ISSN 2082-369X

Przegląd Medyczny Uniwersytetu Rzeszowskiego
i Narodowego Instytutu Leków w Warszawie
Rzeszów 2014, 4, 326–333

PRACE ORYGINALNE

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Assessment of conformity and repeatability of chosen scales used for evaluation of gait after brain stroke

Ocena zgodności i powtarzalności wybranych skal stosowanych w ocenie chodu po udarze mózgu

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ABSTRACT

Introduction: Locomotor disorders at a patient after stroke significantly deteriorate his/her everyday functioning and quality of life. Improvement of gait pattern is often a crucial task in post-stroke neurorehabilitation as the ability to move unaided allows the patient to achieve the highest possible level of independence and actively participate in social life. Various measuring tools are used to evaluate the locomotor functions.

Purpose: The aim of this paper was to assess the conformity and accuracy of chosen tools (i.e. Functional Gait Assessment, Dynamic Gait Index and Wisconsin Gait Scale) enabling the evaluation of gait functions of stroke survivors.

Material and methods: The study included 30 patients with hemiparesis who had undergone a stroke once at least six months before the research. The gait function of each patient was assessed in the ten-point Functional Gait Assessment (FGA) scale, the Dynamic Gait Index (DGI) scale, the Wisconsin Gait Scale (WGS) and 10-meter walk test. Balance, however, was evaluated using the Berg Balance Scale and Get Up and Go test.

Results: The test making use of FGA proved a high level of repeatability (*p=0,64*) as well as high internal (*α=0,86*) and external (*r=0,96*) consistency of the achieved results.

STRESZCZENIE

Wstęp: Zaburzenia lokomocji pacjenta po przebytym udarze mózgu w istotny sposób utrudniają jego codzienne funkcjonowanie oraz obniżają jakość życia. Poprawa wzorca chodu stanowi często kluczowe zadanie poudarowej neurorehabilitacji, bowiem umiejętność samodzielnego przemieszczania się zapewnia osiągnięcie możliwie jak największej samodzielności oraz umożliwia pacjentowi aktywne uczestnictwo w życiu społecznym. W celu oceny funkcji lokomocyjnych konieczne staje się zastosowanie różnorodnych narzędzi pomiarowych umożliwiających ewaluację w tym aspekcie.

Cel: Celem pracy była ocena zgodności i trafności wybranych narzędzi umożliwiających ocenę funkcji chodu pacjentów po udarze mózgu, tj: Functional Gait Assessment, Dynamic Gait Index oraz Wisconsin Gait Scale.

Materiał i metody: W badaniu uczestniczyło 30 chorych z niedowładem połowiczym, którzy przebyli udar mózgu jednokrotnie, a okres od incydentu wynosił co najmniej sześć miesięcy. Funkcję chodu każdego pacjenta oceniono z wykorzystaniem dziesięciopunktowej skali Functional Gait Assessment (FGA), skali Dynamic Gait Index (DGI), Wisconsin Gait Scale (WGS), próby marszowej na dystansie 10 metrów,

Udział współautorów / Participation of co-authors: A – przygotowanie projektu badawczego/ preparation of a research project; B – zbieranie danych / collection of data; C – analiza statystyczna / statistical analysis; D – interpretacja danych / interpretation of data; E – przygotowanie manuskryptu / preparation of a manuscript; F – opracowanie piśmiennictwa / working out the literature; G – pozyskanie funduszy / obtaining funds

Artykuł otrzymano / recived: 2.07.2014 | Zaakceptowano do publikacji / accepted: 3.11.2014

The study found out significant correlation between the gait assessments conducted according to DGI and FGA scale (*r= 0,95*) and strong dependency between values of FGA and WGS (*r= - 0,75*). All correlations were statistically significant.
Conclusion: FGA, DGI and WGS scales are characterised by high internal and external conformity of results. They are good and recommended clinical tests used for assessment of gait of post-stroke patients with paresis.
Keywords: stroke, gait disorders, evaluation of disability

natomiast równowagę oceniono za pomocą skali Równowagi Berga i testu „Get up&go".
Wyniki: Wykazano wysoki poziom powtarzalności badania z wykorzystaniem FGA (*p=0,64*) oraz wysoką zgodność wewnętrzną (*α=0,86*) i zewnętrzną (*r=0,96*) uzyskanych wyników. Stwierdzono bardzo wysoką zależność pomiędzy ocenami chodu dokonanymi na podstawie skali DGI i FGA (*r= 0,95*) oraz silną zależność pomiędzy wartościami FGA i WGS (*r= - 0,75*). Wszystkie korelacje były wysoce istotne statystycznie.
Wnioski: Wyniki oceny z wykorzystaniem skali FGA, DGI oraz WGS charakteryzują się dużą zgodnością wewnętrzną i zewnętrzną wyników. Skale są dobrymi i polecanymi testami klinicznymi w ocenie chodu chorych z niedowładem po przebytym udarze mózgu.
Słowa kluczowe: udar mózgu, zaburzenia chodu, ocena niepełnosprawności

