EFFECTIVENESS OF BODY WEIGHT SUPPORTED TREADMILL TRAINING FOR GAIT RECOVERY IN PATIENTS AFTER ISCHEMIC STROKE
ÚČINNOSŤ TRÉNINGU NA BEŽECKOM PÁSE S PODPOROU TELESNEJ HMOTNOSTI PRI OBNOVE CHÔDZE U PACIENTOV PO ISCHEMICKEJ CIEVNEJ MOZGOVEJ PRÍHODE

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ABSTRACT
Background: Restoring safe, independent and efficient walking is a key element in achieving functional independence for stroke patients.
Objective: To study the effect of body weight supported (BWS) treadmill training on gait recovery in patients at an early subacute phase of ischemic stroke.
Research sample and method: The study recruited 28 patients, who had suffered a stroke and met the selection criteria. Participants in the control group (n = 14) used traditional ground walk training; those of the experimental group (n = 14) did a combination of ground walk training and treadmill training.
Results: The results of the study showed that at an early subacute phase of ischemic stroke, in patients independent of external assistance in walking the use of BWS treadmill training leads to a significant improvement in walking speed and endurance ($p \leq 0.05$), functional ambulation. No statistically significant differences were revealed between the groups at the end of the treatment and within the follow-up period, although the trend analysis was always in favor of the experimental group.
Conclusion: BWS treadmill training can complement traditional ground walk therapy, providing practice for repetitive tasks without requiring excessive effort on the part of physiotherapists. Future studies involving large numbers of patients are required to standardize clinical protocols and identify guidelines for gait recovery in stroke patients.

Key words: Stroke. Physiotherapy. Gait training. Treadmill.

ABSTRAKT
Východiská: Obnovenie bezpečnej, nezávislej a efektívnej chôdze je kľúčovým prvkom pri dosahovaní funkčnej nezávislosti u pacientov s mozgovou príhodou.
Cieľ: Skúmať vplyv tréningu na bežiacom páse s podporou telesnej hmotnosti na zotavenie chôdze u pacientov vo včasnom subakútnom období ischemickej cievnej mozgovej príhody.
Výskumná vzorka a metóda: Štúdie sa zúčastnilo 28 pacientov, ktorí mali cievnu mozgovú príhodu a splnili výberové kritériá. Účastníci kontrolnej skupiny (n =14) používali tradičný tréning chôdze po zemi; v experimentálnej skupine (n =14) – kombinácia pozemného tréningu a tréningu na bežiacom páse.
Výsledky: Výsledky štúdie ukázali, že u pacientov vo včasnom subakútnom období ischemickej cievnej mozgovej príhody, ktorí sú nezávislí od vonkajšej pomoci pri chôdzi, vedie použitie tréningu na bežeckom páse s podporou telesnej hmotnosti k výraznému zlepšeniu rýchlosti a vytrvalosti chôdze ($p \leq 0{,}05$). Na konci liečby a počas sledovania sa medzi skupinami nezistili žiadne štatisticky významné rozdiely, hoci trend bol vždy v prospech experimentálnej skupiny.
Záver: Cvičenie chôdze na bežiacom páse s podporou tela je možné využiť ako doplnok k tradičnému tréningu chôdze po zemi u pacientov s cievnou mozgovou príhodou. Budúce štúdie s veľkými kohortami pacientov sú potrebné na štandardizáciu klinických protokolov a definovanie smerujúcich prístupov na zlepšenie chôdze u pacientov s mozgovou príhodou.

Kľúčové slová: Cievna mozgová príhoda. Fyzioterapia. Tréning chôdze. Bežecký pás.

INTRODUCTION

Stroke remains one of the leading causes of disability and social maladaptation of patients, with the consequences of acute cerebral circulatory disorders of varying severity being observed in more than 65 % of patients (Belagaje, 2017). Despite a significant progress in stroke treatment and rehabilitation in recent decades, the number of patients with varying degrees of neurological deficits, primarily motor deficits, has remained significant (Langhorne et al., 2009; Bannikova et al., 2021). The data provided by national stroke registries in different countries show that only about 20 % of stroke survivors can return to professional activities (Dereka, 2020; Tsao et al., 2023).

