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Improving dynamic balance by means of Functional Gait Assessment (FGA) in the acute phase of neurorehabilitation in neurosurgical patients

Izboljšanje dinamičnega ravnotežja z uporabo lestvice za oceno funkcionalnosti hoje (FGA) v fazi akutne nevrorehabilitacije pri nevrokirurških bolnikih

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Abstract

Background: During the acute phase of neurorehabilitation patients after neurosurgical operations often suffer from balance disorders – both static and dynamic. Functional Gait Assessment Scale (FGA) enables the evaluation of dynamic balance during walking and it is suitable for the evaluation of specific complex movements and appropriate balance responses. The aim of the study was to establish the level of improvement as regards the dynamic balance in patients after the removal of a vestibular tumour, using the FGA as a practice tool during hospitalization.

Methods: The study was prospective. Ten patients after surgical removal of a vestibular tumour were enrolled. All were able to follow instructions, achieved more than 25 points on the Mini Mental Test and had an evaluation on the Barthel Index of over 8 points. During hospitalization, all the patients were included in individually prepared balance programmes, with an emphasis on different functional and cognitive tasks that are included in the FGA. The FGA was used as an effective prac-tice tool. As a measuring tool to assess dynamic balance, the FGA was used at discharge and again 3 months after discharge from the hospital. The patients were discharged to their homes. They were given written instructions and exercises recorded on DVD for home practice after discharge.

Results: The average age of enroled patients (6 females, 4 males,) was 39.5 years (18–57 years). The average duration of hospitalization was 10.5 days (7–14 days). On the FGA, six patients achieved a score of 8–14/30 and four patients a score of 16–20/30 at discharge. This shows moderate to severe disorders of dynamic balance. Three months after discharge, seven patients achieved more than 22 points (22–24/30) meaning they had a mild dynamic balance disorder and three patients achieved less than 22 points (14–18/30) meaning they had a moderate to severe dynamic balance disorder. That is why these three patients needed surveillance and help from other people while walking. In our research, 70% of patients over-came the minimal calculated change of 4 points on FGA scale, which shows an improvement of dynamic balance.

Conclusion: The results of the research show an improvement in dynamic balance. The FGA was shown to be an excellent practice tool for both establishing the existence of a dynamic balance disorder as well as improving dynamic balance, which in turn has beneficial effects on specific movement abilities and thus makes the patient's functioning at home easier.

Izvleček

Izhodišče: V akutni fazi nevrorehabilitacije imajo bolniki po nevrokirurških posegih pogosto motnje statičnega kot tudi dinamičnega ravnotežja. Lestvica za oceno funkcionalnosti hoje (angl. FGA) omogoča oceniti dinamično ravnotežje med hojo in je primerna za izvajanje specifičnih kompleksnih gibalnih spretnosti in temu primernih ravnotežnih odzivov. Namen raziskave je ugotoviti stopnjo izboljšanja dinamičnega ravnotežja pri bolnikih po odstranitvi vestibularnega tumorja z uporabo lestvice za ocenjevanje funkcionalnosti hoje, ki smo jo uporabili kot vadbeno orodje v času hospitalizacije.

Metode: V prospektivno raziskavo smo vključili 10 bolnikov po kirurški odstranitvi vestibularnega tumorja, ki so bili sposobni slediti navodilom in so na Kratkem preizkusu spoznavnih sposobnosti (KPSS) dosegli več kot 25 točk od 30 možnih in dobili oceno po indeksu Barthelove več kot 8 od 20 točk. Med hospitalizacijo smo vse bolnike vključili v individualno prilagojeni program ravnotežnih spretnosti s poudarkom na različnih funkcijskih in kognitivnih nalogah, ki jih vključuje lestvica FGA, in jo uporabili kot učinkovito vadbeno orodje. Kot merilno orodje pa smo lestvico FGA uporabili za oceno dinamičnega ravnotežja ob odpustu bolnikov iz bolnišnice v domače okolje in ponovno po treh mesecih od odpusta. Bolniki so dobili tudi pisna navodila in posnetke vaj na DVD- ju za ustrezno nadaljevanje izvajanja dejavnosti v domačem okolju.