Introduction

30% of people who have experienced an acute stroke do not regain the ability to walk unaided. People with mild or moderate dysfunction can regain the ability to move independently, however, only 40% of them will be able to function independently in family and social environment [1–3]. Paresis, dysesthesia, muscle tone and visual field disorders resulting from stroke lead to various types of motor and functional disorders, gait disorders being most serious ones. Patients walk more slowly than their healthy peers and put much more effort into it. They are also in high risk of falls [4–6]. Low gait speed and its incorrect pattern often adversely influence the performance of activities of daily living.

Considering the fact that unaided walking is a determinant of independence, it significantly lowers the quality of life of patients after stroke [7–10]. In everyday clinical practice, the first question that a specialist is frequently asked by a stroke survivor and his/her family is if the patient would be able to walk independently [11]. Therefore, one of the main aims of a physiotherapeutic procedure is to improve the function of unaided and safe gait and balance [7, 12].

In case of patients after 6 months from a stroke incident, considerable change in the attitude towards the therapeutic procedure can be observed. Rehabilitation is frequently replaced by maintenance training aiming at prevention of physical activity limitation and another stroke [13]. There are, however, proofs that intensive constant task-oriented training, also in case of this group of patients [14, 15], has a positive influence on neurological deficits and activates the mechanisms of brain plasticity [16–18].

The possibility of reliable assessment of current condition is especially important in the process of physiotherapy of post-stroke patients. It is important to accurately determine both disorders and the limitations resulting from them. Therefore the measurement tools used for this purpose should characterize with reliability, accuracy and repeatability of results to pass the information on the patient between centres or share with other therapists and interpret it always in a straightforward manner [19].

The aim of this paper was to evaluate the gait of patients with hemiparesis after stroke using the Functional Gait Assessment, the Dynamic Gait Index and the Wisconsin Gait Scale and to assess the conformity and repeatability of the results achieved. The accuracy of the applied scales was also assessed by defining the level of dependency in comparison to other methods of gait and balance assessment, i.e. walk test, Get Up and Go test and Berg scale.

Material and methods

The research was conducted in a group of patients with hemiparesis who experienced stroke once no sooner than last six months. Exclusion criteria were cerebellar stroke, advanced osteoarthritis impairing gait, spastic tone of lower limb evaluated as score 2 or higher in the modified Ashworth scale and disorders of higher mental activities that prevent patients from understanding the instructions. In total, 30 ambulant patients were qualified for the research including 13 women (43.3%) and 17 men (56.6 %), the average age was 69 years of age. Left-sided paresis was present in sixteen patients (53.3%) and fourteen patients (46.6%) had right-sided paresis. 23 patients (76.6%) had undergone ischemic stroke whereas 7 patients (23.3 %) hemorrhagic stroke.

The tested patients participated in a two-week physiotherapeutic program aimed at re-education of gait functions and improvement of balance reactions. A single training consisted of active exercises of trunk and limbs, education how to stand up and sit down, balance exercises in various positions and walking exercises on a track. Each training session took form of individual work with a physiotherapist and lasted for 45 up to 60 minutes. Gait was assessed using the Functional Gait Assessment (FGA) scale, the Dynamic Gait Index

(DGI) scale and the Wisconsin Gait Scale (WGS) on the basis of records from 2 video cameras registering the gait and motor tasks. Gait speed was measured in the *walk test* and balance was assessed using Berg scale and Get Up and Go test. Functional ability, in so far as basic self-maintenance activities, was defined by means of Barthel index and the FIM scale (The Functional Independence Measure).

The assessment of gait function was performed independently by two experienced physiotherapists not participating in the program. The level of statistical significance in case of all the performed tests was assumed at $p<0.005$.

