

## EVALUATION OF THE APPLICATION OF STANDARDIZED TESTS FOR ASSESSING THE FUNCTIONAL STATUS OF PEOPLE AFTER A STROKE

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**Abstract:** Hemiparesis is a syndrome of brain damage that leads to motor weakness of one half of the body accompanied by changes in sensitivity, speech, as well as frequent psychological and other changes in the patient. The tests we use to measure the functional recovery of patients with hemiparesis in kinesitherapy are Barthel Index (BI), Trunk Control Test (TCT), Motoricity Index (MI), Ashworth Scala (ASHS), Timed Up and Go Test (TUG). The aim of the work was to examine the sensitivity, specificity, and overall accuracy of the applied tests (BI, TCT, MI, ASHS, TUG) through the assessment of the degree of recovery of motor functions, the degree of competence for activities of daily life and the analysis of the effects of kinesitherapy treatment of patients with hemiparesis. The research is retrospective analysis of rehabilitation treatment in 148 patients with hemiparesis, both gender, aged 45-87, conducted at Department B at the Institute for Physical Medicine and rehabilitation "Dr Miroslav Zotović" Banja Luka. The standardized tests we used at the beginning and at the end of the treatment are: Trunk Control Test, Motoricity Index, Ashworth Scala, Timed Up and GO Test and Barthel Index. We performed statistical processing of the data using the Median test and the Wilcoxon signed-rank test, and then examined their sensitivity, specificity and overall accuracy. Variables (gender, side of lesion, age groups) and their sensitivity (Se), specificity (Sp) and overall accuracy (UT) were investigated. The used tests showed statistically significant improvements in functional status at discharge compared to admission except for the Ashworth scale where we did not have a statistically significant improvement at the end of the treatment. We singled out the Barthel Index as the gold standard for assessing the sensitivity, specificity and overall accuracy of other tests. The most significant results were shown by the TUG (Se=74.2%, Sp= 40%, UT= 77%), followed by MI (Se= 71.7%, Sp= 30%, UT= 68.9%), and the lowest values by TCT (Se= 52.9%, Sp= 80% and UT= 54.7%). It has been shown that not all applied tests are equally valid, sensitive and specific for assessing the functional state of patients with hemiparesis.

**Key words:** assessment, measuring instruments, stroke

## Introduction

Hemiparesis is a syndrome of brain damage that leads to motor weakness of one half of the body accompanied by a change in sensibility, speech, as well as frequent psychological and other changes in the patient. Cerebrovascular diseases (CVD) belong to the group of mass chronic non-infectious diseases that are in the third place in terms of mortality and in the first place in terms of disability. Disability among survivors after brain damage is very high and it is believed that 25 to 35% of survivors require the help and care of other people [1,2, 3].

The key factor in stroke (CVA) rehabilitation is proper assessment and training intensity, especially in the acute phase, to improve functional recovery and prevent inactivity-related complications [4]. However, due to the clinical features specific to the patient, treatment programs may vary, especially regarding the duration, intensity and type of rehabilitation. Therefore, the success of rehabilitation processes depends on the clinician's ability to perceive individual levels of impairment and respond to treatment with simple, robust and efficient methods that are implemented by continuous evaluation of patients. Evaluation represents the determination of the degree of disability, respectively, the degree of functional activity that person can do and those that can do with certain difficulties. There are standardized scales for assessing disability for certain diseases. These instruments assess the degree of independence in performing activities of daily living [5].

Within the framework of continuous evaluation, we conduct kinesitherapy treatment based on planned short-term, medium-term and long-term plans that will include treatments of physical procedures, kinesitherapy and occupational therapy with the necessary coordination with other team members. Functional assessment is, therefore, an essential part of rehabilitation protocols after stroke. Currently, patients are mainly assessed using clinical scales, and they should be integrated with targeted neuro-biomechanical assessments, in order to provide a more detailed description of the clinical status of patients [6]. For this purpose, many instrumental approaches that investigate different domains of the hierarchical organization of the neuromusculoskeletal system, including measures of kinematics, muscle and brain activity, can be used.

