw] OR hop test[tw] OR hopping test[tw] OR 40-m walk time[tw] OR 40-m run time[tw] OR figureof-eight run[tw] OR single-limb forward hop[tw] OR single limb forward hop[tw] OR stair hop[tw] OR shuttle run[tw] OR up/down hop[tw] OR hop up[tw] OR hopping up[tw] OR hop down[tw] OR hopping down[tw] OR triple crossover hop[tw] OR single-limb hurdle[tw] OR single limb hurdle[tw] OR single-limb 6-m hop[tw] OR single-limb 30-m hop[tw] OR figureof-eight hop[tw] OR figure of eight hop[tw] OR figure eight hop[tw] OR drop landing[tw] OR vertical jump[tw] OR "Walking Speed"[Mesh] OR "Gait"[Mesh] OR walking speed[tw] OR walking speeds[tw] OR walking gait[tw] OR gait speed[tw] OR gait speeds[tw] OR walking pace[tw] OR walking paces[tw] OR running gait[tw] OR running speed[tw] OR running speeds[tw] OR running pace[tw] OR running paces[tw] OR figure of 8 circumferential measure[tw] OR volumetric measure[tw] OR "Range of Motion, Articular"[Mesh] OR range of motion[tw] OR joint flexibility[tw] OR "Arthrometry, Articular"[Mesh] OR articular arthometry[tw] OR articular goniometry[tw] OR "Supination"[Mesh] OR supination[tw] OR supinations[tw] OR "Pronation"[Mesh] OR pronation[tw] OR pronations[tw] OR tibiopedal dorsiflexion[tw] OR weight-bearing lunge[tw] OR weight bearing lunge[tw] OR algometry[tw] OR "Pain Threshold"[Mesh] OR pain threshold[tw] OR pain thresholds[tw] OR pressurepain threshold[tw] OR pressurepain thresholds[tw] OR cutaneous sensation[tw] OR "Hypesthesia"[Mesh] OR hypesthesia[tw] OR "Hyperesthesia"[Mesh] OR hyperethesia[tw] OR joint position sense[tw] OR "Kinesthesis"[Mesh] OR kinesthesis[tw] OR kinesthesia[tw] OR kinesthesias[tw] OR kinesthetic[tw] OR movement sensation[tw] OR movement sensations[tw] OR isokinetic muscle strength[tw] OR isokinetic test[tw] OR isokinetic tests[tw] OR single-limb balance[tw] OR single limb balance[tw] OR Romberg test[tw] OR balance test[tw] OR balancing test[tw] OR Y balance[tiab] OR Balance Error Scoring System[tw] OR step-down test[tw] OR step down test[tw] OR single leg squat test[tw] OR functional movement screen[tw] OR functional movement screening[tw] OR functional movement screens[tw] OR joint accessory mobility[tw] OR joint play mobility[tw] OR anterior drawer[tw] OR talar tilt inversion[tw] OR talar tilt eversion[tw] OR talar rotation[tw] OR talofibular interval[tw] OR tibiofibular interval[tw] OR distal fibula interval[tw] OR Foot posture Index[tw] OR squeeze test[tiab] OR Cotton test[tiab] OR dorsiflexion maneuver[tw] OR dorsiflexion maneuvers[tw] OR dorsiflexion compression test[tw] OR crossed leg test[tw] OR heel thump test[tw] OR Kleiger dorsiflexion external rotation test[tiab] OR external rotation test[tw] OR Thompson test[tiab] OR function and prognostic score[tw] OR function and prognostic scores[tw] OR ankle function score[tw] OR ankle scoring system[tw] OR de Bie[tiab] OR multisegmented foot[tw] OR ankle-foot complex[tw] OR foot morphology[tw] OR intrinsic foot muscles[tw] OR ankle assessment[tw] OR ankle assessments[tw] OR foot assessment[tw] OR foot assessments[tw] OR feet assessment[tw] OR feet assessments[tw] OR biomechanical assessment[tw] OR biomechanical assessments[tw] OR foot root model[tw] OR ankle root model[tw])	241652

Table continues on page CPG66.

APPENDIX A

Search	Query	Items Found, n
#5	("Risk"[Mesh] OR "Risk Assessment"[Mesh] OR "Risk Factors"[Mesh] OR "Health Risk Behaviors"[Mesh] OR risk[tw] OR risks[tw] OR risk-benefit[tw] OR "Probability"[Mesh] OR probability[tw] OR probabilities[tw] OR likelihood[tw] OR propensity[tw] OR "Logistic Models"[Mesh] OR logistic model[tw] OR logistic models[tw] OR logistic modeling[tw] OR logistic regression[tw] OR logistic regressions[tw] OR "Protective Factors"[Mesh] OR protective factor[tw] OR protective factors[tw] OR "Bayes Theorem"[Mesh] OR Bayes theorem[tw] OR Bayesian[tw] OR "Causality"[Mesh] OR causality[tw] OR causalities[tw] OR causation[tw] OR causations[tw] OR cause[tw] OR causes[tw] OR enabling factor[tw] OR enabling factors[tw] OR reinforcing factor[tw] OR reinforcing factors[tw] OR predisposing factor[tw] OR predisposing factors[tw] OR predisposition[tw] OR "Precipitating Factors"[Mesh] OR precipitating factors[tw] OR precipitating factor[tw] OR predictor[tw] OR predictors[tw] OR odds ratio[tw] OR odds ratios[tw] OR predict[tw] OR prediction[tw] OR predictions[tw] OR predictabilities[tw] OR predictability[tw] OR predicted[tw] OR predictor[tw] OR predictors[tw] OR predictive[tw] OR etiology[tw] OR etiologies[tw] OR etiological[tw] OR etiologic[tw] OR aetiology[tw] OR origin[tw] OR origination[tw] OR originating[tw] OR interact[tw] OR interaction[tw] OR interactions[tw] OR interacting[tw])	8697169
#4	("Incidence"[Mesh] OR incidence[tw] OR incidences[tw] OR "Morbidity"[Mesh] OR morbidity[tw] OR morbidities[tw] OR "Epidemiology"[Mesh] OR epidemiology[tw] OR "epidemiology"[Subheading] OR "Prevalence"[Mesh] OR prevalence[tw] OR prevalent[tw] OR prevalencies[tw])	3328630
#3	("Physical Therapy Modalities"[Mesh] OR physical therapy[tw] OR physical therapies[tw] OR physiotherapy[tw] OR physiotherapies[tw] OR "Recovery of Function"[Mesh] OR recovery[tw] OR restoration[tw] OR reeducation[tw] OR "Rehabilitation"[Mesh] OR "rehabilitation"[Subheading] OR rehabilitation[tw] OR rehab[tw] OR "Early Ambulation"[Mesh] OR early ambulation[tw] OR accelerated ambulation[tw] OR early mobilization[tw] OR therapeutic modality[tw] OR therapeutic modalities[tw] OR "Exercise Therapy"[Mesh] OR exercise therapy[tw] OR therapeutic exercise[tw] OR therapeutic exercises[tw] OR stretching[tw] OR exercise movement[tw] OR strengthen[tw] OR strengthening[tw] OR "Resistance Training"[Mesh] OR resistance training[tw] OR strength training[tw] OR weight-bearing[tw] OR weight-lifting[tw] OR resistance methods[tw] OR training program[tw] OR "Biofeedback, Psychology"[Mesh] OR biofeedback[tw] OR psychophysiologic feedback[tw] OR neuromuscular electrical stimulation[tw] OR neuromuscular reeducation[tw] OR "Pain Management"[Mesh] OR "Pain Measurement"[Mesh] OR pain management[tw] OR pain measurement[tw] OR mobilization[tw] OR mobilizations[tw] OR "Musculoskeletal Manipulations"[Mesh] OR manipulation[tw] OR manipulations[tw] OR ultrasonography[tw] OR ultrasound[tw] OR acupuncture[tw] OR "Patient Education as Topic"[Mesh] OR patient education[tw] OR education of patients[tw] OR iontophoresis[tw] OR "Electric Stimulation"[Mesh] OR "Electric Stimulation Therapy"[Mesh] OR "Transcutaneous Electric Nerve Stimulation"[Mesh] OR electric stimulation[tw] OR nerve stimulation[tw] OR taping[tw] OR tape[tw] OR bracing[tw] OR brace[tw] OR braces[tw] OR orthoses[tw] OR immobilization[tw] OR immobilize[tw] OR orthotic[tw] OR orthotics[tw] OR thermal agent[tw] OR thermal agents[tw] OR diathermy[tw] OR "Range of Motion, Articular"[Mesh] OR range of motion[tw] OR joint flexibility[tw] OR joint movement[tw] OR manual therapy[tw] OR massage[tw] OR massages[tw] OR "Treatment Outcome"[Mesh] OR treatment outcome[tw] OR clinical effectiveness[tw] OR treatment effectiveness[tw] OR treatment efficacy[tw] OR patient outcome[tw] OR patient outcomes[tw])	3226165
#2	("Ankle Injuries"[Mesh] OR "Athletic Injuries"[Mesh] OR "Foot Injuries"[Mesh] OR injuries[tw] OR injury[tw] OR injured[tw] OR "Sprains and Strains"[Mesh] OR sprains[tw] OR sprain[tw] OR sprained[tw] OR strains[tw] OR strain[tw] OR strained[tw] OR swelling[tw] OR swollen[tw] OR swell[tw] OR "Joint Instability"[Mesh] OR instability[tw] OR instabilities[tw] OR unstable[tw] OR joint effusion[tw] oR "Proprioception"[Mesh] OR proprioception deficit[tw] OR proprioception deficits[tw] OR proprioception deficiency[tw] OR proprioception deficiencies[tw] OR "Postural Balance"[Mesh] OR balance[tw] OR unbalanced[tw] OR musculoskeletal equilibrium[tw] OR postural equilibrium[tw] OR hypermobility[tw] OR hypermobilities[tw] OR laxity[tw] OR laxities[tw] OR tear[tw] OR torn[tw] OR external rotation[tw] OR eversion[tw] OR inversion[tw] OR "Injury Severity Score"[Mesh] OR "Abbreviated Injury Scale"[Mesh])	2725758
#1	("Ankle"[Mesh] OR ankle[tw] OR ankles[tw] OR regio tarsalis[tw] OR talus[tw] OR tarsus[tw] OR "Metatarsus"[Mesh] OR metatarsus[tw] OR metatarsal[tw] OR "Ankle Joint"[Mesh] OR "Subtalar Joint"[Mesh] OR subtalar joint[tw] OR talocalcaneal joint[tw] OR talonavicular joint[tw] OR talocrural[tw] OR articulatio talocruralis[tw] OR "Tarsal Joints"[Mesh] OR tarsal joints[tw] OR tarsal joint[tw] OR midtarsal joint[tw] OR midtarsal joints[tw] OR intertarsal joint[tw] OR intertarsal joints[tw] OR intertarsal articulation[tw] OR articulationes intertarseae[tw]OR articulationes intertarsales[tw] OR "Lateral Ligament, Ankle"[Mesh] OR "Ligaments, Articular"[Mesh] OR "Collateral Ligaments"[Mesh] OR ankle lateral ligament[tw] OR ligamentum laterale articulationis talocruralis[tw] OR calcaneofibular[tw] OR tibiofibular[tw] OR tibiotalar[tw] OR tibionavicular[tw] OR tibiocalcaneal[tw] OR talofibular[tw] OR talonavicula[tw] OR calcaneocuboid[tw] OR bifurcate ligament*[tw] OR inferior transverse ligament*[tw] OR deltoid ligament*[tw] OR medial ligament*[tw] OR interosseous ligament*[tw] OR dorsal interossei[tw] OR plantar interossei[tw] OR "Tibial Nerve"[Mesh] OR tibial nerve[tw] OR peroneal nerve[tw] OR peroneus nerve[tw] OR saphenous nerve[tw] OR medial plantar nerve[tw] OR lateral plantar nerve[tw] OR fibular nerve[tw] OR fibularis tertius[tw] OR "Achilles Tendon"[Mesh] OR achilles tendon[tw] OR calcaneal[tw] OR calcaneus[tw] OR interosseous membrane[tw] OR interosseous membranes[tw] OR syndesmosis[tw] OR syndesmoses[tw] OR syndesmotic[tw] OR tibialis anterior[tw] OR fibularis longus[tw] OR fibularis brevis[tw] OR peroneus tertius[tw] OR peroneus longus[tw] OR peroneus brevis[tw] OR flexor hallucis longus[tw] OR flexor digitorum longus[tw] OR extensor digitorum longus[tw] OR tibialis posterior[tw] OR soleus[tw] OR peroneal[tw] OR gastrocnemius[tw] OR abductor halluces[tw] OR adductor halluces[tw] OR flexor hallucis brevis[tw] OR abductor digiti minimi[tw]OR flexor digiti minimi[tw] OR lumbricals[tw] OR quadratus plantae[tw] OR flexor digitorum brevis[tw] OR gluteus medius[tw] OR gluteus maximus[tw] OR gluteal[tw] OR hip abductor[tw] OR hip rotator[tw]) OR ("Foot"[Mesh] OR foot[tw] OR feet[tw] OR articulationes pedis[tw] OR "Foot Joints"[Mesh] OR "Metatarsophalangeal Joint"[Mesh] OR metatarsophalangeal[tw] OR "Heel"[Mesh] OR heel[tw] OR heels[tw] OR sinus tarsi[tw] OR sinus tarsus[tw] OR rearfoot[tw] OR midfoot[tw])	307276

