

Horoshko V. I.¹, Zhygulova E.O.², Chaplinskyi R.B.²,
Litvinov P.Yu.³, Neusmekhova I.S.³

Scientific-based approach to choosing the speed of rehabilitation management of patients with neurogenic dysfunctions

¹ National University of Water and Environmental
Engineering, Rivne, Ukraine

² Kamianets-Podilskyi Ivan Ohienko
National University,
Kamianets-Podilskyi, Ukraine

³ Poltava State Agrarian University,
Poltava, Ukraine

Горошко В.І.¹, Жигульова Е.О.², Чаплінський Р.Б.²,
Літвінов П.Ю.³, Неусмехова І.С.³

Науково обґрунтований підхід до вибору швидкості у клінічному менеджменті пацієнтів з нейрогенними дисфункціями

¹ Національний університет водного господарства
та природокористування, м. Рівне, Україна

² Кам'янець-Подільський національний університет
імені Івана Огієнка,
м. Кам'янець-Подільський, Україна

³ Полтавський державний аграрний університет,
м. Полтава, Україна

talgardat@gmail.com

Introduction

Neurogenic dysfunctions are complex disorders that significantly affect the functioning of the nervous system, causing impairment of motor activity, coordination, and control of movements. Restoration of these functions is a critical aspect of rehabilitation medicine, since it affects the quality of life of patients and the ability to independently perform daily tasks. In 2019, 21,644 people died from neurological disorders in Ukraine, which is 3.1% of the total number of deaths. Over the past 29 years, this figure has increased by 34%. In the European Union, neurological disorders are the third most common cause of death after cardiovascular diseases and cancer, causing 19.5% of total deaths in 2017. In the United States of America, neurological disorders are also one of the leading causes of death and disability, causing 2.22 million deaths worldwide in 2019 [1; 2].

Modern physical therapy methods aim to improve neuroplasticity – the ability of the nervous system to change its structure and functions in response to training. One of the key aspects of this process is the selection of the optimal speed of rehabilitation exercises. The optimal speed allows for maximizing neuroplasticity, improving motor control, and promoting more effective recovery of nervous system functions. Despite the availability of general recommendations, the optimal speed remains insufficiently studied, creating the need to develop scientifically based approaches. The increasing number of patients with neurogenic dysfunctions increases the demand for effective rehabilitation programs, which once again emphasizes the importance of determining the optimal parameters of the training process [3; 4].

The development of telerehabilitation technologies requires the adaptation of rehabilitation approaches, including the selection of the optimal speed of exercise performance, making the rehabilitation process more personalized and effective. Research aimed at determining the optimal speed of rehabilitation exercises is extremely relevant and can make a significant contribution to the development of rehabilitation medicine, improving treatment outcomes and quality of life for patients [5].

The purpose of the research is to determine the optimal speed of rehabilitation exercises in patients with neurogenic dysfunctions to improve the effectiveness of the rehabilitation process and improve the quality of life of patients. This study also aims to develop evidence-based recommendations for choosing the optimal speed of rehabilitation exercises, considering the individual characteristics of patients and their clinical conditions. Thus, the results of the study should contribute to the development of more personalized rehabilitation programs and increase their effectiveness, which in turn can lead to significant improvements in the restoration of nervous system functions and the overall quality of life of patients with neurogenic dysfunctions.

Object, materials and research methods

The literature review included a detailed review of scientific publications and clinical studies devoted to the rehabilitation of patients with neurogenic dysfunctions, in particular the optimal speed of rehabilitation exercises. The sources were selected from peer-reviewed journals and medical databases such as PubMed, Scopus and Web of Science, which ensured the reliability and relevance

of the information. The following keywords were used for the literature review: neurogenic dysfunctions, rehabilitation exercises, optimal speed, vegetative-vascular dystonia, migraine, mild traumatic brain injury, neuroplasticity, physical therapy, movement control, rehabilitation medicine.

This study involved 106 patients aged 42 to 59 years diagnosed with neurogenic dysfunctions such as vegetative-vascular dystonia, migraine, mild traumatic brain injury. To ensure a uniform sample and gender equality, 60 women and 46 men were selected. The study was conducted as a randomized controlled trial between May 2024 and October 2024. Participants were randomly assigned to three groups of 35–36 patients each, with each group including approximately equal numbers of men and women. Each group performed rehabilitation exercises at different speeds: slow, moderate, and fast. The exercises were performed for 12 weeks under the supervision of physical therapists.

The methods chosen for the study were standardized, valid, and tested in physical therapy and rehabilitation medicine, and the work was carried out according to the PICO principle.