Rezultati: Povprečna starost vključenih bolnikov (6 žensk, 2 moška, 2 najstnika) je bila 39,5 let (razpon 18–57 let). Hospitalizacija je povprečno trajala 10,5 dni (razpon od 7 do 14 dni). Šest bolnikov je ob odpustu iz bolnišnice po lestvici FGA dobilo oceno od 8–14/30, štirje bolniki pa vrednosti 16–20/30, kar kaže na prisotnost zmernih do hudih motenj dinamičnega ravnotežja. Tri mesece po odpustu je 7 bolnikov doseglo več kot 22 točk (od 24–28/30), kar pomeni, da so imeli blage motnje dinamičnega ravnotežja, 3 bolniki so dosegli manj kot 22 točk (od 14–18/30), kar pomeni, do so imeli med hojo zmerne do hude motnje dinamičnega ravnotežja, zato so potrebovali nadzor ali pomoč druge osebe. V naši raziskavi je minimalno izračunano zaznavno spremembo 4 točke po FGA preseglo 70 % bolnikov, kar kaže na izboljšanje dinamičnega ravnotežja.

Zaključek: Lestvica za oceno funkcionalnosti hoje se je izkazala kot odlično vadbeno orodje za odkrivanje motenj in izboljšanje dinamičnega ravnotežja, ki ugodno vpliva na specifične gibalne spretnosti in tako olajša bolnikovo delovanje v domačem okolju.

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1 Introduction

Vestibular schwannomas or acoustic neurinomas are benign tumors of the balance nerve sheath, which with growth increasingly put pressure on the balance nerve and gradually destroy it (1,2). This results in balance difficulties (3,4), and with tumor growth other neurological symptoms, such as varying degrees of motor or sensory failure, often occur as well (5,6). Treatment of vestibular schwannomas can be surgical or with a so-called gamma-knife or cyber knife, which destroys the feeding vessels of the tumor and causes the least collateral damage; however, there are no reasonable guarantees that tumors will not grow back in the future (7,8).

Three methods of surgical removal of

tumors are known, and in no method does hearing improve, but it even worsens or is completely destroyed. In all of them, the balance nerve is also permanently damaged (8,9).

Early medical rehabilitation of hospitalized patients is initially focused on the assessment of cognitive (10), sensory and somatosensory abilities (11,12), on the prevention of secondary complications (13), the improvement of sensory motor skills, the interaction of postural control and selective movements to establish coordinated movement patterns and on making patients independent in performing basic daily activities (14,15).

For physiotherapy, it is very important to choose appropriate measuring tools, with which we can identify and assess impaired sensory-motor systems that affect the patient's reduced balance ability sitting, standing and walking (16).

Assessment is also important for selecting appropriate mobility aids, for effectively planning therapeutic procedures, for identifying safe or dangerous physical activities after the impairment, and for measuring the outcome of rehabilitation. At the same time, an appropriate quantitative tool helps to detect changes in the functional status of the hospitalized patient and, if necessary, to adjust the treatment according to the measurement results (17).

Assessing the ability to walk in patients in the initial phase of recovery is part of the activity-level assessment tools such as the Barthel Index (BI). However, this scale does not provide sufficient data to plan treatment and measure the outcome of rehabilitation (18,19). As walking is an activity that is strongly affected by balance, it is necessary to check the patient's balance in order to assess or predict the ability to walk independently as quickly as possible (20).

Physiotherapeutic treatment, in addition to the assessment of the patient's sensory and motor systems, mainly includes the evaluation of the patient's balance impairment.

To assess static balance, the literature mentions the use of the Berg Balance Scale (hereinafter BBS), which has good psychometric properties. In the acute period, however, the use of the scale is less appropriate due to the large amount of time spent on assessment, which is too strenuous for patients in the early stages of recovery because it requires a high level of cognitive ability and attention. Another problem is that the BBS consists of 14 tasks at 5 levels, in which the outcome criteria differ. This can lead to evaluation problems if evaluators have less experience. The third problem is the extremely high internal coherence, which indicates that in order to improve the sensitivity of the scale, it would be necessary to change some evaluation criteria or reduce the number of points in the evaluation of individual movement tasks by one point. This would make it a four- instead of a five-level scale (20,21).

More and more authors are proposing the use of tools for functional gait assessment, which is made possible by the Functional Gait Assessment (FGA) scale, providing quantitative as well as qualitative gait data (22,23). Posture control includes various reactions to external disturbances, expected posture adjustments to interferences caused by one's own movements (lifting loads), and dynamic balance while walking. Until recently, clinical balance tests have not systematically assessed all of these areas. FGA meets extensive measurement requirements for dimensionality, quality of assessment categories, construct validity and reliability indexes, and assesses dynamic balance (24).

The aim of the study was to determine whether the use of tasks that are part of FGA assessment in the period of early neurorehabilitation treatment improves the dynamic balance in patients with balance disorders after surgical removal of the vestibular tumor.

