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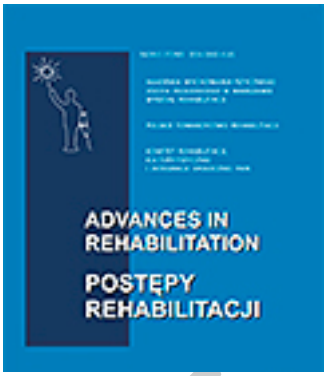

Original article

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Using the Jebsen-Taylor test in patients after radial bone fracture

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Abstract
Introduction: The aim of the study was twofold. First it was to assess the usefulness of the Jebsen-Taylor test of hand function in an analysis of rehabilitation outcomes in patients after radial bone fracture and second, it was to examine whether the results of JTT correlate with other methods applied in objective assessment of patients' functional state after radial bone fracture.
Material and methods: The study population consisted of 64 patients . The study included an assessment of hand functional mobility with the use of the JTT, measurement of the hand muscle strength with a hydraulic dynamometer, measurement of the pressure strength of the thumb with a grip dynamometer and pain measurement with the VAS scale. All tests were performed before and after 21 days of rehabilitation.
Results: The time needed to perform all seven tasks included in the JTT was consistently reduced in both non-dominating and dominating hands and the results showed high reliability. Some correlations were observed between JTT and other methods of assessing outcomes of rehabilitation.
Conclusions: The JTT is a simple, reliable, objective and standardised tool for clinical assessment of the functional state of patients with various hand dysfunctions and it should be widely applied in clinical practice. We found it to be reliable, easy to administer, and comprehensive in an assessment of hand functions. It correlated with several other measurement that assess outcomes of rehabilitation and therefore it is recommended that JTT should be combined with other methods to assess rehabilitation results and provide a comprehensive evaluation of the patient.

Keywords: muscle strength, Jebsen-Taylor hand test, objectivisation of rehabilitation

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Introduction

Forearm bone fractures are usually caused by a fall onto a straightened upper limb or directly on a forearm. They can also result from other direct impact such as a car accident. Forearm bone fractures caused by an overload are less frequent. A fracture of the distal epiphysis of a radial bone, usually referred to as a radial bone fracture in a typical place or Colles' fracture (latin: *fractura radii loco typico seu fractura*Collesi), is caused by falling on a straightened arm. A radial bone fracture is sometimes an articular fracture and is often accompanied by a fracture of the styloid process of the ulnar bone. These are among the most frequent fractures and they occur in 2 per 1,000 people a year and mainly in elderly women [1]. Fractures are treated in accordance with generally accepted rules. Fracture reduction is carried out under anaesthesia. In two-fragment (stable) fractures, immobilisation in a plaster cast embraces the forearm and the hand to the level of heads of metacarpal bones. In a comminuted (unstable) fracture, immobilisation reaches the arm and includes the basal phalanx of the thumb. The time of immobilisation ranges from 4 to 8 weeks, depending on the patient's age and nature of the fracture. Exercises of fingers, shoulder joint and when possible the elbow joint should be conducted already at this time. Work to improve the mobility of joints reduces the risk of swelling, maintains the limb mobility and prevents muscular atrophies. Rehabilitation is necessary both after immobilisation with a plaster cast and after the surgery. Initially, it includes analgesic and oedema-reducing procedures. They are followed with exercises aimed at strengthening and improving elasticity of the upper limb muscles, increasing mobility range, improving joint stabilisation and improving proprioception. It is noteworthy that because of a complicated structure and biomechanics of the wrist joint, in this case the type of surgery and any errors in diagnostics and treatment can result in reduced mobility of the limb [2].

Functional diagnostic is essential in this context, as it allows to evaluate outcomes of rehabilitation. It can be carried out with the use of various scales, such as ADL, Barthel, Quebeck scale, Modified Oswestry Questionnaire, Hanover Activities of Daily Living Questionnaire, upper limb mobility test [3] [4]. Other useful tools include the Functional Independent Measurement (FIM) and Functional Assessment Measurement (FAM) [5]. Mobility of the upper limb can also be assessed with the subjective DASH scale, Gartland and Werley scale [6], Tinel's and Phalen's tests [7] or the PRWE scale [8].

