MEASUREMENT AND ANALYSIS OF THE DISTRIBUTION OF BODY MASS IN PATIENTS AFTER STROKE

POMIAR I ANALIZA ROZKŁADU MASY CIAŁA U PACJENTÓW PO UDARZE MÓZGU

Szymon Wyszyński[1]*, Anna Brzęk[2], Anna Famuła[2], Sylwia Stiler[3], Paweł Jarski[4], Damian Ziaja[1]

[1] Zakład Fizjoterapii, Katedra Fizjoterapii, Wydział Nauk o Zdrowiu, Śląski Uniwersytet Medyczny w Katowicach, 40-752 Katowice, ul. Medyków 12

[2] Zakład Kinezjologii, Wydział Nauk o Zdrowiu, Śląski Uniwersytet Medyczny w Katowicach, 40-752 Katowice, ul. Medyków 12

[3] Studenckie Koło Naukowe Inżynierii Biomedycznej − InBio, Wydział Informatyki i Nauki o Materiałach, Uniwersytet Śląski w Katowicach, 41-205 Sosnowiec, ul. Będzińska 39

[4] Studenckie Koło Naukowe przy Katedrze i Klinice Neurochirurgii, Śląski Uniwersytet Medyczny w Katowicach, 40-752 Katowice, ul. Medyków 12

*e-mail: szym.wysz@wp.pl

ABSTRACT

The study objective was to evaluate the impact of a ten-day rehabilitation process on the change of the distribution of body mass and the load on the lower limbs, using the tandem balance test and the modified tandem balance test in a sitting position in stroke patients. The distribution of load on the lower limbs found its expression in the index, referred to as the Kwolek index, which was developed. It was calculated as the quotient of the greater value to the lesser one, both obtained in the tandem balance test; the normal limits ranged from 1.00 to 1.15.

Material and methods. The test group comprised of 60 stroke patients. 30 people were qualified to the control group. The basis for the analysis was the measurements of the distribution of body mass and load on the lower limbs in the tandem balance test and in the modified tandem balance test. The distribution of body mass test was carried out on the first and last day of rehabilitation. The rehabilitation of ischaemic stroke patients involved comprehensive physiotherapy.

Results. When analyzing the distribution of body mass symmetry before and after the therapy in both the control group and the test group, an increase in the number of people was observed in the groups with a lower Kwolek index, whereas a decrease was present in the number of people in groups with a higher Kwolek index.

Conclusions. Comprehensive rehabilitation affects the improvement of the distribution of body mass.

Keywords: tandem balance test, stability, balance, stroke

STRESZCZENIE

Celem badań była ocena wpływu dziesięciodniowej rehabilitacji na zmianę rozkładu masy ciała oraz obciążenie kończyn dolnych przy użyciu testu dwóch wag oraz zmodyfikowanego testu dwóch wag w pozycji siedzącej u pacjentów po udarze mózgu. Wykorzystano do tego między innymi indeks Kwolka, który obrazuje rozkład masy ciała w teście dwóch wag. Indeks Kwolka wyrażany jest jako iloraz wartości większej do mniejszej uzyskanej w standardowym lub zmodyfikowanym teście dwóch wag.

Materiał i metoda. Badaniom zostało poddane 96 osób. Grupę badaną stanowiło 60 pacjentów po udarze mózgu. Do grupy kontrolnej zakwalifikowano 30 osób. Podstawą analizy były pomiary rozkładu masy ciała i obciążenia kończyn dolnych w teście dwóch wag oraz zmodyfikowanym teście dwóch wag (w pozycji siedzącej). Badanie rozkładu masy ciała wykonano w pierwszym oraz ostatnim dniu rehabilitacji. Rehabilitacja pacjentów po niedokrwiennym udarze mózgu polegała na kompleksowej fizjoterapii.

Wyniki. Analizując rozkład symetryczności masy ciała przed oraz po terapii zarówno w grupie kontrolnej jak i badawczej zaobserwowano tendencję do wzrostu liczby osób w grupach o niższym wskaźniku Kwolka, a zmniej-szeniu się liczebności grup o wyższym wskaźniku Kwolka.

