Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1453-1460 | ISSN:2251-6727

The Efficacy of Digital Application to Improve Muscle Strength Rehabilitation in Adult Post-Stroke: Pilot Study

Rinawati Kasrin*[1,3], Faridah Mohd Said[1], Tukimin Sansuwito[2], Yendrizal Jafri[3], Wenny Lazdia[4]

[1]Faculty of Nursing, Lincoln University College, Selangor Malaysia

[2]Health Sciences Faculty of Applied, Lincoln University College, Selangor Malaysia

[3] Nursing Department, Faculty of Health Science Perintis Indonesia University, West Sumatra Indonesia

[4] Nursing Department, Fort De Kock University West Sumatra Indonesia

(Received: 04 February 2024 Revised: 11 March 2024 Accepted: 08 April 2024)

KEYWORDS
Digital Application, Rehabilitation, Post-Stroke

ABSTRACT:

Pathophysiologically about stroke occurs as a result of ischemia or hemorrhage on cerebral blood vessels which contributes to mortality rates and high morbidity. The results of studies in the field of neurology state that stroke is the number one cause of death in various hospitals in the country. The post-stroke can be regarded as the most difficult time for patients, they will experience a disability and inability to move as usual so they will have difficulty in self-care. In reality there are many barriers for stroke survivors to access rehabilitation. There is way to overcome their problems in rehabilitation is through technological innovation with telerehabilitation base on digital applications. The use of digital technology has changed various aspects of human life, including in the field of health. Based on this gap, this study aims to explore various approaches to increase the effectiveness of muscle strength rehabilitation programs post-strokes. Type of research in this study was experiment design. The use of digital application explored through Quasi Experiment method using the equivalent group experimental design (randomized pretest-posttest with control group). The study involved 40 respondents divided for an intervention group has 20 respondents and 20 control group. Data processing quantitative analysis using univariate, bivariate analysis methods (Mann-Whitney U Test, Chi-Square test). Research results by statistical tests found that the intervention group p-value was 0.001<0.05 and the control group p-value 0.001<0.05 and with independent test results mean difference is 0.15. Based on the results of the study showed that digital application and modul rehabilitation had effect for increasing muscle strength. To improve muscle strength rehabilitation in post-stroke adults more efficacy in the intervention group using digital applications than the control group using modules. This result shows that there is an increase in the progress of post-stroke adult muscle strength rehabilitation using digital applications.

Introduction

Stroke is a condition where the blood supply to the brain is disrupted, resulting in oxygen starvation, brain damage and loss of function and it is most frequently caused by a clot in an artery supplying blood to the brain, a situation known as ischemia. Pathophysiologically stroke occurs as a result of ischemia or hemorrhage on cerebral blood vessels which contributes to mortality rates and high morbidity (World Stroke Organization, 2019). There is a multitude of etiologies that can lead to a stroke. Some of the most common risk factors include hypertension, diabetes mellitus, hypercholesterolemia, physical inactivity, obesity, genetics, and smoking. Cerebral emboli commonly originate from the heart, especially in patients

