

**THE EFFECT OF HIGH-INTENSITY INTERVAL TRAINING
ON POST-STROKE PATIENTS**
**VPLYV VYSOKOINTENZÍVNEHO TRÉNINGU NA PACIENTOV
PO CIEVNEJ MOZGOVEJ PRÍHODE**

LAZARIEVA Olena, VINOHRADOV Maksym

National University of Ukraine on Physical Education and Sport, Physical Therapy and Ergotherapy Department, Kyiv, Ukraine

ABSTRACT

Theoretical background: Achieving the most effective results of stroke recovery in a short period of time is an important task today.

Objective: To study the effect of high-intensity interval training (HIIT) on post-stroke patients and to compare the effectiveness of physiotherapy with and without the use of HIIT.

Research sample and method: The study of the control group was conducted on the premises of the physical rehabilitation center "Phoenix" Kyiv, Ukraine. The study involved 26 men of mature age who suffered an acute cerebrovascular accident. The patients received a course of active physiotherapy at the center in the working conditions of a multidisciplinary team for 8 weeks. The study of the main group was conducted on the premises of the neurological rehabilitation center "Life House", Kyiv, Ukraine. The study involved 27 men of mature age (37 – 50 years old) who suffered an acute cerebrovascular accident. The participants were selected for high-intensity training by means of special inclusion criteria. The patients received a special course of physiotherapy with the elements of high-intensity interval training for 8 weeks.

Results: It has been established that the proposed high-intensity interval training contributes to a statistically significant ($p < 0.05$) restoration of the ability to modify balance while walking in the presence of external demands, reduced fall risk, increased walking speed, improved strength indicators of lower limbs such as the motor control of verticalization, the decrease in the degree of spasticity, as well as a significant improvement in aerobic endurance.

Conclusions: The obtained data confirm the expediency of using high-intensity interval training as an element of complex physiotherapy for people who have suffered an acute cerebrovascular accident, which involves the use of specific criteria for the selection of patients and the use of a trial period.

Key words: Physiotherapy. Stroke. High-intensity interval training (HIIT). Gait after stroke.

ABSTRAKT

Úvod: Dosiachnutie čo najefektívnejších výsledkov zotavenia po cievnej mozgovej príhode v krátkom čase je v súčasnosti dôležitou úlohou.

Cieľ: Cieľom je preskúmať účinok vysoko intenzívneho intervalového tréningu (HIIT) na výkonnosť pacientov po cievnej mozgovej príhode a porovnať účinnosť fyzioterapie s použitím HIIT a bez neho.

Súbor a metódy: Štúdia kontrolnej skupiny sa uskutočnila v centre rehabilitácie Phoenix v Kyjeve na Ukrajine. Štúdie sa zúčastnilo 26 dospelých mužov, ktorí utrpeli akútnu cievnu moz-

govú príhodu. Pacienti počas 8 týždňov absolvovali v centre aktívnu fyzioterapiu pod dohľadom multidisciplinárneho tímu. Štúdia hlavnej skupiny sa uskutočnila v Neurorehabilitačnom centre Life House, Kyjev, Ukrajina. Štúdie sa zúčastnilo 27 mužov v zrelom veku (37 – 50 rokov), ktorí utrpeli akútnu cievnu mozgovú príhodu. Účastníci boli vybraní na vysokointenzívny tréning pomocou špeciálnych inklúzyvých kritérií. Počas 8 týždňov pacienti absolvovali špeciálny kurz fyzioterapie s prvkami vysokointenzívneho intervalového tréningu.

Výsledky: Zistilo sa, že navrhovaný vysokointenzívny tréning podporuje štatisticky významné ($p < 0,05$) obnovenie schopnosti meniť rovnováhu počas chôdze v prítomnosti vonkajších požiadaviek, zníženie rizika pádu, zvýšenie rýchlosti chôdze, zlepšenie sily dolných končatín v zmysle motorickej kontroly vertikalizácie, zníženie stupňa spasticity a významné zlepšenie aeróbnej vytrvalosti.

Záver: Získané údaje potvrdzujú možnosť využitia vysokointenzívneho intervalového tréningu ako prvku komplexnej fyzioterapie osôb, ktoré utrpeli akútnu cievnu mozgovú príhodu, čo zahŕňa použitie špecifických kritérií výberu pacientov a využitie aprobačného obdobia.

Kľúčové slová: Fyzioterapia. Cievna mozgová príhoda. Vysokointenzívny intervalový tréning (HIIT). Chôdza po cievnej mozgovej príhode.

INTRODUCTION

According to the National Health Service of Ukraine (info@nszu.gov.ua), the number of strokes covered by the medical guarantee program as of 2023 is 129,072 cases of stroke in total. And 121,551 patients with stroke in total, of which 1,836 cases of hemorrhagic stroke in men under the age of 50 and 1,678 male patients with hemorrhagic stroke under the age of 50.