Wnioski. Kompleksowa rehabilitacja ma wpływ na poprawę rozkładu masy ciała.

Słowa kluczowe: test dwóch wag, stabilność, równowaga, udar mózgu

1. Background

Human posture changes with age, resulting in changes in stability. A stable position is maintained without much effort [1, 2]. The complicated and complex process of balance adjustment becomes noticeable only in case of lesions or body ageing. Balance control disorders lead to instability that, in extreme cases, may manifest in numerous falls. A considerable number of reasons for falling include neurological causes that interfere with the body's biomechanical system. The maintenance of the upright position in particular, depends on the spatial orientation, impact of various forces on the body, and appropriate mobility control. Balance is a certain state of the postural system that is characterised by a vertical posture [3, 4]. Antigravity muscles play an extremely important role in maintaining balance. Their reflexive tension, ensured by the nervous system, enables you to maintain balance. Stability may be defined as the ability to restore the normal posture after it has been lost as a result of destabilising agents. The degree of distortion of balance depends on the strength of the destabilising stimulus; changes in the antigravity muscle tone can be observed in a stationary position. A method referred to as stabilometry is used to determine the location of the body's centre of gravity; it involves observing the displacement of the resultant force of the centre of feet pressure on the supporting plane [5, 6]. The central nervous system plays a very important role in maintaining the balance. Upon receiving stimuli from the environment and its analysis, the information is transmitted to the effector that adjusts the centre of gravity by changing the body's posture [7, 8]. Destabilising factors include, among others, depression, fatigue, anxiety, pain, movement of the environment, type of substrate, taken medications, sensory, acoustic, or visual stimuli, and diseases [9, 10, 11, 12]. According to the definition, a receptor may be characterised as a specialized nerve structure whose task is to receive stimuli from the environment. Receptors are most commonly divided according to the type of received stimuli, but also according to the location throughout the body and according to the origin of the stimulus. In the case of first classification, we distinguish: mechanoreceptors, chemoreceptors, thermoreceptors, photoreceptors and sensory receptors, whereas in the case of second classification: exteroceptors, telereceptors, interoceptors, and proprioceptors [13, 14]. The sensory systems responsible for controlling the balance are the visual, vestibular, and proprioceptive systems. Cutaneous mechanoreceptors also play an important role. After receiving mechanical stimuli, these receptors complement the proprioceptive information. The source of information about the body position and its orientation are in fact the information from all the above-mentioned systems [3]. A simple method that enables the evaluation of the difference in the load on the lower limbs is the tandem balance test. Two (digital or analogue) balances are required for the test. The patient should let their upper limbs hang down along the trunk. It is also recommended that they look straight ahead. A difference in the load within the range of 4−5 kg is assumed as a standard [15, 16, 17, 18].

2. Study objective

The objective of our research study was to assess the impact of a ten-day physical rehabilitation process on the change of the distribution of body mass and the load on the lower limbs in patients who have suffered from a stroke. For this evaluation, we used the tandem balance test and the tandem balance test in our modification in a sitting position in stroke patients. Taking into consideration the fact that the world scientific literature lacks reports regarding studies of the distribution of body mass in the sitting position, our attempts were made to evaluate the usefulness of the modified tandem balance test and the impact of comprehensive rehabilitation on the distribution of body mass. We have formulated the following research study questions:

- Does short-term rehabilitation improve the distribution of body mass in stroke patients?
- Is it possible and advantageous to use the modified tandem balance test to examine the distribution of body mass in such patients?
- Is there a significant difference between the results obtained in tandem balance test and the modified tandem balance test? What may the possible difference depend on and what has an influence on it?
- What factors affect the distribution of body mass exactly?