APPENDIX A

Embase Update

Updated Searches From June 26, 2018 to June 1, 2020

Search	Query	Items Found, n
#14	#1 AND #9 AND #12 AND #13 AND [embase]/lim	2702
#13	#3 OR #4 OR #5 OR (#6 AND #7) OR #8	20591088
#12	#10 OR #11	3453379
#11	#2 NOT (fracture NOT ('sprain'/exp OR sprains OR sprain OR sprained OR 'strain'/exp OR strains OR strains OR strain OR strained OR 'swelling'/exp OR swelling OR swollen OR swell OR 'instability'/exp OR instability OR instabilities OR unstable OR 'joint effusion'/exp OR 'joint effusion':ti,ab,de,tn OR 'proprioception deficit':ti,ab,de,tn OR 'proprioception deficits':ti,ab,de,tn OR 'proprioception deficiency':ti,ab,de,tn OR 'proprioception deficiencies':ti,ab,de,tn OR 'balance'/exp OR balance OR unbalanced OR 'musculoskeletal equilibrium'/exp OR 'musculoskeletal equilibrium':ti,ab,de,tn OR 'postural equilibrium'/exp OR 'postural equilibrium':ti,ab,de,tn OR 'hypermobility'/exp OR hypermobility OR hypermobilities OR laxity OR laxities OR 'tear'/exp OR tear OR torn OR 'external rotation'/exp OR 'external rotation':ti,ab,de,tn OR 'eversion'/exp OR 'inversion'/exp OR eversion OR inversion))	3338003
#10	#2 NOT (osteoarthritis NOT ('sprain'/exp OR sprains OR sprain OR sprained OR 'strain'/exp OR strains OR strains OR strain OR strained OR 'swelling'/exp OR swelling OR swollen OR swell OR 'instability'/exp OR instability OR instabilities OR unstable OR 'joint effusion'/exp OR 'joint effusion':ti,ab,de,tn OR 'proprioception deficit':ti,ab,de,tn OR 'proprioception deficits':ti,ab,de,tn OR 'proprioception deficiency':ti,ab,de,tn OR 'proprioception deficiencies':ti,ab,de,tn OR 'balance'/exp OR balance OR unbalanced OR 'musculoskeletal equilibrium'/exp OR 'musculoskeletal equilibrium':ti,ab,de,tn OR 'postural equilibrium'/exp OR 'postural equilibrium':ti,ab,de,tn OR 'hypermobility'/exp OR hypermobility OR hypermobilities OR laxity OR laxities OR 'tear'/exp OR tear OR torn OR 'external rotation'/exp OR 'external rotation':ti,ab,de,tn OR 'eversion'/exp OR 'inversion'/exp OR eversion OR inversion))	3441143
#9	(2018:py OR 2019:py OR 2020:py) NOT ([animals]/lim NOT[humans]/lim) NOT ('book'/it OR 'chapter'/it OR 'conference abstract'/it OR 'conference paper'/it OR 'conference review'/it OR 'editorial'/it OR 'letter'/it OR 'note'/it OR 'press release'/it OR 'short survey'/it) AND[embase]/lim AND[english]/lim	1662347
#8	('diagnosis'/exp OR diagnosis OR diagnose OR diagnoses OR 'diagnostic'/exp OR diagnostic OR 'clinical decision-making'/exp OR 'clinical decision-making':ti,ab,de,tn OR 'clinical decision making'/exp OR 'clinical decision making':ti,ab,de,tn OR 'medical decision-making'/exp OR 'medical decision-making':ti,ab,de,tn OR 'medical decision making'/exp OR 'medical decision making':ti,ab,de,tn OR 'diagnostic imaging'/exp OR 'diagnostic imaging':ti,ab,de,tn OR 'medical imaging'/exp OR 'medical imaging':ti,ab,de,tn OR 'radiography'/exp OR radiography OR 'diagnostic x-ray':ti,ab,de,tn OR 'diagnostic x ray':ti,ab,de,tn OR 'diagnostic x-rays':ti,ab,de,tn OR 'magnetic resonance imaging'/exp OR 'magnetic resonance imaging':ti,ab,de,tn OR 'mri'/exp OR mri:ti,ab OR 'fmri'/exp OR fmri:ti,ab OR 'nmr imaging'/exp OR 'nmr imaging':ti,ab,de,tn OR 'mr tomography':ti,ab,de,tn OR 'ultrasonography'/exp OR ultrasonography OR 'ultrasound'/exp OR ultrasound OR ultrasounds OR 'ultrasonic'/exp OR ultrasonic OR 'electromyography'/exp OR electromyography OR electromyographies OR 'electromyogram'/exp OR electromyogram OR electromyograms OR 'electrophysiologic test':ti,ab,de,tn OR 'electrophysiologic tests':ti,ab,de,tn OR 'electrophysiologic testing':ti,ab,de,tn OR 'neural conduction'/exp OR 'neural conduction':ti,ab,de,tn OR 'neural conductions':ti,ab,de,tn OR 'nerve conduction'/exp OR 'nerve conduction':ti,ab,de,tn OR 'nerve conductions':ti,ab,de,tn OR 'actigraphy'/exp OR actigraphy)	9479270
#7	('sensitivity'/exp OR sensitivity OR 'specificity'/exp OR specificity OR 'evaluation indexes'/exp OR 'evaluation indexes':ti,ab,de,tn OR 'evaluation report'/exp OR 'evaluation report':ti,ab,de,tn OR 'evaluation reports':ti,ab,de,tn OR 'evaluation research'/exp OR 'evaluation research':ti,ab,de,tn OR 'use effectiveness'/exp OR 'use effectiveness':ti,ab,de,tn OR 'prepost tests':ti,ab,de,tn OR 'pre post tests'/exp OR 'pre post tests':ti,ab,de,tn OR 'prepost test':ti,ab,de,tn OR 'qualitative evaluation'/exp OR 'qualitative evaluation':ti,ab,de,tn OR 'qualitative evaluations':ti,ab,de,tn OR 'quantitative evaluation'/exp OR 'quantitative evaluation':ti,ab,de,tn OR 'quantitative evaluations':ti,ab,de,tn OR 'theoretical effectiveness'/exp OR 'theoretical effectiveness':ti,ab,de,tn OR 'critique'/exp OR critique OR critiques OR 'evaluation methodology'/exp OR 'evaluation methodology':ti,ab,de,tn OR 'evaluation methodologies':ti,ab,de,tn OR 'reproducibility'/exp OR reproducibility OR 'validity'/exp OR validity OR 'reliability'/exp OR reliability OR 'data accuracy'/exp OR 'data accuracy':ti,ab,de,tn OR 'data accuracies':ti,ab,de,tn OR 'data quality'/exp OR 'data quality':ti,ab,de,tn OR 'data qualities':ti,ab,de,tn OR 'precision'/exp OR precision OR 'responsiveness'/exp OR responsiveness OR 'consistency'/exp OR consistency OR consistencies OR consistent OR 'log-likelihood ratio':ti,ab,de,tn OR 'likelihood-ratio':ti,ab,de,tn OR 'likelihood ratio'/exp OR 'likelihood ratio':ti,ab,de,tn OR 'research design'/exp OR 'research design':ti,ab,de,tn OR 'research designs':ti,ab,de,tn OR 'research strategy':ti,ab,de,tn OR 'research strategies':ti,ab,de,tn OR 'research techniques':ti,ab,de,tn OR 'research technique':ti,ab,de,tn OR 'research methodology'/exp OR 'research methodology':ti,ab,de,tn OR 'research methodologies':ti,ab,de,tn OR 'experimental design'/exp OR 'experimental design':ti,ab,de,tn OR 'experimental designs')	8617240

Table continues on page CPG68.