2 Methods

2.1 Subjects

In the early postoperative period, 10 patients were included in the study after having vestibular tumors surgically removed. All had moderate to severe disorders of static and dynamic balance in sitting and standing position and while walking. The following criteria were met for the inclusion in the study: condition after the first surgery of the pontocerebellar part of the brain (benign vestibular schwannomas), ability to follow instructions and ability to participate (more than 25 points out of a maximum of 30 according to the Mini Mental Test) (10), ability to walk with the help of a therapist or a suitable device for 6 m and at least partially preserved functional ability (more than 8 points out of a maximum of 20 according to BI) (19).

All patients were informed of the importance of the study and gave their written consent. The research was approved by the Ethics Committee of the Ministry of Health, and the principles of the Declaration of Helsinki on Biomedical Research involving human subjects as well as the principles of the Slovenian Code of Medical Deontology were taken into account.

2.2 Implementation

Assessment and treatment of patients after having vestibular schwannomas surgically removed initially took place in the Intensive Care Unit at the Clinical Department of Neurosurgery, University Medical Center Ljubljana. Regarding the patient's initial objective condition, the physician, a specialist in physical medicine and rehabilitation, first assessed in the days right after surgery the patient's ability to cooperate according to the Mini Mental Test, and together with the occupational therapist and physiotherapist, evaluated the patient's level of functional independence according to BI (19). The initial assessment of the patient's static balance was performed in a sitting and standing position, and based on the initial assessments of static balance, the degree of balance impairment was evaluated and included individually in specifically targeted rehabilitation programs with emphasis on improving dynamic balance during walking. For this purpose, we used a standardized four-level FGA scale, translated into Slovenian (22,23), which evaluates walking on an even surface, changing the walking speed, walking with horizontal head turns, walking with the head tilted in the vertical direction, walking and turning on the spot, stepping over obstacles, walking with a narrow base of support - tandem walking, walking with eyes closed, walking backwards and stair climbing. A score of 0 indicates severe impairment of dynamic balance, a score of 1 indicates moderate impairment of balance, a score of 2 indicates mild impairment of dynamic balance, and a score of 3 indicates no impairment of balance. Given that balance is not an independent function, but is associated with different motor and cognitive tasks that can compete for the patient's attention, balance-oriented exercise should be designed to be as specific and functional as possible. Therefore, we have included FGA tasks in the balance program of patients, as with their help we discover and therefore influence and improve the patient's intrinsic factors, such as sensory flow, muscle performance, mobility, and cognitive and emotional factors and extrinsic factors of the environment in which movement takes place. After having vestibular tumors surgically removed, patients have persistent headache, dizziness, and nausea. In addition, they have a completely impaired sense of body orientation in space, are completely deaf in one ear, have half of their face paralyzed, are incapable of normal eating, swallowing, normal facial expressions and have unintelligible speech. They also have very poor vision or no vision at all in one eye, which is extremely painful, itchy and sensitive to strong light. Due to their relatively low

level of self-confidence and high cognitive difficulty, as well as paying attention to the balance tasks included in the FGA scale while walking, patients were often tired during therapeutic exercises, so throughout the hospitalization we individually adjusted the frequency and intensity of therapeutic procedures according to their well-being and motivation.

In order to perform the tasks, we prepared, developed and marked the FGA functional line in accordance with standardized rules. We used a 6-meter rubber pad that was properly measured and marked with red vinyl tape, we made a wooden low and high barrier, we used hospital stairs and a stopwatch. The patients were trained to perform the tasks on a daily basis throughout the hospitalization. Some of these tasks are shown in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6.

The first FGA scores were obtained in patients immediately upon discharge to the home environment. At that time, everyone was also given appropriate and thorough instructions and advice on performing balance exercises in printed and multimedia DVD format. We shot the DVD film with background music in the outdoor environment by the sea and thus tried to bring them closer to performing balance activities every day. We invited them for retesting in three months. All patients responded to the invitation.

3 Results

The study involved 10 patients who were admitted to the Department of Neurosurgery at the University Medical Center Ljubljana in the period from January 2014 to June 2016 due to the planned surgical removal of the vestibular schwannoma. Among the patients included were 6 women and 4 men. Hospitalization time ranged from 7 to 14 days, averaging 10.5 days. The mean age of the patients was 39.5 ranging from 18 years to 57 years. Five patients had left-sided hemisymptoms, four patients showed signs of right-sided hemisymptoms, and one patient had no lateralization. Visual and auditory impairment was present in all patients, with 5 patients having left-sided facial muscle paralysis and left ear deafness, 4 patients having right-sided facial muscle paresis and right ear deafness, and 1 patient hav-

Figure 1: Walking on an even surface.