3. Materials and methods

The study included 96 people. The test group comprised of 30 stroke patients staying in the Upper Silesian Rehabilitation Centre *Repty* in Tarnowskie Góry, and 30 patients of the *Fizjo-Wysz Rehabilitation Centre*. 30 people were qualified to the control group. The test group comprised of 32 women and 28 men. The mean participant age was 61.7 ± 5.8 years, whereas the body mass ranged from 69 to 100 kg (X = 81.8±9.1 kg). The right sided ischaemic stroke prevailed among both women and men. The control group comprised 20 women and 10 men. The mean age was 20.3±1.6 years, whereas the mean body mass, respectively, was from 50 to 90 kg (X = 63.3±9.1 kg.). The exclusion criteria included, among others, the correct distribution of body mass obtained in the tandem balance test and the participant obtaining at least three points in the Barthel ADL index in respect of the mobility and movement parameter [19, 20, 21]. The basis for the analysis was the measurements of the distribution of body mass and load on the lower limbs in the tandem balance test and in the modified tandem balance test (in the sitting position). The test of body mass distribution was carried out on the first and last day of rehabilitation. The rehabilitation of ischaemic stroke patients involved mass bearing exercises, free exercises, passive-active exercises, passive exercises, exercises with resistance, isometric exercises, general rehabilitation exercises, exercises on lower limb and upper limb pedals and gait training.

Table 1. Distribution of the material in terms of age, body mass and damaged hemisphere

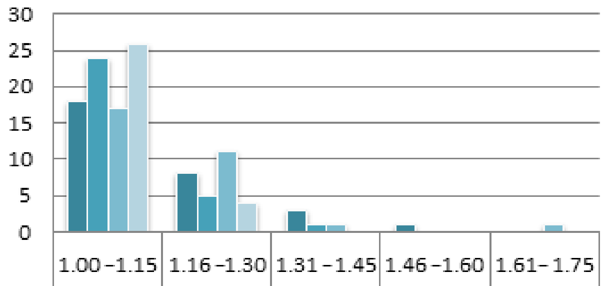
	Test group								Control group							
	Women				Men				Women				Men			
	min	max	X	Sd	min	max	X	Sd	min	Max	X	Sd	min	max	X	Sd
Age	51	67	61.5	6.57	53	72	61.4	6.73	19	26	20.4	3,9	19	24	20.9	1.70
Body mass	69	94	77.6	6.61	69	100	80.6	9.54	50	75	59.9	6.79	65	90	72	8.69

The tests were performed before the commencement of the therapy (pre-test) and afterwards (final test). The pre-test involved two measurements to be completed on each subject. The first measurement was carried out in the sitting position. The patient sat with one buttock on the first balance and the other one on the second balance in a position with the edge of the buttock located on the rear edge of the balance. The patient's feet did not come into contact with the ground; their gaze was focused on one designated point, while physiological curvature was visible in their spine. After 10 seconds, the researcher wrote down the result and entered it into the database. After the test, the patient underwent the standard tandem balance test in the standing position. In this case, the patient placed each foot on a separate balance and also focused their gaze on one point. Afterwards, all the patients underwent a ten-day comprehensive rehabilitation process. The rehabilitation of ischaemic stroke patients involved mass bearing exercises, free exercises, passive-active exercises, passive exercises, exercises with resistance, isometric exercises, general rehabilitation exercises, exercises on lower limb and upper limb pedals, and gait training. After the ten-day rehabilitation process, the tandem balance test and the modified tandem balance test in a sitting position were carried out again. Selected patterns according to the proprioceptive neuromuscular facilitation technique were applied in the control group, taking into account indications after the tandem balance test and the modified tandem balance test. When working with the subject, the flexion-abduction and internal rotation pattern in the combination of isotonic contractions technique was used. The possibility of the irradiation was used in the same technique, working by the extension of the upper torso. The duration of the therapy was 15 minutes and included selected techniques, patterns and starting positions of the proprioceptive neuromuscular facilitation technique. After the therapy, the distribution of body mass was reassessed using the tandem balance test and the modified tandem balance test. The distribution of load on the lower limbs found its expression in the index, referred to as the Kwolek index, which was developed. It was calculated as the quotient of the greater value to the lesser one, both obtained in the tandem balance test; the normal limits ranged from 1.00 to 1.15. On the basis of histograms checked the normality of distributions of individual groups of results. The normal distribution provides $p > 0.05$. The results obtained are characterized by a normal distribution, thus for statistical analysis, t-test was used for dependent samples. For statistical analysis program was used Statistica v 8.0 and the level of statistical significance was $p \leq 0.05$.