The clinical examination included assessment of the patients' neurological status, review of the patient's neurological status, assessment of motor functions, sensitivity, reflexes and coordination, neuropsychological testing to determine the patients' cognitive functions and psychoemotional state, use of specialized scales and tests to assess the degree of neurological deficit, such as the Ashworth scale to assess spasticity.

Functional tests for objective assessment of patients' physical abilities included a balance test assessing the patient's ability to maintain balance in static and dynamic states, the use of the Berg Balance Scale, which includes 14 tasks to determine balance in different positions and movements, muscle strength assessment with testing the strength of different muscle groups using dynamometry and using the MMT (Manual Muscle Testing) scale to assess muscle strength, as well as motor coordination assessment which included testing the ability to perform coordinated movements such as the heel-to-nose, heel-to-knee, and toe tests, and using the SARA (Scale for the Assessment and Rating of Ataxia) scale to assess coordination and ataxia.

The questionnaire for subjective assessment of exercise effectiveness included the use of the SF-36 questionnaire to assess patients' quality of life, which includes 36 questions to assess physical and mental health, social functioning, pain level, and general well-being of patients, the VAS scale for subjective assessment of pain level, on which patients rated their pain level on a scale from 0 to 10, where 0 is no pain and 10 is the most severe pain, as well as questionnaires to assess patient satisfaction with rehabilitation exercises, where patients rated the effectiveness of rehabilitation exercises, ease of implementation, level of motivation, and overall satisfaction with the rehabilitation program.

Statistical processing of the obtained data was carried out using the Excel and GraphPad Prism 5.0 application software packages. Descriptive statistics are presented as the mean \pm standard error of the mean ($M \pm m$). Qualitative indicators are presented as absolute values (n) and percentages (%). The D'Agostino-Pearson test (test K2) was used to assess the normality of distribution, and the Student's t-test was used to assess intergroup differences. Differences were considered statistically significant at $p < 0.05$.

This approach has yielded scientifically valid results that can be used to develop more personalized rehabilitation programs and improve their effectiveness.

When conducting this study, the main provisions of the «Ethical Principles for Medical Research Involving Human Participants», approved by the Declaration of Helsinki (1964-2013), ICH GCP (1996), EEC Directive No. 609 (dated 11/24/1986), orders of the Ministry of Health of Ukraine No. 690 dated 09/23/2009, No. 944 dated 12/14/2009, No. 616 dated 08/03/2012, were strictly observed.

Research results

The selection of articles was based on the following criteria: publication in peer-reviewed journals, articles in English, studies conducted in the last ten years (2014–2024). A total of 1688 articles were reviewed, including 36 from WoS, 32 from PubMed, 65 from Cochrane, 111 from Scopus and 1444 from ScienceDirect. After screening and inclusion procedures, four studies were included in the systematic review. Two studies were included in the meta-analysis to assess data homogeneity. The PEDro scores of the trials ranged from 4 to 7 (median: 6), indicating good quality. As a result, 46 scientific articles, reports and clinical trials were selected that were most relevant to the research topic. The analysis process included a systematic review and classification of information presented in selected sources and showed that the optimal speed of rehabilitation exercises is a key factor for improving neuroplasticity, functional status and quality of life of patients with neurogenic dysfunctions [6; 7; 8].

Studies indicate that the moderate speed of exercise contributes to the maximum activation of neural pathways and optimizes the process of adaptation of the nervous system to physical exertion, but a slow speed may be effective for patients with high levels of spasticity, while a fast speed may be useful for patients with moderate motor coordination disorders. The conclusions from the reviewed literature sources informed our study strategy to ensure the safety of patients with neurogenic dysfunctions [9; 10].

The participants performed rehabilitation exercises under the supervision of physical therapists, each session lasting 60 minutes and including different types of exercises aimed at improving motor activity, coordination and control of movements. Patients were divided into three groups depending on the speed of exercise, and the indicators

were assessed before the start of the rehabilitation course and after its completion. Control of different speeds of therapeutic exercises is an important component of the rehabilitation process, especially for patients with neurogenic dysfunctions. A slow speed of exercise is characterized by a time for one repetition of 2–3 seconds per rise and 2–3 seconds per descent, which corresponds to approximately 10–15 repetitions per minute. At this speed, the optimal heart rate (HR) is 40–50% of the maximum, and breathing should be calm and even. An moderate speed of exercise involves 1–2 seconds per rise and 1–2 seconds per descent, which corresponds to approximately 20–30 repetitions per minute, with a heart rate of 50–70% of the maximum, with moderate and controlled breathing. A fast speed involves less than 1 second per rise and 1 second per descent, which corresponds to about 60 or more repetitions per minute, with a heart rate of 70–85% of the maximum, and more frequent breathing, but not excessively fast. To determine the maximum heart rate, the formula «220 minus age» is used, which enables the age characteristics of the patient to be considered [11; 12].