Conventionally, the assessment process relies heavily on clinical experience and very often quantitative and qualitative analysis of the applied tests lacks. However, the most commonly used clinical scales rely mainly on subjective functional assessments and are not able to provide a complete description of the neuro-biomechanical status of patients.

In clinical practice, the process of physiotherapeutic treatment consists of five components: assessment, conversation with the patient about his problem (interview), data collection, evaluation and analysis of the obtained results. This means that it is necessary to make a good choice of measuring instruments (tests), perform standardize assessment, interpret the results obtained from the assessment and make an adequate choice of therapeutic, rehabilitative or preventive interventions (*evidence based practice*).

Measurements/tests can be further categorized as functional, related to what a person can do, or disability assessment, related to what a person cannot do. The ICF model does not have a hierarchical direction, but it can be used and understood in any direction [7]. By using tests in physiotherapy, we try to assess the patient's condition and predict the outcome or risks of therapy, but it is also possible to assess the quality and adequacy of the applied tests themselves. Observations in practice and interviews are not precise enough to evaluate the applied therapeutic interventions, and therefore the data collected in this way are difficult to compare. The information obtained in observations and interviews can provide a wider knowledge of the problems and experiences of people with stroke and provide guidance on the needs of such patients for the future and achieving the highest possible quality of life. This information can also be valuable in identifying pathology and initiating therapeutic intervention. However, they are not useful in evaluating the effectiveness of the intervention, evaluating the outcome of treatment or comparing the functional state of a person with the normal and/or expected state, characteristic for a certain age. Therefore measuring instruments are used, i.e. tests in which the functional state is shown with grades, i.e. numbers, and the results obtained in this way can be evaluated, along with their interpretation at different levels. Measurements can be divided according to orientation in relation to a given disease into generic/global or specific measurements [8,9].

Generic/global measurement is primarily concerned with physical function and encompasses multidimensional characteristics that include activities of daily living. The disadvantages of generic/global measurements are: less sensitivity to changes and non-specificity for a particular disease. In this research, generic measurement is focused on the compatibility and sensitivity of the following tests [10].

- At the level of body function: Timed Up and Go Test;
- At the level of daily activities: Barthel Index (BI)

Specific measurements are much more sensitive for a certain condition, i.e. disability, due to their narrower focus, and on the other hand, these measurements can probably identify the outcome and possibly the occurrence of unpredictable consequences of treatment. For these reasons, tests specific measurements for people after stroke will be used in the research.

The compatibility and sensitivity of the following specific tests will be tested:

- On the functional level: Test Control Trunk (TCT);
- On the morphological level: Motoricity index (MI) whose side score consists of two tests - Motoricity Index for Upper Extremity (MIR) and Motoricity Index for Lower Extremity (MIN);

The goal of this research is to examine the validity and sensitivity, in fact, the specificity of the applied tests for assessing the functional state of patients with hemiparesis and thus determine whether their application is justified.

## Methodology

The research presents a retrospective analysis of the rehabilitation treatment of patients with hemiparesis who were treated at Neurorehabilitation Department B at Institute "Dr Miroslav Zotović" Banja Luka, from 2014 to 2019. For the purpose of research, the permission of the Ethics Committee was obtained. During the mentioned period, based on the research criteria, 148 patients with hemiparesis were singled out using the method of random selection of every fifth respondent on the drop-down menu of the clinical information system. The average duration of the rehabilitation treatment was 3 weeks. Upon admission to the department, patients were tested, and based on the obtained parameters, analysis of the patient's condition was performed and recorded in the physiotherapist sheet, which was used for detailed planning of rehabilitation treatment course. At the end of the treatment, re-testing was performed, and the analysis gave a certain picture of the patient's condition.

Research criteria:

- Patients of both gender, aged 45-87
- Patients diagnosed with hemiparesis due to ischemic stroke upon admission or discharge from our institution.
- Patients who first came to Institute "Dr Miroslav Zotović" Banja Luka at Neurorehabilitation Department B after a previous stay at neurological clinics in the Republic of Srpska.
- Patients whose rehabilitation lasted minimum 20 days.
- Patients whose general condition did not deteriorate during rehabilitation.