Fig.1. Implementation of the modified test on two scales on the left and two standard test mass on the right

4. Results

The analysis of the results was conducted in accordance with the order of the tests. We first present test results before the therapy and then after the therapy: in the test group and then in the control group. The results are presented starting from the modified tandem balance test and then in respect of the standard tandem balance test, analysing the Kwolek index within the range of 1.00−1.90. The further parameters to be compared included the results of the difference between the results obtained in the standard tandem balance test and in the modified tandem balance test, in the test group and in the control group. When analysing the distribution of body mass symmetry before and after the ten-day comprehensive rehabilitation process with the use of the tandem balance test in the standing position, an increase in the number of people was observed in the groups with a lower Kwolek index, whereas a decrease was present in the number of people in groups with a higher Kwolek index. Despite the ten-day comprehensive rehabilitation process, 3 patients were still in the 1.61−1.75 group. In case of the standing position, a reduction in the number of the groups with high Kwolek index was observed, but an increase in groups with low index. This change is particularly evident in the group with an index > 1.46 in which, before the therapy, there were 15 subjects (25%) qualified in the standard tandem balance test, before the therapy, there were 15 subjects (25%) qualified in the standard tandem balance test, whereas after the therapy, only 6 patients (10%) were qualified. An abnormal Kwolek index was still observed in 35 patients (58%) after the therapy in the sitting position and in 33 subjects in the standing position (55%). A large change was observed in the test group among women in respect of the Kwolek index after the calculation of the results in the standard tandem balance test and the modified tandem balance test to obtain its correct value. Before the comprehensive rehabilitation was commenced, 55 parameters (92%) were above the standard. After the rehabilitation, 35 (58%) of the 60 parameters showed a value exceeding 1.16. A change was also observed in the test group among men in respect of the Kwolek index after the calculation of the results in the standard tandem balance test and the modified tandem balance test to obtain its correct value. In men, 35 parameters (58%) were above the standard after comprehensive rehabilitation, whereas before 55 parameters (92%) had a value exceeding 1.16.



	1.00 – 1.15	1.16 – 1.30	1.31 – 1.45	1.46 – 1.60	1.61 – 1.75
Before therapy sitting control group	18	8	3	1	0
After therapy sitting control group	24	5	1	0	0
Before therapy standing test group	17	11	1	0	1
After therapy standing test group	26	4	0	0	0

Fig.2. Distribution of the load on the lower limbs symmetry parameter (the Kwolek index) in the sitting position and in the standing position in the control group

In the control group, in case of the modified tandem balance test, values significantly lower than the Kwolek index were observed compared to the test group ($t = 2.588019$, $p < 0.018040$). In this case, there is also a trend showing a reduction of the number in groups with a higher Kwolek index after therapy; 86% of the subjects had a distribution of body mass within the normal limits in the standard tandem balance test, and 80% of the subjects had a distribution of body mass within the normal limits in the modified tandem balance test. Before therapy, only 60% of the subjects in the sitting position, and 56% in the standing position had the correct Kwolek index. A change was observed in the control group among men in respect of the Kwolek index after the calculation of the results in the standard tandem balance test and the modified tandem balance test to obtain its correct value. Among men, none of the single parameters in both the standard tandem balance test and the modified tandem balance test exceeded 1.16. Before the therapy, 6 parameters were above the normal limits. A change was observed in the control group among women in respect of the Kwolek index after the calculation of the results in the standard tandem balance test and the modified tandem balance test to obtain its correct value. Among women, 9 parameters (21%) were above the normal limits. Before the therapy, 19 parameters (43%) were above the normal limits.

