Journal of Hand Therapy xxx (2020) 1–7

Contents lists available at ScienceDirect

Journal of Hand Therapy

journal homepage: www.jhandtherapy.org

Investigation of reliability, validity, and cutoff value of the Jebsen-Taylor Hand Function Test

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A R T I C L E I N F O

Article history:
Received 18 May 2019
Received in revised form
19 January 2020
Accepted 19 January 2020
Available online xxx

Keywords:
Adult
Hand injuries
Jebsen-Taylor Hand Function Test
Psychometric
Hand

A B S T R A C T

Study Design: This is a cross-sectional study.
Introduction: The Jebsen-Taylor Hand Function Test (JTHFT) evaluate the efficacy of treatment and assess a broad range of hand functions.
Purpose of the Study: The purpose of this study was to investigate the psychometric properties of the JTHFT and to determine cutoff values.
Methods: The test-retest reliability was assessed by determining intraclass correlation coefficient (ICC), the hypothesis testing validity was assessed by using Spearman rho coefficient, and the receiver operating characteristic curve, area under the curve of the receiver operating characteristic, sensitivity, and specificity were calculated to determine the cutoff values. We administered JTHFT, Disabilities of Arm, Shoulder and Hand Questionnaire (DASH) and assessed grip strength with Jamar dynamometer. We included 162 healthy participants and 143 patients with hand injuries.
Results: The JTHFT subtests and total score have a good to excellent test-retest reliability (except lifting large light object for dominant hand-ICC: 0.77) for both dominant and nondominant hand (ICCs = 0.84-0.97). There was a statistically significant, weak positive correlation between the JTHFT total score and DASH-T ($r = 0.39$, $P < .001$ for the injured hand; $r = 0.35$, $P < .001$ for the uninjured hand) and also statistically significant weak negative correlation between grip strength for injured hand and JTHFT total score for injured hand ($r = -0.33$; $P < .001$). The cutoff value of the total score was found to be 37.08 s for injured hand.
Discussion and Conclusion: JTHFT is a reliable and valid instrument. Clinicians and researchers may use this test with confidence to assess the dexterity of hand injury patients.

Introduction

Hand injuries, which may occur due to traumas, illnesses, or occupational reasons, may cause difficulties in performing activities of daily living, and even may change patient's social roles.[1] After hand injuries, patient-reported outcome measures (PROMs) and performance-based outcome measures (PBOMs) are used to assess the functional level of the hand. PROMs are preferred as they reflect people's perspective of their own health, and because of their ease of use in clinical and scientific studies, being economical and not requiring any standardized equipment. In the current literature, although the validity and reliability of PROMs are high, there are doubts about their clinical reliability because they are subjective evaluations.[2-4]

PBOMs are often defined as tests conducted by experienced practitioners which evaluate activities based on time, number, or distance, and which consist of materials and tasks used in daily life. Hand function tests, which are PBOMs, are used to evaluate manual dexterity of the individual with standardized equipment.[5-7] Hand function tests provide quantitative data about the overall fine and gross hand dexterity relevant to activities of daily living. Contrary to PROMs, PBOMs are objective evaluations that are independent from the person's perception of their performance. These tests guide the therapists during the rehabilitation process. Moreover, they provide assistance for health care professionals in terms of both medical treatment and surgical decision-making, and they allow evaluating the success of all these treatment methods.[8,9]

Conflict of interest: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.
Funding: The author received no financial support for the research, authorship, and/or publication of this article.
Ethical approval details: Hacettepe University Research Ethics Committee reviewed and approved the study procedures.
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0894-1130/$ – see front matter
https://doi.org/10.1016/j.jht.2020.01.004

In the current literature, more than 20 hand function tests are being studied.[2] Rudman and Hannah suggest that various factors should be examined for the selection of the appropriate hand function test. These tests should be affordable, easily applicable, and accessible.[10] Furthermore, the psychometric strength of the instrument should be taken into consideration, as this leads to the improvement of clinical decision-making.[4] Therefore, it is important to correctly define the psychometric properties of the hand function tests.[11] Reliability is defined as the extent to which an evaluation method consistently measures a parameter on the same conditions, where the same results are produced in repeated evaluations. Validity is the ability of an evaluation method to accurately measure the characteristics it wants to measure.[11]