At the department, after reception and processing by the competent physician, the patient comes to the kinesitherapy room with a kinesitherapy list on which we receive information about the basic diagnosis, indications for specific physical program proposed by the competent physician, and contraindications for certain conditions, presence of other diagnoses which will form the guideline and often the backbone of the kinesitherapy protocol in further evaluation.

According to the basic database that is available to physiotherapists, we get an insight into the medical history of each individual patient, his anamnesis, insight into the use of medicines and the results of individual diagnostic methods.

In addition to the knowledge we have, the following tests were performed upon admission: Physiotherapy sheet; Trunk Control Test (TCT); Motoricity index (MI) - score obtained from the values of Motoricity Index for Upper Extremity (MIR) and Motoricity Index for Lower Extremity (MIN); Timed Up and Go Test; Barthel Index (BI).

Based on these tests, we documented all the data with a valid numerical sign. After the initial processing of the obtained results, an assessment of the patient's condition at the beginning and at the end of rehabilitation was carried out and based on the data obtained from the clinical information system, after sorting the data in an Excel table, a descriptive analysis was performed, and then a comparison and correlation of the given tests and the data in them was done, with an assessment of their validity and

sensitivity. Based on such results, the justification for using them in planning and performing physical treatment for patients after a stroke was established.

## Results

The sample of 148 patients was divided into three groups: according to gender (male 88/female 60), side of the lesion (right 67 and left hemiparesis 81) and according to age: Group I - patients up to 65 years of age (able-to-work population – 59 respondents), Group II - patients aged 66-75 (53 respondents), Group III - patients over 76 (36 respondents) which is shown in Table 1.

The results obtained using the Mann-Whitney U test, when monitoring the age of the subject according to the affected side of the body, did not show a statistically significant difference ( $z = -1.220$ ,  $p = 0.222$ ). If we compare the side of the lesion with gender of the subjects, we come to the conclusion that the results obtained using the  $\chi^2$  test ( $\chi^2 = 0.802$  /with correction according to Yates/,  $SS = 1$ ,  $p = 0.371$ ,  $\Phi = 0.087$ ) - show that there is no statistically significant difference between involvement of the right and left side in relation to the female and male gender. In summary, it derives that the analysis of the samples gave the conclusions that there are no statistically significant differences between the age groups I, II and III of the patients in relation to the female/male gender and in relation to the left/right side of the body lesion. As well, there is no statistically significant difference between the involvement of the right/left side in relation to the female/male gender .

Table 1 . Presentation of the distribution of samples according to sex, side of the lesion and age groups in percentages

| 1. According to gender | 2. According to the side of the lesion | 3. According to age : |
|------------------------|----------------------------------------|-----------------------|
| • male (59.45%)        | • right hemiparesis 45%                | • I group 39.9%       |
| • female (40.54%)      | • left hemiparesis 55%                 | • II group 35.8%      |
|                        |                                        | • III group 24.3%.    |

### *Analysis of the used tests*

Through descriptive analysis of the used tests, based on Mean (SD), the Bartel index showed the highest values, i.e. the biggest difference at the beginning and the end of the treatment, therefore, in the further examination of sensitivity, specificity and validity, we used it as the "gold standard" [11].

Table 2. Descriptive analysis of the used tests

|           | BI            |           | TCT           |           | MI            |           | TUG           |           |
|-----------|---------------|-----------|---------------|-----------|---------------|-----------|---------------|-----------|
|           | <i>I mean</i> | <i>SD</i> | <i>I mean</i> | <i>SD</i> | <i>I mean</i> | <i>SD</i> | <i>I mean</i> | <i>SD</i> |
| admission | 64.29         | 20.2      | 65.20         | 16.88     | 60.82         | 19.11     | 15.63         | 12.09     |
| discharge | 78.85         | 17.2      | 76.02         | 17,11     | 68.74         | 16.95     | 15.90         | 9.7       |

Legend: TCT- Trunk control test; MI - Motoricity index; TUG –Timed up and go test; BI - Barthel index.