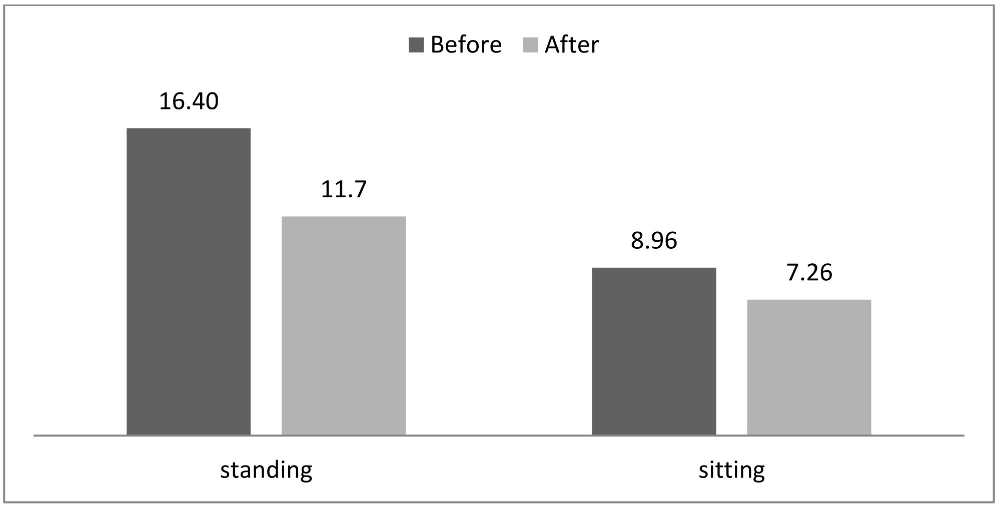


Fig. 3. Distribution of the test results in terms of difference between the larger and the smaller value obtained in the standing position and the sitting positions before and after the rehabilitation for the test group

Another compared parameter was the difference of the value obtained in both performed tests. In case of both tests, a decrease in the difference was observed: in the case of sitting position it was on average by 1.7, whereas in the case of standing position it was on average by 4.7.

Differences in the level of statistical significance ($p < 0.03$, $t = 2.3$) were observed in case of the standing position.

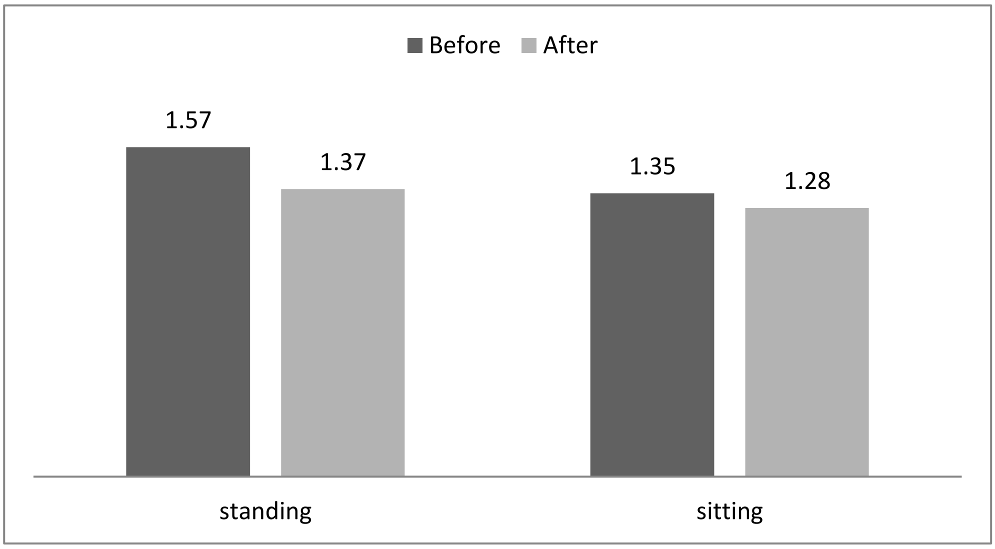


Fig. 4. Distribution of the lower limbs symmetry parameter (the Kwolek index) before and after the rehabilitation for the test group

Similarly, the analysis also included Kwolek index values both before and after the therapy in the test group. A reduction of the Kwolek index was observed in both the standard tandem balance and the modified tandem balance test. Differences in the level of statistical significance ($p < 0.043$, $t = 2.12$) were observed only in the standing position.

