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SYSTEMATIC REVIEW

IS PRE-PERFORMANCE MASSAGE EFFECTIVE TO IMPROVE MAXIMAL MUSCLE STRENGTH AND FUNCTIONAL PERFORMANCE? A SYSTEMATIC REVIEW

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ABSTRACT

Background: Although pre-performance massage is frequently used in sports settings, the evidence regarding its effects on muscle strength and functional performance is equivocal.

Purpose: The purpose of this systematic review was to synthesize the findings of randomized controlled trials (RCTs) investigating the effects of pre-performance massage on strength and functional performance.

Study Design: Systematic review with qualitative analysis.

Methods: Eight electronic databases were searched from inception until June 2017. Methodological quality of included studies were assessed using Physiotherapy Evidence Database scale. Data was synthesized qualitatively.

Results: Nine crossover RCTs with varied methodological qualities met inclusion criteria. Six out of nine studies had low quality, while two were of moderate-quality and one was high-quality. Following the descriptive analysis using within-group effect sizes of interventions used in included studies, no evidence was found to support the use of any kind of massage interventions (passive manual massage or self-massage) to enhance maximal strength, sprint or jump performances of young healthy subjects. In fact, there appears to be limited evidence which implies the negative effects of passive manual massage. In particular, longer-duration (> 9 minutes) of massage interventions tended to result in negative effects on lower-limb maximal strength, sprint performance and jump height.

Conclusion: In conclusion, the use of longer-duration pre-performance massage cannot be recommended for enhancing young athletes' strength and performance in sprint and vertical jump. More high-quality RCTs are necessary to examine overall effects of pre-performance massage on athletes' performance.

Level of Evidence: 1a

Key Words: Functional performance, muscle strength, pre-performance massage, systematic review

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INTRODUCTION

Pre-performance massage is frequently utilized in various sports settings, attempting to prevent injuries, increase range of motion, decrease stiffness and soreness, and enhance athletes' maximal strength and functional performance during competitions.[1] Proposed rationales for improved strength and functional performance generally involve the following; increasing blood flow to provide more efficient metabolism for muscles,[2] releasing trigger points, which are believed to cause muscle weakness[3] and positive psychological effects, such as mood enhancement and increased perceived performance.[4]

The research evidence regarding the immediate effects of pre-performance massage to improve muscle strength and functional performance is equivocal. Some studies have demonstrated that massage might inhibit neurological excitability, which might theoretically decrease motor outputs.[5-7] However, some authors have speculated that the effects of massage on neurological excitability, and hence muscle strength and functional performance, would depend on the types of massage. Based on this assumption, it has been anecdotally suggested that superficial and stimulating massage should be used before competitions to enhance motor output, while deep and relaxing massage should be adopted to encourage relaxation and post-exercise recovery. However, there is no empirical data to support the claim that fast and stimulating massage techniques can increase spinal reflex excitability.[1]

To the best of the authors' knowledge, there is no article which has systematically reviewed relevant papers to address this particular clinical question 'is pre-performance massage effective to improve athletes' strength and functional performance?'. Thus, it would be valuable to undertake a systematic review to enable more evidence-based clinical decision making in sporting environments for clinicians, coaches and athletes.

The purpose of this systematic review was to synthesize the findings of randomized controlled trials (RCTs) investigating the effects of pre-performance massage on strength and functional performance.

METHODS

Study protocol and registration

This systematic review was written in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement.[8] {Liberati, 2009 #29} This review was registered in the international prospective register of systematic reviews PROSPERO network before the study was commenced (registration number CRD42016037609).

Search strategy

A systematic search was undertaken by one author (KM) with seven electronic databases (CINAHL, Cochrane Library, Embase, Ichushi, MEDLINE, SPORTDiscus and Web of Science) to find relevant studies. A search in Google Scholar was also undertaken to strengthen the comprehensiveness of the search strategy. Databases were searched from inception to June 2017. After the initial search, duplicates were removed and titles and abstracts were screened subsequently. Full texts of articles which remained at this stage were retrieved and further assessed for eligibility. Reference lists of included papers were also hand-searched.