Figure 2: Walking backwards.

Figure 3: Walking over obstacles.

Figure 4: Walking with horizontal head turns.

Figure 5: Walking with eyes closed.

Figure 6: Walking in a straight line – tandem walking.

ing double vision and hearing loss in the left ear. Impairment of the proprioceptive system in the form of non-perception of body position and movement and body segments was present in two patients. Despite all the listed impairments of the sensory systems, except for fatigue, none of them mentioned any problems during the implementation of the activity and all of them successfully completed the tests and actively participated in the implementation of the rehabilitation program. None of them fell during the hospitalization. Figure 7 shows the number of patients who needed supervision, physiotherapist's assistance, or various walking aids at the first FGA assessment for safe walking, as well as reduction of the need for walking aids at the second assessment three months later.

Figure 8 shows a comparison of the FGA scores achieved during the first and second tests. Individual analysis of the results of FGA tasks at the first test showed that all patients had severe proprioceptive system disorders (walking backwards, tandem walking, walking with eyes closed and stepping over obstacles) and moderate to severe impairment of the vestibular system (walking with horizontal and vertical head turns). 6 patients received a score of 8–14/30 on the FGA scale, indicating moderate to severe impairment of dynamic balance. According to the FGA scale, 4 patients achieved 16–20/30, which still meant that the patients had moderate impairments of dynamic balance.

At retesting three months after discharge, seven patients scored more than 22 points (24–28/30), indicating that they had mild impairments of dynamic balance. From the subjective conversation with patients, we concluded that they still have minimal disorders of the proprioceptive and vestibular system, especially with rapid turning of the head and body and with multiple bending and increased fatigue with simultaneous divided attention and increased cognitive control during walking and daily activities. Three patients scored less than 22 points (14–18/30), indicating that they were still at high risk for falls and had moderate to severe disturbances of dynamic balance while walking. Therefore, they needed the supervision or help of another person. These patients continued to report severe to moderate disorders of the proprioceptive and ves-

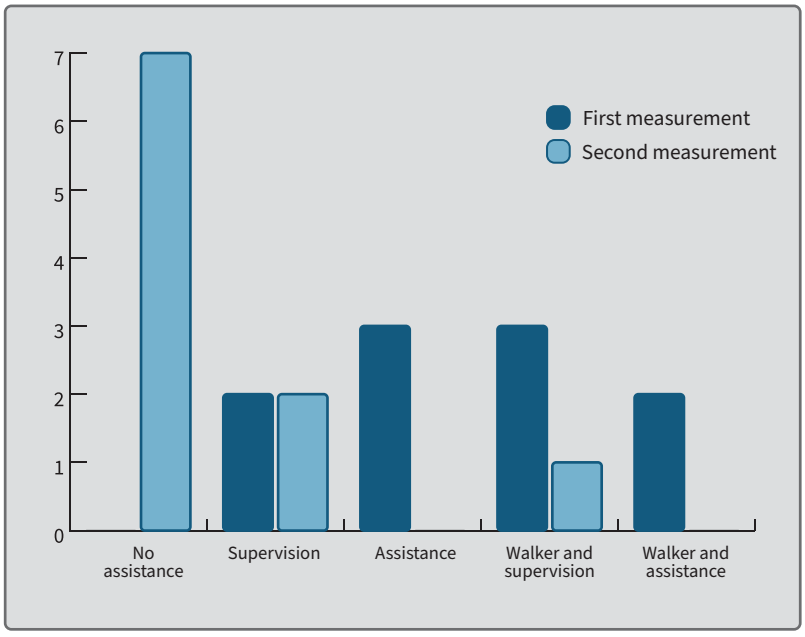

Figure 7: Comparison of gait independence at discharge and after three months.

tibular systems, particularly when walking with the head turned vertically and horizontally, when stepping over obstacles, walking backwards, and when walking with eyes closed. Tandem walks were not possible.