APPENDIX A

Search	Query	Items Found, n
#6	('cumberland ankle instability tool'/exp OR 'cumberland ankle instability tool':ti,ab,de,tn OR 'chronic ankle instability scale':ti,ab,de,tn OR 'ankle joint functional assessment tool':ti,ab,de,tn OR 'foot function index'/exp OR 'foot function index':ti,ab,de,tn OR 'foot and ankle outcome score':ti,ab,de,tn OR 'karlsson ankle function score':ti,ab,de,tn OR 'karlsson score':ti,ab,de,tn OR 'kaikkonen scale':ti,ab,de,tn OR 'kaikkonen score':ti,ab,de,tn OR 'ottawa ankle rules'/exp OR 'ottawa ankle rules':ti,ab,de,tn OR 'buffalo modification':ti,ab,de,tn OR 'foot and ankle ability measure'/exp OR 'foot and ankle ability measure':ti,ab,de,tn OR 'foot ability measure':ti,ab,de,tn OR 'ankle ability measure':ti,ab,de,tn OR 'foot and ankle disability index'/exp OR 'foot and ankle disability index':ti,ab,de,tn OR 'lower extremity function scale'/exp OR 'lower extremity function scale':ti,ab,de,tn OR 'lower extremity functional scale':ti,ab,de,tn OR 'ankle instability scale':ti,ab,de,tn OR 'sports ankle rating system':ti,ab,de,tn OR 'ankle joint function assessment':ti,ab,de,tn OR 'ankle instability index':ti,ab,de,tn OR 'ankle instability instrument':ti,ab,de,tn OR 'identification of functional ankle instability':ti,ab,de,tn OR 'tampa scale of kinesiophobia'/exp OR 'tampa scale of kinesiophobia':ti,ab,de,tn OR 'sway index':ti,ab,de,tn OR 'functional reach test'/exp OR 'functional reach test':ti,ab,de,tn OR 'patient reported outcome measurement information system'/exp OR 'patient reported outcome measurement information system':ti,ab,de,tn OR 'short form health survey':ti,ab,de,tn OR 'short-form health survey':ti,ab,de,tn OR 'Short Form 36'/exp OR 'Short Form 12'/exp OR 'Short Form 20'/exp OR 'Short Form 8'/exp OR 'short form health survey':ti,ab,de,tn OR 'short-form health survey':ti,ab,de,tn OR 'Visual Analogue Scale':ti,ab,de,tn OR 'health utilities index'/exp OR 'health utilities index':ti,ab,de,tn OR HUI:ti,ab OR HUI-III:ti,ab OR HUI-3:ti,ab OR HUI3:ti,ab OR HUI-II:ti,ab OR HUI-2:ti,ab OR HUI2:ti,ab OR HUI-I:ti,ab OR HUI-1:ti,ab OR HUI1:ti,ab OR 'european quality of life 5 dimensions'/exp OR 'European Quality of life 5 Dimensions':ti,ab,de,tn OR EuroQol*:ti,ab OR EQ-5D:ti,ab OR EQ5D*:ti,ab OR EQ 5D:ti,ab OR EORTC:ti,ab OR Rosser:ti,ab OR SF36:ti,ab OR SF-36:ti,ab OR 'SF 36':ti,ab OR 'short form 36':ti,ab OR 'shortform 36':ti,ab OR shortform36:ti,ab OR '36 item short form':ti,ab OR '36-item short form':ti,ab OR SF20:ti,ab OR SF-20:ti,ab OR 'SF 20':ti,ab OR 'short form 20':ti,ab OR 'shortform 20':ti,ab OR shortform20:ti,ab OR '20 item short form':ti,ab OR '20-item short form':ti,ab OR SF12:ti,ab OR SF-12:ti,ab OR 'SF 12':ti,ab OR 'short form 12':ti,ab OR 'shortform 12':ti,ab OR shortform12:ti,ab OR '12 item short form':ti,ab OR '12-item short form':ti,ab OR SF8:ti,ab OR SF-8:ti,ab OR 'SF 8':ti,ab OR 'short form 8':ti,ab OR 'shortform 8':ti,ab OR shortform8:ti,ab OR '8 item short form':ti,ab OR '8-item short form':ti,ab OR SF6:ti,ab OR SF-6:ti,ab OR 'SF 6':ti,ab OR 'short form 6':ti,ab OR 'shortform 6':ti,ab OR shortform6:ti,ab OR '6 item short form':ti,ab OR '6-item short form':ti,ab OR 'QoL Questionnaire':ti,ab,de,tn OR QLQ:ti,ab OR 'health questionnaire':ti,ab,de,tn OR 'godin leisure time':ti,ab,de,tn OR 'numeric pain scale'/exp OR 'numeric pain scale':ti,ab,de,tn OR 'lateral hopping for distance':ti,ab,de,tn OR '6-m crossover hop':ti,ab,de,tn OR 'side hop':ti,ab,de,tn OR 'hopping course':ti,ab,de,tn OR 'square hop':ti,ab,de,tn OR 'cross hop':ti,ab,de,tn OR 'hop test':ti,ab,de,tn OR 'hopping test':ti,ab,de,tn OR '40-m walk time':ti,ab,de,tn OR '40-m run time':ti,ab,de,tn OR 'figureof-eight run':ti,ab,de,tn OR 'single-limb forward hop':ti,ab,de,tn OR 'single limb forward hop':ti,ab,de,tn OR 'stair hop':ti,ab,de,tn OR 'shuttle run':ti,ab,de,tn OR 'up/down hop':ti,ab,de,tn OR 'hop up':ti,ab,de,tn OR 'hopping up':ti,ab,de,tn OR 'hop down':ti,ab,de,tn OR 'hopping down':ti,ab,de,tn OR 'triple crossover hop':ti,ab,de,tn OR 'single-limb hurdle':ti,ab,de,tn OR 'single limb hurdle':ti,ab,de,tn OR 'single-limb 6-m hop':ti,ab,de,tn OR 'single-limb 30-m hop':ti,ab,de,tn OR 'figureof-eight hop':ti,ab,de,tn OR 'figure of eight hop':ti,ab,de,tn OR 'figure eight hop':ti,ab,de,tn OR 'drop landing':ti,ab,de,tn OR 'vertical jump'/exp OR 'vertical jump':ti,ab,de,tn OR 'walking speed'/exp OR 'walking speed':ti,ab,de,tn OR 'walking speeds':ti,ab,de,tn OR 'walking gait':ti,ab,de,tn OR 'gait speed'/exp OR 'gait speed':ti,ab,de,tn OR 'gait speeds':ti,ab,de,tn OR 'walking pace':ti,ab,de,tn OR 'walking paces':ti,ab,de,tn OR 'running gait':ti,ab,de,tn OR 'running speed'/exp OR 'running speed':ti,ab,de,tn OR 'running speeds':ti,ab,de,tn OR 'running pace':ti,ab,de,tn OR 'running paces':ti,ab,de,tn OR 'figure of 8 circumferential measure':ti,ab,de,tn OR 'volumetric measure':ti,ab,de,tn OR 'range of motion'/exp OR 'range of motion':ti,ab,de,tn OR 'joint flexibility'/exp OR 'joint flexibility':ti,ab,de,tn OR 'articular arthometry':ti,ab,de,tn OR 'articular goniometry':ti,ab,de,tn OR 'supination'/exp OR supination OR supinations OR 'pronation'/exp OR pronation OR pronations OR 'tibiopedal dorsiflexion':ti,ab,de,tn OR 'weight-bearing lunge':ti,ab,de,tn OR 'weight bearing lunge':ti,ab,de,tn OR 'algometry'/exp OR algometry OR 'pain threshold'/exp OR 'pain threshold':ti,ab,de,tn OR 'pain thresholds':ti,ab,de,tn OR 'pressurepain threshold'/exp OR 'pressurepain threshold':ti,ab,de,tn OR 'pressurepain thresholds':ti,ab,de,tn OR 'cutaneous sensation'/exp OR 'cutaneous sensation':ti,ab,de,tn OR 'hypesthesia'/exp OR hypesthesia OR hyperethesia OR 'joint position sense'/exp OR 'joint position sense':ti,ab,de,tn OR 'kinesthesis'/exp OR kinesthesis OR 'kinesthesia'/exp OR kinesthesia OR kinesthesias OR kinesthetic OR 'movement sensation':ti,ab,de,tn OR 'movement sensations':ti,ab,de,tn OR 'isokinetic muscle strength':ti,ab,de,tn OR 'isokinetic test':ti,ab,de,tn OR 'isokinetic tests':ti,ab,de,tn OR 'single-limb balance':ti,ab,de,tn OR 'single limb balance':ti,ab,de,tn OR 'romberg test'/exp OR 'romberg test':ti,ab,de,tn OR 'balance test'/exp OR 'balance test':ti,ab,de,tn OR 'balancing test':ti,ab,de,tn OR 'y balance':ti,ab,de,tn OR 'balance error scoring system'/exp OR 'balance error scoring system':ti,ab,de,tn OR 'step-down test':ti,ab,de,tn OR 'step down test'/exp OR 'step down test':ti,ab,de,tn OR 'single leg squat test':ti,ab,de,tn OR 'functional movement screen'/exp OR 'functional movement screen':ti,ab,de,tn OR 'functional movement screening':ti,ab,de,tn OR 'functional movement screens':ti,ab,de,tn OR 'joint accessory mobility':ti,ab,de,tn OR 'joint play mobility':ti,ab,de,tn OR 'anterior drawer':ti,ab,de,tn OR 'talar tilt inversion':ti,ab,de,tn OR 'talar tilt eversion':ti,ab,de,tn OR 'talar rotation':ti,ab,de,tn OR 'talofibular interval':ti,ab,de,tn OR 'tibiofibular interval':ti,ab,de,tn OR 'distal fibula interval':ti,ab,de,tn OR 'foot posture index'/exp OR 'foot posture index':ti,ab,de,tn OR 'squeeze test'/exp OR 'squeeze test':ti,ab,de,tn OR 'cotton test':ti,ab,de,tn OR 'dorsiflexion maneuver':ti,ab,de,tn OR 'dorsiflexion maneuvers':ti,ab,de,tn OR 'dorsiflexion compression test':ti,ab,de,tn OR 'crossed leg test':ti,ab,de,tn OR 'heel thump test':ti,ab,de,tn OR 'kleiger dorsiflexion external rotation test':ti,ab,de,tn OR 'external rotation test':ti,ab,de,tn OR 'thompson test':ti,ab,de,tn OR 'function and prognostic score':ti,ab,de,tn OR 'function and prognostic scores':ti,ab,de,tn OR 'ankle function score':ti,ab,de,tn OR 'ankle scoring system':ti,ab,de,tn OR 'multisegmented foot':ti,ab,de,tn OR 'ankle-foot complex':ti,ab,de,tn OR 'foot morphology':ti,ab,de,tn OR 'intrinsic foot muscles':ti,ab,de,tn OR 'ankle assessment':ti,ab,de,tn OR 'ankle assessments':ti,ab,de,tn OR 'foot assessment':ti,ab,de,tn OR 'foot assessments':ti,ab,de,tn OR 'feet assessment':ti,ab,de,tn OR 'feet assessments':ti,ab,de,tn OR 'biomechanical assessment':ti,ab,de,tn OR 'biomechanical assessments':ti,ab,de,tn OR 'foot root model':ti,ab,de,tn OR 'ankle root model')	258518

Table continues on page CPG69.

APPENDIX A

Search	Query	Items Found, n
#5	('risk'/exp OR risk OR risks OR 'risk benefit':ti,ab,de,tn OR 'probability'/exp OR probability OR probabilities OR likelihood OR propensity OR 'logistic model'/exp OR 'logistic model':ti,ab,de,tn OR 'logistic models':ti,ab,de,tn OR 'logistic modeling':ti,ab,de,tn OR 'logistic regression'/exp OR 'logistic regression':ti,ab,de,tn OR 'logistic regressions':ti,ab,de,tn OR 'protective factor':ti,ab,de,tn OR 'protective factors'/exp OR 'protective factors':ti,ab,de,tn OR 'bayes theorem'/exp OR 'bayes theorem':ti,ab,de,tn OR bayesian OR 'causality'/exp OR causality OR causalities OR causation OR causations OR cause OR causes OR 'enabling factor':ti,ab,de,tn OR 'enabling factors':ti,ab,de,tn OR 'reinforcing factor':ti,ab,de,tn OR 'reinforcing factors':ti,ab,de,tn OR 'predisposing factor'/exp OR 'predisposing factor':ti,ab,de,tn OR 'predisposing factors':ti,ab,de,tn OR 'predisposition'/exp OR predisposition OR 'precipitating factors'/exp OR 'precipitating factors':ti,ab,de,tn OR 'precipitating factor':ti,ab,de,tn OR 'odds ratio'/exp OR 'odds ratio':ti,ab,de,tn OR 'odds ratios':ti,ab,de,tn OR predict OR 'prediction'/exp OR prediction OR predictions OR predictabilities OR 'predictability'/exp OR predictability OR predicted OR predictor OR 'predictors'/exp OR predictors OR predictive OR 'etiology'/de OR etiology OR etiologies OR etiological OR etiologic OR aetiology OR 'origin'/exp OR origin OR origination OR originating OR interact OR interaction OR interactions OR interacting)	13175574
#4	('incidence'/exp OR incidence OR incidences OR morbidity OR morbidities OR 'epidemiology'/exp OR epidemiology OR 'prevalence'/exp OR prevalence OR prevalent OR prevalencies)	5330831
#3	('physical therapy'/exp OR 'physical therapy':ti,ab,de,tn OR 'physical therapies':ti,ab,de,tn OR 'physiotherapy'/exp OR physiotherapy OR physiotherapies OR 'recovery'/exp OR recovery OR restoration OR reeducation OR 'rehabilitation'/exp OR rehabilitation OR rehab OR 'early ambulation'/exp OR 'early ambulation':ti,ab,de,tn OR 'accelerated ambulation':ti,ab,de,tn OR 'early mobilization'/exp OR 'early mobilization':ti,ab,de,tn OR 'exercise therapy'/exp OR 'exercise therapy':ti,ab,de,tn OR 'therapeutic exercise'/exp OR 'therapeutic exercise':ti,ab,de,tn OR 'therapeutic exercises':ti,ab,de,tn OR 'therapeutic modality':ti,ab,de,tn OR 'therapeutic modalities':ti,ab,de,tn OR 'stretching'/exp OR stretching OR 'exercise movement':ti,ab,de,tn OR strengthen OR strengthening OR 'resistance training'/exp OR 'resistance training':ti,ab,de,tn OR 'strength training'/exp OR 'strength training':ti,ab,de,tn OR 'weight bearing'/exp OR weight-bearing OR 'weight lifting'/exp OR weight-lifting OR 'resistance methods':ti,ab,de,tn OR 'training program'/exp OR 'training program':ti,ab,de,tn OR 'biofeedback'/exp OR biofeedback OR 'psychophysiologic feedback':ti,ab,de,tn OR 'neuromuscular electrical stimulation'/exp OR 'neuromuscular electrical stimulation':ti,ab,de,tn OR 'neuromuscular reeducation':ti,ab,de,tn OR 'pain management'/exp OR 'pain management':ti,ab,de,tn OR 'pain measurement'/exp OR 'pain measurement':ti,ab,de,tn OR 'mobilization'/exp OR mobilization OR mobilizations OR 'manipulation'/exp OR manipulation OR manipulations OR 'ultrasonography'/exp OR ultrasonography OR ultrasound OR 'acupuncture'/exp OR acupuncture OR 'patient education'/exp OR 'patient education':ti,ab,de,tn OR 'education of patients':ti,ab,de,tn OR 'iontophoresis'/exp OR iontophoresis OR 'electric stimulation'/exp OR 'electric stimulation':ti,ab,de,tn OR 'nerve stimulation'/exp OR 'nerve stimulation':ti,ab,de,tn OR 'tape'/exp OR taping OR tape OR 'bracing'/exp OR 'brace'/exp OR bracing OR brace OR braces OR orthoses OR 'immobilization'/exp OR immobilization OR immobilize OR 'orthotics'/exp OR orthotic OR orthotics OR 'thermal agent':ti,ab,de,tn OR 'thermal agents':ti,ab,de,tn OR 'diathermy'/exp OR diathermy OR 'range of motion'/exp OR 'range of motion':ti,ab,de,tn OR 'joint flexibility'/exp OR 'joint flexibility':ti,ab,de,tn OR 'joint movement'/exp OR 'joint movement':ti,ab,de,tn OR 'manual therapy'/exp OR 'manual therapy':ti,ab,de,tn OR 'massage'/exp OR massage OR massages OR 'treatment outcome'/exp OR 'treatment outcome':ti,ab,de,tn OR 'clinical effectiveness'/exp OR 'clinical effectiveness':ti,ab,de,tn OR 'treatment effectiveness':ti,ab,de,tn OR 'treatment efficacy':ti,ab,de,tn OR 'patient outcome'/exp OR 'patient outcome':ti,ab,de,tn OR 'patient outcomes')	5266135
#2	('injury'/de OR injuries OR injury OR injured OR 'sprain'/exp OR sprains OR sprain OR sprained OR 'strain'/exp OR strains OR strains OR strain OR strained OR 'swelling'/exp OR swelling OR swollen OR swell OR 'instability'/exp OR instability OR instabilities OR unstable OR 'joint effusion'/exp OR 'joint effusion':ti,ab,de,tn OR 'proprioception deficit':ti,ab,de,tn OR 'proprioception deficits':ti,ab,de,tn OR 'proprioception deficiency':ti,ab,de,tn OR 'proprioception deficiencies':ti,ab,de,tn OR 'balance'/exp OR balance OR unbalanced OR 'musculoskeletal equilibrium'/exp OR 'musculoskeletal equilibrium':ti,ab,de,tn OR 'postural equilibrium'/exp OR 'postural equilibrium':ti,ab,de,tn OR 'hypermobility'/exp OR hypermobility OR hypermobilities OR laxity OR laxities OR 'tear'/exp OR tear OR torn OR 'external rotation'/exp OR 'external rotation':ti,ab,de,tn OR 'eversion'/exp OR 'inversion'/exp OR eversion OR inversion)	3456282

Table continues on page CPG70.

