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Internal consistency and validity of the Jebsen–Taylor hand function test in an Italian population with hemiparesis

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Abstract.
PURPOSE: The aim of this study was to evaluate the internal consistency and validity of the Italian version of the Jebsen–Taylor Hand Function Test (JTHFT-IT) in Italian post-stroke adults with chronic hemiplegia or hemiparesis.
METHODS: The test's internal consistency and validity were assessed by following international guidelines. Its internal consistency was examined using Cronbach's alpha (α) coefficient. Pearson's correlation coefficient was calculated for concurrent validity in comparison with a dynamometer instrument, whereas for construct validity, it was calculated in comparison with the mean execution time of the Wolf Motor Function Test time subscale (WMFT-IT-TIME).
RESULTS: The test was administrated to 48 people with chronic stroke. Cronbach's alpha reported a value of 0.96 for the dominant hand and 0.92 for the non-dominant hand. To define the validity of the scale, Pearson's correlation as measured using the WMFT-IT-TIME, and the dynamometer showed statistically significant results.
CONCLUSIONS: The present study supports the use of the JTHFT-IT as a measure of hand functionality in post-stroke adults with chronic hemiplegia or hemiparesis. It is an important tool for Italian professionals, and it can be useful both in clinical practice to evaluate improvement after rehabilitation treatments and for research in hand rehabilitation.

Keywords: Italian, outcome measure, stroke, upper limb, validation

1. Introduction

Stroke is a major cause of long-term disability worldwide (Langhorne, Bernhardt, & Kwakkel, 2011). Motor impairments of the upper extremities are common and affect approximately 50–70% of stroke survivors (Persson, Parziali, Danielsson, & Sunnerhagen, 2012). Many activities involve the use of different types of grasp and require good bimanual and hand–eye coordination, and adequate force. An individual's ability to perform everyday tasks, as well as his/her social participation and quality of life, can be significantly compromised by

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upper extremity dysfunction (Dobkin, 2004; Nichols-Larsen, Clark, Zeringue, Greenspan, & Blanton, 2005), making it necessary to develop adequate rehabilitation training for those affected. To facilitate treatment planning and the evaluation of progress in a clinical, research, or community setting, stroke survivors require thorough assessment. Moreover, evaluation of the effectiveness of rehabilitation interventions after stroke has been highly prioritized and encouraged in stroke treatment guidelines and policies (Frank, 2017; Intercollegiate Stroke Working Party, 2016). Outcome measures assessing arm and hand functions have been shown to be the second largest category of outcome measures used in randomized clinical trials, after measures of activities of daily living (Galeoto, Iori, et al., 2019; Hoffmann et al., 2008). The availability of national guidelines recommending the use of valid and reliable assessment tools and the more uniform reporting of outcome measures in stroke studies would allow comparisons across studies and enable the pooling of data from different studies for evidence synthesis.

However, both research and clinical guidelines lack consensus of a primary outcome measure (Ali, English, Bernhardt, Sunnerhagen, & Brady, 2013; Woytowicz et al., 2017). The Jebsen–Taylor Hand Function Test (JTHFT) is one of the most widely used non-diagnosis-specific assessment tools in rehabilitation due to its simplicity, convenience, and speed of administration (Resnik, Borgia, Silver, & Cancio, 2017). The JTHFT (Jebsen, Taylor, Trieschmann, Trotter, & Howard, 1969) provides objective measurements of standardized tasks relative to norms; it evaluates broad aspects of those hand functions commonly used in everyday activities, and it can be administered in a short time using readily available materials. From the perspective of the International Classification of Functioning (ICF) categories, it is classified as an activity scale, as it measures changes in functional activities (Santisteban et al., 2016). The JTHFT is very versatile for the assessment of upper limb function and is widely used in many countries around the world (Culicchia et al., 2016; Ferreiro, Santos, & Conforto, 2010; Li-Tsang, Chan, Chan, & Soo, 2004; MAAS, 1982). The JTHFT has also been validated for use in different disorders affecting the upper limbs, including muscular dystrophies (Artilheiro et al., 2018), stroke (Allgöwer & Hermsdörfer, 2017; Ferreiro et al., 2010), Parkinson's disease (Mak, Lau, Tam, Woo, & Yuen, 2015), carpal tunnel syndrome (Davis Sears & Chung, 2010), and rheumatoid arthritis (Savona et al., 2019).

The aim of the current study was to evaluate the internal consistency, concurrent and construct validity of the Italian version of the JTHFT (JTHFT-IT) in Italian post-stroke adults with chronic hemiplegia or hemiparesis.