In statistical procedures, we compared the results of the compared tests using the Wilcoxon signed-rank test and summarized them in Table 3 :

- The Wilcoxon signed-rank test shows a statistically significant increase in the total TCT test at discharge compared to admission ( $z = -7.575$ ,  $p = 0.000$ ) with a large difference ( $r = 0.623$ ). The median TCT score increased from 61.00 at admission to 74.00 at discharge.
- The Wilcoxon signed-rank test shows a statistically significant increase in MIN and MIR as well as MI at discharge compared to admission with a large difference for all observed parameters. Median scores on this individual and summary test increased from admission to discharge in all cases.
- The Wilcoxon signed-rank test shows a statistically significant increase in TUG at discharge compared to admission with a large difference for all observed parameters with a decrease in the median, except for female patients ( $z = -1.919$ ,  $p = 0.055$ ) with a small difference ( $r = 0.248$ ); the median score of the TUG for the female gender increased from 14,450 at admission to 14,565 at discharge and patients of the Group III ( $z = -0.879$ ,  $p = 0.379$ ) with a small difference ( $r = 0.147$ ); the median score of TUG increased from 11.80 at admission to 16.34 at discharge.
- The Wilcoxon signed-rank test shows a statistically significant increase in the Barthel index (BI) total at discharge compared to admission ( $z = -9.640$ ,  $p = 0.000$ ) with a large difference ( $r = 0.792$ ). The median BI score increased from 69.50 at admission to 84.00 at discharge

Table 3. Wilcoxon signed-rank test of used tests

| Variable | N          | z             | P            | r            | 50th (Median)        |
|----------|------------|---------------|--------------|--------------|----------------------|
| TCT      | 148        | -7,575        | 0.000        | 0.623        | 61.00 ↗ 74.00        |
| MIN      | 148        | -7,639        | 0.000        | 0.628        | 63.00 ↗ 75.00        |
| PEACE    | 148        | -7,573        | 0.000        | 0.622        | 65.50 ↗ 76.00        |
| ME       | <b>148</b> | <b>-8,793</b> | <b>0.000</b> | <b>0.723</b> | <b>63.50 ↗ 72.50</b> |
| TUG      | 148        | -4,639        | 0.000        | 0.381        | 14,215 ↘ 12.63       |
| BI       | <b>148</b> | <b>-9,640</b> | <b>0.000</b> | <b>0.792</b> | <b>69.50 ↗ 84.00</b> |

Legend: TCT- Trunc control test!; Motoricity Index for Upper Extremity (MIR); Motoricity Index for Lower Extremity (MIN); MI - Motoricity index; TUG – Timed up and go test; BI - Barthel index.

Further data processing, in which we processed the specificity, sensitivity and overall accuracy of the tests used in relation to the Barthel index as the gold standard, indicated the following:

- Out of 138 patients in whom positive changes were recorded in both BI and TCT, 73 patients with positive changes were identified, so the sensitivity of the TCT is identified with 52.9% of patients with positive changes, while 8 out of 10 patients, have negative changes or no changes, TCT shows specificity of 80%. The overall accuracy of this test is 54.7%.
- Out of 138 patients in whom positive changes were recorded both in the BI and MI identified 99 patients with a positive change, which records a sensitivity of 71.7% of patients with positive changes, while in 3 patients whose changes were negative or without changed, the specificity of MI is 30%, while the overall accuracy of the test is 68.9% compared to BI.
- If we compare MI with TCT, out of the 138 patients in whom positive changes were recorded, the sensitivity of the tests has a value of 78.6%, while in 26 patients with no changes or with negative changes after rehabilitation treatment, the specificity of the test is 35.6%. The total accuracy was 57.4%.
- Comparing TUG with the TCT, we obtained the following results: out of 59 patients with positive changes, the sensitivity of TUG was 78.6%, patients with negative or no changes were 16 out of 73, so the specificity was 21.9 %. The overall accuracy is 50.6%.
- Comparing TUG with MI the following results was obtained: in 83 out of 106 patients with positive changes after rehabilitation treatment, the sensitivity of TUG was 78.3%, and in 9 out of 42 patients with no changes or with negative changes, the specificity was 21.4%. The overall accuracy is 62.1%.