A clinical question and search terms were developed based on a PICO (Participants, Intervention, Comparator and Outcome measures) format for this systematic review (Table 1).[9] This systematic review included all relevant English- and Japanese-language studies. Studies with human participants were considered. Intervention of interests included any types of massage (passive manual massage or active self-massage) performed immediately before physical exertions. Studies examining recovery effects of massage during physical exertions were excluded. No limitation was set for comparator interventions. Included studies were required to use specific outcome measures, such as maximal muscle strength and/or functional performances related to sports, such sprinting, jumping or throwing. In terms of research design, RCTs based on the National Health and Medical Research Council (NHMRC) hierarchy were considered for eligibility.[10] Only papers published in peer-reviewed academic journals were included.

Assessment of methodological quality

Methodological quality of included studies were assessed using Physiotherapy Evidence Database

Table 1. *PICO format and search key words.*

PICOS	Definitions	Search terms
Participants	Any participants	not set
Intervention	Any types of pre-performance massage	(massage OR (foam roll*)) AND (pre-performance OR preperformance OR pre-event OR preevent OR pre-competition OR precompetition OR sports)
Comparison	Any interventions	not set
Outcome	Maximal muscle strength and/or functional performance	strength OR power OR speed OR function* OR performance

* is a wildcard character.

(PEDro) scale.[11] This critical appraisal tool has been demonstrated to be both reliable and valid.[12,13] The quality of each study was classified as 'high' (7/10 or more), 'moderate' (5 or 6/10) or 'poor' (4/10 or less) according to a total score.[14]

When included studies had been already critically appraised in the PEDro database, those scores were extracted. All PEDro scores in the databases are based on critical appraisal by trained PEDro assessors. The remaining papers were independently assessed by two reviewers (LD, KY). Discrepancies regarding study qualities were mediated through discussion. Both reviewers had completed the online PEDro scale training program.

Data extraction and synthesis

Data with regards to study designs, sample characteristics (sample size, age, gender, sports experiences, diagnosis, pain level and functional disability), types of pre-performance massage, outcome measures, results (pre- and post-intervention data, statistical significance and effect size if available) and conclusions were collected from all included papers. Attempts were made to perform subgroup analysis on the basis of types of massage (passive massage versus self-massage) or outcome measures when two or more homogenous studies were available in each group.

RESULTS

Study selection

The systematic search process is shown in Figure 1. The initial electronic database search yielded a total of 483 papers. After the exclusion of duplicates and irrelevant papers through screening, nine papers were chosen for full-text evaluation. After a full-text assessment, four papers were excluded due to incomplete, unclear or no randomisation processes.[15-18] Four additional relevant articles were identified through references or Google Scholar.[3,19-21] As a result, nine English-language RCTs were included in this review.

Study characteristics

A summary of included studies is presented in Table 2. Nine studies were included as crossover RCTs. Although one study used a non-random allocation for a control group, this study was also included by dismissing the control group and regarding it as a crossover RCT.[22] Participants were predominantly college-age and healthy. The mean sample size across the included studies was 56. Sample size ranged from 26 to 90 and the cumulative sample size was 510 (188 women and 322 men), including duplicate participants in different intervention groups in each crossover RCT.

There were 24 intervention or comparator arms in the included nine papers. There was a considerable variability in types of massage techniques examined. Various types of passive massage techniques, such as effleurage, petrissage and tapotement were performed by physiotherapists, massage therapists or masseurs in five papers.[21,23-26] Self-massage using manual massage device was examined in three papers.[3,19,20] In the remaining study, passive massage was conducted by a custom-made machine with a roller-massager.[22] The total duration of massage interventions ranged from five seconds[22] to 30 minutes.[26] In most studies, treatments were performed on lower-limb muscles, except for one study, where massage was also performed for neck and shoulder girdle.[26]

Comparator interventions included active static stretching,[19] warm-up exercise,[20,25] sham massage