It should be also mentioned that military actions can lead to injuries and wounds, which, in turn, increase the risk of post-traumatic strokes. Although direct studies of war-related incidents and the number of strokes may be limited, the connection between military traumatic brain injuries and long-term neurological sequelae is an important field for further research on the effects of war on human health (Kong et al., 2022).

Physiotherapy plays a key role in the treatment of nervous system diseases (Bannikova et al., 2021; Vitomskyi et al., 2022) and pathologies of other systems of the human body (Balazh et al., 2020; Vitomskyi, 2019, 2020; Fedorenko et al., 2019, 2021). At the same time “lack of time” remains one of the most common barriers to regular exercise, so low-volume HIIT is a time-efficient training strategy that deserves the attention of physicians and fitness professionals (Gillen et al., 2014; Dereka, 2020).

The available national literature has no works on justification for the specifics of selecting the parameters of high-intensity interval training for the patients in Ukraine. The level of medical care, conditions of inpatient treatment, physiological and personal factors of patients, which are prospective for further research and determine the relevance of the chosen research topic (Lazarieva et al., 2020).

OBJECTIVE

To study the effect of high-intensity interval training (HIIT) on post-stroke patients and to compare the effectiveness of physiotherapy with and without the use of HIIT.

RESEARCH SAMPLE

The study of the control group was conducted on the premises of the physical rehabilitation center

“Phoenix” Kyiv, Ukraine. The study involved 26 men of mature age who suffered an acute cerebrovascular accident. The patients received a course of active physiotherapy at the center in the working conditions of a multidisciplinary team for 8 weeks.

The study of the main group was conducted on the premises of the neurological rehabilitation center “Life House” Kyiv, Ukraine. The study involved 27 men of mature age (37 – 50 years old) who suffered an acute cerebrovascular accident. Participants were selected for high-intensity training by means of special inclusion criteria, one of which was a mandatory trial period (table 1). The patients received a special course of physiotherapy with the elements of high-intensity interval training for 8 weeks.

METHODOLOGY

The total duration of the physiotherapy program corresponded to the period of the patient's stay at the inpatient rehabilitation stage and comprised 8 weeks. The program, both for MG and CG, consisted of walking training, strength training and functional training. The main difference between the groups was the use of HIIT by MG patients (table 2).

Under the conditions of stay in the center, patients of the control group received an individual

Table 1 Methodological features of the trial period of high-intensity interval training (Vinogradov et al., 2023)

Algorithm of high-intensity interval training during the trial period					
Tanaka formula $HR_{max}: 208 - (Age \times 0.7)$					
Training components	Day 1	Day 2	Day 3	Day 4	Day 5
HR	70 – 85 %	70 – 85 %	70 – 85 %	70 – 85 %	70 – 85 %
Performance	1 min	2 min	3 min	4 min	5 min
Number of intervals	5 intervals of the performance	5 intervals of the performance	5 intervals of the performance	5 intervals of the performance	5 intervals of the performance
Rest between the intervals	5 min between the intervals	5 min between the intervals	5 min between the intervals	5 min between the intervals	5 min between the intervals

Table 2 Physical therapy exercises in the main and control groups

Intervention parameters	Main group	Control group
Rehabilitation exercises	Walking training Functional skills training Bed mobility training Strength training of the lower limbs	Walking training with high-intensity intervals Strength training of the lower limbs Functional skills training
Duration of the program	8-week program of sessions	
Beginning of active rehabilitation	From the 2nd week after ACVA	
Frequency of physiotherapy sessions	5 days a week 2 sessions a day	
Duration of physiotherapy sessions	50-60-minute sessions	
Specific inclusion criteria	Absent	Present + trial period

rehabilitation program, which consisted of a 5-day work week. Each day the patients had 2 sessions with a physiotherapist lasting from 50 minutes to 1 hour.

The sessions of the control group with physiotherapist were aimed at training bed mobility, recovery of walking, training of functional skills.

The patients of the main group worked 5 days a week during the whole period, having 2 sessions with a physiotherapist that lasted 50 – 60 minutes (Lazarieva et al., 2023). The sessions of the main group were aimed at functional skills training, strength training, walking training with high-intensity intervals.

RESULTS

The study showed that both the traditional approach to the rehabilitation of men aged from 37 to

50 years who suffered an acute cerebrovascular accident and high-intensity interval training have a statistically significant ($p < 0.05$) effect on restoring balance, which is an important factor in preventing falls and improving the quality of life.