The summary results are shown in Table 4.

Table 4. Summary results of the used tests - sensitivity, specificity and overall accuracy

|                    | Barthel Index |            |              | Trunk Control Test |              |              | Motoricity Index |              |              |
|--------------------|---------------|------------|--------------|--------------------|--------------|--------------|------------------|--------------|--------------|
|                    | SE            | SP         | UT           | SE                 | SP           | UT           | SE               | SP           | UT           |
| Trunk Control Test | <b>0.529</b>  | <b>0.8</b> | <b>0.547</b> |                    |              |              |                  |              |              |
| Motoricity Index   | <b>0.717</b>  | <b>0.3</b> | <b>0.689</b> | <b>0.786</b>       | <b>0.356</b> | <b>0.574</b> |                  |              |              |
| TUG                | <b>0.742</b>  | <b>0.4</b> | <b>0.77</b>  | <b>0.786</b>       | <b>0.219</b> | <b>0.506</b> | <b>0.783</b>     | <b>0.214</b> | <b>0.621</b> |

*Legend: Se- Sensitivity, Sp- Specificity, UT - Overall accuracy*

By comparing the test results in relation to BI, we come to the conclusion that:

- The highest sensitivity with BI has TUG -74.2%, while the lowest has TCT 52.9%,

- TCT has the highest specificity value in relation to BI - 80%, and the lowest with MI, whose specificity is 30%
- overall accuracy has the highest value with TUG and it is 77%, the lowest value of overall accuracy is with TCT and is 54.7%
- By comparing MI, TUG with TCT, the sensitivity of both tests had the same values of 78.6%, the specificity was higher with MI and was 35.6% compared to TUG, whose specificity was 21.9%, but also overall accuracy showed a small difference of 57.4% with MI compared to TUG, whose accuracy was 50.6%
- By comparing TUG and MI, sensitivity was 78.3%, specificity 21.4% and overall accuracy 62.1%.

## Discussion

Research on the topic of medical rehabilitation of patients after stroke is difficult to compare due to the application of different research methods, and especially due to differences in the definition of the functional outcome of medical rehabilitation. Different authors evaluate the outcome of medical rehabilitation in different ways. Some assess the outcome of rehabilitation based on mortality and morbidity. Most define the outcome of medical rehabilitation after stroke based on: degree of disability, ability to perform ADL, patient mobility, length of hospitalization, treatment costs, time of discharge, quality of life and integration into the social environment [12]. In the evaluation and rehabilitation planning of patients with hemiparesis, adequate and sensitive measuring instruments used to assess the patient's disability play a major role. During the work at the department, the physiotherapists got the impression that measuring instruments do not adequately detect locomotion problems, but also the patients' remaining abilities. The measurements we perform have the task to focus on incapacitation, they are easy to perform and do not require a lot of time. The choice of measuring instruments is a crucial moment in clinical practice because an adequate choice enables therapists to accurately and precisely characterize and monitor changes in patients during rehabilitation. This choice is not easy due to the existence of many tests and measuring instruments. The neurological condition after stroke leads to a variety of consequences at different levels of the patient's functioning. Even minor damage to range of motion and strength can have an impact on the patient's inclusion in society. Measuring instruments/tests have been developed for various reasons, including discrimination, prognosis and evaluation of patient status [13,14]. The aim of the discriminative tests is to describe the patient in a time difference in order to notice the difference between the subjects. Evaluation tests are designed to measure changes over time and therefore must have excellent validity, specificity, overall accuracy and sensitivity. In the evaluation of the tests, we used contingency tables that show combinations of possible values of two categorical variables, whereby we wanted to prove and emphasize the importance of the connection between the described properties of the tests, to assess the validity of the methods, and to assess the intensity connection of the described properties. Barthel Index was used as the gold standard in the assessment of sensitivity, specificity and overall accuracy of TCT, MI (side score) and TUG [15,16,17]. By applying



assessment for functional status of the patient, it is established that after kinesitherapeutic treatment, statistically significant improvements occur in quality of motor activities of patient with hemiparesis. It turned out that all applied tests weren't equally valid, sensitive and specific for assessment of functional conditions of patient with hemiparesis. Barthel index is used for many years as the gold standard for assessment of functional status of the patient with hemiparesis both in clinical and scientific trials, and in our research also showed the biggest credibility.