The Jebsen-Taylor Hand Function Test (JTHFT) was developed in 1969 to evaluate the efficacy of treatment and disability in patients with hand injuries. JTHFT consists of tasks to assess a broad range of unimanual hand functions required for activities of daily living.[6] Until now, JTHFT was proposed as a method valid for evaluating hand functions in people with different types of hand disabilities such as rheumatoid arthritis, osteoarthritis, stroke, spinal cord injury, and traumatic brain injury.[12-14] However, Sears reports that JTHFT should not be used as a measure of hand disability, as it cannot demonstrate clinical change after surgical intervention in patients with rheumatoid arthritis, osteoarthritis, carpal tunnel syndrome, and distal radius fracture because of low correlation between JTHFT and Michigan Hand Questionnaire.[15] It is clearly stated in the literature that there lacks a strong correlation between PROMs and PBOMs.[16] We hypothesize that JTHFT may not be as responsive or able to detect meaningful change as a disease-specific questionnaire because PROMs and PBOMs detect different dimensions of physical function.

Therefore, this study aims to evaluate the psychometric properties of JTHFT in patients with hand injuries. For assessing the validity of the questionnaire, McDowell[17] recommends the use of hypothesis testing analysis instead of criterion validity in studies for the reason that there is no evaluation method that can be considered as the "gold standard" especially in terms of PBOMs. Thus, in this study, we examine components of validity by assessing hypothesis testing for construct validity with correlation of performance among measures and reliability by correlation of performance over time. Furthermore, we aim to evaluate whether JTHFT can aid in the distinguishing persons with impaired hand function from persons with unimpaired hand function and find the appropriate cutoff value. Accordingly, receiver operating characteristic (ROC) curves, area under the curve (AUC) of the ROC, sensitivity, and specificity are calculated to determine JTHFT scores that allow differentiating between hand injury patients and control subjects the best.

Methods

Participants

This study was conducted at Hacettepe University Occupational Therapy Department. Healthy individuals and patients with hand injuries were included in the study. The group of healthy individuals was chosen from patients' family members, as well as the staff and students of Hacettepe University, who were considered eligible if they were aged between 18 and 65 years and were not suffering from neurological, orthopedic, or systemic diseases that would affect their hand function. On the other hand, the patients with hand injuries who were included in the study were between the ages of 18 and 65 years, and had had a hand injury for 6-12 months. Patients who had neurological disorders, systemic diseases, or any other comorbidities limiting their ability to manipulate objects were excluded from the study.

Hacettepe University Research Ethics Committee reviewed and approved the study procedures. Before conducting the study, all participants filled out the informed consent form.

Study design and outcome measures

This is an observational cross sectional study using a cross-sectional study. It was completed through 3 steps: 1) evaluating the reliability by using test-retest method of the JTHFT in healthy individuals, 2) measuring validity by using hypothesis testing method, and 3) determining cutoff values according to ROC.

The assessments (JTHFT, DASH-T, and grip strength evaluation) were completed approximately in 30 min and were carried out under the same condition for all participants without causing fatigue or pain for participants.

Outcome measures

Participants (both of healthy individuals and patients with hand injuries) completed the subtests of JTHFT, which are simulated page turning, lifting small objects, simulated feeding, stacking checkers, lifting large light objects, lifting large heavy objects of with both dominant and nondominant hands except writing a sentence which is performed only by the dominant hand.[18] All assessments were administered by an occupational therapist who had clinical and research experience on JTHFT. For each subtest, participants were given one practice trial for purposes of familiarization. Each subtest was performed by the dominant hand followed by the nondominant one. Participants rested after the completion of each subtest. The completion time of the tasks were recorded in seconds reported in two decimals on the score sheet. A total score for the dominant and nondominant hand was calculated from the sum of the individual scores for each subtest with the exception of the writing sentence subtest. It took about 15 to 20 min to complete seven subtests.