Gait disorders are the most common consequence, occurring in about 80 % of patients after a stroke. The inability to walk independently disadapts patients, deprives them of freedom of movement, makes them dependent on assistance of strangers, increases the risk of falling and other risk factors (Blennerhassett et al., 2018; Miller et al., 2021).

At early stages of stroke, the typical examples of impaired functional ambulation involve muscle weakness, a decrease in active movements in the paretic limb, later – the formation of spasticity and the emergence of motor synergies, which prevents the performance of movements in a particular segment of the limb (Kennedy et al., 2021). The lack of physiological support on the paretic leg significantly changes the walking pattern, decreases the speed and endurance of walking, reduces a step length, provokes instability during walking, and causes a high risk of falling. Shortening the support phase and lengthening the swing phase of the paretic leg leads to an increase in the load on the healthy limb and emergence of walking asymmetry, which is characteristic of 40 – 80 % of patients with spastic paresis of the lower limb (Park et al., 2015). Therefore, achieving safe, independent and efficient walking as a key element of restoring functional independence is one of the top priorities for stroke survivors.

The analysis of numerous clinical studies made over the past decade suggests that patients after a stroke experiencing walking difficulties should be offered treadmill training as a way to perform repetitive tasks. Such trainings provide systematic speed development, patients can potentially perform higher aerobic intensity exercises, and the use of a body weight support system can reduce the need for manual support from a physiotherapist for patients who need assistance when moving around (Brauer et al., 2018). However, separate systematic reviews show that compared to ground walk training, the impact of treadmill training on gait improvement is controversial. Treadmill training should only be complementary to regular ground walk training or used when ground-based training is not available (Duncan et al., 2011; Franceschini et al., 2009).

At the same time, it is proved that treadmill training can be more effective than regular gait training in improving certain gait parameters, namely stride length and walking speed (Stretton et al., 2017; Nascimento et al., 2021). Most of these studies are focused on treadmill walking training for patients with chronic stroke at the outpatient rehabilitation stage, but this type of training is not commonly used during inpatient rehabilitation. Therefore, one of promising research areas consists in assessing the impact of treadmill training on the recovery of walking at the early subacute phase in the patient population in Ukraine.

OBJECTIVE

To study the effect of BWS (Body weight supported) treadmill training on gait recovery in patients at an early subacute phase of ischemic stroke.

RESEARCH SAMPLE

The research was conducted at the Department of Physical and Rehabilitation Medicine of the Zaporizhzhia Regional Clinical Hospital located in the city of Zaporizhzhia, Ukraine, with the participation of 28 people (aged from 47 to 60), who had suffered an acute violation of cerebral circulation. The research participants signed an informed consent form. The research was approved by the University Ethics Committee (№ 1/2021) and was conducted in accordance with the international principles of the Helsinki Declaration of the World Medical Association (2013) and in accordance with the Law of Ukraine "Fundamentals of Ukrainian Health Care Legislation" (1992) on ethical norms and rules of medical research with human participation.

The study included the participants who had undergone inpatient rehabilitation and met the following selection criteria: Age – over 18 years old; confirmed diagnosis of a primary ischemic stroke; number of days after the stroke – over two weeks, which corresponds to the early subacute phase of the disease; neurological deficit in the form of hemiparesis with preserved movements in the lower limb; ability to walk 10 m (with minimal assistance provided by one person, with or without an auxiliary/orthosis walking device); self-selected walking speed in the 10-meter Walk Test (i0mwt) < 1.0 m/s; ability to understand simple instructions and the Mini-Mental State Examination score of at least 24 points. The exclusion criteria were as follows: Decompensated somatic diseases, unstable state of the cardiovascular system, concomitant diseases associated with lower limbs that might affect walking, walking speed > 1 m/s.

After completing the initial evaluation, patients included in the research were randomly assigned to the experimental (EG) and control (CG) groups in a 1:1 ratio.