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1453-1460 | ISSN:2251-6727

with preexisting heart arrhythmias (atrial fibrillation), valvular disease, structural defects (atrial and ventricular septal defects) and chronic rheumatic heart disease (Prasanna Tadi & Forshing Lui, 2021). Stroke has already reached epidemic proportions. Globally 1 in 4 adults over the age of 25 will have a stroke in their lifetime. 13.7 million people worldwide will have their first stroke this year and five and a half million will die as a result (WSO 2019). The burden of stroke remains a huge public health concern. In 2019, stroke was the second leading cause of death and disability worldwide (Owolabi et al., 2021). In the United States, there are 800,000 new strokes every year. There is one new stroke every 40 seconds. Stroke is the 5th leading cause of death and the first leading cause of disability (Prasanna Tadi & Forshing Lui, 2021). China faces the greatest challenge from stroke in the world. The death rate for cerebrovascular diseases in China was 149.49 per 100 000, accounting for 1.57 million deaths in 2018. It ranked third among the leading causes of death behind malignant tumours and heart disease (Wang et al., 2020). In Indonesia alone, strokes are the highest cause of death in hospitals, with a mortality rate of 15.4%, and the prevalence of strokes has increased from 7 cases per 1,000 per capita in 2013, to 10.9 cases per 1,000 per capita in 2018 (Base research 2018). The results of studies in the field of neurology state that stroke is the number one cause of death in various hospitals in the country (Noor, 2023). Weakness of the arms and legs in stroke patients will affect muscle contractions, so one of the rehabilitation programs that can be given to stroke patients is joint mobilization with range of motion exercises to increase muscle strength (Potter and Perry, 2010). Weakness of the hands and feet in stroke patients will affect muscle contraction, so one rehabilitation program that can be given to stroke patients is the mobilization of joints with range of motion exercises. The post-stroke can be regarded as the most difficult time for patients with post-stroke, they will experience a disability and inability to move as usual so that they will have difficulty in self care (Ismatika & Soleha, 2018). To sustain life rehabilitation is an important component of post-stroke management to avoid disability. In reality there are many barriers for stroke survivors to access rehabilitation care face-to-face and many patients do not derive maximal benefit due to access, time restrictions, limited resources, geographical isolation, adherence to rehabilitation, lack of awareness, and cost ((Whitehead & Baalbergen, 2019). The use of digital technology has changed various aspects of human life, including in the field of health. In this digital era, digital technology provides great potential to optimize health services through increasing efficiency, accessibility, and quality of services. Advances in digital technology have enabled a transformation in the way we access information, communicate, and interact with health systems. The application of digital technology in public health services includes various innovations such as healing post-stroke rehabilitation (Vargas-Hernández, 2021). Digital health applications offer a versatile approach to overcome current medical care gaps. Digital health applications are essentially mobile applications used for medical purposes (Knitza et al., 2023). There is a need for evidence-based information and digital applications (Iwaya et al., 2023). Digital health solutions are an emerging and promising type of care delivery. It could potentially change the spectrum of chronic diseases healthcare (Blanchard, 2023). Digital systems are digital applications: software or apps, digital devices, computers or smartphones, and digital environments (the internet or messaging services). Digital applications are very influential in helping patient health, as well as digital applications in improving muscle strength rehabilitation in post-stroke adults. Because stroke is a disease that requires healing long enough. Therefore, stroke healing rehabilitation must be done at home using digital applications so that patients get mental encouragement in their recovery efforts. However, the use of this digital application requires maximum effort, sometimes in fact the casein is a bit male and bored to use the digital application, because there is no motivation and requires the help of others. Based on this, it is very important to have these improvement efforts.

Method

Type of research in this study was experiment design. The use of digital application explored through Quasi Experiment method using the equivalent group experimental design (randomized pretest-posttest with control group). Sampling teachnique applied non-randome sampling technique were used. The study involved 40 respondents (20 in intervention group and 20 in control group). Data processing quantitative analysis using univariate, bivariate analysis methods

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1453-1460 | ISSN:2251-6727

(Mann-Whitney U Test, Chi-Square test). The research was conducted on May to July 2023 in the Bukittinggi city. Inclusion criteria for our study were: Willing to be a respondent after discharge from hospital, diagnosis by a doctor is a stroke with hemipegic upper and lower extremity without complication, age of respondent is 26-45 years old, fully and not experiencing mental disorders, the longest post-stroke is less than 6 months, and can communicate well. Exclusion criteria in this study: Not continue to be a respondent more than 3 days, undergoing other complementary therapies, there is no network around the house of respondent, and unstable physical condition.

Results

Characteristics of respondents in this study including gender, education level, employment, marital status and income ecomonic. Distribution respondents based on gender, level education, employment, marital status, and income ecomonic are presented in the following table:

Table 4.1 Characteristics of Respondents

Variables	**Intervention group n = 20 (%)**	**Control group n = 20 (%)**
Gender		
Female	8 (40)	13 (65.0)
Male	12 (60.0)	7 (35.0)
Married		
single	1 (5.0)	1 (5.0)
married	18 (90.0)	17 (85.0)
widow/widower	1 (5.0)	2 (10.0)
Education		
Senior High School	3 (15.0)	8 (40.0)
Diploma	2 (10.0)	2 (10.0)
Bachelor	6 (30.0)	7 (35.0)
Master	2 (10.0)	3 (15.0)
Doctor	0	0
Occupation		
housewives	3 (15.0)	1 (5.0)
civil servants	6 (30.0)	5 (25.0)
private employees	7 (35.0)	3 (15.0)
retirees	0	0
farmers/laborers	0	3 (15.0)
entrepreneurs	4 (20.0)	8 (40.0)
others	0	0
Income economic status		
< Rp. 1.000.000	3 (15.0)	3 (15.0)
> Rp. 3.000.000	7 (35.0)	7 (35.0)
Rp.1.000.000-3.000.000	10 (50.0)	10 (50.0)
dependent Variable		
Muscle strength		
Increase	8 (40.0)	8 (40.0)
Not increase	12 (60.0)	12 (60.0)