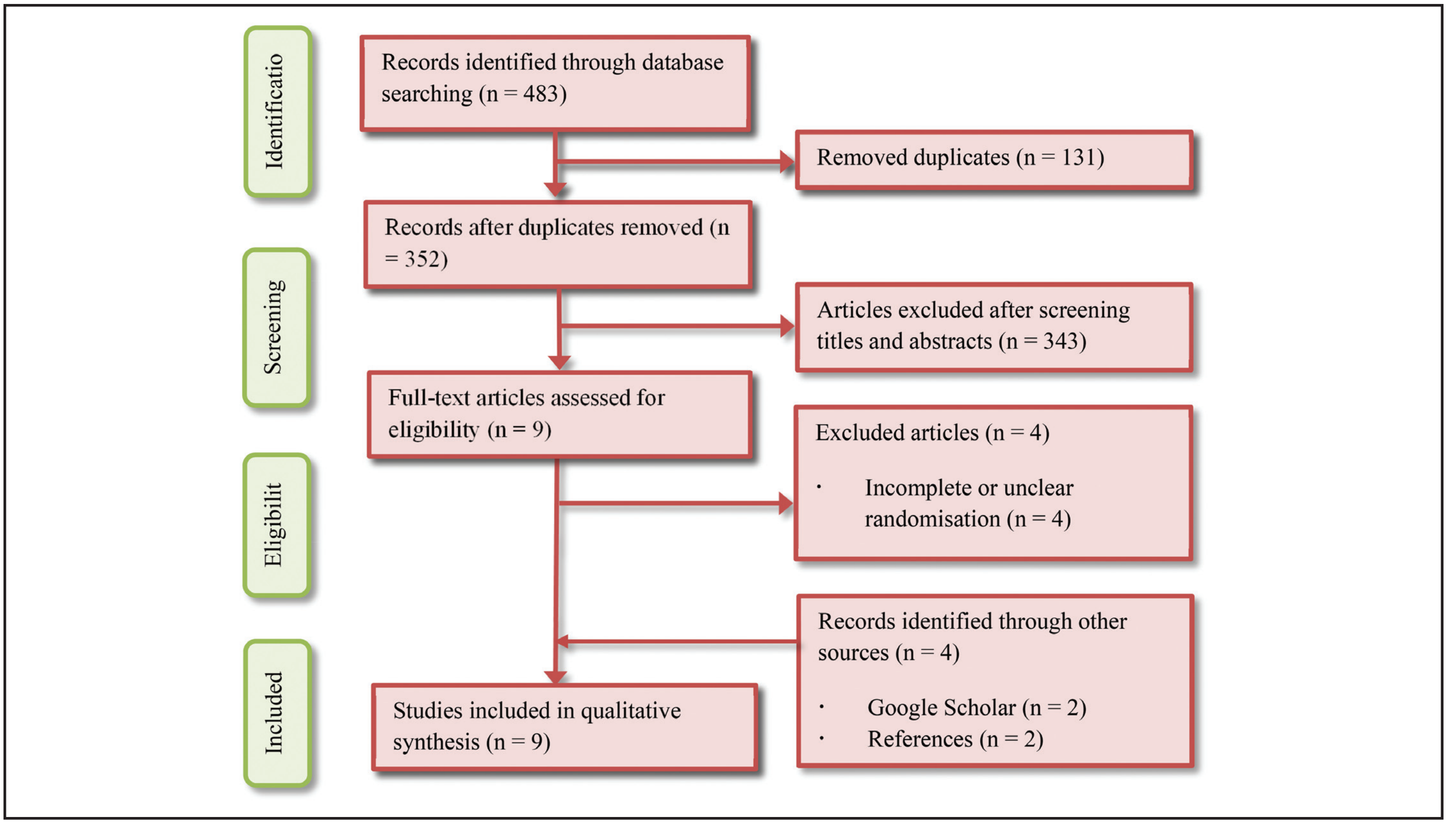

Figure 1. *PRISMA flow diagram.*

or electrophysical agents,[3,21,24] motor imagery,[3] and no intervention. [22,26] In terms of outcome measures, strength was evaluated as forms of isometric or isokinetic maximal strength, or maximal voluntary contraction (MVC) measured via electromyography in four studies.[19,20,22,24] Vertical jump or drop jump height were examined in four studies.[3,20,21,23] In the drop jump, athletes were instructed to step off the 30-centimeter step and jump upwardly as high as possible.[21] Short-distance sprint performance was also investigated in four articles.[3,23,25,26] Additionally, two papers also evaluated balance and agility respectively.[19,20]

Methodological quality

The results of quality assessment are presented in Table 3. As three included papers had been already evaluated in the PEDro database, those scores were utilized.[3,20,25] Included studies had a median score of 4 out of 10, ranging from 3 to 7. Six out of nine studies were low-quality, while two studies were moderate-quality and only one study was considered to be high quality. Common methodological flaws were no blinding for therapists or participants (100%), no allocation concealment (89%), and no blinding for assessors, failing to report if 85% participants completed reassessments and no intention to treat analysis (78%).