METHODOLOGY

Locomotor training in the EG of patients included partial BWS treadmill training for 30 minutes, followed by 30 minutes of traditional ground walk training. To control the paretic lower limb and pelvis, BWS gait training involved at least one physiotherapist for one patient. The body weight support system (Guldmann GH3 equipped with dynamic Trainer Module) provided the patients' weight control throughout the entire gait cycle and ergonomic operation of physiotherapists. The body weight support level was adapted to the patients' abilities and restricted to 40 % of body weight. Body weight support was performed with walking slings (Guldmann Active Trainer) and gradually reduced during training depending on the patient's progress. The speed of the treadmill (Runner Pro 8000) was adjusted starting from 0.1 m/s and reaching ≥ 1.2 m/s, with the increment being 0.1 m/s based on the patient's progress.

Training sessions were conducted five times per week within the period of four weeks after the research start, with 20 training sessions in total. The amount and intensity of walking trainings were determined individually for each patient. When restoring functional ambulation, the monitoring of uniform distribution of body weight on the paretic and healthy legs as well as of the similarity of steps' length and rhythm was carried out. It was controlled that the paretic leg should not move to the side while moving forward, and the foot should not touch the floor with its toe. The monitoring of training sessions intensity was conducted according to the heart rate indicators or Borg Rating of Perceived Exertion Scale. The research participants started training at an intensity of 40 % of the heart rate reserve, gradually progressing to reach 60 % of the heart rate reserve. For the participants who could not reach 40 % of their heart rate reserve at the beginning of treadmill training, the treadmill speed was set at the highest level tolerable.

The CG underwent 20 sessions, with the traditional approach of ground walk training with partial body weight support being applied, during four weeks after the enrollment in the research. In addition, patients in both groups underwent approximately one hour of complex therapy per day without gait training, using repetitive tasks aimed at correcting the disorders and activity restrictions specific to each individual participant.

The research participants were evaluated before the rehabilitation intervention (I), after 20 walking training sessions (II), and three months after the program (III). To evaluate the results of the intervention, we used the walking speed indicator of the 10-Meter Walk Test (the average of two attempts) as well as the distance indicator measured in the 6-Minute Walk Test (6MWT). The assessment of overall ambulation was carried out according to the Functional Ambulation Category (FAC) scale, which is an effective tool for evaluating mobility in patients and determining how much human support the patient requires for independent walking. All the tools selected are recommended for application by the Neurology Section of the American Physical Therapy Association's Stroke Taskforce (Strok-EDGE). These recommendations were developed by a panel of research and clinical experts using a modified Delphi process.

Statistical analysis: Statistical processing of the results obtained was carried out based on Statistica 6.0 software package. For evaluation of significance of intergroup diversities, Mann-Whitney-Wilcoxon criteria were applied. Spearman's rank correlation coefficient technique was used to summarize a relationship and strength of a relationship between two variables. The diversity was always considered statistically significant, with $p < 0.05$.

RESULTS

The study involved 28 patients at an early subacute phase of ischemic stroke, who were sent for inpatient rehabilitation. At the initial stage, all participants in the EG and CG completed the 10-meter Walk Test, 6MWT, and were evaluated using the FAC test. After a three-month period, one CG participant could not be evaluated due to his changing the place of residence. During the initial evaluation, the average indicator of the walking speed indicator in EG made up 0.41 ± 0.11 m/s (me 0.4); in CG it was 0.43 ± 0.12 m/s (me 0.4) respectively. Therefore, according to this indicator, the participants were at the border of the first and second functional ambulation categories, according to Schmid et al. (2007). After 4 weeks of treadmill training and traditional ground walk training, both groups showed a significant improvement in walking speed: By 0.41 m/s in EG (IQR 0.32 – 0.50), and 04 m/s in CG (IQR 0.34 – 0.46) respectively, compared to the initial speed recorded (Table 1). The evaluation conducted three months after the end of inpatient rehabilitation showed a decrease in walking speed in both groups. None of the walking speed results showed statistically significant differences between the EG and CG.