Disability of Arm, Shoulder and Hand Questionnaire (DASH)

Disability of Arm, Shoulder and Hand Questionnaire (DASH) developed by the "American Academy of Orthopaedic Surgeons" and "Institute for Work and Health" is a region-specific PROM of disability and symptoms in people with musculoskeletal disorders of the upper limb. It has 3 parts: DASH Function/Symptoms module, DASH Work module and DASH Sports/Music module. It consists of 5 response options (1-no difficulty, 2-mild difficulty, 3-moderate difficulty, 4-severe difficulty, and 5-unable).[19,20] The total score of DASH is between 0 indicating no disability and 100 indicating maximum disability.[20]

We used the Turkish version of Disabilities of Arm, Shoulder and Hand (DASH-T) in our study. DASH-T is a reliable and valid questionnaire for measuring all upper limb disorder (carpal tunnel syndrome, nerve injury, tendon injury, fracture etc.) in the Turkish population. It has strong clinimetric evidence for test-retest reliability (intraclass correlation coefficient [ICC]: 0.77-0.91) and validity (construct, convergent, and discriminant).[21]

Grip strength evaluation

Grip strength was evaluated by Jamar dynamometer during which the participants sat on a chair with shoulders and wrist in neutral position and the elbow in 90° flexion. According to the recommendations of the American Hand Therapist Association, grip strength was measured 3 times on second handle position. The participants were asked to grip the dynamometer as strong as

Table 1
Demographic data of healthy individuals and patients with hand injury

Variable	Healthy individuals ($n = 162$)	Patients ($n = 143$)	P
	X (SD)	X (SD)	
Age, yr	38.4 (10)	40.4 (12.9)	.144
	n(%)	n(%)	
Gender			
Male	64 (40)	64 (45)	.354
Female	98 (60)	79 (55)	
Dominant hand			
Left	16 (10)	7 (5)	
Right	146 (90)	136 (95)	
Injured hand			
Dominant		80 (56)	
Nondominant		63 (44)	
Type of injuries			
Fracture		53 (37)	
Nerve injuries		35 (25)	
Tendon injuries		29 (20)	
Ligament injuries		11 (8)	
Multiple trauma		10 (7)	
Other		5 (3)	

X = Mean; SD = Standard deviation.

possible, and then to relax. The average score was calculated in kilograms for each hand.[22,23]

Data analysis

Shapiro–Wilk Statistic Test was used to establish the normality of the data, and statistically significant level was determined as $P < .05$. Categorical variables were demonstrated as number (n) and percentage (%), while continuous variables were demonstrated as mean and standard deviation. In the comparison analyses of healthy participants with patients, the nondominant hand scores of healthy participants were matched with the injured hand scores of the patients.

To investigate the test-retest reliability of JTHFT, healthy participants were reassessed by the same therapist on the same conditions with an interval of 7-14 days. It was assumed that the participants did not remember the subtests in the reassessment session. Two separate score sheets were used during the test and retest sessions.[24]

Following Kottner et al.,[25] for reliability reporting, we assessed test-retest reliability in 3 steps: 1) using the ICC by comparing the baseline JTHFT scores with the repeated one, 2) using standard error of measurement (SEM) to determine the stability between test and retest, and 3) using minimal detectable change (MDC) to estimate the smallest amount of detectable change. Based on the 95% confident interval, the ICC value of <0.5 indicates poor reliability; 0.5 to 0.75 indicates moderate reliability; 0.75 to 0.9 indicates good reliability, and >0.90 indicates excellent reliability.[26]

We measured the validity of JTHFT by using hypothesis testing. Our first hypothesis was that there is a weak, positive correlation between JTHFT and DASH-T scores. Our second hypothesis was that there is a weak, negative correlation between JTHFT score and grip strength. We evaluated hypothesis testing for construct validity of JTHFT by using correlation coefficient of Spearman rho. The value of correlation coefficient (r) is $+1$ and -1. Spearman rho coefficient values were interpreted as <0.5: weak; 0.5 to 0.79: moderate; 0.8 to 1.00: strong.[27]

Sensitivity, specificity, and AUC of the ROC were calculated. The cutoff values were determined by using ROC curve and were generated with sensitivity and 1-specificity. Moreover, optimal cutoff point was chosen as the closest point to the high left corner of the ROC curve. If the ROC curve reaches with 45° from (0,0) to (1,1), this means that the test has poor ability to distinguish patients from healthy participants.[28] The grades of ROC curve are accepted as follows: 0.90 to 1: excellent, 0.80 to 0.90: good, 0.70 to 0.80: fair, 0.60 to 0.70: poor, 0.50 to 0.60: fail.[29]