Data extraction and synthesis

Due to the absence of common types of massage interventions, comparator interventions and outcome measures in the included studies, it was not appropriate to perform a meta-analysis. A qualitative descriptive synthesis of the available data was undertaken instead. The subsequent intention was to compare within-group effect sizes of different interventions by calculating mean changes and 95% confidence intervals, based on means and standard deviations in each pre- and post-intervention arm (Table 4). Since pre-intervention baseline data were lacking in three studies, however, it was not possible to calculate effect sizes in those studies.[3,25,26] Four first authors were contacted and requested to provide additional data to enable further analysis.[19,24-26] This request was met from two author groups.[19,26]

Table 2. *Characteristics of included studies.*

Authors	Participants	Targeted Muscles	Massage Interventions	Comparator Interventions	Outcome Measures	Between-Group Results
Halperin et al. 2014	N = 28 14 collegiate active healthy participants (2 women and 12 men)	Triceps surae muscles	Self-massage with a roller massager (30 sec × 3 sets)	Active static stretching (30 sec × 3 sets)	• MVC in ankle plantarflexion • Maximal isometric force in ankle plantarflexion • Single-leg balance test • Dorsiflexion ROM	• Participants in the massage group showed significantly greater MVC 10 min after interventions compared to stretching. • There was no difference in changes in single-leg balance between the 2 groups
Healey et al, 2013	N = 52 26 college-aged healthy participants (13 women and 13 women)	Quadriceps, hamstring, Iliotibial band, triceps surae, latissimus dorsi, and rhomboid muscles	Self-massage using a foam roller (30 sec for each muscle group)	Isometric exercises (eg. planks) to activate the same muscle groups (30 sec for each position)	• Maximal isometric squat force • Vertical jump height • 5-10-5 yard shuttle run • Muscle Soreness • Fatigue • Perceived Exertion	• Baseline data were not collected. • According to the post-intervention data, there were no significant differences between foam rolling and plank for strength and functional performance.
Sullivan, et al, 2013	N = 77* 17 collegiate participants (10 women and 7 men)	Hamstring muscles	Massage with a roller-massager performed by a custom-made machine • 5 sec × 1 set • 5 sec × 2 sets • 10 sec × 1 set • 10 sec × 2 sets	Not applicable.	• MVC in knee flexion • Maximal isometric force in knee flexion • Evoked contractile force • Sit-and-reach test.	• There were no statistically significant differences between the conditions for MVC and isometric force. • Main effects for sets and duration demonstrated that evoked contractile force significantly decreased ($p<0.05$).
Arroyo-Morales et al. 2011	N = 46 23 collegiate active healthy participants (11 women and 12 men)	Calf, hamstring, quadriceps and craniofacial muscles in the dominant side	Passive massage consisted of effleurage, petrissage and finally tapotement (a total of 20 min). They were performed by one physiotherapist.	Detuned, sham ultrasound was applied to the same parts in the same positions for the same amount of time. Participants were informed that ultrasound would be as effective as massage.	• Isokinetic peak torque in knee flexion and extension • Mood states • Salivary flow rate • Cortisol concentration • α-amylase activity • MDT	• Passive massage led to significantly less knee extension isokinetic strength at 240°/s and 180°/s, but not at 120°/s and 60°/s, compared to placebo interventions. • There was no significant difference in changes in knee flexion strength between the 2 groups.
Fletcher, 2010	N = 60 20 male collegiate athletes	Calf, tibialis anterior, hamstring, quadriceps and gluteal muscles	Passive massage consisted of effleurage and petrissage (a total of 9 min). They were performed by one massage therapist in superficial and fast manners.	• Active warm-up exercises • Combined interventions of massage and warm-up	20-metre sprint performance • Time • Knee angular velocity • Step length • Step rate	• Baseline data were not collected. • According to the post-intervention data, participants in the massage alone group showed significantly increased time, and slower knee angular velocity and step rate, compared to warm-up alone group or the combined group.
Arabaci, 2008	N = 72 24 male active healthy participants	Gluteal, hamstring, quadriceps and calf muscles	Passive Swedish massage consisting of effleurage, friction, petrissage, vibration and tapotment, was performed by 2 masseurs simultaneously for 15 min.	• 15-min active stretching program for both lower limb muscles (20 sec × 2 sets for each) • 15-min rest (Postures were unclear.)	• Vertical jump • 30-metre sprint performance • Sit and reach test	Compared to rest, both massage and stretching led to significantly compromised 10-metre acceleration time and vertical jump, and significantly improved sit and reach test.
McKechnie et al, 2007	N = 57 19 collegiate healthy active participants (8 women and 11 men)	Calf muscles	Passive massage performed by one massage therapist • Petrissage (3 min per each leg) • Tapotement (3 min per each leg)	Control: Paritipants lay in prone and therapists rested hands on each leg over calf for 3 min.	• Drop jump performance • Dorsiflexion ROM	• Baseline data regarding jump performance were not collected. • There was no significant change in jump performance in any groups. • Dorsiflexion ROM significantly increased in both 2 massage groups compared to the control group.
Mikesky et al, 2002	N = 90 30 collegiate athletes (23 women and 7 men)	Hamstring, gluteal, calf and quadriceps muslces	Self-massage using the Stick was performed for 2 min before each test.	• Control: 2-min motor imagery in supine • Placebo: Motor imagery and 2-min sham electrical stimulation on both ankles	• Vertical jump • Flying-start 20-yard sprint • SLR with ankle dorsiflexed	• Baseline data were not collected. • According to the post-intervention data, there was no significant difference between 3 groups.
Harmer et al, 1991	N = 28 14 young male sprint-related athletes	Neck, shoulder girdle, chest, toes, foot, ankle, leg, thigh and buttock muscles	Passive massage, including effleurage, petrissage and tapotement, were performed by one massage therapist for approximately 30 min in total.	Control: No intervention	• Stride frequency	• Baseline data were not collected. • According to the post-intervention data, there was no significant difference between 2 groups.