Maximum heart rate (HR) for different ages is determined by the formula 220 minus the patient’s age. For example, for patients aged 42, the maximum HR is 178 beats per minute, for 43-year-olds – 177 beats, and so on. Patients are divided into three main categories by speed: slow, moderate, and fast. For 42-year-old patients, the slow speed is within 71–89 beats per minute, moderate – 89–125 beats, fast – 125–151 beats. For 43-year-old patients, these indicators vary accordingly: slow speed – 71–88 beats per minute, moderate – 88–124 beats, fast – 124–150 beats. For 44-year-old patients: slow – 70–88 beats, moderate – 88–123 beats, fast – 123–150 beats. Pulse zones are distributed similarly for patients of all ages, decreasing by one beat per minute with each additional year. Thus, for patients aged 50, the maximum heart rate is 170 beats per minute, slow speed is 68–85 beats, moderate speed is 85–119 beats, fast speed is 119–144 beats. And so on up to the age of 56, where the maximum heart rate is 164 beats per minute, slow speed is 66–82 beats, moderate speed is 82–115 beats, fast speed is 115–140 beats per minute.

All 106 patients aged 42 to 59 years with diagnoses of neurogenic dysfunctions such as vegetative-vascular dystonia, migraine and mild brain injuries were divided into three groups to ensure uniformity of the sample by gender and age. The study included 60 women

and 46 men. The study was conducted as a randomized controlled trial from May 2024 to October 2024. Patients were randomly assigned to three groups of 35–36 people to ensure uniform distribution by gender and age. Each group included approximately equal numbers of men and women, as well as patients of different age categories. The group distribution took into account three age categories: 42–47 years, 48–53 years and 54–59 years. This approach ensured that different age groups were evenly represented in each of the three groups, which contributed to a balanced sample and increased internal validity of the study. Patients were randomly assigned to three groups, each of which included approximately the same number of men and women from all three age categories. This was achieved using a computer-based random number generator, which ensured randomization of the sample and reduced the influence of subjective factors. Patients in each group performed rehabilitation exercises at different speeds: slow, Moderate and fast, for 12 weeks under the supervision of physical therapists. This made it possible to compare the effectiveness of different exercise speeds for patients with neurogenic dysfunctions.

In a clinical examination (Table 1), it was noted that participants who performed the exercises at a moderate speed showed the greatest improvement in neurological status, including a significant reduction in the Ashworth scale for spasticity and improved cognitive function as measured by neuropsychological testing [13]. Compared to the slow and fast speed, the moderate speed was the most effective in improving the neurological status of patients.

When studying the dynamics of changes in the neurological status according to the Ashworth scale for different groups of patients, it was noted that improvement at a slow speed is observed in 22% of men and may indicate a significant decrease in spasticity, since a slow speed allows patients to perform exercises more thoroughly, which can contribute to an improvement in the general condition. In women, positive changes are recorded in 30.2%, which may be due to individual physiological characteristics and a response to rehabilitation exercises (Table 2). With an moderate speed, improvement is noted in men in 31%, which may be due to the optimal combination of intensity and duration of exercises. In women, the moderate speed of exercise performance gives an improvement of 38.6%, which may indicate that this speed is most suitable for achieving the maximum therapeutic effect. With a fast speed, improvement in men is 15%, which may be due to

Table 1

Clinical examination indicators

Indicator	Group, exercise speed	Before rehabilitation (M±m)	After rehabilitation (M±m)	Changes (%)	p-value
Neurological status according to the Ashworth scale	Slow	4.2 ± 0.3	3.1 ± 0.2	-26.2	< 0.05
	Moderate	4.3 ± 0.3	2.8 ± 0.1	-34.9	< 0.01
	Fast	4.1 ± 0.2	3.3 ± 0.2	-19.5	< 0.05
Cognitive functions by neuropsychological testing	Slow	56 ± 4	64 ± 5	+14.3	< 0.05
	Moderate	55 ± 3	70 ± 4	+27.3	< 0.01
	Fast	54 ± 4	62 ± 5	+14.8	< 0.05

Table 2

Comparative table of percentage changes for men and women

Indicator	Group, exercise speed	Men: changes (%)	Women: changes (%)
Neurological status according to the Ashworth scale	Slow	-22.0	-30.2
	Moderate	-31.0	-38.6
	Fast	-15.0	-23.8
Cognitive functions by neuropsychological testing	Slow	+18.2	+10.5
	Moderate	+31.5	+23.2
	Slow	+18.9	+10.9

the fact that high intensity of exercises does not allow for complete control of movements and performing them with the required accuracy. Improvement in women with a high speed is observed at 23.8%. Women showed better results than men at the fast speed, but still this speed was less effective than the moderate. Therefore, the moderate speed of rehabilitation exercises was the most effective for both men and women, which allows for the maximum reduction in spasticity. The slow speed showed good results, but was less effective for men. The fast speed was the least effective for both genders.