2. Methods

This study was conducted by a research group composed of medical doctors and rehabilitation professionals from the Sapienza University of Rome and from the Rehabilitation & Outcome Measure Assessment (R.O.M.A.) association (Berardi et al., 2018; Castiglia et al., 2017; Covotta et al., 2018; Dattoli et al., 2018; Galeoto et al., 2019; Massai et al., 2018; Ruggieri et al., 2018; Savona et al., 2018; Tofani et al., 2019).

2.1. Participants

The sample was recruited from September and November 2018 in the Department of Neurology of the Polyclinic Umberto I of Rome and the Rehabilitation Clinic of the Nomentana Hospital of Rome. To be included in the study, participants had to be post-stroke adults with chronic hemiplegia or hemiparesis (at least one year since the acute event); have the ability to understand instructions and perform the scale activities; and have extension of the wrist, movement of the thumb, and at least two phalanges $\geq 10^{\circ}$. Individuals with emotional or psychiatric impairments, as determined by clinical screening, were excluded because of being unable to perform the activities of the JTHFT. All participants were informed about the study, and their interest in taking part was recorded; those who subsequently entered the study gave their written consent before inclusion (Galeoto, De Santis, Marcolini, Cinelli, & Cecchi, 2016; Galeoto, Mollica, Astorino, & Cecchi, 2015).

2.2. Validation procedures

The JTHFT-IT was administered to the study population by two trained raters (an occupational therapists and a physiotherapists) who had previously screened all eligible individuals for their recruitment and applied the inclusion/exclusion criteria. The recruited participants who met the study inclusion criteria were scheduled to undergo one testing session. The testing session included the JTHFT-IT administration, the dynamometer measurement, and the Wolf

Motor Function Test (WMFT) for all participants included.

2.3. Instruments

The JTHFT consists of seven unilateral items that are administered using standardized procedures and verbal instructions and are performed first with the non-dominant hand and then with the dominant hand. The functional tasks include writing a 24-letter, third-grade reading difficulty sentence; turning 3"×5" (7.62 cm×12.7 cm) cards in simulated page-turning; picking up small common objects including pennies, paper clips, and bottle caps and placing them in a container; stacking checkers; simulated feeding; and moving light cans and heavier (1 pound) cans. The subtests are scored by recording the number of seconds required to complete each task. Increased time to complete the test is related to decreased hand function. A stopwatch was used to time the completion of each task. Normative data from the original scoring system is available for both dominant and non-dominant hands (Culicchia et al., 2016).

Consistent with previous studies, the instrument used in this study to assess grip strength was the Jamar J00105 (Hamilton, McDonald, & Chenier, 2013), a dynamometer model that calculates the strength of the flexor muscles of the hand. When grip is measured, the arm should be at the patient's side, with the elbow flexed at approximately 90 degrees and the forearm neutral. The wrist should be neutral, but there should be no more than 30 degrees of extension or 15 degrees of ulnar deviation. When ready, the patient is encouraged to squeeze the dynamometer with maximum isometric effort, which is maintained for about 5 seconds. This instrument is scored using force production in kilograms (0–90) or pounds (0–200).

The culturally adapted Italian version of the Wolf Motor Function Test time subscale (WMFT-IT) was also administered to the population. The current version of the scale includes 17 items: two explore the subject's strength (strength-based tasks) and the other 15 explore functional ability (function-based tasks). The mean execution time (WMFT-TIME), in seconds, is calculated as the sum of the execution times of the single tasks (each has an upper limit of 120 seconds) divided by the number of tasks. The total score is also referred to as the "functional ability" subscale (WMFT-FAS) score, but this subscale was not considered in this study.

2.4. Data analyses

The reliability and validity of the JTHFT-IT were assessed by following the Consensus-Based Standards for the Selection of Health Status Measurement Instruments (COSMIN) checklist (Mokkink et al., 2010). The internal consistency was examined using Cronbach's alpha (α) to assess the interrelatedness of the items and the homogeneity of the scale; the α coefficient must be at least 0.70 to indicate the satisfactory homogeneity of all the items within a scale. Cronbach's α was calculated separately for the affected and non-affected hand in order to record any difference.