APPENDIX A

Search	Query	Items Found, n
#1	('ankle'/exp OR ankle OR ankles OR 'regio tarsalis':ti,ab,de,tn OR 'tarsus'/exp OR talus OR tarsus OR 'metatarsus'/exp OR metatarsus OR metatarsal OR 'subtalar joint'/exp OR 'subtalar joint':ti,ab,de,tn OR 'talonavicular joint'/exp OR 'talocalcaneal joint'/exp OR 'talocalcaneal joint':ti,ab,de,tn OR talocrural OR 'articulatio talocruralis':ti,ab,de,tn OR 'tarsal joint'/exp OR 'tarsal joints':ti,ab,de,tn OR 'tarsal joint':ti,ab,de,tn OR 'midtarsal joint'/exp OR 'midtarsal joint':ti,ab,de,tn OR 'midtarsal joints':ti,ab,de,tn OR 'intertarsal joint'/exp OR 'intertarsal joint':ti,ab,de,tn OR 'intertarsal joints':ti,ab,de,tn OR 'intertarsal articulation'/exp OR 'intertarsal articulation':ti,ab,de,tn OR 'articulationes intertarseae':ti,ab,de,tn OR 'articulationes intertarsales':ti,ab,de,tn OR 'ligamentum laterale articulationis talocruralis':ti,ab,de,tn OR calcaneofibular OR tibiofibular OR tibiotalar OR tibionavicular OR tibiocalcaneal OR talofibular OR talonavicula OR calcaneocuboid OR 'ankle lateral ligament'/exp OR 'ankle lateral ligament':ti,ab,de,tn OR 'bifurcate ligament*':ti,ab,de,tn OR 'inferior transverse ligament*':ti,ab,de,tn OR 'deltoid ligament*':ti,ab,de,tn OR 'medial ligament*':ti,ab,de,tn OR 'interosseous ligament*':ti,ab,de,tn OR 'peroneus nerve'/exp OR 'tibial nerve'/exp OR 'tibial nerve':ti,ab,de,tn OR 'peroneal nerve':ti,ab,de,tn OR 'peroneus nerve':ti,ab,de,tn OR 'saphenous nerve'/exp OR 'saphenous nerve':ti,ab,de,tn OR 'medial plantar nerve'/exp OR 'medial plantar nerve':ti,ab,de,tn OR 'lateral plantar nerve'/exp OR 'lateral plantar nerve':ti,ab,de,tn OR 'fibular nerve'/exp OR 'fibular nerve':ti,ab,de,tn OR 'fibularis tertius':ti,ab,de,tn OR 'achilles tendon'/exp OR 'achilles tendon':ti,ab,de,tn OR calcaneal OR calcaneus OR 'interosseous membrane'/exp OR 'interosseous membrane':ti,ab,de,tn OR 'interosseous membranes':ti,ab,de,tn OR 'dorsal interossei':ti,ab,de,tn OR 'plantar interossei':ti,ab,de,tn OR syndesmosis OR syndesmoses OR syndesmotic OR 'tibialis anterior':ti,ab,de,tn OR 'fibularis longus':ti,ab,de,tn OR 'fibularis brevis':ti,ab,de,tn OR 'peroneus tertius':ti,ab,de,tn OR 'peroneus longus'/exp OR 'peroneus longus':ti,ab,de,tn OR 'peroneus brevis'/exp OR 'peroneus brevis':ti,ab,de,tn OR 'flexor hallucis longus'/exp OR 'flexor hallucis longus':ti,ab,de,tn OR 'flexor digitorum longus'/exp OR 'flexor digitorum longus':ti,ab,de,tn OR 'extensor digitorum longus':ti,ab,de,tn OR 'tibialis posterior':ti,ab,de,tn OR 'soleus'/exp OR soleus OR peroneal OR 'gastrocnemius'/exp OR gastrocnemius OR 'abductor hallucis'/exp OR 'abductor hallucis':ti,ab,de,tn OR 'adductor hallucis':ti,ab,de,tn OR 'flexor hallucis brevis'/exp OR 'flexor hallucis brevis':ti,ab,de,tn OR 'abductor digiti minimi'/exp OR 'abductor digiti minimi':ti,ab,de,tn OR 'flexor digiti minimi':ti,ab,de,tn OR 'lumbricals':ti,ab,de,tn OR 'quadratus plantae':ti,ab,de,tn OR 'flexor digitorum brevis':ti,ab,de,tn OR 'gluteus muscle'/exp OR 'gluteus medius':ti,ab,de,tn OR 'gluteus maximus':ti,ab,de,tn OR 'gluteal':ti,ab,de,tn OR 'hip abductor':ti,ab,de,tn OR 'hip rotator' OR 'foot'/exp foot OR feet OR 'foot muscle'/exp OR 'flexor digitorum brevis'/exp OR 'flexor digitorum brevis muscle'/exp OR 'plantaris muscle'/exp OR 'plantaris muscle':ti,ab,de,tn OR 'articulationes pedis':ti,ab,de,tn OR metatarsophalangeal OR 'heel'/exp OR heel OR heels OR 'sinus tarsi':ti,ab,de,tn OR 'sinus tarsus':ti,ab,de,tn OR 'rearfoot'/exp OR rearfoot OR 'midfoot'/exp OR midfoot)	133956

CINAHL Update

Updated Searches From June 26, 2018 to June 1, 2020

Search	Query	Items Found, n
#10	#1 AND #2 AND #9 AND [Published Date: 20180601-20201231, Publication Types: Case Study, Clinical Trial, Journal Article, Meta Analysis, Meta Synthesis, Nursing Diagnoses, Nursing Interventions, Practice Acts, Practice Guidelines, Protocol, Questionnaire/Scale, Randomized Controlled Trial, Research, Research Instrument, Review, Standards, Statistics, Systematic Review]	2855
#9	#3 OR #4 OR #5 OR (#6 AND #7) OR #8	3215476
#8	(MH "Diagnosis" OR MH "Diagnosis, Computer Assisted" OR MH "Diagnosis, Delayed" OR MH "Diagnosis, Differential" OR MH "Early Diagnosis" OR MM "Diagnosis, Musculoskeletal" OR MH "Diagnostic Imaging" OR diagnosis OR diagnose OR diagnoses OR diagnostic OR "clinical decision-making" OR "clinical decision making" OR "medical decision-making" OR "medical decision making" OR "diagnostic imaging" OR "medical imaging" OR MH "Magnetic Resonance Imaging" OR MH "Ultrasonography" OR MH "Tomography, X-Ray" OR MH "Radiography" OR radiography OR "diagnostic x-ray" OR "diagnostic x ray" OR "diagnostic x-rays" OR "magnetic resonance imaging" OR MRI OR fMRI OR "NMR imaging" OR "MR tomography" OR ultrasonography OR ultrasound OR ultrasounds OR ultrasonic OR MH "Electromyography" OR electromyography OR electromyographies OR electromyogram OR electromyograms OR "electrophysiologic test" OR "electrophysiologic tests" OR "electrophysiologic testing" OR "neural conduction" OR "neural conductions" OR "nerve conduction" OR "nerve conductions" OR MH "Actigraphy" OR actigraphy OR MH "Physical Therapy Assessment")	1317355
#7	(MH "Sensitivity and Specificity" OR sensitivity OR specificity OR MH "Evaluation Research" OR "evaluation indexes" OR "evaluation report" OR "evaluation reports" OR "evaluation research" OR use-effectiveness OR "use effectiveness" OR "prepost tests" OR "pre post tests" OR "prepost test" OR "qualitative evaluation" OR "qualitative evaluations" OR "quantitative evaluation" OR "quantitative evaluations" OR "theoretical effectiveness" OR critique OR critiques OR "evaluation methodology" OR "evaluation methodologies" OR MH "Reproducibility of Results" OR reproducibility OR MH "Validity+" OR validity OR MH "Reliability" OR reliability OR MH "Reliability and Validity" OR "data accuracy" OR "data accuracies" OR "data quality" OR "data qualities" OR MH "Precision" OR precision OR responsiveness OR consistency OR consistencies OR consistent OR "log-likelihood ratio" OR "likelihood-ratio" OR "likelihood ratio" OR MH "Study Design" OR "research design" OR "research designs" OR "research strategy" OR "research strategies" OR "research techniques" OR "research technique" OR MH "Research Methodology" OR "research methodology" OR "research methodologies" OR "experimental design" OR "experimental designs")	828261

Table continues on page CPG71.

APPENDIX A

Search	Query	Items Found, n
#6	(ZQ "cumberland ankle instability tool" OR ZQ "cumberland ankle instability tool (cait)" OR "Cumberland ankle instability tool" OR ZQ "chronic ankle instability scale (cais)" OR "Chronic Ankle Instability Scale" OR ZQ "sports ankle rating system" OR "Sports Ankle Rating System" OR ZQ "ankle joint functional assessment tool" OR "Ankle Joint Functional Assessment Tool" OR ZQ "foot function index" OR ZQ "foot function index (ffi)" OR "Foot Function Index" OR ZQ "foot and ankle outcome score" OR ZQ "foot and ankle outcome score (faos)" OR ZQ "foot and ankle outcome scores (faos)" OR "Foot and Ankle Outcome Score" OR ZQ "karlsson score" OR "Karlsson Ankle Function Score" OR "Karlsson Score" OR ZQ "kaikkonen scale" OR "Kaikkonen scale" OR "Kaikkonen score" OR ZQ "ottawa ankle rules" OR ZQ "ottawa ankle rules (oar)" OR "Ottawa ankle rules" OR "Buffalo modification" OR ZQ "foot and ankle ability measure (faam)" OR "foot and ankle ability measure" OR "foot ability measure" OR "ankle ability measure" OR ZQ "foot and ankle disability index (fadi)" OR "foot and ankle disability index" OR ZQ "lower extremity functional scale (lefs)" OR "lower extremity functional scale" OR "ankle instability scale" OR "sports ankle rating system" OR ZQ "ankle joint functional assessment tool (ajfat)" OR "ankle joint function assessment" OR ZQ "ankle instability index" OR "ankle instability index" OR ZQ "ankle instability instrument" OR "ankle instability instrument" OR "identification of functional ankle instability" OR ZQ "tampa scale for kinesiophobia (tsk)" OR "Tampa scale of kinesiophobia" OR "sway index" OR ZQ "functional reach test" OR ZQ "functional reach test (frt)" OR "functional reach test" OR ZQ "patient reported outcomes measurement information system (promis)" OR "Patient Reported Outcome Measurement Information System" OR MH "Short Form-36 Health Survey (SF-36)" OR ZQ "short form health survey (sf-36)" OR ZQ "short form health survey" OR "short form health survey" OR "short-form health survey" OR ZQ "visual analogue scale" OR ZQ "visual analogue scale (vas)" OR "Visual Analogue Scale" OR ZQ "health utilities index (hui)" OR "health utilities index" OR "European Quality of life 5 Dimensions" OR EuroQol OR "short form 36" OR "shortform 36" OR shortform36 OR "36 item short form" OR "36-item short form" OR "short form 20" OR "shortform 20" OR shortform20 OR "20 item short form" OR "20-item short form" OR "short form 12" OR "shortform 12" OR shortform12 OR "12 item short form" OR "12-item short form" OR "short form 8" OR "shortform 8" OR shortform8 OR "8 item short form" OR "8-item short form" OR "short form 6" OR "shortform 6" OR shortform6 OR "6 item short form" OR "6-item short form" OR "QoL Questionnaire" OR "health questionnaire" OR ZQ "godin leisure time exercise questionnaire" OR ZQ "godin leisure time exercise questionnaire (glteq)" OR "Godin leisure time" OR ZQ "numeric pain scale" OR "Numeric Pain Scale" OR ZQ "hop test" OR "lateral hopping for distance" OR "6-m crossover hop" OR "side hop" OR "hopping course" OR "square hop" OR "cross hop" OR "hop test" OR "hopping test" OR "40-m walk time" OR "40-m run time" OR "figureof-eight run" OR "single-limb forward hop" OR "single limb forward hop" OR "stair hop" OR "shuttle run" OR "up/down hop" OR "hop up" OR "hopping up" OR "hop down" OR "hopping down" OR "triple crossover hop" OR "single-limb hurdle" OR "single limb hurdle" OR "single-limb 6-m hop" OR "single-limb 30-m hop" OR "figureof-eight hop" OR "figure of eight hop" OR "figure eight hop" OR "drop landing" OR "vertical jump" OR "walking speed" OR "walking speeds" OR "walking gait" OR "gait speed" OR "gait speeds" OR "walking pace" OR "walking paces" OR "running gait" OR "running speed" OR "running speeds" OR "running pace" OR "running paces" OR "figure of 8 circumferential measure" OR "volumetric measure" OR MH "Range of Motion" OR "range of motion" OR "joint flexibility" OR "articular arthometry" OR "articular goniometry" OR MH "Supination" OR supination OR supinations OR MH "Pronation" OR pronation OR pronations OR "tibiopedal dorsiflexion" OR "weight-bearing lunge" OR "weight bearing lunge" OR MH "Algometry" OR algometry OR MH "Pain Threshold" OR "pain threshold" OR "pain thresholds" OR "pressurepain threshold" OR "pressurepain thresholds" OR "cutaneous sensation" OR MH "Hypesthesia" OR hypesthesia OR hyperethesia OR "joint position sense" OR MH "Kinesthesis" OR kinesthesis OR kinesthesia OR kinesthesias OR kinesthetic OR "movement sensation" OR "movement sensations" OR "isokinetic muscle strength" OR "isokinetic test" OR "isokinetic tests" OR "single-limb balance" OR "single limb balance" OR ZQ "romberg test" OR ZQ "romberg's test" OR "Romberg test" OR ZQ "balance test" OR "balance test" OR "balancing test" OR ZQ "y balance test" OR "Y balance" OR ZQ "balance error scoring system (bess)" OR "Balance Error Scoring System" OR ZQ "step-down test"OR "step-down test" OR "step down test" OR "single leg squat test" OR ZQ "functional movement screen" OR ZQ "functional movement screen (fms)" OR "functional movement screen" OR "functional movement screening" OR "functional movement screens" OR "joint accessory mobility" OR "joint play mobility" OR ZQ "anterior drawer test" OR "anterior drawer" OR "talar tilt inversion" OR "talar tilt eversion" OR "talar rotation" OR "talofibular interval" OR "tibiofibular interval" OR "distal fibula interval" OR ZQ "foot posture index" OR ZQ "foot posture index (fpi)"OR "foot posture index" OR "squeeze test" OR "Cotton test" OR "dorsiflexion maneuver" OR "dorsiflexion maneuvers" OR "dorsiflexion compression test" OR "crossed leg test" OR "heel thump test" OR "Kleiger dorsiflexion external rotation test" OR "external rotation test" OR ZQ "thompson test" OR "Thompson test" OR "function and prognostic score" OR "function and prognostic scores" OR ZQ "ankle function score" OR "ankle function score" OR "ankle scoring system" OR "multisegmented foot" OR "ankle-foot complex" OR "foot morphology" OR "intrinsic foot muscles" OR "ankle assessment" OR "ankle assessments" OR "foot assessment" OR "foot assessments" OR "feet assessment" OR "feet assessments" OR "biomechanical assessment" OR "biomechanical assessments" OR "foot root model" OR "ankle root model")	103455
#5	(MH "Risk Assessment" OR MH "Risk Factors" OR risk OR risks OR risk-benefit OR MH "Probability" OR probability OR probabilities OR likelihood OR propensity OR MH "Multiple Logistic Regression" OR "logistic model" OR "logistic models" OR "logistic modeling" OR "logistic regression" OR "logistic regressions" OR "protective factor" OR "protective factors" OR "Bayes theorem" OR Bayesian OR MH "Causal Attribution" OR causality OR causalities OR causation OR causations OR cause OR causes OR "enabling factor" OR "enabling factors" OR "reinforcing factor" OR "reinforcing factors" OR "predisposing factor" OR "predisposing factors" OR predisposition OR "precipitating factors" OR "precipitating factor" OR predictor OR predictors OR MH "Odds Ratio" OR "odds ratio" OR "odds ratios" OR predict OR prediction OR predictions OR predictabilities OR predictability OR predicted OR predictor OR predictors OR predictive OR etiology OR etiologies OR etiological OR etiologic OR aetiology OR origin OR origination OR originating OR MH "Interaction (Research)" OR interact OR interaction OR interactions OR interacting)	2001260
#4	(MH "Incidence OR incidence OR incidences OR MH "Morbidity" OR morbidity OR morbidities OR MH "Epidemiology" OR epidemiology OR MH "Prevalence" OR prevalence OR prevalent OR prevalencies)	258799