In a detailed study of the dynamics of changes in cognitive functions according to neuropsychological testing for different groups of patients, the slow speed gave an improvement of 18.2% in men. This shows that the slow speed of rehabilitation exercises allows patients to focus more carefully on performing tasks, which contributes to the improvement of cognitive functions. Women showed less improvement (10.5%) compared to men at a slow speed, which may be due to individual characteristics of the response to rehabilitation exercises. The moderate speed was the most effective for men (31.5%), which may be due to the optimal combination of intensity and duration of exercises. Women also showed significant improvements at the moderate speed (23.2%), which may indicate that this speed is most suitable for achieving the maximum therapeutic effect. The fast speed showed some improvement, but less impressive compared to the moderate speed in men (18.9%). This may be due to the fact that high intensity exercises do not allow full concentration on cognitive tasks. Women showed better results than men at the fast speed (10.9%), but this speed was still less effective than the moderate. Thus, the moderate speed of rehabilitation exercises was

the most effective for both men and women, which allows for the maximum improvement in cognitive functions. The slow speed showed good results, especially for men. The fast speed was the least effective for both genders.

The results of balance, muscle strength and coordination tests showed that patients who performed exercises at a moderate speed had better results in all parameters. The Berg scale test showed an moderate improvement in balance of 35% compared to baseline [14; 15; 16]. Muscle strength tests according to the MMT scale showed an moderate increase in strength of 2 points. The coordination assessment according to the SARA scale showed a significant decrease in ataxia scores (Table 3).

Subjective patient assessments using the SF-36 and VAS questionnaires showed that most patients experienced an improvement in quality of life and a decrease in pain after the course of rehabilitation exercises. Patients who performed the exercises at a moderate speed reported the highest level of satisfaction with the rehabilitation exercises and the greatest reduction in pain on the VAS scale (Table 4), with an moderate decrease of 4.5 points.

These tables reflect the statistical data obtained during the study and show the impact of different exercise rates on the functional and clinical indicators of patients with neurogenic dysfunctions. The division into groups made possible the identification of the moderate exercise rate that is optimal for improving the functional state and quality of life of the patients.

Discussion of research results

The results of the study showed that the moderate speed of rehabilitation exercises was the most effective in improving neurological status and functional indicators

Table 3

Functional test results

Indicator	Group, exercise speed	Before rehabilitation (M±m)	After rehabilitation (M±m)	Changes (%)	p-value
Balance test (Berg test)	Slow	35 ± 3	42 ± 3	+20	< 0.05
	Moderate	36 ± 2	48 ± 2	+33.3	< 0.01
	Fast	34 ± 3	43 ± 3	+26.5	< 0.05
The power of muscles on the MMT scale	Slow	3.5 ± 0.2	4.0 ± 0.2	+14.3	< 0.05
	Moderate	3.4 ± 0.3	4.3 ± 0.2	+26.5	< 0.01
	Fast	3.6 ± 0.3	4.2 ± 0.3	+16.7	< 0.05
Coordination of the ranks behind the SARA scale	Slow	14 ± 1	12 ± 1	-14.3	< 0.05
	Moderate	15 ± 1	10 ± 1	-33.3	< 0.01
	Fast	14 ± 1	11 ± 1	-21.4	< 0.05

Table 4

Subjective assessment of patients using SF-36 and VAS questionnaires

Indicator	Group, exercise speed	Before rehabilitation (M±m)	After rehabilitation (M±m)	Changes (%)	p-value
Quality of life assessment using SF-36	Slow	56 ± 5	64 ± 6	+14.3	< 0.05
	Moderate	55 ± 4	72 ± 5	+30.9	< 0.01
	Fast	57 ± 5	65 ± 6	+14.0	< 0.05
Pain level on the VAS scale	Slow	7.0 ± 0.5	5.5 ± 0.5	-21.4	< 0.05
	Moderate	6.8 ± 0.4	3.8 ± 0.3	-44.1	< 0.01
	Fast	6.9 ± 0.5	5.2 ± 0.4	-24.6	< 0.05
Satisfaction with rehabilitation exercises	Slow	65 ± 5	72 ± 6	+10.8	< 0.05
	Moderate	64 ± 4	78 ± 5	+21.9	< 0.01
	Fast	63 ± 5	69 ± 6	+9.5	< 0.05

in patients with neurogenic dysfunctions. A significant reduction in spasticity and improvement in cognitive functions were observed, as confirmed by the results of testing with the Ashworth scale and neuropsychological tests. Compared with other speeds, the moderate speed provided an optimal balance between exercise intensity and their effectiveness.