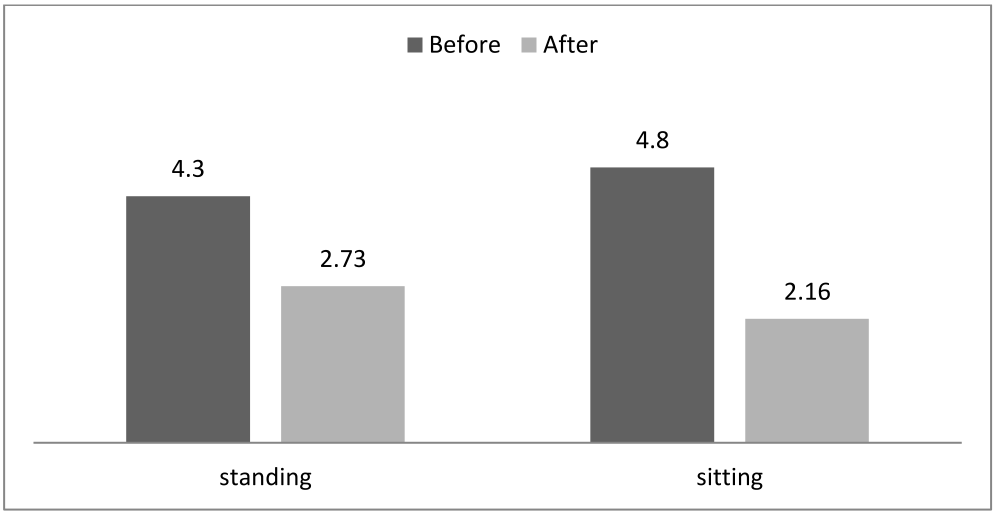


Fig. 5. Distribution of the test results in terms of difference between the larger and the smaller value in the standing position and the sitting positions before and after the rehabilitation for the control group

In the control group, the analysis started from the results obtained after deducting the greater value from the smaller one (results obtained from the tandem balance test) recorded in both tests in the sitting position and standing position. In case of both positions, the difference decreased. In both cases, differences were also observed at the level of statistical significance in case of the standing position ($t = 3.35$, $p < 0.003$), whereas for the sitting position ($p < 0.003$, $t = 3.22$).

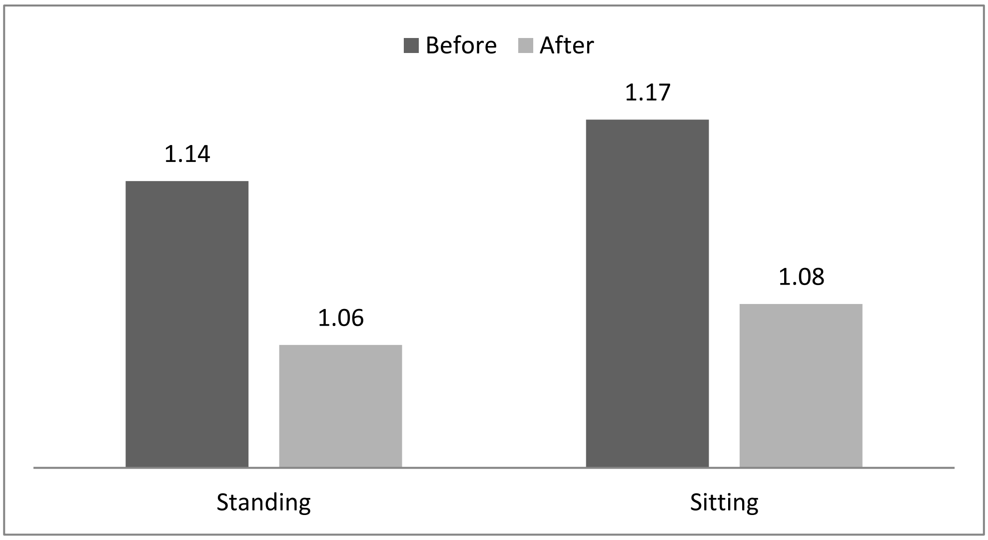


Fig. 6. Distribution of the Kwolek index before and after the therapy for the control group

As in case of the test group, the analysis also included the results of the Kwolek index for the control group for both tests. The result decreased in case of both tests. After the therapy, the mean test score in both groups was within the normal limits. In both cases, changes were observed at the level of statistical significance in case of the standing position ($p < 0.003$, $t = 3.2$), whereas for the sitting position ($p < 0.0006$, $t = 3.91$).