Description of the tools used in the study

The **DGI scale** (Dynamic Gait Index) consists of 8 tasks, i.e.: walking forward, walking task by changing walking speeds, walking with head turns both horizontally and vertically, pivoting while walking, walking while stepping over and around obstacles, stair climbing. Each activity was scored from 0 to 3. Maximal score of 24 points indicates normal gait [20].

The **FGA scale** (Functional Gait Assessment) has 7 tasks in common with the DGI scale and three new tasks, including gait with narrow base of support, ambulating backwards, and gait with eyes closed [21]. Each item is scored on a scale from 0 - 3. Higher score indicates normal gait. Parallel to gait, the FGA scale evaluated balance dysfunctions on the basis of deviation from movement direction during the performed tasks [22].

The **WGS scale** (Wisconsin Gait Scale) indicates the clinical characteristics of gait pattern [23]. It was elaborated to visually evaluate the gait of people with post-stroke hemiparesis. It consists of 14 observable measurements of disorders of gait phases connected with clinical symptoms divided into four submeasures. The grading scale, which is a sum of submeasures, ranges from 13.35 to 42 points, the higher the score the more seriously affected the gait.

Berg balance scale consists of 14 balance related tasks evaluated in the scale from 0 to 4 points. Maximal number of points (56 points) indicates proper balance [24].

Gait speed was assessed by means of **10-meter-long walk test**. Subjects walked with chosen velocity starting the gait ahead of the line indicating the 10 meter distance. The time measurement was started after the subject crossed the start line and stopped after crossing the finish line. The subject turned around and walked again, as instructed. The results consisted of the average value of the results in both tests.

Get Up and Go Test is used to assess balance and detect the risk of falling in a group of elderly people and people with neurological disorders. The patient's task is to get up from a chair without help, walk a 3-meter distance and get back to the sitting position. The measure is the time necessary to complete this task.

Barthel Index is used to assess the level of independence of patients with hemiparesis. It measures the performance in daily life activities scored from 0 to 3 points [25]. There are many modifications of this scale suggested by many authors. Changes concern among others grading system and the number of evaluated motor tasks [26].

The **Functional Independence Measure** (FIM) is a six-score scale of patient's independence in daily life activities. 18 motor tasks connected among others with self-service, communication and locomotion are evaluated. The maximum number of points is 7 and it indicates that the patient is completely independent [27].

Results

The analysis of results evaluated internal and external conformity of FGA, DGI and WGS scales. Internal conformity was evaluated by Cronbach's alpha coefficient, whereas external conformity by Bland-Altman graphical analysis and Spearman's correlation coefficient.

Two assessments of efficiency performed by two physiotherapists were compared in the evaluation of external conformity, however, in case of the evaluation of internal conformity, the results were compared independently for each therapists. It was assumed that the scale is internally compliant when Cronbach's coefficient amounts to at least 0.70.

The analysis of data revealed a very high internal conformity of FGA scale- Cronbach's alpha coefficient was 0.92 (in case of each assessing therapist) (Tab. 1).

The highest results were achieved for constituents no. 1, 4 and 5, and the lowest scores were granted for constituent no. 7 (on the average 1.10 points in case of the first therapist and 1.03 in case of the second one). The values of Cronbach's coefficient achieved after elimination of each considered constituent did not change significantly oscillating between 0.91 and 0.92.

The evaluation of external conformity was conducted by means of comparison of efficiency in FGA scale performed independently by both therapists. Table 4 presents values of descriptive statistics of evaluations conducted by both therapists and analogical listing of differences between evaluations performed by therapist 2 and therapist 1. Difference in evaluation of the entire population assessed by Wilcoxon's test was at the edge of statistical significance (p minimally above 0.05) which may indicate that the therapist 2 had a tendency to underrate. Spearman's rank correlation coefficient of two evaluations performed by both therapists was very high ($R = 0.99$) and very significant statistically.

The value of Cronbach's alpha coefficient was 0.91(for each examiner) (Tab. 2) in the evaluation of internal conformity in DGI scale. The average value of assessments given by both therapists was almost identical (Wilcoxon's test $p=0.2013$). What is more, there was also really high correlation between the results ($R = 0.99$). The maximal