The concurrent validity of the JTHFT-IT was studied by calculating Pearson's correlation coefficient between the JTHFT-IT and the dynamometer instrument (Cincura et al., 2009). Concurrent validity measures the test against a gold-standard test, and high correlation indicates that the test has strong validity, showing whether a test reflects a certain set of abilities—in this case, time in performing JTHFT-IT tasks and strength. The construct validity of the JTHFT-IT was studied by calculating Pearson's correlation coefficient between the JTHFT-IT and the WMFT-IT-TIME (Berardi, Dhrami, et al., 2018). Construct validity defines how well a test measures up to its claims; it tests whether the constructs that are expected to be related are, in fact, related. The following ranges were considered in interpreting the results: $\rho > 0.70 =$ strong correlation, $0.50 < \rho < 0.70 =$ moderate correlation, and $\rho < 0.50 =$ weak correlation. The significance level was set as a p-value less than or equal to 0.05.

All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 20.0 for Windows. The descriptions of the variables were carried out using frequency tables, means, and standard deviations (SDs).

3. Results

All the recruited participants who met the inclusion criteria and agreed to participate were enrolled in the study. Table 1 summarizes the demographic characteristics of the 48 participants.

3.1. Reliability and validity

It was found that the JTHFT-IT is a reliable tool to assess hand performance in people with hemiparesis

or hemiplegia after a stroke. The internal consistency of the JTHFT-IT showed values of Cronbach's α of 0.96 for the dominant hand and 0.92 for the non-dominant hand. The analysis of internal consistency was also considered in relation to the limb affected by hemiplegia or hemiparesis. Table 2 reports the results for the dominant hand in the total population, in participants for whom the dominant hand was affected (plegic or paretic) and in participants for whom the non-dominant hand was affected. Table 3 reports the results for the non-dominant hand in the total population, in participants for whom the dominant hand was affected and in participants for whom the non-dominant hand was affected. In general, it is clear that the affected hand requires a longer time for the execution of the tasks. The JTHFT-IT was found to

Table 1
Demographic characteristics of the 48 post-stroke participants in the JTHFT-IT reliability study

Characteristics	Sample $n = 48$
Age, mean ± SD	69.88 ± 13.36
Gender men, number (%)	14 (58)
Subjects with dominant right hand, number	16 (67)
Subjects with affected right hand, number	10 (42)
Subjects with affected dominant hand	6 (25)

Table 2
Mean score, standard deviation (SD) and Cronbach's alpha values for dominant hand

DOMINANT HAND SCORES	All participants (48)	Participants with dominant hand affected (12)	Participants dominant hand not affect (36)
ITEM 1 Mean score ± SD	52.7 ± 41.4	110 ± 23.4	33.6 ± 25.5
ITEM 2 Mean score ± SD	20.2 ± 31.5	54 ± 52.7	9 ± 4.1
ITEM 3 Mean score ± SD	35.3 ± 44.4	105 ± 36.7	12.1 ± 6.4
ITEM 4 Mean score ± SD	37 ± 44.1	109.6 ± 25.4	12.8 ± 4.4
ITEM 5 Mean score ± SD	30.5 ± 41.7	86.7 ± 52.5	11.7 ± 9.8
ITEM 6 Mean score ± SD	24.1 ± 36.9	68.5 ± 56.6	9.3 ± 3.2
ITEM 7 Mean score ± SD	26.7 ± 36.2	71.4 ± 53.6	11.8 ± 5.3
Cronbach's alpha	0.96	0.89	0.79*

*if item 1 deleted.

Table 3
Mean score, standard deviation (SD) and Cronbach's alpha values for non-dominant hand

NON-DOMINANT HAND SCORES	All participants (48)	Participants with dominant hand affected (12)	Participants with dominant hand not affect (36)
ITEM 1 Mean score ± SD	92.6 ± 32	73.7 ± 37.8	98.9 ± 28.8
ITEM 2 Mean score ± SD	44.5 ± 49.7	9.15 ± 3.9	56.2 ± 53.1
ITEM 3 Mean score ± SD	54 ± 48	10.9 ± 5.5	68.4 ± 47.9
ITEM 4 Mean score ± SD	55 ± 47	20.2 ± 13.5	66.7 ± 49.27
ITEM 5 Mean score ± SD	55.4 ± 51.8	14.8 ± 8.9	68.9 ± 53.9
ITEM 6 Mean score ± SD	35.7 ± 44.4	7 ± 2.5	45.2 ± 47.6
ITEM 7 Mean score ± SD	43.5 ± 47.8	7.9 ± 3.3	55.3 ± 49.8
Cronbach's alpha	0.93	0.73*	0.91

*if item 1 deleted.

be a valid tool to assess hand performance in people with hemiparesis or hemiplegia after a stroke. Pearson's coefficient showed statistically significant values both for concurrent validity (dynamometer) and construct validity (WMFT-IT-TIME), but this was mainly for the dominant hand. All the values are reported in Tables 4 and 5.