MVC = maximal voluntary contraction in electromyography, EMG = electromyography, ROM = range of motion, MDT = mechanical detection threshold, SLR = straight leg raise,
*: Nine participants were chosen for a control group.

Table 3. *Critical appraisal of included studies using the PEDRO scale.*

Study	1	2	3	4	5	6	7	8	9	10	11	Total	Quality
Halperin et al., 2014	Y	Y	N	Y	N	N	N	N	N	Y	Y	4/10	Low
Healey et al, 2013	Y	Y	N	N	N	N	N	N	N	Y	Y	3/10	Low
Sullivan, et al, 2013	Y	Y	N	Y	N	N	N	N	N	Y	Y	4/10	Low
Arroyo-Morales et al, 2011	Y	Y	N	Y	N	N	Y	N	N	Y	Y	5/10	Moderate
Fletcher, 2010	Y	Y	N	N	N	N	N	N	N	Y	Y	3/10	Low
Arabaci, 2008	N	Y	Y	Y	N	N	N	Y	Y	Y	Y	7/10	High
McKechnie et al, 2007	Y	Y	N	N	N	N	N	Y	Y	Y	Y	5/10	Moderate
Mikesky et al, 2002	N	Y	N	N	N	N	Y	N	N	Y	Y	4/10	Low
Harmer et al, 1991	N	Y	N	N	N	N	N	N	N	Y	Y	3/10	Low

PEDro scale:
1, eligibility criteria 2, random allocation; 3, concealed allocation; 4, similarity at baseline; 5, blinding of participants; 6, blinding of therapists; 7, blinding of assessors; 8, measures of at least one key outcome from at least 85% of participants initially allocated to groups; 9, intention to treat analysis; 10, between-group comparison; 11, point measures and measures of variability
1= Yes (1 point), 0 = No (0 point), maximum score = 10 (criterion 1 is not included in scores)

Table 4. *A comparison of within-group effect sizes, when able to be calculated.*