4 Discussion

Regaining the ability to walk independently and safely is the most important goal of rehabilitation for most patients in the hospital early after surgery, as it has a decisive impact on their work, integration into society and quality of life. Balance disorders during walking are one of the most important risk factors for falls, and at the same time, especially in the early hospital period, they affect the low level of mobility, which leads to reduced cardiovascular capacity and further deterioration of functional status (25). Assessment of balance with appropriate functional tests is crucial for the precise identification of the patient's impaired motor and sensory body systems, their degree of balance impairment, and their response to individually prepared rehabilitation procedures (26). Most of the tests established so far are suitable for assessing balance reactions in a sitting and standing position, and only a few assessment instruments are suitable for assessing dynamic balance while walking (27).

In our study, we used the direct assessment method according to the authors' instructions, with one investigator taking care of safety and security while performing FGA tasks, another being a direct assessor, and a third documenting it all with a video camera. Based on the videos, all three investigators re-evaluated the patients and agreed on the final evaluation. Thieme and colleagues found in their research, while assessing the adequacy of the German translation of FGA in stroke patients by analysing the results of their assessors, excellent agreement between them and realised that the choice of direct assessment or assessment by video observation and assessment does not affect the result (28).

In patients, their static or dynamic balance can be assessed. A BBS is commonly used to assess static balance. Most recent research confirms the opinions of various authors. These report that the assessment of balance with BBS has to do with the ceiling effect, which means that the scale is not sensitive to the risk factors for falls that occur during functional walking, such as, for example, walking around or over obstacles, changing the direction of walking, requirement of divided attention. Thus, Franchignoni and colleagues have already identified potential risk factors for falls in healthy older people (24); Leddy and colleagues also report a high risk of falls in patients with Parkinson's disease, especially in those who scored high on the BBS (25). Similar findings were reported by Wrisley and colleagues who assessed the degree of imbalance in patients with vestibular disorders (22) and by Thieme and colleagues in the assessment of patients post stroke when determining correlations between BBS and other assessment tools. (28).

According to these studies, the short

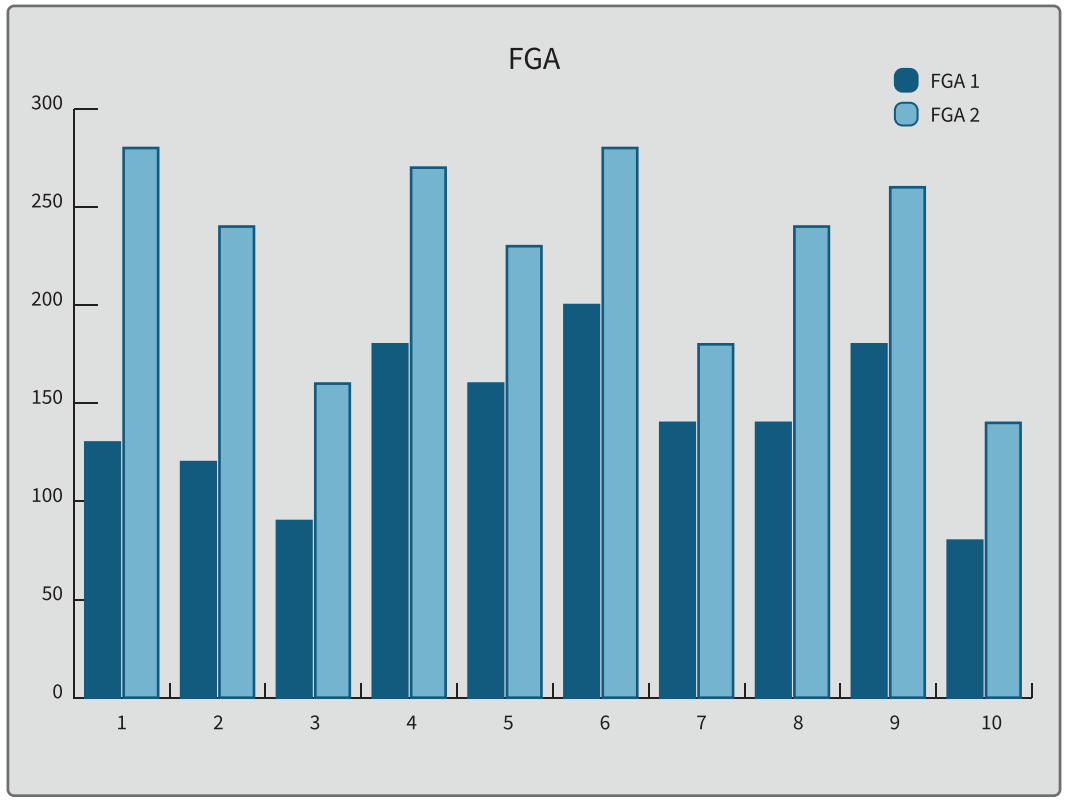

Figure 8: Comparison of FGA scores for each patient at the first and second tests.