4. Discussion

The aim of the study was to evaluate the psychometric properties of the JTHFT-IT in post-stroke adults with chronic hemiplegia or hemiparesis. The results of this study showed that the JTHFT-IT is a reliable and valid instrument for this population. To evaluate the consistency of the scale, Cronbach's α coefficient was used, reporting a high rate of internal consistency for both the dominant and non-dominant hand. Cronbach's α also showed positive results when evaluated in relation to the plegic or paretic arm. However, when analyzing the internal consistency for the hand when it was not affected by hemiplegia or hemiparesis, both for dominant and non-dominant hands, Cronbach's α values were lower than 0.7 (0.33 and 0.26, respectively). If the first item on the JTHFT-IT (i.e., writing a 24-letter sentence) is removed, however, the α value increases to higher values (Ferreiro et al., 2010; Mak et al., 2015; Savona et al., 2019). Previously, it has been demonstrated that this item requires the longest length of time for the subject to finish the task, both with the dominant and non-dominant hand.

To define the validity of the scale, Pearson's correlation was also performed and showed statistically significant results, associating the JTHFT-IT with the dynamometer and proving an optimal concurrent validity, as previously shown in other study (Culicchia et al., 2016; Savona et al., 2019). Pearson's correlation was also performed and showed statistically significant results, associating JTHFT-IT with the WMFT-IT-TIME (Berardi, Dhrami, et al., 2018) and proving a good construct validity of the test for the dominant hand; previously demonstrated correlations with the WMFT-IT were positive mainly for the items related to the arm and hand (9 to 16), which was as expected, given that the WMFT-IT assesses the arm, not only the hand.

4.1. Limits of the study

The present study has some limitations. Consistent with previous studies, grip strength was tested using the Jamar dynamometer, but because we were assessing fine hand use, use of a pinch gauge could also have been interesting. The small subsample of people with a dominant paretic hand represents the main limitation, compromising the possibility of having comparable results for the subsamples. In future studies, the authors recommend that this study could be furthered by the inclusion of a larger subsample of this population. Finally, the authors agree with previous studies that the JTHFT itself has some limitations (Allgöwer & Hermsdörfer, 2017; Artilheiro et al., 2018; Davis Sears & Chung, 2010). The score of the test does not reflect different compensation mechanisms for positioning the upper limb. Hence, it is important to provide appropriate instructions before starting the test and to ask patients to not change their strategy while being tested or, in clinical trials that use the JTHFT score as an endpoint, to not change strategies in follow-up evaluations. Furthermore, patients with moderate-to-severe functional impairment are often not testable with the JTHFT.

4.2. Conclusions

In conclusion, it is possible to state that the JTHFT-IT is a useful scale for assessing the function of the hand in everyday activities in the post-stroke population with chronic hemiplegia or hemiparesis. Even though no test used in isolation can provide a realistic assessment of hand function and it is important to consider the potential usefulness of JTHFT in a battery of tests (van de Ven-Stevens, Munneke, Terwee, Spauwen, & van der Linde, 2009), the JTHFT-IT seems very suitable for clinic assessments because the objects used in the test can be easily purchased and the implementation of the JTHFT-IT is inexpensive. The instructions are simple and straightforward, and gaining expertise in administering the test is not time-consuming. Another important advantage of the JTHFT scale is the evaluation of movements related to activities of daily living, which makes it an ideal tool for use in a rehabilitation program for people post-stroke to assess the individual at baseline, to register improvements, and as an outcome measure. Finally, given the fact that in the literature there exist plenty of assessment tools, it is extremely important to determine which have better characteristics and have been used more extensively internationally. Having specific information regarding tools' reliability in the different categories of patients allows researchers and clinicians to choose the right tool among the multitude of existing tools.