At the same time, the average absolute increase in static and dynamic balance of CG men was 6 (4; 13) points, in relative terms – 16.7 (9.1; 40.6), and MG men – 16 (15; 17) points and 61.3 (57.7; 65.2) %, respectively (Figure 1).

Along with a statistically significant ($p < 0.05$) improvement in the aerobic endurance of men under the influence of rehabilitation measures, which is manifested in the ability of the body to maintain long-term physical activity without fatigue, MG patients also showed a significant improvement in aerobic endurance as compared to the participants of CG, proving a greater intensity of the proposed

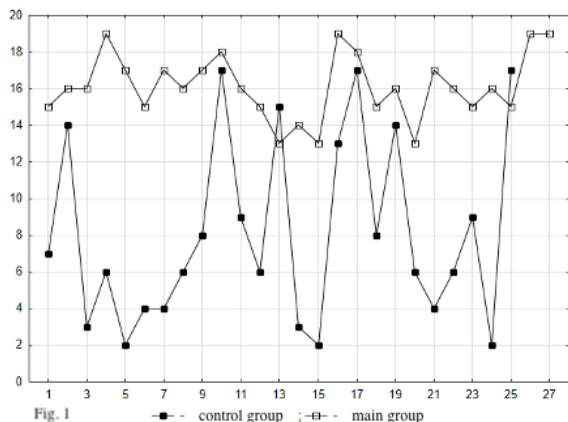


Figure 1 Comparative analysis of individual absolute increases in static and dynamic balance of men aged 37 – 50 years who suffered an acute cerebrovascular accident (n = 52)

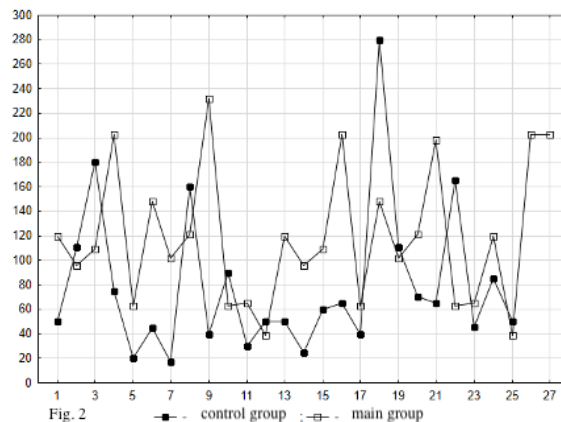


Figure 2 Individual absolute increases in aerobic endurance of men aged 37 – 50 years who suffered an acute cerebrovascular accident (n = 52)

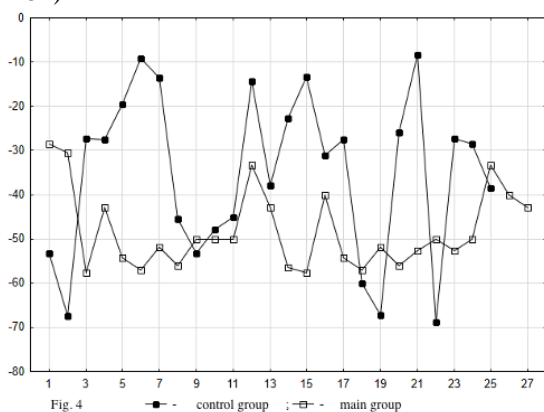


Figure 3 Individual absolute increases in the assessment of mobility, balance, walking ability and fall risk in men aged 37 – 50 years who suffered an acute cerebrovascular accident (n = 52)

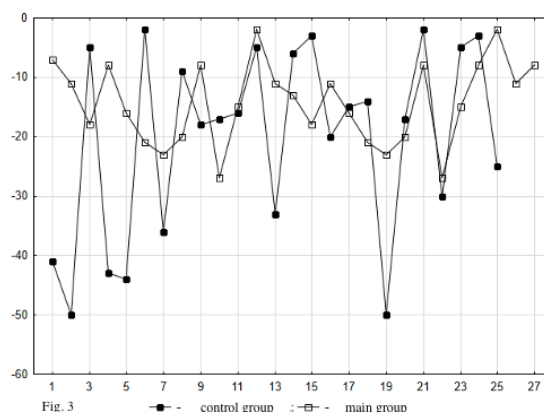


Figure 4 Individual relative increases in the time to cover a 10-meter distance by men 37-50 years old who suffered an acute cerebrovascular accident (n=52)