Because the scales used to assess the functional state are so diverse, it is difficult to compare literature data and to make an objective assessment of the outcome of a comprehensive therapy[9]. Therefore, there is a need for a test of rehabilitation outcomes which would apply

a set of objective techniques of functional mobility. Such a tool should produce valuable findings by documenting patients' progress during rehabilitation therapy and in accordance with the principles of Evidence Based Medicine. One of such objective methods of assessment of the functional state of a patient, but one which is rarely used in Poland, is the Jebsen-Taylor Hand Function Test (JTT) [10]. JTT is used to assess the mobility and function of the hand.

Past studies suggest that the JTT test is reliable in assessing hands' function in patients of different ages and with various diseases. The statistical tests described in the literature which compare the results of the Jebsen-Taylor Hand Function Test with other assessment tools have demonstrated poor to excellent correlation (r=0.60-0.99). Such a broad range of correlation coefficients alone indicates that it is justifiable to attempt to analyse the usefulness of this tool as a part of comprehensive functional assessment of a patient.

The main aim of this study was to assess the usefulness of the JTT Test in the analysis of rehabilitation outcomes in patients after radial bone fracture. To see how JTT assessment compares with other methods an examination of correlation between the results of JTT and other methods assessing patients' functional state (hand strength, pain) was also conducted. It is worth noting that this is the first study reporting the results of the validation protocols of the JTT in Poland. It provides a new tool for Polish professionals to measure the functionality of the hand in patients with radial bone fracture, a tool that is needed to objectively evaluate rehabilitation outcomes.

Material and methods

The study was conducted between 01.02.2016 and 31.03.2018 at the Outpatient Rehabilitation Centre and approved by the Ethics Committee for Scientific Research (decision no. 5/2015). All the patients were informed about the aim and scope of the study before it started and gave written consent to processing and disclosing data related to their participation (signed consent forms are included in the medical documentation).

The study population consisted of 64 patients (54 female and 10 male), aged 35 to 92 years with the mean age 61. Among the tested patients 28 had a radial bone fracture in the dominant hand and 36 in the non-dominant hand. The study included patients after a radial bone fracture who were staying at the Outpatient Rehabilitation Centre, received a positive decision of the attending physician, and signed a consent to participate in the study. Study excluded patients with sensory disorders, those not approved by a physician, and those who did not sign a consent to participate in the study.

The rehabilitation process was supervised by a doctor, a rehabilitation specialist, and included a Each patient was examined physical examination, a review of history, establishing the rehabilitation programme, and supervising its course. before the rehabilitation started and after 21 days of the therapy. The examination included an assessment of the hand function with the Jebsen-Taylor Hand Function Test, measurement of the hand muscle strength, measurement of the strength of the precision grip and assessment of pain.

Jebsen-Taylor Hand Function Testis intended for simulation of everyday activities, it consists of seven tasks:

1. Writing a text,
2. Turning pages,
3. Lifting and carrying small objects,
4. Simulation of eating,
5. Arranging checkers pieces,
6. Lifting large light objects and,
7. Lifting large heavy objects.

In order to ensure the reliability of the results, each task was performed according to standards, first with the non-dominating hand, and then with the dominating hand. The examination was performed before and after a cycle of rehabilitation procedures. The time to perform each task was measured and the results were used for comparison. The results were also compared with the standards [10].

Dynamometric measurements were conducted with a hydraulic dynamometer and a thumb grip strength dynamometer, which comprise the 5030 KIT hand assessment kit. These measurements were conducted in the sitting position, with an arm straight, an elbow bent at the right angle and the forearm at a neutral position. Each measurement was conducted three times and the mean value was calculated. Pain in the injured limb before and after the rehabilitation was assessed with the Visual Analog Scale. This scale is regarded as a reliable tool for assessing the effectiveness of pain treatment. Hand strength before and after rehabilitation was compared using paired samples Wilcoxon test. Spearman rank correlation was used to see how the results of Jebsen-Taylor test correlated with hand strength test results. The results meeting the condition of $p \leq 0.05$ were regarded as statistically significant. The calculations were performed using STATISTICA 13 software.