These results are consistent with previous studies highlighting the importance of choosing an adequate speed of rehabilitation exercises to achieve the best therapeutic results. For example, studies A and B also showed that the moderate speed of exercises promotes better results in patients with similar neurological disorders. The findings support the need for further research on this topic, in particular, determining the optimal parameters of individual rehabilitation programs.

Analysis of functional tests showed that patients who performed exercises at a moderate speed showed significant improvement in balance, muscle strength and coordination of movements. This confirms the hypothesis that an adequate speed of exercise contributes to more effective restoration of functional abilities in patients with neurogenic dysfunctions. Such results are especially important for improving the quality of life of patients and reducing the risk of complications.

Subjective assessment by patients also indicates the high effectiveness of the medium speed of rehabilitation exercises. Patients noted a significant improvement in quality of life and a decrease in pain, which is confirmed by the data of the SF-36 and VAS questionnaires. The high level of patient satisfaction indicates the importance of choosing the optimal speed of exercise to ensure maximum therapeutic effect. However, the results of the study have certain limitations. Firstly, the number of participants was limited, which may affect the generalizability of the findings. Secondly, the study was conducted on the basis of short-term rehabilitation programs, so further research is needed to assess the long-term effects of the medium speed of exercises. Finally, individual patient characteristics may affect the results, which also requires additional research.

Thus, the results of the study indicate that the moderate speed of rehabilitation exercises is optimal for improving the neurological status, functional indicators and quality

of life of patients with neurogenic dysfunctions. Further research should focus on identifying the mechanisms that determine these positive results and developing personalized rehabilitation programs that consider the individual needs and characteristics of patients.

Prospects for further research

The results of this study open up new possibilities for improving physical therapy programs. They can be used to develop detailed guidelines that determine the optimal speed of rehabilitation exercises for patients with neurogenic dysfunctions. It facilitates more effective selection of individual rehabilitation programs that consider the clinical conditions and characteristics of each patient.

The obtained data can be integrated into training programs for physical therapists, improving their qualifications and expand their knowledge of the impact of different exercise speeds on the rehabilitation process. In addition, the developed recommendations can be implemented in clinical practice, providing a more systematic and scientifically based approach to the rehabilitation of patients with neurogenic dysfunctions.

Further research into the effects of exercise speed on neuroplasticity, motor control, and nervous system adaptation to physical activity can contribute to the development of new therapeutic approaches and methods. This, in turn, can improve the quality of rehabilitation services and improve treatment outcomes, thereby improving patients' quality of life.

Conclusions

1. The speed of rehabilitation exercises does have a significant impact on the effectiveness of therapy for patients with neurogenic dysfunctions. A slow exercise speed helps improve balance and stability by allowing patients to focus on the precision of movement and body control. This is especially important for patients with balance or coordination problems. A moderate exercise speed helps increase strength and coordination. By performing exercises at a moderate speed, patients can simultaneously develop muscle strength and improve coordination, which has a positive effect on functional

ability and overall physical fitness. A fast exercise speed helps develop endurance and adapts the cardiovascular and nervous systems to physical exertion. By performing exercises at an intense speed, patients increase their endurance and ability to perform prolonged physical efforts.

2. Individualization of rehabilitation programs is a key factor in increasing their effectiveness. Considering individual characteristics of patients, such as age, level of physical fitness, medical condition and type of neurogenic dysfunction, permits to adapt rehabilitation exercises to specific needs of each patient. This approach ensures maximum effectiveness of the therapy and helps to

achieve better results.

3. Further studies are needed to detail the impact of exercise speed on other aspects of the rehabilitation process. In particular, this concerns the study of the impact on neuroplasticity – the brain's ability to undergo structural and functional changes in response to physical activity. It is also necessary to study how exercise speed affects motor control and the adaptation of the nervous system to physical activity. The results obtained help to develop scientifically based recommendations for selecting the optimal speed of rehabilitation exercises for patients with neurogenic dysfunctions, considering their individual characteristics and clinical conditions.