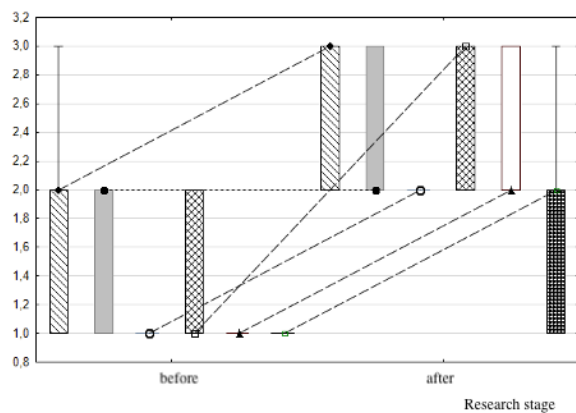


Fig. 5 1; 2; 3; 4; 5; 6

Figure 5 Dynamics of motor verticalization indicators of men aged 37 – 50 who suffered an acute cerebrovascular accident ($n = 27$), where 1 is hip flexion; 2 – knee flexion; 3 – foot flexion; 4 – hip extension; 5 – knee extension; 6 – foot extension.

measures, which require more physical effort than in the case of using traditional rehabilitation measures (Figure 2).

Besides, the men participating in the study, regardless of the group, showed a statistically significant ($p < 0.05$) decrease in the risk of falling, which is manifested in an increased probability of losing balance until falling, which can lead to injuries and complications (Figure 3).

The participants of the study, regardless of the group, showed a statistically significant increase in walking speed ($p < 0.05$), however, its increase was more significant in MG representatives as compared to the first group (Figure 4).

The study confirmed that the proposed high-intensity interval training contributes to a statistically significant ($p < 0.05$) recovery of the ability to modify balance while walking in the presence of external demands, improvement of lower limb strength indicators under motor control of verticalization (Figure 5).

DISCUSSION

For many years, Ukrainians have faced high rates of morbidity and mortality from ACVA, which is the second most frequent cause of death and the main cause of disability in the country (Grygus et al., 2019).

The study supplemented the data on a randomized, blind trial (Miller et al. 2021) conducted at 3 sites involving 50 persons who overcame chronic (> 6 months) strokes.

The study supplemented and extended the data of a HIIT protocol developed by Boyne et al. (2016, 2020), that involved 30-second bouts of walking on a treadmill at a maximum safe speed, interchanged with 30 – 60-second recovery periods, during which the treadmill stopped.

The study confirmed and supplemented the data obtained by Norwegian colleagues (Gjellesvik et al., 2021), who proved that HIIT combined with standard treatment improved walking distance, balance and executive function immediately after the intervention as compared to standard treatment.

The study supplemented the data of the authors (Hugues et al., 2021), stating that HIIT should be included in post-stroke rehabilitation due to its beneficial effect on neuroplasticity processes.

The study supplemented the data of the presented protocols (Macko et al., 2005) for testing exercises and progression of longitudinal aerobic training, which provide fundamental formulas that safely approach the complex task of adapting aerobic training to the severity of gait deficits among people at high risk of CVD stroke. In their study Ivey et al. (2008), included continuous walking on a treadmill at a speed adjusted to maintain a heart rate of $45 \% \pm 5 \%$ of heart rate. The target heart rate (HR) was increased to $50 \% \pm 5 \%$ HR after 2 weeks of training.

The study confirmed and supplemented the data obtained by our colleagues (Hornby et al., 2015), who revealed the results of sequential walking applied to stroke patients and changes in the number of steps during the day.

A particular interest is paid to step trainings conducted in a large volume as compared to the standard treatment of patients at the inpatient stage (Hornby et al., 2015).

The study supplemented the data (FIRST-Oslo Team, 2020) on the difference in daily step loading (e.g., steps/day) between groups, with almost 1800 more steps/day during HIIT as compared to standard care (5777 ± 2784 steps/day vs 3917 ± 2656 steps/day, $p < 0.001$).

The study supplemented the data of the research (Crozier et al., 2018) pointing out that preliminary data from 10 studies show improvements in functional, cardiovascular and neuroplastic outcomes after stroke associated with HIIT; however, the optimal parameters of HIIT remain unclear.

The study supplemented the data (Gillen et al., 2014) proving that a growing amount of research

suggests that high-intensity interval training (HIIT) is an effective exercise strategy for improving cardiorespiratory and metabolic health that does not require much time.

CONCLUSION

According to the results of a comparative analysis, high-intensity interval training is an effective means of rehabilitation for men aged 37 – 50 who have suffered an acute cerebrovascular accident. The use of HIIT contributes to speeding up their walking recovery, allowing more effective recovery of their ability to modify balance while walking in the presence of external demands, leads to an increase in motor verticalization and is accompanied by a decrease in spasticity degree.

The obtained data confirm the expediency of using HIIT as an element of a complex physiotherapy for people who have experienced an acute cerebrovascular accident, which involves the use of specific patient selection criteria and a trial period. Prospects for further research consist in an in-depth study of the effectiveness of the developed trial period and HIIT itself, in the study of their long-term effect for restoring the functioning of patients with acute cerebrovascular accidents.

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