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1453-1460 | ISSN:2251-6727

The characteristics of respondents by type of gender in this study shows that the gender of most respondents was male 12 people (60.0%) and 8 people (40%) female. From the table above it can be seen that the highest level of education is a bachelor's degree with a total of 6 people (30.0%). On This research can be seen that the respondents 15 people (35,7%) work as private employees. Marital status of respondents in the study, this shows that the majority of respondents 18 people are married (90.0%), the last from the table above it can be seen that the highest level of Income economic status is Rp. 1.000.000-Rp 3.000.000 with a total of 10 people (50.0%).

Univariate

Univariate Analysis In this study, distribution respondents increased muscle strength rehabilitation in post-stroke patients before and after intervention in the intervention group and control group as follows:

Table 4.2
Distribution Muscle Strength Respondent Pre-Test and Post-Test
between intervention group and control group (n=40)

No	Group	Mean	N	SD	SE	CI 95%
1.	**intervention**					
	Pre-test	1.75	20	0.851	0.190	1.021-6.79
	Post-test	2.60	20	0.754	0.169	1.021-6.79
2.	**control**					
	Pre-test	1.90	20	0.788	0.176	0.789-3.11
	Post-test	2.45	20	0.686	0.153	0.789-3.11

From table 4.2 above it can be seen that muscle strength rehabilitation in the group intervention before given the intervention has a mean value of 1.75 (SD: 0.851) while the average value of increasing muscle strength after intervention in 7 days was 2.60 (SD:0.754). While the average value of muscle strength rehabilitation at control group at the beginning of the examination was 1.90 (SD: 0.788) and the average value increasing muscle strength after 7 days was 2.45 (SD: 0.686).

Bivariate

Analysis In this study, the results of the analysis of the differences in the effect of increasing muscle strength function on respondents who were used digital aplication and those who were given modul application as fallow:

Table 4.3
differences in the effect of increasing the muscle strength
Pre-Test and Post-Test in the intervention group and the control group
Significant = p<0,05* (therefore, if significant indicate with*)

No	Group	Mean	SD	SE	Difference Mean	p-value
1.	**intervention**					
	Pre-test	1.75	0.851	0.190	2.60	0.001
	Post-test	2.60	0.754	0.169		
2.	**control**					
	Pre-test	1.90	0.788	0.176	2.45	0.001
	Post-test	2.45	0.686	0.153		

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1453-1460 | ISSN:2251-6727

From table 4.3 above it can be seen that muscle strength rehabilitation in the group intervention before given the intervention has a mean value of 1.75 (SD: 0.851) while the average value of increasing muscle strength after intervention in 7 days was 2.60 (SD:0.754). The test results are different Two means get a p-value was 0.001<0.05 it was concluded that there was an influence significant relationship between increasing muscle strength on measurements before and after used digital application in the group intervention. While the average value of muscle strength rehabilitation at control group at the beginning of the examination was 1.90 (SD: 0.788) and the average value increasing muscle strength after 7 days was 2.45 (SD: 0.686). The test results for the difference between two means were obtained the p-value is 0.001<0.05 then it can be concluded that there is significant influence increasing muscle strength measurement before and after intervention on control group.

Table 4.4
Independent Sample Test

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	**Sig.**	**t**	**df**	**Sig.(2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
Observation	Equal Variance assumed	.172	.681	-.658	38	.039	-.0.15	3.8951	-18.2347	-.6120
	Equal Variance Not assumed			-.658	37.6	.039	-.0.15	3.7782	- 17.9852	-.8615

Based on the Independent sample Test output table, it is known that Sig. (2 tailed) value is 0.039<0.05 for that it can be concluded that there is a significant difference in muscle strength between the use of digital applications and the use of modules to increase muscle strength in the rehabilitation of post-stroke patients. The intervention group had an average increase in muscle strength that was greater than the increase in muscle strength in the control group, namely -0.15 (0.15).