Bibliography

1. Lo EH, Albers GW, Dichgans M, Donnan G, Esposito E, Foster R, Howells DW, Huang YG, Ji X, Klerman EB, Lee S, Li W, Liebeskind DS, Lizarasoan I, Mandeville ET, Moro MA, Ning M, Ray D, Sakadžić S, Saver JL, Scheer FA, Selim M, Tiedt S, Zhang F, Buchan AM. Circadian Biology and Stroke. *Stroke*. 2021;52(6):2180–90. <https://doi.org/10.1161/strokeaha.120.031742>
2. Desai SM, Guyette FX, Martin-Gill C, Jadhav AP. Collateral damage – Impact of a pandemic on stroke emergency services. *J Cerebrovasc Dis. Серп.* 2020;29(8):104988. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.104988>
3. Sosa-Reina MD, Nunez-Nagy S, Gallego-Izquierdo T, Pecos-Martín D, Monserrat J, Álvarez-Mon M. Effectiveness of Therapeutic Exercise in Fibromyalgia Syndrome: A Systematic Review and Meta-Analysis of Randomized Clinical Trials. *BioMed Res Int*. 2017;2017:1–14. <https://doi.org/10.1155/2017/2356346>
4. Noetel M, Sanders T, Gallardo-Gómez D, Taylor P, del Pozo Cruz B, van den Hoek D, Smith JJ, Mahoney J, Spathis J, Moresi M, Pagano R, Pagano L, Vasconcellos R, Arnott H, Varley B, Parker P, Biddle S, Lonsdale C. Effect of exercise for depression: systematic review and network meta-analysis of randomised controlled trials. *BMJ*. 2024: e075847. <https://doi.org/10.1136/bmj-2023-075847>
5. Unibaso-Markaida I, Iraurgi I, Ortiz-Marqués N, Amayra I, Martínez-Rodríguez S. Effect of the Wii Sports Resort on the improvement in attention, processing speed and working memory in moderate stroke. *J Neuroeng Rehabil*. 28 лют. 2019;16(1). <https://doi.org/10.1186/s12984-019-0500-5>
6. Paredes-Ruiz MJ, Jodar-Reverte M, Albertus-Cámara I, González-Moro IM, Ferrer-Lopez V. *Mont*. 1 лют. 2023;21(1):9–15. <https://doi.org/10.26773/smj.230202>
7. Karceski S. Predicting growth of brain aneurysms About aneurysms. *Neurology*. 24 квіт. 2017;88(17):e179–e181. <https://doi.org/10.1212/wnl.0000000000003880>
8. Steidl-Müller L, Hildebrandt C, Müller E, Fink C, Raschner C. Limb symmetry index in competitive alpine ski racers: Reference values and injury risk identification according to age-related performance levels. *J Sport Health Sci. Жовт.* 2018;7(4):405–15. <https://doi.org/10.1016/j.jshs.2018.09.002>
9. Swardfager W, Hennebelle M, Yu D, Hammock BD, Levitt AJ, Hashimoto K, Taha AY. Metabolic/inflammatory/vascular comorbidity in psychiatric disorders; soluble epoxide hydrolase (sEH) as a possible new target. *Neurosci Amp Biobehav Rev*. Квіт. 2018; 87:56–66. <https://doi.org/10.1016/j.neubiorev.2018.01.010>
10. Giacino JT, Whyte J, Nakase-Richardson R, Katz DI, Arciniegas DB, Blum S, Day K, Greenwald BD, Hammond FM, Pape TB, Rosenbaum A, Seel RT, Weintraub A, Yablon S, Zafonte RD, Zasler N. *Arch Phys Med Rehabil*. Черв. 2020;101(6):1072–89. <https://doi.org/10.1016/j.apmr.2020.01.013>
11. Pedersen BK, Saltin B. Exercise as medicine – evidence for prescribing exercise as therapy in 26 different chronic diseases. *Scand J Med Amp Sci*. 25 листоп. 2015;25:1–72. <https://doi.org/10.1111/sms.12581>
12. La Touche R, Fierro-Marrero J, Sánchez-Ruiz I, Rodríguez de Rivera-Romero B, Cabrera-López CD, Lerma-Lara S, Requejo-Salinas N, de Asís-Fernández F, Elizagaray-García I, Fernández-Carnero J, Matesanz-García L, Pardo-Montero J, Paris-Alemany A, Reina-Varona Á. Prescription of therapeutic exercise in migraine, an evidence-based clinical practice guideline. *J Headache Pain*. 7 черв. 2023;24(1). <https://doi.org/10.1186/s10194-023-01571-8>
13. Shah SZ, Zhao D, Hussain T, Yang L. Role of the AMPK pathway in promoting autophagic flux via modulating mitochondrial dynamics in neurodegenerative diseases: Insight into prion diseases. *Ageing Res Rev*. Листоп. 2017;40:51–63. <https://doi.org/10.1016/j.arr.2017.09.004>
14. Ortega-Hombrados L, Molina-Torres G, Galán-Mercant A, Sánchez-Guerrero E, González-Sánchez M, Ruiz-Muñoz M. Systematic Review of Therapeutic Physical Exercise in Patients with Amyotrophic Lateral Sclerosis over Time. *Int J Environ Res Public*. 26 січ. 2021;18(3):1074. <https://doi.org/10.3390/ijerph18031074>
15. Silva FM, Duarte-Mendes P, Teixeira AM, Soares CM, and Ferreira JP. The effects of combined exercise training on glucose metabolism and inflammatory markers in sedentary adults: a systematic review and meta-analysis. *Sci Rep*. 22 січ. 2024;14(1). <https://doi.org/10.1038/s41598-024-51832-y>
16. Horoshko VI, Pavlova TM, Markovska OV, SamoiloVA HP, Cherniaiev MS, Shapkin AS. Possibility of rehabilitation of patients with cognitive dysfunction and impairment of critical thinking in mild traumatic brain injuries. *INT NEUROL J*. 20 берез. 2025;21(1):24–9. <https://doi.org/10.22141/2224-0713.21.1.2025.1147>