Study	Outcome measure (timeframe)	Intervention	Effect size (95% CI)
Halperin et al., 2014	Maximal isometric force (1 min after)	RM*30s	0.05 (-50.61 to 50.70)
		ST	-0.14 (-55.24 to 54.96)
	Maximal isometric force (10 min after)	RM*30s	0.21 (-51.33 to 51.74)
		ST	-0.28 (-52.92 to 52.36)
	Single-leg balance test (1 min after)	RM*30s	-0.63 (-2.07 to 0.82)
		ST	-0.80 (-2.65 to 1.05)
	Single-leg balance test (10 min after)	RM*30s	-0.53 (-1.95 to 0.89)
		ST	-0.35 (-2.34 to 1.64)
Sullivan, et al, 2013	Maximal isometric force	RM5s×1	-0.24 (-2.46 to 1.98)
		RM5s×2	0.22 (-1.96 to 2.39)
		RM10s×1	0.13 (-1.63 to 1.90)
		RM10s×2	-0.09 (-1.54 to 1.35)
Arabaci, 2008	Vertical jump	SM15m	-0.34 (-1.85 to 1.17)
		ST	-0.22 (-1.87 to 1.43)
		RS	-0.03 (-1.84 to 1.76)
	30-metre sprint	SM15m	-0.60 (-0.65 to -0.55)*
		ST	-0.42 (-0.47 to -0.37)*
		RS	-0.20 (-0.24 to -0.16)*

95% CI = 95% confidence interval, RM30s = Self-massage with roller massager (30 sec × 3 sets), RM5s1 = self-massage with roller massager (5 sec × 1 set), RM5s2 = self-massage with roller massager (5 sec × 2 sets), RM10s1 = self-massage with roller massager (10 sec × 1 set), RM10s2 = self-massage with roller massager (10sec × 2 sets), ST = static stretching, FM6m = Self-massage with foam roller (6 min in total), PL = plank exercises, PM20m = passive massage (20 min in total), SU = sham ultrasound, SM15m = Swedish massage (15 min), RS = rest, PET6m = petrissage (6 min in total), TAP6m = tapotement (6 min in total), CON = control group with placebo massage, * = 95% CI not crossing zero

Considering the apparently different effects of massage with different timeframes in chosen studies, where the nine-minute duration seemed to be a cut-off point to determine the effects massage on motor outputs, massage for less than nine minutes were defined as short-duration massage, while massage of nine minutes or longer was defined as long-duration for the purposes of this review.

Effects of pre-performance massage on maximal muscle strength

Three low-quality studies examined the effects of self- or machine assisted massage with a roller massager or a foam roller.[19,20,22] Two studies showed no significant statistical difference between these massage interventions and other interventions, such as plank exercises and no intervention to improve maximal strength or MVC.[20,22] The findings in one of these studies corresponded with the additional analysis with effect sizes, being not clinically significant (see Table 4). On the other hand, the most recent article found that self-massage with a roller massager resulted in significantly greater improvement in maximal strength of ankle plantarflexors compared to active 30-second static stretching.[19] However, it should be noted that static stretching seemed to decrease maximal strength in this study, which was in line with the current evidence regarding longer-duration static stretching.[27-29] In fact, further analysis revealed that effect sizes of the massage intervention used in this paper turned out to be small and not clinically significant (see Table 4). One moderate-quality study found that a total of 20-minute passive massage led to significantly less isokinetic strength in knee extension, but not in knee flexion.[24]

In summary, very limited evidence suggests no better immediate effects of massage using a roller massager or a foam roller on maximal strength compared to plank exercises or no intervention. There is very limited evidence suggesting that self-massage with a roller massager might be more effective than static stretching to improve maximal strength immediately. Limited evidence was also found that 20-minute pre-performance passive massage can lead to less maximal strength of knee extensors in the short term.

Effects of pre-performance massage on vertical jump

Four studies with varied methodological qualities investigated the effects of pre-performance massage on vertical jump or drop jump. One high-quality study found that 15-minute Swedish massage significantly compromised vertical jump height compared to no intervention.[23] In further analysis, 95% confidence intervals of both interventions overlapped, which meant that the difference of effects is not significant (Table 4). One moderate-quality article compared two different 12-minute passive massage techniques (petrissage and tapotement) and rest (no intervention), and found no significant difference between three groups to increase vertical jump height.[21] The other two low-quality papers compared self-massage using a foam roller or the Stick (Intracell Technology, USA) with other interventions, including motor imagery, sham electrical stimulation or plank exercises, and found no statistically significant difference.[3,20]

In summary, there is limited evidence which suggests 15-minute Swedish massage can cause a decrease in vertical jump height. Limited evidence also suggests that 12-minute passive massage is not more effective than no intervention. There was very limited evidence which suggests that self-massage with a foam roller or the Stick are no more effective than motor imagery, sham electrical stimulation or plank exercises.