Discussion

The loss of muscle strength is a common occurrence in patients who have suffered a stroke. This debilitating condition can greatly impact their ability to perform daily tasks and have a negative effect on their quality of life. Understanding the importance of addressing muscle weakness in patients post stroke is crucial for providing optimal care and support to those affected by this condition. One of the major consequences of stroke is the impact it has on muscle strength (Owolabi, 2021). The impact of stroke on patients is profound and can significantly affect their quality of life. Many individuals require long-term rehabilitation and support to regain lost abilities and adapt to their new circumstances. Traditional methods of stroke rehabilitation have limitations, which has led to the development of digital applications specifically designed for stroke patients. These innovative tools aim to enhance recovery outcomes, provide personalized

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1453-1460 | ISSN:2251-6727

care, and improve patient engagement throughout the rehabilitation process (Whilehead 2019). Digital applications have revolutionized various aspects of our lives, and healthcare is no exception. In recent years, there has been a growing interest in using digital technology for stroke rehabilitation. Stroke, a leading cause of disability worldwide, often requires intensive and long-term rehabilitation to restore lost functions and improve quality of life. Traditional rehabilitation methods are effective but can be time-consuming and costly. Digital applications offer a promising solution by providing accessible, engaging, and personalized tools for stroke survivors to continue their recovery journey at home. Digital applications have revolutionized the field of stroke rehabilitation by offering innovative solutions to improve patient outcomes. These applications leverage technology to provide personalized and interactive therapies, making the rehabilitation process more engaging and effective. Through a combination of virtual reality, gamification, and remote monitoring, digital applications have transformed stroke rehabilitation into a dynamic and accessible experience for patients (Ulfert, 2022). The implementation of medical digital technologies can provide better accessibility and flexibility of healthcare for the public. It encompasses the availability of open information on the health, treatment, complications, and recent progress on biomedical research. At present, even in low-income countries, diagnostic and medical services are becoming more accessible and available. However, many issues related to digital health technologies remain unmet, including the reliability, safety, testing, and ethical aspects (Adeniji et al., 2023). The role that technological advances may have in increasing the effectiveness interventions, as well as more novel intervention approaches, some of the key considerations in delivering digital and mobile health (mHealth) based interventions (Anton et al., 2020). With continuing growth in the Internet and use of smartphones, the development of digital health applications can significantly broaden rehabilitation and health care opportunities for patients. The full potential of digital health technologies to reach a large number of people with disabilities who exhibit a range of physical and psychosocial secondary health conditions and provide them with effective dose of interventions has yet to be realized (Frontera et al., 2017). Regardless of the digital gap, digital literacy and education in information systems is another key aspect. This can be addressed by familiarising users with healthcare information systems (Milioris et al., 2022). The rehabilitation of patients with neurological deficit is very important for their adaptation to ordinary life. The success in neurorehabilitation allowed a large number of patients to return to normal conditions that became a matter of social and medical rehabilitation services. However, no more than 15–20% of post-stroke patients are able to recover their mobility functions. The best recovery result is achieved when rehabilitation starts as early as the doctor observing the post-stroke patient, considers feasible, as soon as the patient state becomes medically stable. Early rehabilitation procedures are very important for recovering motor functions (Zhuralvev et al., 2020).

Conclusions

Based on the results of the study and discussion above, it shows that the results in the intervention group for adult muscle strength with post-stroke before and after the intervention using digital applications with a p-value of 0.001<0.05, which means there is an increase in muscle strength rehabilitation before the intervention and after the intervention using digital applications at home. Improvement in muscle strength rehabilitation in adults with more post-stroke efficacy in the intervention group using digital applications than in the control group using modules with independent test results in mean difference was 0.15 This suggests that the use of digital applications has an effect on increasing muscle strength rehabilitation in post-stroke adults.

Acknowledgment

We thank to all personality public health office who give productive ideas and comments for contacting the patients and carrying out the interviews and thank you very much for good cooperation to all respondents who willingly in the research activities.