Table 4
Pearson's correlation coefficient between JTHFT-IT and the dynamometer for concurrent validity and the WMFT-IT-TIME for construct validity. Results for the dominant hand

DOMINANT HAND	Dynamometer	WMFT																
		1 Forearm to table	2 Forearm to box	3 Extend elbow	4 Extend elbow	5 Hand to table	6 Hand to box	7 Weight to box	8 Reach and retrieve	9 Lift can	10 Lift pencil	11 Lift paper clip	12 Stack checkers	13 Flip cards	14 Grip strength	15 Turn key in lock	16 Fold towel	17 Lift basket
Jebsen – writing a short sentence	–0.25	0.19	0.301*	0.132	0.137	0.27	0.14	0.140	0.137	0.262	0.26	0.27	0.30*	0.194	–0.10	0.27	0.22	0.22
Jebsen – Turning over a 3×5 inch card	–0.34*	0.24	0.11	0.30*	0.30*	0.22	–0.08	0.29*	–0.05	0.224	0.23	0.23	0.24	040**	–0.10	0.23	0.41**	0.15
Jebsen – Picking up small objects	–0.44**	0.18	0.28	0.16	0.17	0.26	0.17	0.18	0.21	0.309*	0.31*	0.31*	0.33*	0.24	–0.07	0.31*	0.24	0.23
Jebsen – Simulated feeding	–0.46**	0.17	0.27	0.15	0.16	0.25	0.17	0.16	0.20	0.307*	0.31*	0.31*	0.33*	0.24	–0.07	0.31*	0.22	0.23
Jebsen – stacking checkers	–0.46**	0.24	0.20	0.18	0.18	0.25	0.15	0.16	0.04	0.349*	0.35*	0.35*	0.35*	0.26	–0.05	0.35*	0.27	0.27
Jebsen – Picking up large light cans	–0.40**	0.19	0.06	0.23	0.23	0.14	–0.08	0.22	–0.12	0.143	0.14	0.15	0.15	0.29*	0.06	0.15	.32*	0.09
Jebsen – Picking up large heavy cans	–0.40**	0.20	0.09	0.22	0.22	0.16	–0.06	0.22	–0.08	0.145	0.15	0.15	0.15	0.28	0.06	0.15	0.31*	0.09

**Correlation is significant at 0.05 (2-tailed). *Correlation is significant at 0.01 (2-tailed).

Table 5
Pearson's correlation coefficient between JTHFT-IT and the dynamometer for concurrent validity and the WMFT-IT-TIME for construct validity. Results for the non-dominant hand

NON-DOMINANT HAND	Dynamometer	WMFT-IT-TIME																
Jebsen		1 Forearm to table time	2 Forearm to box time	3 Extend elbow time	4 Extend elbow time	5 Hand to table time	6 Hand to box time	7 Weight to box time	8 Reach and retrieve time	9 Lift can time	10 Lift pencil time	11 Lift paper clip time	12 Stack checkers time	13 Flip cards time	14 Grip strength time	15 Turn key in lock time	16 Fold towel time	17 Lift basket time
Writing a short sentence	–0.48**	0.03	0.17	0.15	0.13	–0.32*	0.02	–0.18	0.06	–0.21	–0.13	–0.13	–0.09	–0.11	0.04	–0.06	–0.10	–.31*
Turning over a 3×5 inch card	–0.61**	–0.06	0.25	0.26	0.15	–0.20	–0.14	–0.18	–0.05	–0.09	–0.11	–0.11	–0.19	–0.17	0.02	–0.17	–0.10	–0.08
Picking up small objects	–0.68**	–0.09	0.21	0.24	0.18	–0.24	–0.05	–0.23	–0.14	–0.112	–0.06	–0.07	–0.14	–0.14	–0.04	–0.14	–0.05	–0.13
Simulated feeding	–0.66**	–0.02	0.06	0.09	0.11	–0.22	–0.15	–0.08	–0.06	–0.127	–0.10	–0.10	–0.19	–0.17	0.07	–0.16	–0.08	–0.23
Stacking checkers	–0.64**	0.03	0.21	0.26	0.24	–0.23	–0.12	–0.132	–0.09	–0.087	–0.07	–0.07	–0.14	–0.13	–0.05	–0.13	–0.03	–0.14
Picking up large light cans	–0.63**	–0.09	0.12	0.12	0.09	–0.16	–0.06	–0.09	0.06	–0.133	–0.07	–0.07	–0.15	–0.17	0.04	–0.11	–0.01	–0.13
Picking up large heavy cans	–0.64**	–0.03	0.28	0.27	0.20	–0.19	0.03	–0.15	0.06	–0.092	–0.03	–0.03	–0.11	–0.15	–0.09	–0.08	0.01	–0.07

**Correlation is significant at 0.05 (2-tailed). *Correlation is significant at 0.01 (2-tailed).

Compliance with ethical standards

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all participants for being included in the study.

Conflict of interest

All authors declare no conflict of interest.

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