Results

In our study, there were 162 healthy individuals (98 female, 64 male) with a mean age of 38.4 (SD 10.0) years, and 143 patients with hand injuries (79 female, 64 male) with mean age of 40.4 (SD 12.9) years. The diagnoses of the patients were fracture ($n = 53$), nerve injuries ($n = 35$), tendon injuries ($n = 29$), ligament injuries ($n = 11$), multiple trauma ($n = 10$), and other injuries ($n = 5$). The healthy participants and patients who participated in the study were similar in terms of age and gender ($P > .05$).The demographic data of the participants are shown in Table 1. The JTHFT scores of healthy individuals and patients are shown in Table 2. This study demonstrates significantly higher timed scores both for dominant and nondominant hand for all JTHFT subtests in hand injured patients compared with healthy participants.

The test-retest reliability of JTHFT was assessed by calculating the ICC value between test and retest trail in healthy individuals. For all of the JTHFT subtests, the ICC value was above 0.8, which indicates good to excellent reliability, with the exception of lifting large light object (ICC:0.77) for the dominant hand. The ICC values, 95% of confidence interval and standard error of the means of test-retest reliability are displayed in Table 3.

There was a statistically significant, weak positive correlation between the JTHFT total score and DASH-T score ($r = 0.39$, %95 CI 0.24-0.52, $P < .001$ for the injured hand; $r = 0.35$, %95 CI 0.20-0.49, $P < .001$ for the uninjured hand). Between lifting large light object subtests of JTHFT in injured hand and DASH-T score, correlation was statistically significant, moderate positive ($r = 0.51$; %95 CI 0.38-0.62; $P < .001$). Similarly, correlation between lifting large heavy object subtests of JTHFT in injured hand and DASH-T score was also moderate positive, statistically significant ($r = 0.55$; %95 CI 0.42-

Table 2
Comparison of mean and standard deviation on JTHFT subtest and total score between healthy individuals and patient with hand injury

JTHFT subtests	Healthy individuals X (SD) ND/D	Patient with hand injury X (SD) I/NI	P (ND-I/D-NI)
Stacking checkers (s)	2.5(0.75)/2.37(0.77)	4.37(1.89)/3.71(1.47)	<.001[a]/<.001[a]
Simulated page turning(s)	4.7(1.19)/4.58(1.3)	8.88(5.37)/7.04(4.0)	<.001[a]/<.001[a]
Lifting small objects (s)	5.31(1.36)/4.97(1.12)	8.8(4.23)/7.18(2.49)	<.001[a]/<.001[a]
Simulated feeding (s)	11.64(4.83)/8.44(2.07)	12.54(5.93)/11.51(5.02)	0.12/<.001[a]
Writing sentences (s)	-/9.19 (1.96)	17.55(7.81)/13.99(7.43)	-/<.001[a]
Lifting large light objects (s)	3.59(0.78)/3.59(0.78)	5.56(1.15)/4.62(0.92)	<.001[a]/<.001[a]
Lifting large heavy objects (s)	3.74(0.8)/3.75(0.76)	6.06(1.28)/5.0(0.89)	<.001[a]/<.001[a]

JTHFT = Jebsen-Taylor Hand Function Test; X = mean; SD = standard deviation; ND = nondominant hand score; D = dominant hand score; I = injured hand score; NI = noninjured hand score.
[a] $P < .05$.

Table 3
Test-retest reliability of JTHFT subtest and total score in healthy individuals