hospital stay after surgery (our patients had a hospitalization time of 7–14 days), their extensive imbalance impairments, and the fact that patients are mostly left to fend for themselves after discharge from the hospital, with no option for any appropriate further rehabilitation, the members of the entire rehabilitation team focused all our energy on improving their functional gait and thus effective participation in the home environment. We analysed the assessments of FGA tasks in order to determine in which areas the patient has the most problems. The entire individually prepared program was focused on the areas where the most problems with dynamic balance could be detected. Prior to discharge from the hospital, we also invited the patient's relatives for an individual interview. We reminded them of the internal and external environmental risk factors for falls in written and multimedia form (DVD) with all relevant advice and guidance. We gave them exercises to improve balance in sitting and standing position and while walking. The specificity of balance training was based on the principle of the autonomous phase of motor learning, the ability to focus on the inflow from the proprioceptive system and the ability to implement motor strategies that would become almost completely automatic after prolonged repetition, but with the least level of cognitive control. From this, we concluded that patients will be able to transfer newly learned movement strategies from exercises to everyday life. For better physical well-being, we also suggested recreational activities, such as dancing, yoga or walks in nature in good company.

Based on the assessment of healthy elderly individuals, Wrisley and colleagues considered that the increased risk of falls and thus the presence of disturbances of dynamic balance was indicated by a total FGA score of less than 22 points, as they correctly predicted 6/7 falls within

6 months after the assessment, and also proved that FGA strongly correlates with BBS (r = 0.84) (22,23). In contrast, Leddy and colleagues found that those most at risk for falls were those with Parkinson's disease who scored less than 15 points out of a maximum of 30 according to the FGA, and estimated the accuracy of the prediction at 80% (25).

We talk of severe or moderate impairment of dynamic balance when most of the balance tasks included in the FGA scale are rated with points 0 and 1, or when the total number of FGA points is less than 15 points out of a maximum of 30. We talk of moderate and mild disturbance of dynamic balance when the total number of FGA points is more than 15 and most of the movement balance-based FGA tasks are evaluated with points 1 or 2. Based on the results of our study, therefore, 60% of patients had severe to moderate disturbances in dynamic balances and were therefore dependent on a device or assistance from one person, and 40% of patients had mild to moderate balance disorders and were independent in walking on shorter distances, and when walking longer distances they needed the supervision of one person.

After three months, all patients were invited to the Institute of Medical Rehabilitation, where we re-evaluated the functionality of walking with FGA. Assessments show an improvement in dynamic balance, 70% of the included patients exceeded 22 points out of a maximum of 30 and were independent in daily activities and reported minimal disturbances in balance while walking, but with rapid turning of the head and body in all directions and multiple bending. 30% of the included patients improved their dynamic balance, but did not exceed 22 points out of a maximum of 30. FGA scores also improved by more than 15 points. For a clinically relevant change in FGA in patients post stroke, Lin and colleagues suggested 5 points (20). Beninato and colleagues, who compared the effects of exercises for improving balance on a sample of 135 healthy people, also found the minimal detectable change important to improve dynamic balance, to be 5 points on the FGA scale (29).

A clinically relevant change between the two FGA scores showing improvement in dynamic balance is 5 points (26,29). The results of our study show the minimal detectable change between the first and second assessment according to FGA to be 4 points, and the average score difference was 8.6 points. 70% of patients exceeded the minimal detectable change, thus improving dynamic balance, and 30% did not make sufficient progress. Despite the small number of patients included in our study, we can conclude that an individually prepared program for performing tasks that are part of FGA already at the time of hospitalization and appropriate follow-up guidelines after discharge is a suitable way to improve dynamic balance in patients with walking difficulties. It should be part of any neurorehabilitation treatment.

5 Conclusion

The Functional Gait Assessment (FGA) is an excellent exercise tool in the early postoperative period for detecting and improving dynamic balance and for transferring specifically learned motor skills from the hospital to everyday life activities. As a measuring tool, due to its specificity of assessing various tasks important for functional walking, it comes into consideration only before discharge from the hospital to the home environment. Regular use of the FGA would provide patients with initial estimates of their dynamic balance. In this way, targeted instructions would also enable easier transition from the hospital to the home environment, as well as increase the quality of rehabilitation treatment. However, the next research is underway, in which we want to use the scale as a predictive indicator of the risk of falls in a wider group of patients.

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