Table continues on page CPG72.

APPENDIX A

Search	Query	Items Found, n
#3	(MH "Physical Therapy" " OR "physical therapy" OR "physical therapies" OR physiotherapy OR physiotherapies OR MH "Recovery" OR MH "Recovery, Exercise" OR recovery OR restoration OR reeducation OR MH "Rehabilitation" OR rehabilitation OR rehab OR MH "Early Ambulation" OR "early ambulation" OR "accelerated ambulation" OR "early mobilization" OR MH "Therapeutic Exercise OR "exercise therapy" OR "therapeutic exercise" OR "therapeutic exercises" OR "therapeutic modality" OR "therapeutic modalities" OR stretching OR "exercise movement" OR MH "Gait Training" OR strengthen OR strengthening OR MH "Resistance Training" OR MH "Muscle Strengthening" OR "resistance training" OR "strength training" OR weight-bearing OR weight-lifting OR "resistance methods" OR "training program" OR MH "Biofeedback" OR biofeedback OR "psychophysiologic feedback" OR "neuromuscular electrical stimulation" OR "neuromuscular reeducation" OR MH "Pain Management" OR MH "Pain Measurement" OR "pain management" OR "pain measurement" OR MH "Joint Mobilization" OR mobilization OR mobilizations OR manipulation OR manipulations OR MH "Ultrasonography" OR ultrasonography OR ultrasound OR MH "Acupuncture" OR acupuncture OR MH "Patient Education"OR "patient education" OR "education of patients" OR MH "Iontophoresis" OR iontophoresis OR MH "Electrotherapy" OR "electric stimulation" OR "nerve stimulation" OR MH "Taping and Strapping" OR taping OR tape OR MH "Orthoses" OR orthoses OR bracing OR brace OR braces OR immobilization OR immobilize OR orthotic OR orthotics OR "thermal agent" OR "thermal agents" OR diathermy OR "range of motion" OR "joint flexibility" OR "joint movement" OR MH "Manual Therapy" OR "manual therapy" OR MH "Massage" OR massage OR massages OR MH "Treatment Outcomes" OR "treatment outcome" OR "clinical effectiveness" OR "treatment effectiveness" OR "treatment efficacy"OR MH "Outcomes (Health Care)"OR "patient outcome" OR "patient outcomes")	889646
#2	(MH "Wounds and Injuries" OR MH "Athletic Injuries+" OR MH "Leg Injuries" OR MH "Ligament Injuries" OR MH "Ankle Injuries+" OR MH "Foot Injuries+" OR MH "Tendon Injuries+"OR injuries OR injury OR injured OR MH "Ankle Sprain, Syndesmosis" OR MH "Sprains and Strains+" OR MH "Calf Strain" OR sprains OR sprain OR sprained OR strains OR strain OR strained OR swelling OR swollen OR swell MH "Joint Instability+" OR instability OR instabilities OR unstable OR "joint effusion" OR "proprioception deficit" OR "proprioception deficits" OR "proprioception deficiency" OR "proprioception deficiencies" OR MH "Balance, Postural" OR balance OR unbalanced OR "musculoskeletal equilibrium" OR "postural equilibrium" OR hypermobility OR hypermobilities OR laxity OR laxities OR MH "Tears and Lacerations+" OR tear OR torn OR "external rotation" OR MH "Eversion" OR MH "Inversion" OR eversion OR inversion)	530619
#1	(MH "Ankle"OR ankle OR ankles OR regio tarsalis OR MH "Talus" OR talus OR tarsus OR metatarsus OR metatarsal OR MH "Ankle Joint" OR "subtalar joint" OR "talocalcaneal joint" OR talocrural OR "articulatio talocruralis" OR "tarsal joints" OR "tarsal joint" OR "midtarsal joint" OR "midtarsal joints" OR "intertarsal joint" OR "intertarsal joints" OR "intertarsal articulation" OR "articulationes intertarseae" OR "articulationes intertarsales" OR "ligamentum laterale articulationis talocruralis" OR calcaneofibular OR tibiofibular OR tibiotalar OR tibionavicular OR tibiocalcaneal OR talofibular OR talonavicula OR calcaneocuboid OR MH "Lateral Ligament, Ankle" OR "ankle lateral ligament" OR "bifurcate* ligament*" OR "inferior transverse ligament*" OR "deltoid ligament*" OR "medial ligament*" OR "interosseous ligament*" OR MH "Tibial Nerve" OR "tibial nerve" OR MH "Peroneal Nerve" OR "peroneal nerve" OR "saphenous nerve" OR "medial plantar nerve" OR "lateral plantar nerve" OR "fibular nerve" OR "fibularis tertius" OR MH "Achilles Tendon" OR "achilles tendon" OR calcaneal OR calcaneus OR "interosseous membrane" OR "interosseous membranes" OR "dorsal interossei" OR "plantar interossei" OR syndesmosis OR syndesmoses OR syndesmotic OR "tibialis anterior" OR "fibularis longus" OR "fibularis brevis" OR "peroneus tertius" OR "peroneus longus" OR "peroneus brevis" OR "flexor hallucis longus" OR "flexor digitorum longus" OR "extensor digitorum longus" OR "tibialis posterior" OR MH "Soleus Muscles" OR soleus OR peroneal OR MH "Gastrocnemius Muscle" OR gastrocnemius OR "abductor hallucis" OR "adductor hallucis" OR "flexor hallucis brevis" OR "abductor digiti minimi" OR "flexor digiti minimi" OR "lumbricals" OR "quadratus plantae" OR "flexor digitorum brevis" OR MH "Gluteal Muscles" OR "gluteus medius" OR "gluteus maximus" OR "gluteal" OR "hip abductor" OR "hip rotator") OR (foot OR MH "Foot" OR feet OR "articulationes pedis" OR metatarsophalangeal OR MH "Heel" OR heel OR heels OR "sinus tarsi" OR "sinus tarsus" OR rearfoot OR midfoot)	94360

Cochrane Library Update

Updated Searches From June 26, 2018 to June 1, 2020

Search	Query	Items Found, n
#10	#1 AND #2 AND #9 AND Cochrane Library publication date from Jun 2018 to Dec 2020	2318
#9	#3 OR #4 OR #5 OR (#6 AND #7) OR #8	869066
#8	(diagnosis OR diagnose OR diagnoses OR diagnostic OR "clinical decision-making" OR "clinical decision making" OR "medical decision-making" OR "medical decision making" OR "diagnostic imaging" OR "medical imaging" OR radiography OR "diagnostic x-ray" OR "diagnostic x ray" OR "diagnostic x-rays" OR "magnetic resonance imaging" OR MRI OR fMRI OR "NMR imaging" OR "MR tomography" OR ultrasonography OR ultrasound OR ultrasounds OR ultrasonic OR electromyography OR electromyographies OR electromyogram OR electromyograms OR "electrophysiologic test" OR "electrophysiologic tests" OR "electrophysiologic testing" OR "neural conduction" OR "neural conductions" OR "nerve conduction" OR "nerve conductions" OR actigraphy)	249235
#7	(sensitivity OR specificity OR "evaluation indexes" OR "evaluation report" OR "evaluation reports" OR "evaluation research" OR use-effectiveness OR "use effectiveness" OR "prepost tests" OR "pre post tests" OR "prepost test" OR "qualitative evaluation" OR "qualitative evaluations" OR "quantitative evaluation" OR "quantitative evaluations" OR "theoretical effectiveness" OR critique OR critiques OR "evaluation methodology" OR "evaluation methodologies" OR reproducibility OR validity OR reliability OR "data accuracy" OR "data accuracies" OR "data quality" OR "data qualities" OR precision OR responsiveness OR consistency OR consistencies OR consistent OR "log-likelihood ratio" OR "likelihood-ratio" OR "likelihood ratio" OR "research design" OR "research designs" OR "research strategy" OR "research strategies" OR "research techniques" OR "research technique" OR "research methodology" OR "research methodologies" OR "experimental design" OR "experimental designs")	152431

Table continues on page CPG73.