JTHFT subtests	Dominant hand					Non-dominant hand				
	Test X (SD)	Retest X (SD)	ICC (95% CI)	SEM	MDC_{95}	Test X (SD)	Retest X (SD)	ICC (95% CI)	SEM	MDC_{95}
Stacking checkers (s)	2.37 (0.77)	2.16 (0.65)	0.93 (0.91-0.95)	0.36	1.00	2.50 (0.75)	2.32 (0.62)	0.88 (0.84-0.91)	0.44	1.22
Simulated page turning (s)	4.58 (1.30)	4.17 (1.17)	0.90 (0.87-0.93)	0.73	2.02	4.70 (1.19)	4.48 (1.24)	0.91 (0.88-0.94)	0.68	1.89
Lifting small objects (s)	4.97 (1.12)	4.62 (1.07)	0.93 (0.90-0.95)	0.56	1.54	5.31 (1.36)	5.07 (1.20)	0.88 (0.84-0.91)	0.82	2.28
Simulated feeding (s)	8.44 (2.07)	7.61 (1.71)	0.84 (0.79-0.88)	1.38	3.83	11.64 (4.83)	9.68 (3.02)	0.79 (0.72-0.85)	3.30	9.14
Writing sentences (s)	9.19 (1.96)	8.79 (2.05)	0.96 (0.94-0.97)	0.77	2.13	-	-	-	-	-
Lifting large light objects(s)	3.57 (0.84)	3.29 (1.04)	0.77 (0.69-0.83)	0.81	2.25	3.59 (0.78)	3.37 (0.74)	0.97 (0.96-0.98)	0.25	0.70
Lifting large heavy objects (s)	3.75 (0.76)	3.50 (0.75)	0.95 (0.94-0.97)	0.31	0.87	3.74 (0.80)	3.59 (0.77)	0.97 (0.96-0.98)	0.26	0.73
Total score (s)	36.90 (5.69)	34.17 (5.29)	0.95 (0.94-0.97)	2.28	6.32	31.51 (6.58)	28.54 (5.14)	0.89 (0.86-0.92)	3.65	10.12

JTHFT = Jebsen-Taylor Hand Function Test; ICC = intraclass correlation coefficient; SEM = standard error of measurement; MDC = minimal detectable change; X = mean; SD = standard deviation.
$SEM = SD \times \sqrt{(1-ICC)}$; $MDC_{95} = 1.96 \times (SEM \times \sqrt{2})$.

0.65; $P < .001$). In addition, there was also a statistically significant, weak negative correlation between the JTHFT total score for the injured hand and the grip strength of the injured hand ($r = -0.33$; provide %95 CI −0.47 to −0.17; $P < .001$) (Table 4).

Ability to distinguish between healthy participants' and patients' hand function was good, except for the simulated feeding and writing subtests. The AUC values' range of subtests was 0.52 to 0.92 (Figure 1). The cutoff value of JTHFT total score was 37.08 s for the injured hand (Table 5).

Discussion

In this study, the psychometric properties of JTHFT were evaluated. JTHFT is a reliable and valid hand function test. Accordingly, we concluded that JTHFT can aid in the distinguishing persons with impaired hand function from persons with unimpaired hand function. For the cutoff value for the injured hand, the JTHFT total score was determined as 37.08 s.

Table 4
Spearman correlation coefficients between JTHFT subtest and total score and grip strength for patient with hand injury; Spearman correlation coefficients between JTHFT subtest and total score and DASH-T for patient with hand injury

JTHFT subtests	Grip strength of injured hand		Grip strength uninjured hand		DASH-T	
	r	P	r	P	r	P
Stacking checkers (I)	−0.39	<.001[a]	−0.15	0.06	0.47	<.001[a]
Stacking checkers (NI)	−0.24	0.003[a]	−0.17	0.03[a]	0.31	<.001[a]
Simulated page turning (I)	−0.28	<.001[a]	−0.05	0.54	0.28	<.001[a]
Simulated page turning (NI)	−0.18	0.03[a]	−0.09	0.25	0.15	0.06
Lifting small objects (I)	−0.39	<.001[a]	0.42	0.62	0.38	<.001[a]
Lifting small objects (NI)	−0.20	0.01[a]	−0.01	0.83	0.3	<.001[a]
Simulated feeding (I)	−0.22	0.008[a]	−0.003	0.96	0.34	<.001[a]
Simulated feeding (NI)	−0.15	0.06	0.02	0.76	0.24	0.003[a]
Writing sentences (I)	−0.10	0.23	−0.06	0.46	0.06	0.44
Writing sentences (NI)	0.01	0.89	0.08	0.28	0.01	0.85
Lifting large light objects (I)	−0.35	<.001[a]	0.13	0.10	0.51	<.001[a]
Lifting large light objects (NI)	−0.19	0.02[a]	−0.19	0.01[a]	0.3	<.001[a]
Lifting large heavy objects (I)	−0.35	<.001[a]	−0.08	0.30	0.55	<.001[a]
Lifting large heavy objects (NI)	−0.23	0.004[a]	−0.10	0.19	0.33	<.001[a]
Total score (I)	−0.33	<.001[a]	−0.03	0.72	0.39	<.001[a]
Total score (NI)	−0.21	0.009[a]	−0.03	0.67	0.35	<.001[a]

JTHFT = Jebsen-Taylor Hand Function Test; I = Injured hand score; NI = noninjured hand score.
[a] $P < .05$.