Tab.1. Evaluation of internal conformity of FGA scale

FGA scale constituents	Therapist no. 1			Therapist no. 2		
	$\bar{x}$	*s*	Cronbach's alpha	$\bar{x}$	*s*	Cronbach's alpha
1	1.93	0.69	0.92	1.90	0.71	0.92
2	1.83	0.70	0.92	1.73	0.74	0.91
3	1.93	0.69	0.91	1.87	0.68	0.92
4	2.03	0.85	0.92	1.87	0.86	0.92
5	1.83	0.87	0.91	1.90	0.88	0.91
6	1.73	1.01	0.92	1.77	1.04	0.91
7	1.10	1.06	0.91	1.03	1.07	0.92
8	1.27	0.83	0.92	1.30	0.84	0.92
9	1.53	0.82	0.91	1.53	0.82	0.91
10	1.53	0.63	0.92	1.53	0.63	0.92
In total	16.7	6.4	0.92	16.4	6.5	0.92

* FGA – Functional Gait Assessment

Tab. 2. Evaluation of internal conformity of DGI scale

DGI scale constituents	Therapist no. 1			Therapist no. 2		
	$\bar{x}$	*s*	Cronbach's alpha	$\bar{x}$	*s*	Cronbach's alpha
1	1.93	0.69	0.89	1.90	0.71	0.90
2	1.83	0.70	0.90	1.73	0.74	0.90
3	1.93	0.69	0.89	1.87	0.68	0.90
4	2.03	0.85	0.90	1.87	0.86	0.91
5	1.83	0.87	0.89	1.90	0.88	0.90
6	1.73	1.01	0.89	1.77	1.04	0.90
7	2.37	0.72	0.89	2.43	0.73	0.90
8	1.53	0.63	0.90	1.53	0.63	0.91
In total	15.2	4.8	0.91	15.0	5.0	0.91

* DGI – Dynamic Gait Index

Tab. 3. Evaluation of internal conformity of WGS

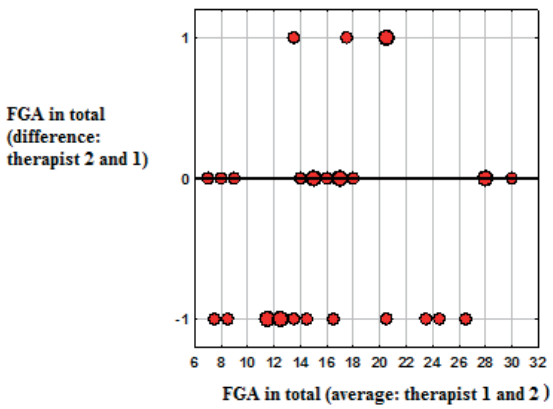
WGS scale constituents	Therapist no. 1			Therapist no. 2		
	$\bar{x}$	*s*	$\bar{x}$	*s*	$\bar{x}$	*s*
1	1.18	0.88	0.90	1.10	0.79	0.90
2	1.43	0.68	0.90	1.33	0.55	0.90
3	1.27	0.45	0.90	1.27	0.45	0.90
4	1.50	0.56	0.91	1.48	0.57	0.91
5	1.27	0.58	0.90	1.13	0.35	0.91
6	1.53	0.68	0.90	1.50	0.63	0.90
7	1.73	0.64	0.90	1.70	0.60	0.91
8	1.93	0.64	0.89	1.87	0.68	0.89
9	1.67	0.71	0.89	1.60	0.67	0.90
10	1.87	0.73	0.90	1.77	0.63	0.90
11	2.10	0.80	0.90	2.03	0.72	0.90
12	1.30	0.65	0.90	1.30	0.65	0.90
13	1.90	0.48	0.90	1.83	0.46	0.90
14	1.77	0.57	0.89	1.80	0.61	0.90
In total	22.4	6.2	0.91	21.7	5.7	0.91

* WGS - Wisconsin Gait Scale

Tab. 4. Evaluation of conformity of result in assessment of two examining physiotherapists