Comparing with BI as golden standard, it was determined that the TUG had the most significant results (sensitivity 74.2%, specificity 40%, overall accuracy 77%), something weaker was Motoricity index (sensitivity 71.7%, specificity 30% and total accuracy 68.9%), and the weakest result had Trunk control test (sensitivity 52.9%, specificity 80%, overall accuracy 54.7%).

Used clinical scales rely mostly on subjective functional assessments and they are not able to provide complete description of neuro- biomechanical status of the patients.

## Conclusion

It has been shown that not all applied tests are equally valid, sensitive and specific for assessing the functional state of patients with hemiparesis. Current clinical examinations based on unequal validity, sensitivity and overall accuracy should have be integrated with specific physiological measurements, i.e. kinematic, muscular and cerebral activities, in order to achieve deep understanding of patient's conditions and his evolution through time and rehabilitation intervention.

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## EVALUACIJA PRIMJENE STANDARDIZOVANIH TESTOVA ZA PROCJENU FUNKCIONALNOG STANJA OSOBA NAKON MOŽDANOG UDARA

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**Sažetak:** Hemipareza predstavlja sindrom oštećenja mozga koji dovodi do motorne slabosti jedne polovine tijela praćene sa promjenom senzibiliteta, govora, kao i čestim psihičkim i drugim promjenama bolesnika. Testovi korišteni za mjerenje funkcionalnog oporavka bolesnika sa hemiparezom u kineziterapiji su Barthel Indeks (BI), Trunk

*Control Test (TCT), Motoricity index (MI), Ashworth Scala (ASHS), Test UP&GO (TUG). Cilj rada je bio da se ispita senzitivnost, specifičnost i ukupna tačnost primjenjivanih testova (BI, TCT, MI, ASHS, TUG) kroz procjenu stepena oporavka motornih funkcija, stepena osposobljenosti za aktivnosti svakodnevnog života i analizu efekata kineziterapijskog tretmana bolesnika sa hemiparezom. Istraživanje predstavlja retrospektivnu analizu rehabilitacionog terapijskog tretmana kod 148 bolesnika sa hemiparezom, oba pola, starosti od 45-87, na Odjelenju B za neuror rehabilitaciju u Institutu FMIR "Dr Miroslav Zotović" Banja Luka. Standardizovani testovi koje smo koristili na početku i kraju tretmana su: Trunc Control Test, Motoricity Index, Ashworth Scala, Test UP&GO i Barthel. Statističku obradu podataka smo vršili primjenom testa Medijane i Wilcoxon-ovog testa sume rangova, a zatim smo ispitivali njihovu senzitivnost, specifičnost i ukupnu tačnost. Svi podaci koji su dobijeni primjenom navedenih testova su obrađeni i na osnovu njih je vršena procjena stanja bolesnika, upoređivani su testovi sa varijablama (pol, strana lezije, starosne grupe) i ispitivana je njihova senzitivnost (Se), specifičnost (Sp) i ukupna tačnost (UT). Korišteni testovi su pokazali statistički značajna poboljšanja funkcionalnog statusa na otpustu u odnosu na prijem izuzev kod Ashwort skale gde nismo imali statistički značajnog poboljšanja na kraju tretmana. Izdvojili smo Barthel Index kao zlatni standard za procjenu senzitivnosti, specifičnosti i ukupne tačnosti ostalih testova. Najznačajnije rezultate pokazao je test UP&GO (Se=74,2%, Sp= 40%, UT= 77%), zatim MI (Se= 71.7%, Sp= 30%, UT=68.9%) a najniže vrijednosti među njima je imao TCT (Se= 52.9%, Sp= 80% i UT= 54.7%). Pokazalo se da nisu svi primenjeni testovi jedanko validni, senzitivni i specifični za procjenu funkcionalnog stanja bolesnika sa hemiparezom.*

**Ključne riječi:** procjena, mjerni instrumenti, moždani udar