The ICC values in our study ranged from good to excellent in all subtest of the JTHFT in both the dominant and nondominant hands, in support with studies by Reedman et al performed in typically developing children aged between 6 and 10 years, the test-retest reliability of JTTHF for the dominant hand (ICC: 0.74) and nondominant hand (ICC: 0.72) has good reliability[18] and in another study carried out with older patients with Parkinson disease, it was found that test-retest reliability for both dominant and nondominant hands ranged between good and excellent.[30] The test-retest reliability of JTHFT has also been assessed for patients with hemiplegia and traumatic brain injury (ICC = 0.60-0.99), and rheumatoid arthritis (ICC = 0.68-0.98).[6,31] The test-retest reliability of the Chinese version of JTHFT was determined as good to excellent in healthy subjects (ICC ¼ 0.88 and 0.99 for the dominant and nondominant hand, respectively).[32] In our study, the JTHFT was observed as good to excellent ICC values with the exception of lifting large light object (ICC:0.77) for the dominant hand, which reflects that the test is stable over time. In his study, Mak et al find that the test-retest reliability of large light objects on dominant hand is relatively low (ICC ¼ 0.64).[30]

In the light of the aforementioned analysis, we supported our first hypothesis that there is a weak positive correlation between JTHFT total score for injured and uninjured hand and DASH-T total scores. But we found moderate positive correlation between lifting large light objects for injured hand ($r = 0.51$; $P < .001$) and lifting large heavy objects for injured hand ($r = 0.55$; $P < .001$) of subtest JTHFT and DASH-T score. Lifting large light/heavy objects subtest of JTHFT carry out with using the whole upper limb which is mostly questioned by DASH-T items, so that there is a moderate positive correlation between these subtests and DASH-T score. Our result corresponds with the findings in the literature that there is a weak relationship between JTHFT and PROMs.[33-36]

Similarly, we supported our second hypothesis that there is a weak negative correlation between the JTHFT score and grip strength of the patients. While O'neil et al.[37] demonstrate a weak correlation between O'neil Hand Function Assessment and grip strength, and Weng et al.[38] report a moderate correlation between the Sollerman Hand Function Test and grip strength, currently, there is no study in the literature that investigates the relationship between the grip strength and JTHFT.

In the literature, many studies indicate that the correlation between PBOMs and PROMs is not good.[15,16] In their study, Sears and Chung emphasize that there is a poor correlation between the changes in JTHFT and absolute JTHFT scores after surgery compared with the changes in Michigan Hand Outcome Questionnaire and absolute Michigan Hand Outcome Questionnaire scores.[15] There are considerable differences between PROMs and PBOMs of outcome measures. Hand function tests are objective tools that are