According to table 2, after 4 weeks of gait training, the average distance traveled in the 6MWT test in EG was 187.20 ± 14.10 m, which is 76.6 m (IQR

Table 1 The dynamics of walking speed according to the 10-Meter Walk Test in patients of the EG and CG during the research, m/s

Test period	CG (n = 14)		EG (n = 14)	
	M ± SD	Me	M ± SD	Me
I	0.41 ± 0.11	0.4	0.43 ± 0.12	0.4
II	0.81 ± 0.13*	0.75	0.84 ± 0.09*	0.8
III	0.72 ± 0.11	0.65	0.72 ± 0.10	0.7

Note: hereafter, I – before the intervention; II – after 20 sessions of walking training; III – 3 months after the program; * $p \leq 0.05$ – reliability of differences compared to the research start

Table 2 The dynamics of 6-Minute Walk Test indicators in experimental and control patients during the research, m

Test period	CG (n = 14)		EG (n = 14)	
	M ± SD	Me	M ± SD	Me
I	112.25 ± 10.15	100	110.80 ± 15.14	101
II	161.25 ± 11.23*	140	187.20 ± 12.10*	165
III	145.30 ± 20.20	140	168.50 ± 15.20	156

Note: * $p \leq 0.05$ – reliability of differences compared to the research start

Table 3 The dynamics of Functional Ambulance Category Test indicators of the experimental and control groups during the research, scores 0-5

Test period	CG (n=14)		EG (n=14)	
	IQR	Me	IQR	Me
I	2 – 3	3	2 – 3	3
II	3 – 5	4	3 – 5	4
III	3 – 5	4	3 – 5	4

Note: IQR – indicates interquartile range

55 – 112) longer than in the initial test ($p \leq 0.05$). In CG participants, the average distance traveled in the 6MWT test was 161.25 ± 11.23 m, which is 49 m (IQR 23 – 78) longer than in the initial test ($p \leq 0.05$). The Test II results after 20 sessions of walking training were significantly better in EG patients, but none of the groups was able to maintain this result after three months of living in the community.

The results of the FAC scale assessment (Table 3) showed that patients in both groups met the FAC 3 assessment criterion at the research start, i.e. they were able to walk independently without any physical assistance from a physiotherapist but needed supervision or verbal prompts.

At the end of the inpatient rehabilitation phase, the majority of patients in both groups achieved a FAC 4 score, which means the ability to safely walk independently on a flat surface without supervision; individual patients demonstrated a FAC 5 score corresponding to a safe independent walking on any surface, including stairs. An increase in ambulation based on the FAC scores correlated with an increase in the walking speed immediately after inpatient rehabilitation. Therefore, with a decrease in the walking speed after three months in the community, patients did not worsen their FAC-based level.

DISCUSSION

Despite the fact that many experts have studied the impact of treadmill training on the gait recovery in stroke patients, the issue of optimal time, intensity, duration and effectiveness of this approach remains unclear.

The 2024 study conducted by the scholars from Istanbul University (Cakmak et al., 2024) evaluated the impact of traditional rehabilitation and the combination of BWS treadmill training on the walking speed, endurance, balance, mobility, and quality of life of stroke survivors. Thirty stroke patients were divided into two groups, with both groups receiving gait training for three consecutive weeks, five days per week, 30 minutes each day. The EG received an additional 30 minutes of treadmill training per session. The authors noted that after the intervention, both groups showed significant improvements across all scales. The EG showed particularly noticeable improvements in the comfort scores of 10-Meter Walk Test and TUG ($p = 0.043$ and $p = 0.025$ respectively) compared to the CG. The results of the study show that additional training on a treadmill has significantly improved walking speed in the EG patients. On the other hand, an integrated approach involving traditional means of physiotherapy improves various aspects of mobility and ensures the cost-effectiveness of interventions.