APPENDIX A

Search	Query	Items Found, n
#6	("Cumberland ankle instability tool" OR "Chronic Ankle Instability Scale" OR "Sports Ankle Rating System" OR "Ankle Joint Functional Assessment Tool" OR "Foot Function Index" OR "Foot and Ankle Outcome Score" OR "Karlsson Ankle Function Score" OR "Karlsson Score" OR "Kaikkonen scale" OR "Kaikkonen score" OR "Ottawa ankle rules" OR "Buffalo modification" OR "foot and ankle ability measure" OR "foot ability measure" OR "ankle ability measure" OR "foot and ankle disability index" OR "lower extremity functional scale" OR "ankle instability scale" OR "sports ankle rating system" OR "ankle joint function assessment" OR "ankle instability index" OR "ankle instability instrument" OR "identification of functional ankle instability" OR "Tampa scale of kinesiophobia" OR "sway index" OR "functional reach test" OR "Patient Reported Outcome Measurement Information System" OR "short form health survey" OR "short-form health survey" OR "Visual Analogue Scale" OR "health utilities index" OR "European Quality of life 5 Dimensions" OR EuroQol OR "short form 36" OR "shortform 36" OR shortform36 OR "36 item short form" OR "36-item short form" OR "short form 20" OR "shortform 20" OR shortform20 OR "20 item short form" OR "20-item short form" OR "short form 12" OR "shortform 12" OR shortform12 OR "12 item short form" OR "12-item short form" OR "short form 8" OR "shortform 8" OR shortform8 OR "8 item short form" OR "8-item short form" OR "short form 6" OR "shortform 6" OR shortform6 OR "6 item short form" OR "6-item short form" OR "QoL Questionnaire" OR "health questionnaire" OR "Godin leisure time" OR "Numeric Pain Scale" OR "lateral hopping for distance" OR "6-m crossover hop" OR "side hop" OR "hopping course" OR "square hop" OR "cross hop" OR "hop test" OR "hopping test" OR "40-m walk time" OR "40-m run time" OR "figureof-eight run" OR "single-limb forward hop" OR "single limb forward hop" OR "stair hop" OR "shuttle run" OR "up down hop" OR "hop up" OR "hopping up" OR "hop down" OR "hopping down" OR "triple crossover hop" OR "single-limb hurdle" OR "single limb hurdle" OR "single-limb 6-m hop" OR "single-limb 30-m hop" OR "figureof-eight hop" OR "figure of eight hop" OR "figure eight hop" OR "drop landing" OR "vertical jump" OR "walking speed" OR "walking speeds" OR "walking gait" OR "gait speed" OR "gait speeds" OR "walking pace" OR "walking paces" OR "running gait" OR "running speed" OR "running speeds" OR "running pace" OR "running paces" OR "figure of 8 circumferential measure" OR "volumetric measure" OR "range of motion" OR "joint flexibility" OR "articular arthometry" OR "articular goniometry" OR supination OR supinations OR pronation OR pronations OR "tibiopedal dorsiflexion" OR "weight-bearing lunge" OR "weight bearing lunge" OR algometry OR "pain threshold" OR "pain thresholds" OR "pressurepain threshold" OR "pressurepain thresholds" OR "cutaneous sensation" OR hypesthesia OR hyperethesia OR "joint position sense" OR kinesthesis OR kinesthesia OR kinesthesias OR kinesthetic OR "movement sensation" OR "movement sensations" OR "isokinetic muscle strength" OR "isokinetic test" OR "isokinetic tests" OR "single-limb balance" OR "single limb balance" OR "Romberg test" OR "balance test" OR "balancing test" OR "Y balance" OR "Balance Error Scoring System" OR "step-down test" OR "step down test" OR "single leg squat test" OR "functional movement screen" OR "functional movement screening" OR "functional movement screens" OR "joint accessory mobility" OR "joint play mobility" OR "anterior drawer" OR "talar tilt inversion" OR "talar tilt eversion" OR "talar rotation" OR "talofibular interval" OR "tibiofibular interval" OR "distal fibula interval" OR "foot posture index" OR "squeeze test" OR "Cotton test" OR "dorsiflexion maneuver" OR "dorsiflexion maneuvers" OR "dorsiflexion compression test" OR "crossed leg test" OR "heel thump test" OR "Kleiger dorsiflexion external rotation test" OR "external rotation test" OR "Thompson test" OR "function and prognostic score" OR "function and prognostic scores" OR "ankle function score" OR "ankle scoring system" OR "multisegmented foot" OR "ankle-foot complex" OR "foot morphology" OR "intrinsic foot muscles" OR "ankle assessment" OR "ankle assessments" OR "foot assessment" OR "foot assessments" OR "feet assessment" OR "feet assessments" OR "biomechanical assessment" OR "biomechanical assessments" OR "foot root model" OR "ankle root model")	78741
#5	(risk OR risks OR risk-benefit OR probability OR probabilities OR likelihood OR propensity OR "logistic model" OR "logistic models" OR "logistic modeling" OR "logistic regression" OR "logistic regressions" OR "protective factor" OR "protective factors" OR "Bayes theorem" OR Bayesian OR causality OR causalities OR causation OR causations OR cause OR causes OR "enabling factor" OR "enabling factors" OR "reinforcing factor" OR "reinforcing factors" OR "predisposing factor" OR "predisposing factors" OR predisposition OR "precipitating factors" OR "precipitating factor" OR predictor OR predictors OR "odds ratio" OR "odds ratios" OR predict OR prediction OR predictions OR predictabilities OR predictability OR predicted OR predictor OR predictors OR predictive OR etiology OR etiologies OR etiological OR etiologic OR aetiology OR origin OR origination OR originating OR interact OR interaction OR interactions OR interacting)	462091
#4	(incidence OR incidences OR morbidity OR morbidities OR epidemiology OR prevalence OR prevalent OR prevalencies)	220299
#3	("physical therapy" OR "physical therapies" OR physiotherapy OR physiotherapies OR recovery OR restoration OR reeducation OR rehabilitation OR rehab OR "early ambulation" OR "accelerated ambulation" OR "early mobilization" OR "exercise therapy" OR "therapeutic exercise" OR "therapeutic exercises" OR "therapeutic modality" OR "therapeutic modalities" OR stretching OR "exercise movement" OR strengthen OR strengthening OR "resistance training" OR "strength training" OR weight-bearing OR weight-lifting OR "resistance methods" OR "training program" OR biofeedback OR "psychophysiologic feedback" OR "neuromuscular electrical stimulation" OR "neuromuscular reeducation" OR "pain management" OR "pain measurement" OR mobilization OR mobilizations OR manipulation OR manipulations OR ultrasonography OR ultrasound OR acupuncture OR "patient education" OR "education of patients" OR iontophoresis OR "electric stimulation" OR "nerve stimulation" OR taping OR tape OR bracing OR brace OR braces OR immobilization OR immobilize OR orthotic OR orthotics OR "thermal agent" OR "thermal agents" OR diathermy OR "range of motion" OR "joint flexibility" OR "joint movement" OR "manual therapy" OR massage OR massages OR "treatment outcome" OR "clinical effectiveness" OR "treatment effectiveness" OR "treatment efficacy" OR "patient outcome" OR "patient outcomes")	402118
#2	(injuries OR injury OR injured OR sprains OR sprain OR sprained OR strains OR strain OR strained OR swelling OR swollen OR swell OR instability OR instabilities OR unstable OR "joint effusion" OR "proprioception deficit" OR "proprioception deficits" OR "proprioception deficiency" OR "proprioception deficiencies" OR balance OR unbalanced OR "musculoskeletal equilibrium" OR "postural equilibrium" OR hypermobility OR hypermobilities OR laxity OR laxities OR tear OR torn OR "external rotation" OR eversion OR inversion)	118796

Table continues on page CPG74.

APPENDIX A

Search	Query	Items Found, n
#1	(ankle OR ankles OR regio tarsalis OR talar OR tarsus OR metatarsus OR metatarsal OR "subtalar joint" OR "talocalcaneal joint" OR talocrural OR "articulatio talocruralis" OR "tarsal joints" OR "tarsal joint" OR "midtarsal joint" OR "midtarsal joints" OR "intertarsal joint" OR "intertarsal joints" OR "intertarsal articulation" OR "articulationes intertarseae" OR "articulationes intertarsales" OR "ligamentum laterale articulationis talocruralis" OR calcaneofibular OR tibiofibular OR tibiotalar OR tibionavicular OR tibiocalcaneal OR talofibular OR talonavicula OR calcaneocuboid OR "bifurcate* ligament*" OR "inferior transverse ligament*" OR "deltoid ligament*" OR "medial ligament*" OR "interosseous ligament*" OR "tibial nerve" OR "peroneal nerve" OR "saphenous nerve" OR "medial plantar nerve" OR "lateral plantar nerve" OR "fibular nerve" OR "fibularis tertius" OR "achilles tendon" OR calcaneal OR calcaneus OR "interosseous membrane" OR "interosseous membranes" OR "dorsal interossei" OR "plantar interossei" OR syndesmosis OR syndesmoses OR syndesmotic OR "tibialis anterior" OR "fibularis longus" OR "fibularis brevis" OR "peroneus tertius" OR "peroneus longus" OR "peroneus brevis" OR "flexor hallucis longus" OR "flexor digitorum longus" OR "extensor digitorum longus" OR "tibialis posterior" OR soleus OR peroneal OR gastrocnemius OR "abductor hallucis" OR "adductor hallucis" OR "flexor hallucis brevis" OR "abductor digiti minimi" OR "flexor digiti minimi" OR "lumbricals" OR "quadratus plantae" OR "flexor digitorum brevis" OR "gluteus medius" OR "gluteus maximus" OR "gluteal" OR "hip abductor" OR "hip rotator") OR (foot OR feet OR "articulationes pedis" OR metatarsophalangeal OR heel OR heels OR "sinus tarsi" OR "sinus tarsus" OR rearfoot OR midfoot)	27650

PEDro Advanced Search Update

Updated Searches From June 26, 2018 to June 1, 2020

Search	Query	Items Found, n
#15	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14	...
#14	Abstract & Title: diagnos* Body Part: Foot OR Ankle Published Since: 2018	34
#13	Abstract & Title: inversion Body Part: Foot OR Ankle Published Since: 2018	15
#12	Abstract & Title: eversion Body Part: Foot OR Ankle Published Since: 2018	13
#11	Abstract & Title: external rotation Body Part: Foot OR Ankle Published Since: 2018	2
#10	Abstract & Title: tear Body Part: Foot OR Ankle Published Since: 2018	2
#9	Abstract & Title: equilibrium Body Part: Foot OR Ankle Published Since: 2018	3
#8	Abstract & Title: balance Body Part: Foot OR Ankle Published Since: 2018	129
#7	Abstract & Title: proprioception Body Part: Foot OR Ankle Published Since: 2018	10
#6	Abstract & Title: swell* Body Part: Foot OR Ankle Published Since: 2018	5
#5	Abstract & Title: injury Body Part: Foot OR Ankle Published Since: 2018	47
#4	Abstract & Title: strain* Body Part: Foot OR Ankle Published Since: 2018	1
#3	Abstract & Title: sprain* Body Part: Foot OR Ankle Published Since: 2018	29

Table continues on page CPG75.

APPENDIX A

Search	Query	Items Found, n
#2	Abstract & Title: unstable Body Part: Foot OR Ankle Published Since: 2018	7
#1	Abstract & Title: instability Body Part: Foot OR Ankle Published Since: 2018	38

APPENDIX B

SEARCH RESULTS

Database/ Platform	Original Date	Original Results, n	2020 Update	2020 Update Results, n
PubMed National Library of Medicine	June 26, 2018	13753	June 1, 2020	4826
Embase Elsevier	June 26, 2018	7327	June 1, 2020	1204
CINAHL EBSCO	June 26, 2018	1616	June 1, 2020	987
Cochrane Library Wiley	June 26, 2018	808	June 1, 2020	1028
PEDro University of Sydney	June 26, 2018	182	June 1, 2020	131

APPENDIX C

ARTICLE INCLUSION AND EXCLUSION CRITERIA

Articles published in English from 2013 to June 1, 2020 in peer-reviewed journals that include studies of the following types: systematic reviews, meta-analyses, experimental and quasi-experimental, cohort, case series (10 or more participants), and cross-sectional studies were included.

Meeting abstracts, press releases, theses, nonsystematic review articles, case reports (fewer than 10 participants), and articles that could not be retrieved in English were excluded.

Inclusion Criteria

We included articles reporting on

- The functional anatomy of the ankle-foot complex (to include the distal tibiofibular, talocrural, subtalar, talonavicular, calcaneocuboid, and tarsometatarsal joints; extrinsic and intrinsic foot muscles) relevant to lateral ankle sprains and chronic ankle instability

OR

- Tests and measures for differential diagnosis of lateral ankle sprains and chronic ankle instability within the scope of physical therapist practice, including but not limited to symptoms, functions, activity and participation such as patient-reported outcome measures and examination techniques of joint structure and function, neurophysiologic and sensorimotor function, balance, gait, psychosocial contributors, and occupation and sports-specific activity

OR

- Measurement properties of instruments and tests specific to measuring lateral ankle sprains and chronic ankle instability outcomes, including but not limited to symptoms, functions, and activity and participation such as the Identification of Functional Ankle Instability, Cumberland Ankle Instability Tool, and Ankle Instability Instrument

OR

- Measurement properties of instruments that are not specific to lateral ankle sprains and chronic ankle instability but are specific to pain, general health, physical activity, psychosocial function, or lower extremity function, used in the assessment of individuals with lateral ankle sprains and chronic ankle instability. This included but was not limited to the following: the Patient-Reported Outcomes Measurement Information System, Tampa Scale of Kinesiophobia, Lower Extremity Functional Scale, Foot and Ankle Outcome Score, Foot and Ankle Ability Measure activities of daily living subscale, Foot and Ankle Ability Measure sports subscale, Ankle Joint Functional Assessment Tool, Star Excursion Balance Test/Y Balance Test, single-leg squat, step-down test, STAR, lateral hopping, balance, weight-bearing dorsiflexion range of motion, Foot Function Index, and Foot Posture Index

OR

- Primarily adults (13 years old or older)
  - Studies reporting on persons younger than 13 years old when the proportion in the sample was small (less than 5%) or when separate data were available for adults

AND

Lateral ankle sprains and chronic ankle instability, including the following topics:

- Risk of lateral ankle sprains and chronic ankle instability, including but not limited to sex, body mass index, prior injury, and ability to step down following injury
- Diagnostic characteristics of lateral ankle sprains and chronic ankle instability, including but not limited to pain location, duration, and quality, and related body system impairments and activity limitations
- Preventative and rehabilitation interventions within the scope of practice of physical therapists, to include therapeutic electrophysical agents (including but not limited to cryotherapy, diathermy, electrotherapy, low-level laser therapy, ultrasound, and dry needling), manual therapy, orthotic devices and bracing, taping, therapeutic exercise, neuromuscular re-education, and sport-specific training
- Engagement of the multidisciplinary team and referral

We included all outcomes.