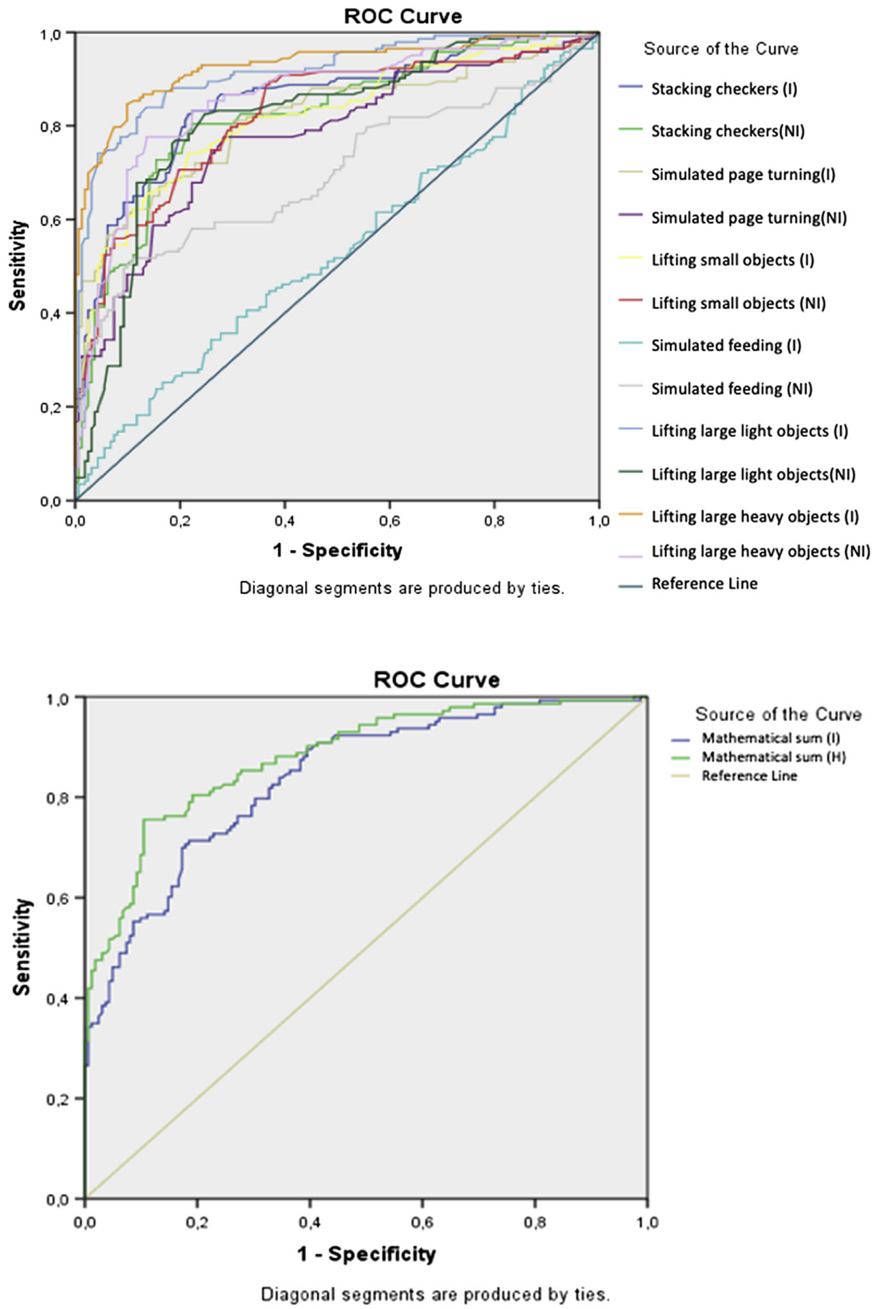

Figure 1. Receiver operating characteristic (ROC) curve for JTHFT subtests and total. JTHFT = Jebsen-Taylor Hand Function Test.

independent from the patient's and therapist's points of view. They evaluate various hand activities using different grip patterns. PROMs are subjective tests and assess how the patient perceives the performance of his/her hand. These two measures distinguish different constructs. The weak correlation between hand function tests and PROMs does not mean that these methods are not valid methods, but that they cannot be used interchangeably.[39,40] These two types of outcome measures should complement each other when measuring someone's activity and participation levels. Self-report measures ought be supported with objective performance tests to achieve optimal assessment results.[7,41]

Jebsen in 1969 defined the norm scores of JTHFT for both men and women aged between 20 and 59, and 60 and 94.[6] However, because these norms have not been updated since then, there have been doubts about their clinical use. To be able to interpret the results of hand function tests, in clinic, we mainly compare the results of the injured hand with the uninjured one, or the difference between the initial and last test scores. The lack of relationship between hand function tests and PROM and grip strength also makes it difficult to find a reference value when evaluating hand functions. For these reasons, in this study, we aimed to determine the optimal cutoff value and AUC of JTHFT. The optimal cutoff was chosen as the point that jointly maximized sensitivity and specificity. We utilized two independent groups (healthy and hand injured individuals) to reach the JTHFT cutoff points that differentiate between the two groups. The greater the AUC is, the greater the measure's ability to distinguish patients from healthy participants.[42,43] The AUC values of the JTHF subtests were high (except

Table 5
Cutoff values, sensitivity, specificity, and AUC of ROC for JTHFT subtests and total score