The study by an international group of scientists (Gama et al., 2017) was conducted to assess the impact of BWS treadmill gait training compared to ground-based training in individuals with chronic stroke (> 6 months). The participants were randomly assigned to complete BWS gait training on a treadmill (n = 14) or on the ground (n = 14) three times per week during six weeks. The results showed that people with chronic stroke equally improved gait speed and other gait parameters after 18 sessions of BWS gait training both on a treadmill and on the ground. However, only the group involved in the ground walk training improved the step length of the paretic limb and the step length ratio ($p = 0.01$ and $p = 0.01$ respectively).

The scientists from the University of Florida, USA (Lura et al., 2019) evaluated the clinical effectiveness of BWS treadmill training in rehabilitation of stroke patients compared to traditional therapy. Forty people (> 3 month after a stroke event) were randomly assigned to either treadmill weight-bearing exercise or traditional therapy as part of standard medical treatment in an emergency rehabilitation facility. The results of evaluating the patients at the time of discharge showed that only the walking speed indicator was significantly different, being lower in the group, which had training sessions on a BWS treadmill. Thus, the authors conclude that the clinical effectiveness of BWS treadmill training is similar to that of traditional ground-based therapy.

In a pilot randomized trial with a three-month follow-up, involving 20 patients with chronic stroke able to walk independently, American scientists (Combs-Miller et al. 2014) evaluated the effectiveness of 30-minute BWS treadmill trainings compared to overground walking sessions five times per week during two weeks. The overground walking training group demonstrated significantly greater improvements in comfortable walking speed compared with the BWS treadmill training group immediately (0.11 m/s vs. 0.06 m/s, respectively; $p = 0.047$) and three months after the training (0.14 m/s vs. 0.08 m/s, respectively; $p = 0.029$). Only the overground walking training group significantly improved comfortable walking speed ($p = 0.001$), aspects of gait symmetry ($p = 0.032$), and activity ($p = 0.003$) immediately after the training. Gains were maintained at the three-month follow-up ($p < 0.05$) for all measures except activity.

The 2017 systematic review (Mehrholz et al., 2017) analyzed the results of 56 studies with 3,105 participants, who received treadmill training and body weight support for walking after a stroke. The findings indicate that using treadmill training to rehabilitate walking in stroke patients significantly increased their walking speed and walking endurance. The pooled mean difference (MD) (random-effects model) for walking speed was 0.06 m/s (95% CI 0.03 to 0.09; 47 trials, 2323 participants; $P < 0.0001$; $I^2 = 44$ %; moderate-quality evidence) and the pooled MD for walking endurance was 14.19 m (95% CI 2.92 to 25.46; 28 trials, 1680 participants; $P = 0.01$; $I^2 = 27$ %; moderate-quality evidence). However, this review did not find that improvements in walking speed and endurance might have persisting beneficial effects The authors note that further research should specifically investigate the effects of different frequencies, durations, or intensities (in terms of speed increases and escalation) of treadmill training.

Moore et al (2022) in their study analyze the current evidence for walking recovery after stroke (Moore et al., 2022) states that treadmill training is recommended to perform repetitive tasks in clinical guidelines. Treadmill training allows systematic speed development: People can potentially perform higher aerobic intensity exercises, whereas using a body weight support system can reduce the need for a manual therapist's support for patients who need assistance with ambulation. However, treadmill training is recommended as complementary to ground walk training, or in cases where ground-based walking is not available, since an increase in treadmill walking speed does not correlate with community walking speed. Recent preliminary results support a combination of treadmill training and ground walk training to improve gait recovery, but these results require further study.

CONCLUSION

The research results show that in patients at an early subacute phase of ischemic stroke, who are independent of external assistance when walking, the use of BWS treadmill training leads to a significant improvement in walking speed and endurance, functional ambulation. No statistically significant differences were found between the ground walk training and combined treadmill training groups at the end of the treatment and during the follow-up, although the trend analysis was always in favor of the experimental group. The assistance and monitoring of a patient's walk on a treadmill was performed by a physiotherapist.

In this way, BWS treadmill training can complement traditional ground walk therapy, providing practice for repetitive tasks and not requiring excessive effort on the part of therapists. Future randomized trials involving large numbers of patients are required to standardize clinical protocols and identify guidelines for gait recovery in stroke patients.

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