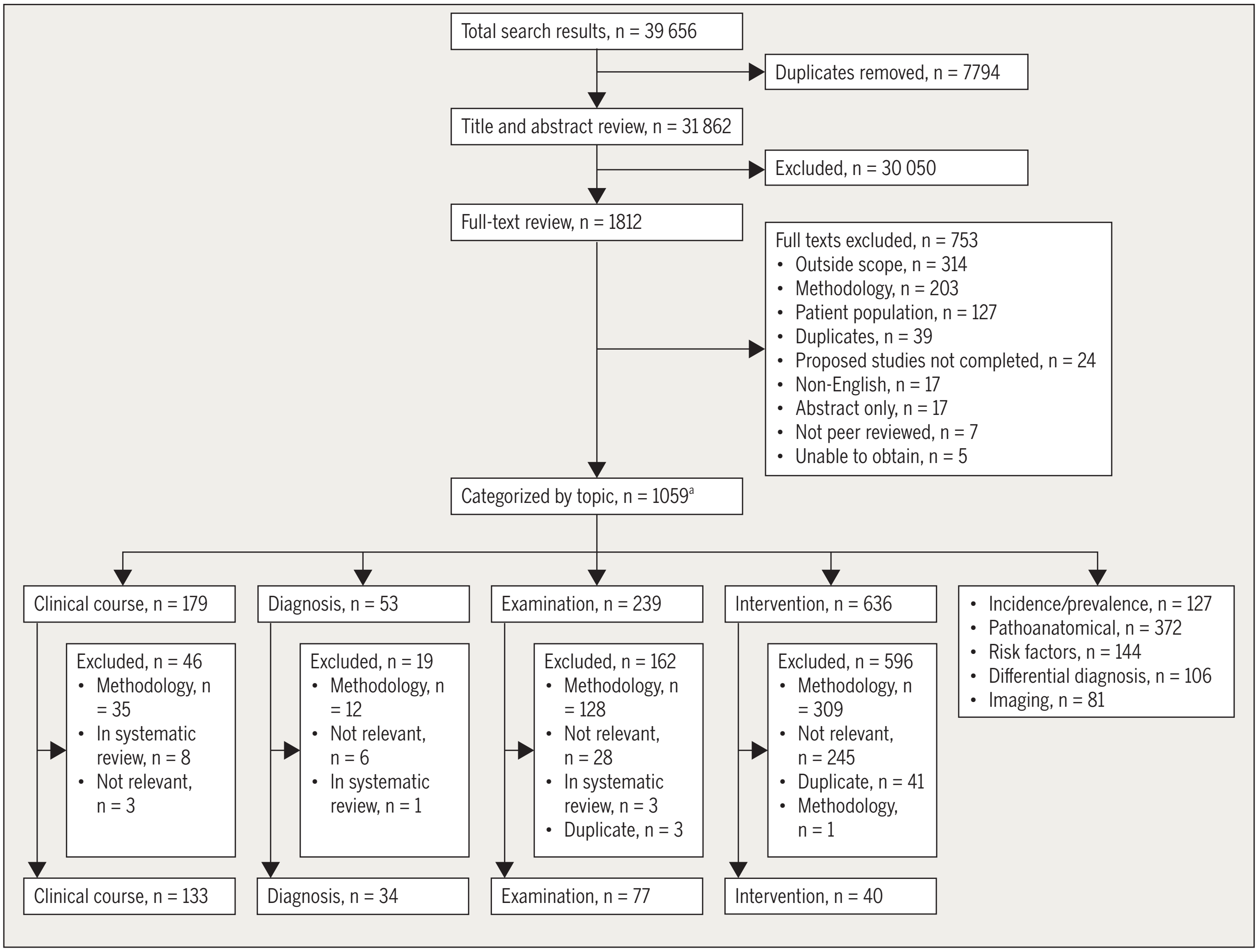
Exclusion Criteria

We excluded articles reporting on

- Animal studies
- Primarily infants and children (younger than 13 years old)
- Symptoms, body system impairments, activity limitations, and participation restrictions related primarily to conditions other than lateral ankle sprains and chronic ankle instability
  - Tumors
  - Metabolic or vascular diseases, such as
    - Gout
    - Diabetes
    - Lupus
    - Rheumatoid arthritis
    - Psoriatic arthritis
  - Posterior heel pain related to calcaneal tendinopathy
  - Medial ankle pain related to posterior tibial tendinopathy
- Topics outside the scope of physical therapist practice
  - Systemic processes (autoimmune, rheumatology)

APPENDIX D

PRISMA FLOW CHART OF ARTICLES (2013-2020)



[a]*Articles could be placed into multiple categories.*

APPENDIX E

LEVELS OF EVIDENCE TABLE[a]

Level	Intervention/Prevention	Pathoanatomic/Risk/Clinical Course/Prognosis/Differential Diagnosis	Diagnosis/Diagnostic Accuracy	Prevalence of Condition/ Disorder	Exam/Outcomes
I	Systematic review of high-quality RCTs High-quality RCT[b]	Systematic review of prospective cohort studies High-quality prospective cohort study[c]	Systematic review of high-quality diagnostic studies High-quality diagnostic study[d] with validation	Systematic review, high-quality cross-sectional studies High-quality cross-sectional study[e]	Systematic review of prospective cohort studies High-quality prospective cohort study
II	Systematic review of high-quality cohort studies High-quality cohort study[c] Outcomes study or ecological study Lower-quality RCT[f]	Systematic review of retrospective cohort study Lower-quality prospective cohort study High-quality retrospective cohort study Consecutive cohort Outcomes study or ecological study	Systematic review of exploratory diagnostic studies or consecutive cohort studies High-quality exploratory diagnostic studies Consecutive retrospective cohort	Systematic review of studies that allows relevant estimate Lower-quality cross-sectional study	Systematic review of lower-quality prospective cohort studies Lower-quality prospective cohort study
III	Systematic reviews of case-control studies High-quality case-control study Lower-quality cohort study	Lower-quality retrospective cohort study High-quality cross-sectional study Case-control study	Lower-quality exploratory diagnostic studies Nonconsecutive retrospective cohort	Local nonrandom study	High-quality cross-sectional study
IV	Case series	Case series	Case-control study		Lower-quality cross-sectional study
V	Expert opinion	Expert opinion	Expert opinion	Expert opinion	Expert opinion

Abbreviation: RCT, randomized clinical trial.
[a]*Adapted from the Centre for Evidence-Based Medicine 2009 levels of evidence (https://www.cebm.ox.ac.uk/resources/levels-of-evidence/oxford-centre-for-evidence-based-medicine-levels-of-evidence-march-2009). See also* **APPENDIX F.**
[b]*High quality includes RCTs with greater than 80% follow-up, blinding, and appropriate randomization procedures.*
[c]*High-quality cohort study includes greater than 80% follow-up.*
[d]*High-quality diagnostic study includes consistently applied reference standard and blinding.*
[e]*High-quality prevalence study is a cross-sectional study that uses a local and current random sample or censuses.*
[f]*Weaker diagnostic criteria and reference standards, improper randomization, no blinding, and less than 80% follow-up may add bias and threats to validity.*

APPENDIX F

PROCEDURES FOR ASSIGNING LEVELS OF EVIDENCE

- Level of evidence is assigned based on the study design using the Levels of Evidence table (**APPENDIX E**), assuming high quality (eg, for intervention, randomized clinical trial starts at level I)
- Study quality is assessed using the critical appraisal tool, and the study is assigned 1 of 4 overall quality ratings based on the critical appraisal results
- Level of evidence assignment is adjusted based on the overall quality rating:
  - High quality (high confidence in the estimate/results): study remains at assigned level of evidence (eg, if the randomized clinical trial is rated high quality, its final assignment is level I). High quality should include:
    - Randomized clinical trial with greater than 80% follow-up, blinding, and appropriate randomization procedures
    - Cohort study includes greater than 80% follow-up
    - Diagnostic study includes consistently applied reference standard and blinding
    - Prevalence study is a cross-sectional study that uses a local and current random sample or censuses
  - Acceptable quality (the study does not meet requirements for high quality and weaknesses limit the confidence in the accuracy of the estimate): downgrade 1 level
    - Based on critical appraisal results
  - Low quality: the study has significant limitations that substantially limit confidence in the estimate: downgrade 2 levels
    - Based on critical appraisal results
  - Unacceptable quality: serious limitations—exclude from consideration in the guideline
    - Based on critical appraisal results

American Journal of Emergency Medicine xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

American Journal of Emergency Medicine

journal homepage: www.elsevier.com/locate/ajem

Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in a pediatric population

Amy L. Ellenbogen, MD [a,*], Amy L. Rice, PhD [b], Pranav Vyas, MD [c]

[a] Department of Radiology, George Washington University Hospital, Washington, DC 20037, United States
[b] Independent Consultant (Biostatistics), Chevy Chase, MD 20815, United States
[c] Department of Radiology, Children's National Medical Center, Washington, DC 20010, United States

ARTICLE INFO

Article history:
Received 18 January 2017
Received in revised form 18 March 2017
Accepted 19 March 2017
Available online xxxx

Keywords:
Ankle x-ray
Pediatric radiology
Pediatric emergency medicine
Clinical decision rules
Ankle fracture
Ankle trauma

ABSTRACT

Background: A recent multicenter prospective Canadian study presented prospective evidence supporting the Low Risk Ankle Rules (LRAR) as a means of reducing the number of ankle radiographs ordered for children presenting with an ankle injury while maintaining nearly 100% sensitivity. This is in contrast to a previous prospective study which showed that this rule yielded only 87% sensitivity.
Objective: It is important to further investigate the LRAR and compare them with the already validated Ottawa Ankle Rules (OAR) to potentially curb healthcare costs and decrease unnecessary radiation exposure without compromising diagnostic accuracy.
Methods: We conducted a retrospective chart review of 980 qualifying patients ages 12 months to 18 years presenting with ankle injury to a commonly staffed 310 bed children's hospital and auxiliary site pediatric emergency department.
Results: There were 28 high-risk fractures identified. The Ottawa Ankle Rules had a sensitivity of 100% (95% CI 87.7–100), specificity of 33.1% (95% CI 30.1–36.2), and would have reduced the number of ankle radiographs ordered by 32.1%. The Low Risk Ankle Rules had a sensitivity of 85.7% (95% CI 85.7–96), specificity of 64.9% (95% CI 61.8–68), and would have reduced the number of ankle radiographs ordered by 63.1%. The latter rule missed 4 high-risk fractures.
Conclusion: The Low Risk Ankle Rules may not be sensitive enough for use in Pediatric Emergency Departments, while the Ottawa Ankle Rules again demonstrated 100% sensitivity. Further research on ways to implement the Ottawa Ankle Rules and maximize its ability to decrease wait times, healthcare costs, and improve patient satisfaction are needed.

1. Introduction

With healthcare costs in the United States continuing to rise and emergency rooms becoming overcrowded [1,2] it becomes crucial to find ways to cut costs without compromising healthcare quality. Pediatric Emergency Departments (PEDs) are an important setting to cut costs while maintaining quality.

Roughly 85–100% of children presenting to United States PEDs with a history of ankle injury receive an ankle radiograph [3]. While the Ottawa Ankle Rule (OAR) has been validated for use in the pediatric population [4], a less well-studied rule, the Low Risk Ankle Rule (LRAR), has also shown promising results. A large multicenter prospective study conducted in Canada and published in 2013 suggested that the LRAR could reduce the number of ankle x-rays performed in PEDs by up to 60%, while maintaining nearly 100% sensitivity [5]. While such results are promising, further validation is needed prior to implementation. This is particularly true given that a smaller 272 subject prospective study performed several years earlier showed only 87% sensitivity for the LRAR, missing 6 clinically significant fractures, versus 100% sensitivity for the OAR [6].

Thus, our aim was to further investigate the LRAR and to compare this clinical decision rule to the well-validated OAR in a pediatric population. To the best of our knowledge, there has never been a retrospective study comparing the two clinical decision rules, which could provide another perspective and eliminate possible expectation bias introduced by non-blinded clinicians in prior discordant prospective studies.

2. Methods

2.1. Definitions

The Low Risk Ankle Rules state that an ankle radiograph is not required if an ankle examination reveals tenderness and swelling isolated to the distal fibula and/or adjacent lateral ligaments distal to the tibial

* Corresponding author.
E-mail address: ale2t@virginia.edu (A.L. Ellenbogen).

http://dx.doi.org/10.1016/j.ajem.2017.03.058
0735-6757/© 2017 Published by Elsevier Inc.

anterior joint line [7]. The Ottawa Ankle Rules state that an ankle radiograph is required if examination reveals pain in the malleolar zone and one of the following: 1) inability to bear weight immediately after the injury and in the Emergency Department for four steps or 2) bone tenderness along the distal 6 cm of the posterior edge of the tibia or tip of the medial malleolus 3) bone tenderness along the distal 6 cm of the posterior edge of the fibula or tip of the lateral malleolus [8]. A high-risk ankle injury is defined as any fracture of the foot, distal tibia, and fibula proximal to the distal physis; tibiofibular syndesmosis injury, or ankle dislocation, with increased risk of requiring surgical intervention [5].

2.2. Study design and data collection

We conducted an institutional review board (IRB) approved retrospective chart review at a 310 bed children's hospital and one auxiliary site. We used the radiology search engine Montage (Philadelphia, Pennsylvania) to identify all ankle x-rays performed on patients between 12 months and 18 years of age at either PED between 1/1/2011 and 4/30/2014. Relevant data including patient gender, age, presence and type of fracture were accessed in January 2015 and manually entered into an Excel spreadsheet. Each ankle radiograph series had already been interpreted by an attending fellowship-trained pediatric radiologist. If the radiographic report impression was indeterminate for the presence of a fracture, the subject was excluded from the study. Otherwise, the radiologic interpretation as to whether a fracture was present and if so, what type of fracture was entered into the study data spreadsheet. The accession numbers obtained from Montage were entered into our picture archiving and communication system (PACS, Synapse, Fujifilm) in order to obtain the patient's medical record number (MRN).

The MRN was then used to obtain the patient's electronic medical record (Cerner, Kansas City) note in order to determine if the patient met criteria for ankle x-ray under each the OAR and the LRAR criteria. If there was inadequate documentation in the patient's EMR note to make this determination for either rule, the subject was excluded.

Additional exclusion criteria included inability to walk prior to ankle injury, physical deformity on exam, previous diagnosis of fracture, and underlying disease that could influence decision for x-ray (these conditions included history of bony neoplasm, sickle cell disease, osteogenesis imperfecta and osteopetrosis) (Table 1).