Results

The Jebsen-Taylor test was used as the basic tool for assessment of rehabilitation outcomes in patients with mobility deficits in the upper limb after a radial bone fracture. The test was easy to administer and, in contrast to other methods, it was comprehensive in its ways to evaluate different functions of the hands such as writing, lifting objects of different sizes, simulating eating etc. It is the first time such a test was used in Poland, where few ways of objective assessment of functional outcomes of rehabilitation, are used.

When the dominant limb was injured, a significant improvement was noted with the JTT test as a result of rehabilitation. The time needed to perform all the tasks in JTT test after rehabilitation was reduced by between 1 second to 3.4 seconds and the differences were statistically significant ($p<0.00$). The largest reduction of the time needed to perform a task was noted for task 1 which involved writing a text (tab. 1).

Tab. 1. Results of the Jebsen-Taylor test in patients following a radial bone fracture (N = 28) – injury of the upper dominating limb (paired samples Wilcoxon test $p \leq 0.05$).

Type of task	Time of assessment	Min. time [s]	Max. time [s]	$\bar{x} \pm$ SD [s]	P
1. Writing a text	before therapy after therapy	8.4 8.0	34.3 23.1	16.6 ± 6.54 13.2 ± 3.90	0.000
2. Turning pages	before therapy after therapy	7.0 3.0	14.0 12.5	7.0 ± 3.38 5.1 ± 2.39	0.000
3. Lifting and carrying small objects	before therapy after therapy	5.1 4.8	35.1 29.7	11.3 ± 7.86 9.1 ± 6.77	0.000
4. Simulation of eating	before therapy after therapy	5.2 4.7	21.9 9.0	9.7 ± 4.17 7.0 ± 1.29	0.000
5. Arranging checkers pieces	before therapy after therapy	2.8 2.6	14.8 14.2	5.6 ± 3.54 4.6 ± 2.91	0.000
6. Lifting light large objects	before therapy after therapy	3.2 2.7	10.2 7.1	5.3 ± 2.34 3.8 ± 1.14	0.000
7. Lifting large heavy objects	before therapy after therapy	2.7 2.7	10.2 6.3	5.4 ± 2.23 3.9 ± 1.00	0.000

A reduction in time needed to perform all the tasks was also observed in patients that had rehabilitation after fractures in the non-dominant limb and these differences were also significant ($p<0.00$) (tab. 2). Here, the differences in the time needed to perform individual tasks ranged from 0.2 seconds (task 3 - lifting and carrying small objects) to 6 seconds (task 1 – writing a text) (tab. 2).

Tab. 2. Results of the Jebsen-Taylor test in patients following a radial bone fracture (N = 36) – injury of the upper non-dominating limb (paired samples Wilcoxon test $p \leq 0.05$).

Type of task	Time of assessment	Min. time [s]	Max. time [s]	$\bar{x} \pm$ SD [s]	P
1. Writing a text	before therapy after therapy	8.7 7.6	55.0 33.4	30.1 ± 13.58 24.1 ± 7.79	0.000
2. Turning pages	before therapy after therapy	2.9 2.9	8.5 5.8	5.3 ± 1.91 4.1 ± 0.95	0.000
3. Lifting and carrying small objects	before therapy after therapy	0.0 4.2	10.2 9.5	7.1 ± 2.67 6.9 ± 1.54	0.000
4. Simulation of eating	before therapy after therapy	6.4 5.8	14.3 12.6	10.6 ± 2.44 8.7 ± 2.11	0.000
5. Arranging checkers pieces	before therapy after therapy	2.4 2.4	8.4 6.3	4.8 ± 1.63 3.7 ± 1.10	0.000
6. Lifting light large objects	before therapy after therapy	2.9 2.0	6.4 5.0	4.6 ± 1.01 3.6 ± 0.90	0.000
7. Lifting large heavy objects	before therapy after therapy	3.0 2.8	6.1 4.8	4.5 ± 1.07 3.7 ± 0.67	0.000