JTHFT subtests	Cutoff values	Sensitivity	Specificity	AUC	*P*	95% CI
Stacking checkers (I)	2.87	0.83	0.77	0.85	<.001[a]	0.81-0.89
Stacking checkers (NI)	2.59	0.80	0.77	0.82	<.001[a]	0.77-0.87
Simulated page turning (I)	6.22	0.62	0.88	0.81	<.001[a]	0.76-0.86
Simulated page turning (NI)	4.77	0.77	0.71	0.77	<.001[a]	0.72-0.83
Lifting small objects (I)	5.99	0.74	0.78	0.82	<.001[a]	0.77-0.86
Lifting small objects (NI)	4.96	0.89	0.63	0.82	<.001[a]	0.77-0.87
Simulated feeding (I)	12.89	0.39	0.69	0.53	.38	0.46-0.59
Simulated feeding (NI)	10.58	0.51	0.88	0.69	<.001[a]	0.63-0.76
Lifting large light objects (I)	4.38	0.83	0.86	0.91	<.001[a]	0.88-0.94
Lifting large light objects (NI)	4.09	0.76	0.80	0.81	<.001[a]	0.76-0.86
Lifting large heavy objects (I)	4.90	0.84	0.90	0.93	<.001[a]	0.89-0.95
Lifting large heavy objects (NI)	4.68	0.77	0.86	0.86	<.001[a]	0.81-0.90
Total score (I)	37.08	0.713	0.815	0.83	<.001[a]	0.79-0.88
Total score (NI)	33.10	0.755	0.895	0.88	<.001[a]	0.84-0.91

AUC = area under the curve; JTHFT = Jebsen-Taylor Hand Function Test; I = Injured hand score; NI = noninjured hand score; ROC, receiver operating characteristic.
[a] $P < .05$.

for the simulated feeding), and the ability to diagnose the cutoff values was found to be strong. JTHFT consist of subtests which evaluate unilateral activities. On the other hand, in daily living, feeding is a bilateral activity. Hence, the poor AUC value of simulated feeding may be related to this reason. Our ROC cutoff values were slightly superior to our MDC_{95}. This indicated ROC cutoff values free from measurement error. The cutoff values of the JTHFT total score (simulated page turning, lifting small objects, simulated feeding, stacking checkers, lifting large light objects, lifting large heavy objects, except for writing sentence) were 37.08 s and 33.10 s for the injured and uninjured hands, respectively. Longer than 37.08 s of JTHFT total score for injured hand indicates hand dysfunction. Accordingly, therapists may use the cutoff values of each subtest separately, or the JTHFT total score cutoff value.

The highest AUC value was observed in lifting large heavy objects and lifting large light objects for the injured hand with an AUC value of 0.93 and 0.91, respectively. The AUC value of simulated feeding was graded as fail value (AUC: 0.53). Therefore, the cutoff value of this subtest does not indicate a difference in hand function between healthy individuals and patients with hand injuries. Moreover, simulated feeding SEM is high whereas the ICC value is low. This result indicates that the reliability of simulated feeding is moderate.

Limitations

It is evident that there are limitations to our research. As the population of the study was not large enough to analyze the effects of sex or age in a widespread manner, there is still the need for broad-based studies. Furthermore, a major limitation of our study was that we did not calculate the minimal clinically important difference—also known as the minimal important change—which focuses on within-person change over time. Hence, further studies are needed to determine the minimal clinically important difference of JTHFT.

Conclusion

The responsibility of the clinician is to select the evidence-based instrument(s) that best address (es) the patient's condition and the impact of treatment. The ability of an outcome measure to improve decision-making in clinic, relies on the psychometric strength of that instrument. Our study provides evidence for strong test-retest reliability and validity of JTHFT in assessing hand function. The present results provide a cutoff point for JTHFT which may help to improve patient care. To understand typical hand function or to determine the success of hand therapy program, cutoff values will be very useful for clinical assessments of patients' hand functions. Based on our results, we conclude that JTHFT is a reliable and valid outcome measure to assess broad aspects of common hand functions of daily use.

Acknowledgments

The authors would like to thank to all participants in this study. Also, thanks to Sevilay KARAHAN, PhD, for statistical advice provided and also thanks to M. Pinar GOZEN ERCAN PhD for revision of the language.

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