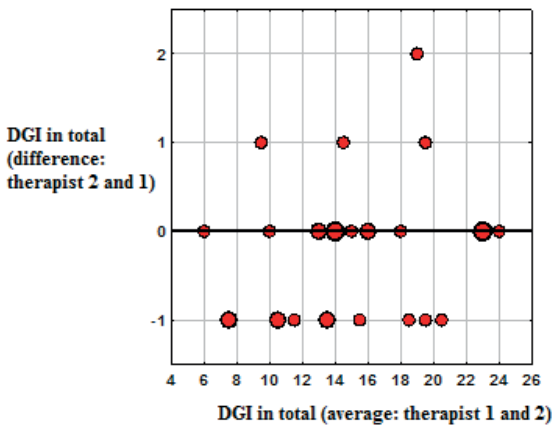
scale	examiner	$\bar{x}$	Me	*S*	Min	max	p	R
FGA	therapist 1	16.7	15.5	6.4	7	30	0.0552	0.99***
	therapist 2	16.4	15.5	6.5	7	30		
	therapist 1 vs. therapist 2	-0.3	0.0	0.7	-1	1	0.0552	0.99***
DGI	therapist 1	15.2	14.0	4.8	6	24	0.2013	0.99***
	therapist 2	15.0	14.5	5.0	6	24		
	therapist 1 vs. therapist 2	-0.2	0.0	0.8	-1	2	0.2013	0.99***
WGS	therapist 1	22.4	22.5	6.2	13.4	38.3	0.0016**	0.97***
	therapist 2	21.7	22.2	5.7	13.4	35.7		
	therapist 1 vs. therapist 2	-0.7	-0.1	1.0	-2.6	1.0	0.0016**	0.97***

* FGA – Functional Gait Assessment * DGI – Dynamic Gait Index * WGS – Wisconsin Gait Scale



* FGA - Functional Gait Assessment

Fig. 1 Analysis of conformity of evaluations according to FGA scale by Blant-Altman



* DGI- Dynamic Gait Index

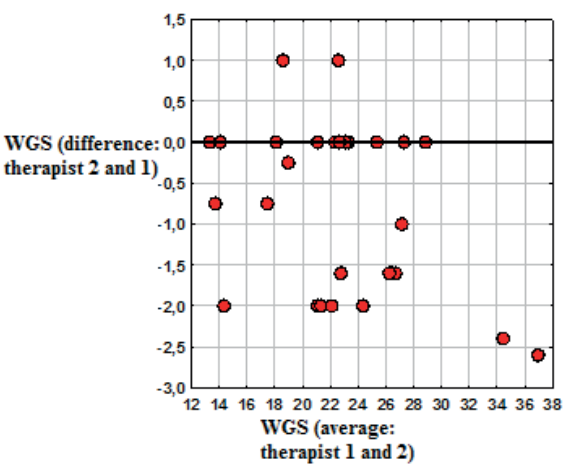
Fig. 2 Analysis of conformity of evaluations according to DGI scale by Blant-Altman

difference between results achieved by both examiners was 2 points.

Cronbach's alpha coefficient was 0.91 (Tab. 3) in evaluation on the basis of WGS scale. The assessment of external conformity revealed very high level of conformity between the therapists' evaluations (*R=0.97*). The result of Wilcoxon's test (*p=0.0016*) indicated certain systematic deviation in evaluations conducted by therapist no. 2. These differences, however, were not distinct as they amounted maximally 2.6 points, which constituted less than 10% of the average level of both scales (Tab. 4).

The analysis of external conformity of all scales (FGA, DGI, WGS) according to Blant-Altman was graphically presented on Fig. 1, 2 and 3 as a difference between evaluations in both examinations (therapist 1 and therapist 2) in comparison to the average value of measurement for each patient.

Analysis of dependency of efficiency evaluated according to FGA scale and for other two scales was conducted using Spearman's rank correlation coefficient.



* WGS - Wisconsin Gait Scale

Fig. 3 Analysis of conformity of evaluations according WGS scale by Blant-Altman

The analysis was conducted independently for evaluations of both physiotherapists. Very high dependency between gait assessments conducted on the basis of DGI and FGA scales (*r= 0.95*) was stated, as well as strong dependency

Tab. 5. Level of correlation of assessment according to DGI, FGA, WGS scales in comparison with balance assessment in Berg's scale, result of Get Up&Go test and gait speed

Correlation analisys (*R*)	Berg's scale	V (gait speed)	Get Up&Go Test
DGI	0.53**	0.60***	-0.73***
FGA	0.57***	0.57***	-0.65***
WGS	-0.78***	-0.63***	0.88***

* FGA – Functional Gait Assessment * DGI – Dynamic Gait Index * WGS – Wisconsin Gait Scale

between values of FGA and WGS (*r= - 0.75*). All correlations are very significant statistically.

Analysis of conformity of result of gait evaluation by DGI, FGA and WGS scale with other gait and balance measurement tools was conducted on the basis of evaluation of correlation of results achieved during evaluation by Berg's scale and during Get Up and Go test. It was stated that the strongest dependency concerned the parameters of efficiency tested on the basis of WGS and Get Up and Go test. Moreover, WGS Index was strongly connected with Berg's scale values. Other evaluated correlations were also statistically significant and were characterized by at least average strength (Tab. 5).