Effects of pre-performance massage on sprint

In one high-quality study, both 15-minute Swedish massage and static stretching led to significantly compromised sprint performance compared to rest (no intervention).[23] Further analysis implied that 15-minute Swedish massage can have more adverse effects on sprint performance with moderate effect size, compared to static stretching or rest (see Table 4). One low-quality article found no significantly superior effects of 30-minute passive massage compared to no intervention to increase stride length.[26] In one low-quality study nine-minute passive massage significantly undermined sprint performance compared to active warm-up exercises.[25] Another low-quality paper found that self-massage using the Stick did not have superior effects compared to motor imagery and electrical stimulation.[3]

In summary, there is limited evidence which suggests negative immediate effects of passive massage (nine to 15 minutes) on sprint performance. Very limited evidence suggests that 30-minute passive massage or self-massage using the Stick have no effects on sprint performance.

Effects of pre-performance massage on balance and agility

Balance function was assessed by only one study using single-leg balance test.[19] This low-quality article found that self-massage with a roller massager did not improve the results of this test compared to active static stretching. Another low-quality study evaluated participants' agility with the 5-10-5-yard shuttle run and found no statistically significant difference between self-massage with foam roller and plank exercises.[20]

In summary, there is no evidence to suggest positive effects of self-massage using a roller massager or a foam roller to improve balance or agility.

Effects of short-duration passive pre-performance massage

Only one study examined the effects of short-duration passive massage.[22] In summary, very limited evidence suggests that there is no better immediate effects of passive massage using a roller massager on maximal strength.

Effects of short-duration active pre-performance massage

The effects of short-duration active massage were investigated by three studies.[3,19,20] In summary, very limited evidence suggests that 30-minute passive massage or self-massage using the Stick have no effects on sprint performance. There is limited evidence that that self-massage with a roller massager might be more effective than static stretching to improve maximal strength of plantar flexors immediately. Very limited evidence suggests no superior effects of self-massage using a foam roller to improve balance or agility, compared to plank exercises.

Effects of long-duration passive pre-performance massage

In total, five studies investigated the effects of long-duration passive pre-performance massage.[21,23-26] In summary, limited evidence also suggests that 12-minute passive massage is not more effective than no intervention to improve vertical jump. There is limited evidence which suggests negative effects of passive massage (nine to 15 minutes) on sprint performance. Limited evidence suggests that 20-minute passive massage can lead to an acute decline in maximal strength of knee extensors.

DISCUSSION

The aim of this systematic review was to collect, assess and synthesise the findings of RCTs investigating the immediate effects of pre-performance massage on maximal muscle strength and/or functional performance. To the best of the authors' knowledge, this paper is the first systematic review addressing this clinical question. The systematic search found nine crossover RCTs examining the effects of various types of massage techniques with varied dosages. Meta-analysis was not appropriate due to the absence of homogeneity of the included studies. Following the descriptive analysis using within-group effect sizes of interventions used in included studies, no evidence was found to support the positive effects of any kinds of massage interventions to enhance maximal strength, vertical jump, sprint, agility and balance performance of young healthy participants. In fact, there appears to be limited evidence which indicates the negative effects of passive manual massage. In particular, longer-duration (> 9 minutes) of passive massage interventions tended to result in negative effects on lower-limb maximal strength, sprint performance and jump height.[23-25]

Although it is not entirely clear why massage can have negative effects on motor outputs, there are several hypotheses. Massage is thought to decrease stiffness and lengthen muscles.[21] This means that massage can result in increased sarcomere shortening distance, which can decrease force production due to altered force-velocity relationship.[30] Secondly, massage can temporarily increase mechanical threshold, decreasing afferent inputs from cutaneous tissues.[24] This can lead to decreased motor unit activation. Thirdly, nociceptive input during massage is likely to result in reciprocal inhibition in antagonist muscles.[31] This might explain a compromise in a functional performance, which requires coordinated activations of all muscles. In addition to these peripheral mechanisms, a recent evidence suggests the involvement of central modulation. Massage might inhibit corticospinal excitability, leading to less motor outputs.[32] Lastly, massage-induced increased parasympathetic nervous system activity might explain negative effects of massage as noted in the included studies.[33]