5. Discussion

Elderly people use the strategy of placing asymmetric load on the lower limbs while standing freely. Studies performed by Błaszczyk suggest that elderly people alternately place load on the lower limbs and remove the load. Studies also suggest that the disturbances in the frontal plane are a better indicator of stability than the ones in the sagittal plane. Worse results in this case were observed in elderly people when the plane of support was reduced and when visual control was eliminated. This demonstrates a significant impact of vision and age on the balance control. Gait is in the centre of focus in theory in stroke patients, including also the higher load on the directly affected limb. Some are of the opinion that this may have a positive effect on the proprioceptive stimulation of the directly affected lower limb. Based on study involving 200 people, Kwolek proposed a thesis that the tandem balance test was an easy and repeatable tool that might evaluate the impairment and progress of therapy. Based on the analysis, he proposed that significantly important differences in patients were found in the tandem balance test. Another study carried out by Kwolek on a group of stroke patients also suggested the validity of the use of the tandem balance test. In these studies, significant statistical changes after rehabilitation on a dynamometric platform were recorded in respect of the Kwolek index. The main objective posed while working with the described group of patients on the dynamometric platform was to teach them how to symmetrically place a load on the lower limbs. Based on the results, the author of the paper concluded that the improvement of the static balance affects the improvement of walking speed and number of steps over a distance of 20 m (Horst, 2010). The studies that are worth noting due to testing of long-term effects are those carried out by Czesak et al. The researchers assessed the symmetry of the load on the lower limbs in people who were over 65 years old. After a six-month physiotherapy programme, which included exercises performed in both low and high positions with the use of rehab pillows, tapes, Thera-bands and Swiss balls, improvement on the basis of the Kwolek index was reported in 25 patients, deterioration – in 11 patients, and no change – in 3. 50% of the subjects took part in testing of long-term effects. After 3 months, no change was observed in 14 patients on the Kwolek index, whereas deterioration in 11. A conclusion may be drawn in this case that physiotherapy affects the normalization of the Kwolek index. At the same time, the overriding goal of modern physiotherapy is to restore a lost function including, among others, balance reactions that are the key to independent living. In our study, 30 stroke patients participated in the test group. On the basis of the performed tests, considerable abnormalities in the distribution of body mass were observed. Prior to the therapy, both the tandem balance test and the modified tandem balance test showed abnormalities in over 75% of patients. After a ten-day comprehensive rehabilitation process, 60 patients required further work on the distribution of body mass. It is noteworthy that the group of patients that required further work on the distribution of body mass decreased. However, this begs the question of whether comprehensive rehabilitation is the right tool for the effective yet rapid physical improvement of patients. The answer to this question requires further studies. Nevertheless, it is worth paying attention to the growing popularity of neurophysiological methods such as proprioceptive neuromuscular facilitation and Bobath. 30 healthy volunteers comprised the control group in our study; they were subject to the distribution of body mass evaluation using the tandem balance test and the modified tandem balance test. The abnormal distribution of body mass was observed in both tests in approx. 40% of the subjects. Therapy using the proprioceptive neuromuscular facilitation technique was used in this group. After the therapy using the proprioceptive neuromuscular facilitation technique, 20% of the subjects required further work on the distribution of body mass. Both therapy using the proprioceptive neuromuscular facilitation technique and the ten-day comprehensive rehabilitation process have an impact on improving the distribution of body mass. If studies are continued, the long-term effects must be assessed for both the test group and the control group. On the basis of the performed tests, it was observed that the test group is largely characterised by a non-symmetrical distribution of body mass, potentially indicating a greater risk of falling. The rehabilitation of patients in the hospital department focused on the improvement of the distribution of body mass, which might affect the performance of functional activities requiring stability.

6. Conclusions

1. Comprehensive rehabilitation affects the improvement of the distribution of body mass.
2. The standard tandem balance test and the modified tandem balance test modified test are considered appropriate when examining the distribution of body mass.
3. The proprioceptive neuromuscular facilitation technique is recommended to improve the distribution of the load on the lower limbs in stroke patients.

4. The tandem balance test and the modified tandem balance test may not be used interchangeably; this results from the differences in the obtained results and tested parameters.
5. The factors that affect the distribution of body mass may include the position of the subject during the measurement, age, general physical fitness and motor coordination.

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