The total time needed to perform all seven tasks was compared with the standards in order to assess the reliability of the Jebsen-Taylor test [10]. The study analysed two age groups as theprogress in completing these tasks tends to be far less for older individuals. All of the patients' results, both in the group aged 20-59 years and in those aged 60-94 years, showed progress, and it was within the limits provided for in the standards for the Jebsen-Taylor test (tab. 3).

Tab. 3.A comparison of results for patients with the standards for the Jebsen-Taylor test (D - dominant hand, ND - non-dominant hand).

No. of task	Aged 20-59 years (N=28)				Aged 60-94 years (N=36)			
	D [s]	D – standard [s]	ND [s]	ND – standard [s]	D [s]	D – standard [s]	ND [s]	ND – standard [s]
1. Writing a text	9.74	11.7 ± 2.1	23.04	30.2 ± 8.6	16.43	15.7 ± 4.7	33.16	38.9 ± 14.9
2. Turning pages	3.57	4.3 ± 1.4	3.88	4.8 ± 1.1	4.45	4.9 ± 1.2	4.62	5.5 ± 1.1

3. Lifting and carrying small objects	5.27	5.5 ± 0.8	6.10	6.0 ± 1.0	7.18	6.6 ± 1.3	8.87	6.6 ± 0.8
4. Simulation of eating	5.78	6.7 ± 1.1	7.73	8.0 ± 1.6	6.92	6.8 ± 1.1	8.78	8.7 ± 2.0
5. Arranging checkers pieces	3.13	3.3 ± 0.6	3.08	3.8 ± 0.7	4.01	3.6 ± 0.6	4.83	4.4 ± 1.0
6. Lifting light large objects	3.02	3.1 ± 0.5	3.28	3.3 ± 0.6	3.52	3.5 ± 0.6	3.93	3.4 ± 0.6
7. Lifting large heavy objects	3.11	3.2 ± 0.5	3.41	3.3 ± 0.5	3.81	3.5 ± 0.6	3.96	3.7 ± 0.7

Apart from the functional aspect, the strength of the injured hand and the strength of the thumb before and after the therapy were assessed. A considerable improvement was observed in all cases, and the post-treatment results differed significantly from the baseline (tab. 4 and 5). When the dominant limb was fractured, the post-treatment hand strength increased by 5.4 kg and the precision grip strength of the thumb increased by 1.2 kg. When the non-dominant limb was fractured, the hand strength increased by 5 kg and the thumb pressure increased by 1.5 kg. (tab. 4 and 5).

Tab. 4. The effect of rehabilitation on the strength of an injured dominant hand (paired samples Wilcoxon test $p \leq 0.05$).

Variable	Min. [kg]	Max. [kg]	$\bar{x} \pm$ SD [kg]	p
Hand strength before therapy	1.00	20.00	9.04 ± 5.841	0.00122
Hand strength after therapy	6.00	28.00	14.49 ± 6.737	
Thumb strength before therapy	0.50	5.70	2.91 ± 1.644	0.00317
Thumb strength after therapy	2.50	6.70	4.14 ± 1.262	

Tab. 5. The effect of rehabilitation on the strength of an injured non-dominant hand (paired samples Wilcoxon test $p \leq 0.05$)

Variable	Min. [kg]	Max. [kg]	$\bar{x} \pm$ SD [kg]	p
Hand strength before therapy	2.00	22.70	8.85 ± 6.734	0.00033

Hand strength after therapy	3.00	30.70	13.84 ± 8.672	
Thumb strength before therapy	0.80	6.30	3.59 ± 1.856	0.00020
Thumb strength after therapy	1.80	8.50	5.10 ± 2.157	