Declarations of Conflicting Interest

All authors report that there are no conflicts of interest in this work of research.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1453-1460 | ISSN:2251-6727

References

1. Adeniji, T., Nadasan, T., Michael Olagbegi, O., & Dada, O. (2023). Telerehabilitation-based exercises with or without transcranial direct current stimulation for pain, motor and cognitive function in older adults with mild cognitive impairments post-stroke: A multi-arm parallel-group randomized controlled trial study protocol. *Brain Hemorrhages*, *4*(3), 122–128. https://doi.org/10.1016/j.hest.2023.01.004
2. Anton, S. D., Cruz-Almeida, Y., Singh, A., Alpert, J., Bensadon, B., Cabrera, M., Clark, D. J., Ebner, N. C., Esser, K. A., Fillingim, R. B., Goicolea, S. M., Han, S. M., Kallas, H., Johnson, A., Leeuwenburgh, C., Liu, A. C., Manini, T. M., Marsiske, M., Moore, F., … Pahor, M. (2020). Innovations in Geroscience to enhance mobility in older adults. *Experimental Gerontology*, *142*(July), 111123. https://doi.org/10.1016/j.exger.2020.111123
3. Blanchard, M. (2023). User experience research in the development of digital health products: Research letter. *Health Policy and Technology*, *12*(2), 100753. https://doi.org/10.1016/j.hlpt.2023.100753
4. Chen, W. C., Hsiao, M. Y., & Wang, T. G. (2022). Prognostic factors of functional outcome in post-acute stroke in the rehabilitation unit. *Journal of the Formosan Medical Association*, *121*(3), 670–678. https://doi.org/10.1016/j.jfma.2021.07.009
5. Frontera, W. R., Bean, J. F., Damiano, D., Ehrlich-Jones, L., Fried-Oken, M., Jette, A., Jung, R., Lieber, R. L., Malec, J. F., Mueller, M. J., Ottenbacher, K. J., Tansey, K. E., & Thompson, A. (2017). Rehabilitation Research at the National Institutes of Health: Moving the Field Forward (Executive Summary). *Archives of Physical Medicine and Rehabilitation*, *98*(4), 795–803. https://doi.org/10.1016/j.apmr.2017.02.001
6. Iwaya, L. H., Nordin, A., Fritsch, L., Børøsund, E., Johansson, M., Varsi, C., & Ängeby, K. (2023). Early Labour App: Developing a practice-based mobile health application for digital early labour support. *International Journal of Medical Informatics*, *177*(June). https://doi.org/10.1016/j.ijmedinf.2023.105139
7. Ismatika, I., & Soleha, U. (2018). Hubungan Self Efficacy Dengan Perilaku Self Care Pasien Pasca Stroke Di Rumah Sakit Islam Surabaya. *Journal of Health Sciences*, *10*(2), 139–148. https://doi.org/10.33086/jhs.v10i2.140
8. Knitza, J., Muehlensiepen, F., & Kuhn, S. (2023). Digital Health Applications: Toward a Lifecycle and Pay-for-Performance Approach. *Mayo Clinic Proceedings: Digital Health*, *1*(3), 393–394. https://doi.org/10.1016/j.mcpdig.2023.07.001
9. Kozelka, E. E., Acquilano, S. C., Al-Abdulmunem, M., Guarino, S., Elwyn, G., Drake, R. E., & Carpenter-Song, E. (2023). Documenting the digital divide: Identifying barriers to digital mental health access among people with serious mental illness in community settings. *SSM - Mental Health*, *4*(February), 100241. https://doi.org/10.1016/j.ssmmh.2023.100241
10. Meyerhoff, J., Kornfield, R., Lattie, E. G., Knapp, A. A., Kruzan, K. P., Jacobs, M., Stamatis, C. A., Taple, B. J., Beltzer, M. L., Berry, A. B. L., Reddy, M., Mohr, D. C., & Graham, A. K. (2023). From formative design to service-ready therapeutic: A pragmatic approach to designing digital mental health interventions across domains. *Internet Interventions*, *34*(May), 100677. https://doi.org/10.1016/j.invent.2023.100677
11. Milioris, K., Konstantopoulos, C., Papageorgiou, K., & Skordoulis, M. (2022). The use of healthcare information systems: a research study about health professionals' needs. *International Journal of Healthcare Technology and Management*, *19*(1), 77–89. https://doi.org/10.1504/IJHTM.2022.123580
12. Oanmun, K., & Dhippayom, J. P. (2023). Development of occupational therapy screening tool for clients with stroke. *Journal of Associated Medical Sciences*, *56*(3), 5–12. https://doi.org/10.12982/JAMS.2023.048
13. Owolabi, M. O., Thrift, A. G., Martins, S., Johnson, W., Pandian, J., Abd-Allah, F., Varghese, C., Mahal, A., Yaria, J., Phan, H. T., Roth, G., Gall, S. L., Beare, R., Phan, T. G., Mikulik, R., Norrving, B., Feigin, V. L., & on behalf of the Stroke Experts Collaboration Group. (2021). The state of stroke services across the globe: Report of World Stroke Organization–World Health Organization surveys. *International Journal of Stroke*, *0*(0), 1–13. https://doi.org/10.1177/17474930211019568
14. Small, R., Wilson, P. H., Wong, D., & Rogers, J. M. (2022). Who, what, when, where, why, and how: A