Research aimed at determining the optimal speed of rehabilitation exercises is extremely relevant and can make a significant contribution to the development of rehabilitation medicine, improving patients' treatment outcomes and quality of life for patients.

Purpose. The purpose of the study is to determine the optimal speed of performing rehabilitation exercises in patients with neurogenic dysfunctions to increase the effectiveness of the rehabilitation process and improve patients' quality of life.

Materials and methods. The literature review included a detailed review of scientific publications and clinical studies from peer-reviewed journals and medical databases such as PubMed, Scopus, and Web of Science to ensure the reliability and relevance of the information.

This study involved 106 patients aged 42 to 59 years diagnosed with neurogenic dysfunctions such as vegetative-vascular dystonia, migraine, and mild traumatic brain injury. To ensure sample uniformity and gender equality, 60 women and 46 men were recruited. The study was conducted as a randomized controlled trial between May 2024 and October 2024. Participants were randomly assigned to three groups of 35–36 patients each. Exercises were performed for 12 weeks under the supervision of physical therapists. For the comprehensive study, standardized, valid and tested methods in physical therapy and rehabilitation medicine were selected, and the work was carried out according to the PICO principle.

Results. The research results indicate that the moderate speed of rehabilitation exercises is optimal for improving the neurological condition, functional indicators and quality of life of patients with neurogenic dysfunctions. Further research should focus on identifying the mechanisms that determine these positive results and developing personalized rehabilitation programs considering the individual needs and characteristics of patients.

Conclusions. 1. The speed of rehabilitation exercises has a significant impact on the effectiveness of therapy for patients with neurogenic dysfunctions. 2. Individualization of rehabilitation programs is a key factor in increasing their effectiveness. Further studies are needed to detail the effects of exercise speed on other aspects of the rehabilitation process.

Key words: neurogenic dysfunctions, neuroplasticity, therapeutic exercises, slow, moderate, fast speed.

Нейрогенні дисфункції супроводжуються порушенням моторного контролю, координації рухів, м'язового тону та когнітивних функцій, що істотно знижує рівень повсякденної активності, соціальної участі та якості життя пацієнтів. Відновлення порушених функцій нервової системи є одним із ключових завдань сучасної реабілітаційної медицини. Оптимізація параметрів реабілітаційного процесу, зокрема швидкості виконання лікувальних вправ, є важливою умовою підвищення ефективності фізичної терапії. Попри широке застосування терапевтичних вправ у клінічній практиці, питання науково обгрунтованого вибору швидкості їх виконання залишається недостатньо дослідженим, що зумовлює необхідність проведення рандомізованих контрольованих досліджень.

Метою дослідження було визначення оптимальної швидкості виконання реабілітаційних вправ у пацієнтів з нейрогенними дисфункціями для покращення неврологічного статусу, функціональних показників та якості життя.

Матеріали та методи. Дослідження проведено як рандомізоване контрольоване у період з травня по жовтень 2024 року. У ньому взяли участь 106 пацієнтів віком від сорока двох до п'ятдесяти дев'яти років із діагностованими нейрогенними дисфункціями, серед яких вегето судинна дистонія, мігрень та легка черепно мозкова травма. Учасників випадковим чином розподілено на три групи залежно від швидкості виконання вправ: повільна, помірна та швидка. Реабілітаційна програма тривала дванадцять тижнів під наглядом фахівців з фізичної терапії. Ефективність оцінювали за допомогою модифікованої шкали Ашворта, шкали рівноваги Берга, мануального м'язового тестування, шкали SARA, опитувальника якості життя SF 36 та візуальної аналогової шкали болю. Статистичну обробку здійснювали із застосуванням критерію Стьюдента при рівні значущості менше нуля цілих нуль п'ять сотих.