Source of bias and limitations of included studies

Six out of nine RCTs had low methodological quality, which compromised the strength of the overall evidence presented in this review. None of the included RCTs blinded therapists or participants. However, blinding might be inherently difficult and impractical due to the nature of massage interventions. Most included papers (78%) failed to blind assessors, which might have caused observer bias.[34] Four studies did not collect baseline data for primary outcome measures, which made it impossible to calculate within-group effect sizes.[3,20,25,26] Failure to ensure the baseline comparability may also have resulted in less statistical precision in their findings. One low-quality study failed to report the sampling method for a control group, which was another source of bias.[22]

Limitations of this review

Several limitations should be recognized in this review. The main limitation in this review lies in the fact that the primary outcome measures were restricted to immediate improvements in strength and functional performance. In fact, all studies focused on maximal strength, sprint or jump performances, but not other functional outcome measures, such as endurance. In reality, however, pre-performance massage might be performed for various reasons, such as preventing injuries and fatigue during sports performance, decreasing subjective stiffness and soreness and enhancing athletes' mood and confidence. Therefore, the overall effects of pre-performance massage for each individual athlete should be considered during the clinical decision-making process. This review was potentially biased due to its search strategy, where only studies published in peer-reviewed journals were included. This strategy can be subject to publication bias.[35] This review failed to perform a subgroup analysis according to the types of massage techniques. Since passive manual massage and active self-massage might be different in nature and have different effects, the absence of a subgroup analysis can be another weakness of this review. Due to the lack of meta-analysis, it might have been difficult to achieve sufficient statistical power to overcome potential false negative results in individual studies. Lastly, no study investigating upper-limb strength or functions, such as throwing in baseball or tennis serves, was identified. It is unclear whether the findings achieved in this review are applicable to upper-limb strength and functions or not.

Implications for Clinical Practice

Based on the findings of this review, the use of pre-performance massage specifically to improve athletes' strength and functional performance should be reconsidered and challenged. The findings of this review indicate that longer duration (>9 minutes) passive manual massage techniques should not be used for the purposes of immediately enhancing young athletes' lower-limb maximal strength, vertical jump or sprint performance. Although there is no evidence which clearly demonstrates positive effects of any types of short-duration pre-performance massage techniques on strength and functional performance, these interventions might be justifiable to achieve other outcomes, such as increasing range of motion, preventing injuries and fatigue, and enhancing athletes' confidence and motivation, based on athletes' specific demands and clinicians' sound clinical reasoning.

Implications for future research

A great variability in the dosage of massage techniques has been identified. Future research needs to investigate potentially time-dependent effects of massage. This systematic review has highlighted prevalent risk of bias in the current research evidence. Since there is a serious lack of good-quality research, all findings in this review were inconclusive. Thus, it is recommended that future research should address the following methodological issues. Firstly, future research need to collect baseline data to allow more statistically accurate analysis. Secondly, blinding for assessors should be ensured to avoid observer bias in outcome measurements. Thirdly, future studies should conceal allocation in order to avoid sampling bias. Furthermore, future studies should describe data using exact values for mean, standard deviation, effect size and 95% confidence interval. To use critical appraisal tools, such as PEDro scale in designing research will lead to higher internal validity and a consistency across future RCTs, which may allow data pooling in future systematic reviews. Lastly, future primary or secondary studies are required to examine various outcome measures, including injury prevention, improvement in range of motion and endurance, and psychological benefits to complement the findings of this review and accurately assess the overall effects of pre-performance massage for athletes.

CONCLUSIONS

This study systematically reviewed RCTs investigating the immediate effects of pre-performance massage on strength and functional performance. Based on the narrative synthesis of the findings from nine crossover RCTs, there is limited evidence to suggest no positive immediate effects of any types of pre-performance massage on maximal muscle strength, sprint, jump, balance and agility performance among asymptomatic young subjects. Limited evidence also indicates the negative effects of longer-duration passive manual massage on lower-limb maximal strength, vertical jump and sprint performance. Future research with less methodological flaws are required to strengthen the evidence identified in this review.

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