Dependencies between results achieved for FIM scale and gait evaluation conducted on the basis of FGA, DGI and WGS scale were also considered. Results achieved by the 1st therapist were considered again. Strong correlation between values of FIM and WGS scale (*r=- 0.84*) was observed. Two other scales hand (DGI and FGA) on the other connected with FIM scale (*r=0.59; r=0.56*) to a moderate extend.

Discussion

Objective evaluation of condition of the patient after stroke is connected with the necessity to constantly keep medical records considering all functional problems of the patient. It is the basis for making a prognosis and observe of the effects of rehabilitation. Computer based systems of movement analysis, dynamometric platforms, electromyography or video records used for that purpose, enable precise evaluation of parameters of gait function at people after stroke, which is considerably impaired in majority of cases [28, 29]. The basic drawback of the above mentioned measurement devices is the fact that they are time consuming and expensive what often disqualifies the use of them in everyday clinical practice. What is crucial is fast evaluation as well as simplicity, repeatability and sensitivity of measurement tool that enables recognition of changes in further stages of treatment and rehabilitation. It is very difficult to create single method of patients' evaluation. Therefore, various observation methods characterized by certain margin of error resulting from subjectivity of such methods are usually used in clinical practice. The level of reliability of clinimetric methods commonly used at post-stroke patients and the analysis of conformity of results of particular scales is often a subject of scientific research [30-33].

Evaluation of locomotor functions is one of the most important research elements in physiotherapeutic practice. It can be performed among others during the gait test on a defined distance (so called walk test) when time of the task and number of steps are measured, and 2, 6 or 12-minute walk test checking the efficiency of gait. Get Up and Go test is also useful for functional evaluation as it includes the assessment of gait and balance [34]. Conformity of results of 6 different functional tests of gait (among others Get Up and Go test and 6-minute walk test) was studied by Swedish scientists, i.e. Flansbjer, Holmback, Downham et.al. The analyses of chosen gait tests conducted twice with a week interval on the group of 50 people with post-stroke hemiparesis indicated that the differences between all 6 analysed tests ~~was~~ were less than 6% [35].

However, these tests do not provide complex information on gait disorders at a given patient, as they only evaluate chosen constituents of this function. Apart from assessing time-spatial parameters of gait, a physiotherapist requires also to recognise the scope of its functionality and conduct a comparative qualitative analysis [36-38]. In such case, numeric scales used for assessment of locomotor and balance functions in stroke survivors are a useful complementation. These are among others DGI, WGS and FGA - applied in this research.

The conformity and reliability of FGA scale was evaluated by Thieme et.al. in the assessment of 28 patients with post-stroke paresis. The researchers proved very high internal (0.97) and external (0.94) conformity of the conducted evaluation. What is more, significant dependency between evaluation in FGA, the result of balance evaluation in Berg's scale, speed gate and functional efficiency was observed [39].

Use of DGI scale for evaluation of gait ability was supported by the recent scientific research conducted, among others, by Tuomel, Paltama and Hakkinen. The analyses of Finnish researchers confirmed high internal (0.90) and external (0.91) conformity of DGI scale [39]. Similar conclusions were drawn by Jonsdottir and Cattaneo who evaluated the gait of 25 postictal patients with help of two independent examiners. Very small difference in evaluations (0.42+/- 1.33) and good correlation of DGI with other measurement scales for balance and motor functions among others Get Up and Go test and 6-minute walk test were stated [41].

The gait analyses with use of Wisconsin Gait Scale (WGS) conducted in Turkey on 35 patients with hemiparesis after stroke also confirmed the sufficient sensitivity of the device used for the recognition of patient's functional progress in the scope of locomotion [35]. Pizzi, Carlucci et.al. indicated other benefits of use of Wisconsin Gait Scale concerning among others planning of individual rehabilitation programs, monitoring of detailed progresses of the patient, good availability and lack of additional costs [42].

The authors' own research and reports of other authors confirm the fact that FGA, DGI and WGS scales are good and recommended clinical tests for evaluation of gait of the patients with hemiparesis after stroke and that they can be successfully used in everyday clinical practice.

Conclusions

FGA (Functional Gait Assessment), DGI (Dynamic Gait Index) and WGS (Wisconsin Gait Scale) scales are characterized with high internal and external conformity of results, which proves high level of their reliability and repeatability. The scales are good and recommended clinical tests for evaluation of gait of patients with post-stroke hemiparesis.

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