An analysis of the correlation between the results for patients in the Jebsen-Taylor test and the hand strength has shown that there are statistical relationships between the hand strength before therapy and the time needed to perform a task in the test (tab. 6). The correlation coefficient was over 0.5 for the injured non-dominant hand, which indicates strong correlation according to J. Guilford's classification. The correlation is negative, which means that the decreased hand strength resulted in a longer time needed to perform the tasks in the Jebsen-Taylor test. No statistically significant correlation was observed after rehabilitation between the hand strength and the time needed for task 1 (writing a text) and task 6 (lifting large, light objects). The correlation was high and very high in the other tasks, which indicates that an increase in the hand strength reduces the duration of functional actions. A statistically significant correlation was observed regarding the injured dominant hand after the therapy between the hand strength and the time needed for task 1 (writing a text) and task 4 (simulation of eating) (tab. 6).

Tab. 6. The relationship between the results of the Jebsen-Taylor test and the patients' hand strength (Spearman rank correlation $p \leq 0.05$)

Type of Task	Time of assessment	Injured non-dominant hand		Injured dominant hand	
		Hand strength before therapy [kg]	Hand strength after therapy [kg]	Hand strength before therapy [kg]	Hand strength after therapy [kg]
1. Writing a text	before therapy	-0.55		not observed	
	after therapy		not observed		-0.62
2. Turning pages	before therapy	-0.59		not observed	
	after therapy		-0.60		not observed
3. Lifting and carrying small objects	before therapy	-0.52		not observed	
	after therapy		-0.82		not observed
4. Simulation of eating	before therapy	-0.52		not observed	
	after therapy		-0.70		-0.53
5. Arranging checkers pieces	before therapy	-0.69		not observed	
	after therapy		-0.73		not observed
6. Lifting light large objects	before therapy	-0.56		not observed	

	after therapy		not observed		not observed
7. Lifting large heavy objects	before therapy after therapy	-0.69	 -0.66	not observed	 not observed

The rehabilitation also resulted in reduction of pain by a mean of 3 VAS points. The pain in VAS scale was reduced from before therapy 5.3 ± 2.51 to 2.1 ± 1.43 and it was statistically significant ($p<0.000$).

No statistically significant relationship between pain and results of the Jebsen-Taylor test was observed in patients with an injured non-dominant hand. Conversely, a statistically significant effect of pain on time needed for task 7 which included lifting large heavy objects, was observed in patients with an injured dominant hand. Here the correlation coefficient was 0.55.

Discussion

An assessment of the rehabilitation outcome is an extremely important part of the treatment process as it allows for monitoring the progress of therapy and its modification if needed. But this evaluation needs to be done objectively with a use of comprehensive tools such as JTT test that uses multiple tasks for assessment. This study results show that JTT is a reliable and sensitive method that clearly detect changes in functional mobility in patients after rehabilitation. The time to complete all the tasks in the Jebsen-Taylor test was significantly reduced for patients following rehabilitation after a radial bone fracture for both the upper dominating and upper non-dominating limb. The results show that Jebsen-Taylor test results for two analysed age groups were within the established standards for this test indicating its high reliability.

To improve objectivity in outcome assessment of rehabilitation, the use of several methods seems justified. This study measures the outcomes of rehabilitation in patients after radial bone fracture in the hand with the use of the Jebsen-Taylor test as well as other methods. The results of Jebsen-Taylor test also correlated with the test for strength for the injured non-dominant hand for most tasks, however they were not correlated with the tasks for a dominant hand. Finally, the reduction of pain test results correlated only with one task in Jebsen-Taylor test for a dominant hand. These results indicate the importance of using multiple tools of assessment of functional abilities of patients as they provide a fuller picture of the patient functional state and help objectivise assessment of rehabilitation.