2.3. Statistical methods

The baseline characteristics of the study subjects were summarized in terms of counts and percentages, or means (standard deviation), and ranges. All data were analyzed using Stata IC/13.1 (College Station, TX).

The same set of analyses were performed for both of the clinical decision rules (Ottawa Ankle Rules and the Low Risk Ankle Rules) and three different age groups of patients: 1) all patients (1–18 y), 2) preschool-adolescents (3–16 y), and 3) toddlers (1–2 y). The age range for the second group was chosen because it is similar to what was used in other published studies [5,8].

Table 1
Eligibility status of all subjects who received an ankle radiograph in the emergency department.

Total number of age-eligible exams (≥1 and ≤ 18 years) identified using Montage	N = 1378
Number of excluded cases	
X-ray report indeterminate for fracture	71
Exam data insufficient to determine if OAR criteria met	218
Already diagnosed with fracture, presenting for post-reduction	15
Underlying disease that could predispose to fracture (e.g. osteogenesis imperfecta)	18
Obvious physical deformity on exam	6
Exam data insufficient to determine if LRAR criteria met	70
Total number of eligible exams	N = 980

Sensitivity was calculated as the percentage of patients with a radiographically-confirmed high-risk fracture that would have been correctly identified by applying the clinical decision rule in the PED. Likewise, specificity was calculated as the percentage of patients without a radiographically confirmed high-risk fracture that would have been correctly identified by applying the clinical decision rule. MedCalc's online diagnostic test evaluation calculator was used to generate the estimates and 95% confidence intervals for sensitivity and specificity [9].

The potential reduction in ankle radiographs was expressed as a percent reduction and was calculated as follows: [Total number of radiographs actually performed − number of radiographs that would have been ordered solely based on the clinical decision rule] / total number of radiographs actually performed) ∗ 100.

The number of radiographically confirmed high-risk fractures that would have been missed by each of the clinical decision rules was recorded along with the total number of radiographically confirmed high-risk fractures that actually occurred in each group.

3. Results

A total of 980 subjects with an average age of 11.7 years (range 1–18) met the inclusion criteria (Table 2). A mere 21/980 (2%) reviewed charts mentioned the Ottawa Ankle Rules and 0/980 (0%) mentioned the Low Risk Ankle Rules as justification for obtaining an ankle x-ray. There were a total of 28 high-risk fractures within the study population.

Systematically applying the OAR in the ER to these 980 patients would have identified all 28 high-risk ankle fractures, with 100% sensitivity and 33.1% specificity and reduced the number of ankle x-rays ordered by 32.1%. Systematically applying the LRAR in the ER would have missed 4 high-risk ankle fractures, including a spiral fracture of the tibia and Salter Harris II, III, and IV fractures of the tibia. The LRAR had 85.7% sensitivity and 64.9% specificity. The LRAR would have decreased the number of ankle x-rays ordered by 63.1% (Table 3).

Additional analyses performed after excluding subjects <3 and >16 years of age (in line with the age criteria used in the recent multicenter Canadian study investigating the LRAR [5] and many of the studies on the OAR [6]) showed similar results as compared to the analysis that included all 980 subjects ages 1 through 18 years.

When the same analysis was performed on the very youngest group of children (1 to 2 years of age), both the OAR and LRAR had 100% sensitivity and 77.8% specificity. However, these are rather imprecise estimates (as evidenced by the wide confidence intervals) because they were based on a very small group of children (n = 29) with only 2 high-risk fractures.

4. Discussion

The sensitivity of the LRAR among children 1–18 years of age in our study was lower than that found in the 2013 study by Boutis et al. [5], but similar to those of the 2009 study by Gravel et al. [6]. As with the

Table 2
Characteristics of the study population (N = 980).

Characteristic	
Age (y)[a]	11.7 (4.0)
Sex[b]	
Male	485 (49.5)
Female	495 (50.5)
Duration of symptoms[b]	
≤24 h	720 (73.5)
>24–≤72 h	134 (13.6)
>72 h	81 (8.3)
Unknown	45 (4.6)
High risk fractures[c]	28

[a] Mean (SD).
[b] n(%).
[c] (n).

Please cite this article as: Ellenbogen AL, et al, Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in a pediatric population, American Journal of Emergency Medicine (2017), http://dx.doi.org/10.1016/j.ajem.2017.03.058

Table 3
Performance of the Ottawa Ankle Rules compared to the Low Risk Ankle Rules.

Age group & rule	Sensitivity % (95% CI)	Specificity % (95% CI)	Potential reduction in radiographs	High-risk fractures (missed/total)
1–18 y (N = 980)				
Ottawa Ankle Rules	100 (87.6, 100)	33.1 (30.1, 36.2)	32.1%	0/28
Low Risk Ankle Rules	85.7 (67.3, 96.0)	64.9 (61.8, 68.0)	63.4%	4/28
3 y–16 y (N = 857)				
Ottawa Ankle Rules	100 (86.8, 100)	31.3 (28.2, 34.6)	30.3%	0/26
Low Risk Ankle Rules	84.6 (65.1, 95.6)	64.4 (61.0, 67.6)	62.9%	4/26
1–2 y (N = 29)				
Ottawa Ankle Rules	100 (15.8, 100)	77.8 (57.7, 91.4)	72.4%	0/2
Low Risk Ankle Rules	100 (15.8, 100)	77.8 (57.7, 91.4)	72.4%	0/2

latter study, the specificity of the LRAR was greater than that of the OAR. In agreement with prior meta-analyses [8], the sensitivity of the OAR was 100%. Despite its greater specificity, the lower sensitivity of the LRAR and the fact that four high-risk ankle fractures were missed using this rule argues against its use in the PED setting.

A disadvantage of the prospective study performed by Boutis et al. [5] was that patients who met criteria for the LRAR or the OAR did not receive x-rays. Only some of these patients were followed up by phone or physical examination and thus, there is a possibility that high-risk fractures were missed. In our study, imaging was available for all subjects. Additionally, only a portion of subjects in the study performed by Boutis et al. [5] had documented physical examinations, thus limiting reproducibility as compared to our study.

The study by Boutis et al. [5] found that the implementation of the ankle rules did not significantly change patient or physician satisfaction or length of stay. Further research is needed to determine if this would hold true in the United States, with a healthcare system distinct from that of Canada. For example, Canadians use the Emergency Department more often and 31% of Emergency Room patients waited >4 h versus a mere 13% of those in the United States [11]. Additionally, utilization of malpractice litigation differs in the two countries.

Another potential application of the OAR that was not investigated in the study by Boutis et al. [5] and could potential curb PED wait times and thus increase parent satisfaction is use of these rules by triage nurses. The accuracy and reproducibility with which nurses applied the OAR in one study performed in the United States including 185 five to nineteen year olds was 98% [12]. While the effect of triage nurse use of the OAR on length of stay and patient satisfaction has been studied in adult Emergency Departments with mixed results [13,14,15], there has been little research on such outcomes in PED. Thus, this is a promising area for future research.

Though effects on wait times and patient satisfaction as a result of OAR implementation have not been satisfactorily studied in the pediatric population, OAR implementation has been found to decrease healthcare costs [16]. One study found savings between $614,226 and $3,145,910 per 100,000 patients [16].

5. Limitations

One limitation of our study was that it was a retrospective chart review, which was dependent on EMR records to determine which criteria were met. A total of 288 (22.7%) subjects were excluded secondary to inadequate information included in the EMR. Changes or updates to the search engine Montage could also result in a slightly different patient sample, reducing reproducibility. Additionally, the experience of clinicians whose notes were reviewed varied and included residents, nurse practitioners, fellow, and attending physicians. This also makes our results more generalizable, as most PEDs have clinicians at a variety of skill levels.

At the time of our study, there was no standardized method to evaluate whether a child qualified for an ankle x-ray at our institution. At times, the triage nurse would order a radiograph and in other instances, the resident, fellow, or attending physician would do so. Thus, the percentage of patients with ankle injuries receiving x-rays varied depending on the PED staff at any specific time. However, the majority of children (approximately 70–80% by the author's estimation) with ankle injuries had x-rays performed. Given the retrospective nature of our study, it remains possible that fractures were missed simply by not being imaged. Part of justification of the LRAR, though, is that missing low-risk fractures is acceptable since they are treated conservatively.

With a mere 2% of clinicians' notes mentioning these clinical decision rules according to our data, the OAR may not have been widely utilized. It is possible, though, that more clinicians took the OAR or LRAR into consideration without specifying as such in the EMR. A study conducted in Canada [10] showed 87.5% of PED clinicians using the OAR. However, this study was conducted via a mail survey. Another study [17] found that United States clinicians had much less positive attitudes towards and were much less likely to use the OAR as compared to clinicians from Canada and the United Kingdom. Thus, more research is needed to determine what percentage of PED clinicians utilizes the OAR, what barriers to usage of the rules exist, and how to motivate more clinicians to adopt these clinical decision rules.

6. Conclusions

Our retrospective study further supports the use of the OAR in the pediatric population and suggests that the LRAR are not sensitive enough for implementation. With only a small number of clinicians documenting use of the OAR, it remains important to continue to investigate methods of implementation of this clinical decision rule. Specifically, research into the use of this rule by triage nurses and the effect such application of this rule would have on PED wait times, healthcare costs, and patient and parent satisfaction should remain important future research considerations.

References

[1] Timm NL, Ho ML, Luria JW. Pediatric emergency department overcrowding and impact on patient flow outcomes. Acad Emerg Med 2008;15(9):832–7.
[2] Hoot NR, Aronsky DA. Systematic review of emergency department crowding: causes, effects, and solutions. Ann Emerg Med 2008;52(2):126–36.
[3] Boutis K, Constatine E, Schuh S, Pecaric M, Stephens D, Narayanan UG. Pediatric emergency physician opinions on ankle radiograph clinical decision rules. Acad Emerg Med 2010;17(7):709–17.
[4] Dowling S, Spooner CH, Liang Y, Dryden DM, Friesen C, Klassen TP, et al. Accuracy of Ottawa Ankle Rules to exclude fractures of the ankle and midfoot in children: a meta-analysis. Acad Emerg Med 2009;16(4):277–87.
[5] Boutis K, Grootendorst P, William A, Plint AC, Babyn P, Brison RJ, et al. Effect of the Low Risk Ankle Rules on the frequency of radiography in children with ankle injuries. Can Med Assoc J 2013;185(15):731–8.
[6] Gravel J, Hedrei P, Grimard G, Gouin S. Prospective validation and head-to-head comparison of 3 ankle rules in a pediatric population. Ann Emerg Med 2009;54(4):534–40.

Please cite this article as: Ellenbogen AL, et al, Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in a pediatric population, American Journal of Emergency Medicine (2017), http://dx.doi.org/10.1016/j.ajem.2017.03.058

[7] Boutis K, Komar L, Jaramillo D, Babyn P, Alman B, Synder B, et al. Sensitivity of a clinical examination to predict the need for radiography in children with ankle injuries: a prospective study. Lancet 2001;358(9299):2118–21.
[8] Plint AC, Bullock B, Osmond MH, Stiell I, Dunlap H, Reed M, et al. Validation of the Ottawa Ankle Rules in children with ankle injuries. Acad Emerg Med 1999;6(10): 1005–9.
[9] MedCalc Online Diagnostic Test Evaluation Calculator. accessed March 9, 2016. Available from: https://www.medcalc.org/calc/diagnostic_test.php.
[10] Dowling SK, Wishart I. Use of the Ottawa Ankle Rules in children: a survey of physicians' practice patterns. Can J Emerg Med 2011;3(5):333–8.
[11] Pines JM, Hilton JA, Weber EJ, Alkemade AJ, Al Shabanah H, Anderson PD, et al. International perspective on emergency department crowding. Acad Emerg Med 2011; 18(12):1358–69.
[12] Karpas A, Hennes H, Walsh-Kelly CM. Utilization of the Ottawa Ankle Rules by nurses in a pediatric emergency department. Acad Emerg Med 2002;9(2):130–3.
[13] Fan J, Woolfrey K. The effect of triage-applied Ottawa Ankle Rules on the length of stay in a Canadian urgent care department: a randomized controlled trial. Acad Emerg Med 2006;13(2):153–7.
[14] Sorensen E, Keeling A, Snyder A, Syverud S. Decreasing ED length of stay with use of the Ottawa Ankle Rules among nurses. J Emerg Nurs 2012;38(4):350–2.
[15] Rowe BH, Villa-Roel C, Guo X, Bullard MJ, Ospina M, Vandermeer B, et al. The role of triage nurse ordering on mitigating overcrowding in emergency departments: a systematic review. Acad Emerg Med 2011;18(12):1349–57.
[16] Anis AH, Stiell IG, Stewart DG, Laupacis A. Cost-effectiveness analysis of the Ottawa Ankle Rules. Ann Emerg Med 1995;26(4):433–8.
[17] Graham ID, Stiell IG, Laupacis A, McAuley L, Howell M, Clancy M, et al. Awareness and use of the Ottawa Ankle and Knee Rules in 5 countries: can publication alone be enough to change practice? Ann Emerg Med 2001;37(3):259–66.

Please cite this article as: Ellenbogen AL, et al, Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in a pediatric population, American Journal of Emergency Medicine (2017), http://dx.doi.org/10.1016/j.ajem.2017.03.058