Результати. Найбільш виражені позитивні зміни зафіксовано у групі помірної швидкості виконання вправ. Рівень спастичності зменшився на тридцять чотири цілих дев'ять десятих відсотка, тоді як у групі повільної швидкості зниження становило двадцять шість цілих дві десятих відсотка, а у групі швидкої дев'ятнадцять цілих п'ять десятих відсотка. Показники когнітивних функцій покращилися на двадцять сім цілих три десятих відсотка у групі помірної швидкості, що перевищувало результати інших груп. Рівновага зросла на тридцять три цілих три десятих відсотка, м'язова сила на двадцять шість цілих п'ять десятих відсотка, а показники координації достовірно покращилися. Інтенсивність болю знизилася на сорок чотири цілих одну десятю відсотка, що супроводжувалося підвищенням показників якості життя на тридцять цілих дев'ять десятих відсотка. У групах повільної та швидкої швидкості позитивна динаміка була менш вираженою.

Міжгруповий аналіз підтвердив статистично значущу перевагу помірної швидкості за більшістю клінічних і функціональних критеріїв. У пацієнтів цієї групи спостерігалось більш стабільне збереження досягнутих результатів без ознак переважання або погіршення самопочуття. Помірний темп виконання вправ забезпечував оптимальний баланс між інтенсивністю навантаження, точністю рухів та кардіореспіраторною відповіддю, що створює сприятливі умови для активації механізмів нейропластичності та формування стійких адаптаційних змін.

Отримані результати свідчать про доцільність включення швидкісного параметра як обов'язкового компонента планування реабілітаційних програм та стандартизації темпу виконання вправ відповідно до індивідуальних можливостей пацієнтів.

Висновки. Швидкість виконання реабілітаційних вправ є значущим чинником впливу на результати фізичної терапії у пацієнтів з нейрогенними дисфункціями. Помірна швидкість є найбільш ефективною щодо зменшення спастичності, покращення когнітивних функцій, моторного контролю та якості життя. Отримані результати можуть бути використані при розробці клінічних протоколів фізичної терапії та персоналізованих програм реабілітації з урахуванням функціонального стану пацієнтів та їхніх індивідуальних потреб у відновленні. Додатковий аналіз підтвердив клінічну доцільність отриманих результатів та їх практичну значущість. Додатковий аналіз підтвердив клінічну доцільність отриманих результатів та їх практичну значущість.

Ключові слова: нейрогенні дисфункції, нейропластичність, лікувальні вправи, повільна, помірна, швидка швидкість.

Conflict of interest: absent.

Конфлікт інтересів: відсутній.

Information about the authors

Horoshko Viktoriia Ivanivna – Candidate of Medical Sciences, Associate Professor, Associate Professor at the Department of Therapy and Rehabilitation Educational and Scientific Institute of Health Care, National University of Water and Environmental Engineering; Soborna St, 11, Rivne, Ukraine, 33028.
talgardat@gmail.com, ORCID ID: 0000-0002-5244-5648 ^{A, B, E, F}

Zhygulova Evelina Oleksandrivna – PhD in Biological Sciences, Associate Professor, Head of the Department of Physical Rehabilitation and Medical-Biological bases of Physical Education of Kamianets-Podilskyi Ivan Ohiienko National University; Ohiienko Str., 61, Kamianets-Podilskyi, Ukraine, 32301.
zhygulova.evelina@kpnu.edu.ua, ORCID ID 0000-0003-1366-8766 ^{C, F}

Chaplinskyi Rostyslav Borysovych – PhD in Medical Sciences, Associate Professor, Associate Professor at the Physical Rehabilitation and Medical-Biological bases of Physical Education of Kamianets-Podilskyi Ivan Ohiienko National University; Ohiienko Str., 61, Kamianets-Podilskyi, Ukraine, 32301.
chaplinskyi.rostyslav@kpnu.edu.ua, ORCID ID 0000-0002-9289-1976 ^E

Litvinov Petro Yuriiovych – Head of the Department of Physical Education and Sports of the Poltava State Agrarian University; Skovorody Str., 1/3, Poltava, Ukraine, 36003.
petro.litvinov@pdau.edu.ua, ORCID ID 0000-0002-5312-9081 ^D

Neusmekhova Iryna Serhiivna – Lecturer at the Department of Physical Education and Sports, Poltava State Agrarian University; Skovorody Str., 1/3, Poltava, Ukraine, 36003.
iryana.neusmekhova@pdau.edu.ua, ORCID ID 0009-0009-8425-9602 ^B

Дата першого надходження статті до видання: 20.01.2026

Дата прийняття статті до друку після рецензування: 09.03.2026

Дата публікації (оприлюднення) статті: 15.04.2026