This is one of few studies in this area. The scarcity of studies regarding objectivisation of rehabilitation outcomes has been noted by Mikołajewska, who analysed research from the

PubMed database [12]. Objectivisation of an assessment of a functional patient's state and the outcome of therapy aims at separating the subjective feelings of the doctor, the physiotherapist and the patient from the specific outcome of therapy. It also provides grounds for reliable scientific analyses complying with the principles of Evidence Based Medicine. This is why so much importance is attached to actions aimed at developing simple, reliable sets of objective methods which can be applied in rehabilitation. According to the American Society for Surgery of the Hand, objective methods of assessment of hand mobility are necessary for proper planning and conducting of the rehabilitation process. Owing to their sufficient precision, they enable tracing individual stages of improvement and precisely identifying the final outcome of therapy [13]. According to Cytowicz-Karpiłowska, both objective and subjective methods should be used to assess rehabilitation properly[14]. An analysis of the literature shows that attempts have been made to identify a set of assessment methods of the functional state of a patient. Błaszczyk and Czerwosz [15] analysed the usefulness of numerous tests used for assessment of postural stability in the aging process. Tryniszewki et al.[1] presented an attempt to objectivise the outcome of physiotherapy in patients with pain syndromes in the spine. Golec et al. [16] also analysed the usefulness of the scales used for assessment of the hip joint function in a degenerative disease. Culicchia et al. reports the result of the translation, cultural adaptation, and validation protocols of the JTHFT for Italians. The study provides a new tool for Italian professionals to measure the functionality of the hand in participants with various upper limb pathologies [17].

The result of this study support prior findings. The effectiveness of using several methods for patient functional assessment was confirmed by Stamm et al. [18] in a study on a group of 100 patients with the joint degenerative disease of the hand. Six questionnaires were used to measure joint degenerative disease, JTT and three function tests that included the Moberg picking-up test (MPUT), a button test (BT) and a grip strength. Moreover, the health status of the patients was also assessed with the SF-36 test. The strongest correlation was found for the JTT results and the results of the AIMS2-SF and SACRAH questionnaire. On the other hand, a study by Sears & Chung[19] conducted on a group of 111 patients who underwent rehabilitation after hand surgeries and fractures of distal radius, conducted before the surgery and after a 9 to 12 month period using the Jebsen-Taylor test and the Michigan Hand Outcomes Questionnaire (MHQ) showed low discriminative reliability of the JTT compared to MHQ as the standard. Much better results were achieved when JTT was used in a clinical assessment of patients after a stroke [19, 20. The JTT reliability coefficients in these studies were excellent with the Cronbach α correlation coefficient equal to 0.924, which shows that

JTT can be a valuable tool for dexterity assessment. Similarly good effects of the use of the JTT were observed in a study with patients 8-12 years old with cerebral palsy [21, 22].It is important to note that the use of objective ways to assess outcomes of rehabilitation is not be prevalent everywhere. For example, rehabilitation in Poland infrequently includes functional examination with a range of functional tests for assessment of improvements.This is a very important issue, from the treatment perspective but also from the economic point of view, because using healthcare services can quickly become expensive and not necessarily therapeutically effective if not objectively assessed. Physiotherapists should be well equipped to objectively assess the functional capabilities of a patient using multiple methods before the patients are discharged from hospital [11]. This first study conducted in Poland shows a great promise for the JTT method.

Conclusions

The outcome of rehabilitation can be objectivised by using simple, comprehensive and rapid diagnostic tasks to assess a patient. These are the features of the Jebsen-Taylor Hand Function Test, which is a simple and standardised tool that assesses multiple functions of a hand with various dysfunctions. The results of this study support the past findings that the JTT method is reliable and can be easily used in conjunction with other methods in countries, such as Poland, which still lack simple, objective, and comprehensive diagnostic tools. Studies conducted in the past and the results of this study show the high usefulness of the JTT for objective assessment of the functional state of patients with deficiencies in the upper limb, which provides grounds for recommending the test for broader use in the clinical practice. It is recommended that an assessment with this test should be combined with other methods as the use of multiple methods provides even more objective picture of a patients' functional state. The study presented in this paper was conducted on a small number of patients, which is why it can be regarded as a pilot study. It is recommended that a study with larger sample sizes be conducted and especially aimed at clarifying the relationship between the function and strength of the hand.

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