systematic review of the quality of post-stroke cognitive rehabilitation protocols. *Annals of Physical and Rehabilitation Medicine*, *65*(5), 101623. https://doi.org/10.1016/j.rehab.2021.101623

15. Prasanna Tadi, & Forshing Lui. (2021). Acute Stroke - StatPearls - NCBI Bookshelf. In *StatPearls*. https://www.ncbi.nlm.nih.gov/books/NBK535369/
16. Ulfert-Blank, A. S., & Schmidt, I. (2022). Assessing digital self-efficacy: Review and scale development. *Computers and Education*, *191*(March), 104626. https://doi.org/10.1016/j.compedu.2022.104626
17. Viñas-Diz, S., & Sobrido-Prieto, M. (2016). Virtual reality for therapeutic purposes in stroke: A systematic review. *Neurología (English Edition)*, *31*(4), 255–277. https://doi.org/10.1016/j.nrleng.2015.06.007
18. Tan, T. F., Thirunavukarasu, A. J., Jin, L., Lim, J., Poh, S., Teo, Z. L., Ang, M., Chan, R. V. P., Ong, J., Turner, A., Karlström, J., Wong, T. Y., Stern, J., & Ting, D. S. W. (2023). Artificial intelligence and digital health in global eye health: opportunities and challenges. *The Lancet Global Health*, *11*(9), e1432–e1443. https://doi.org/10.1016/S2214-109X(23)00323-6
19. Tran, P. M., Zhu, C., Harris, W. T., Raghavan, S. K. K., Odoi, A., & Tran, L. (2024). An examination of geographic access to outpatient stroke rehabilitation services in Tennessee, a stroke belt state. *Journal of Stroke and Cerebrovascular Diseases*, *33*(1), 107472. https://doi.org/10.1016/j.jstrokecerebrovasdis.2023.107472
20. Ulfert-Blank, A. S., & Schmidt, I. (2022). Assessing digital self-efficacy: Review and scale development. *Computers and Education*, *191*(March), 104626. https://doi.org/10.1016/j.compedu.2022.104626
21. Viñas-Diz, S., & Sobrido-Prieto, M. (2016). Virtual reality for therapeutic purposes in stroke: A systematic review. *Neurología (English Edition)*, *31*(4), 255–277. https://doi.org/10.1016/j.nrleng.2015.06.007
22. Vargas-Hernández, J. G. (2021). *Info scipedia*. University of Guadalajara, Mexico. https://doi.org/DOI: 10.4018/978-1-7998-7603-8.ch005
23. Weerakkody, A., White, J., Hill, C., Godecke, E., & Singer, B. (2023). Delivering constraint-induced movement therapy in stroke rehabilitation requires informed stakeholders, sufficient resources and organisational buy-in: a mixed-methods systematic review. *Journal of Physiotherapy*, *69*(4), 249–259. https://doi.org/10.1016/j.jphys.2023.08.007
24. Whitehead, S., & Baalbergen, E. (2019). Post-stroke rehabilitation. *South African Medical Journal*, *109*(2), 81–83. https://doi.org/10.7196/SAMJ.2019.v109i2.00011
25. Zhuralvev, M., Runnova, A., & Kiselev, A. (2020). Characteristics of post-stroke patients brain activity with real and imagined movements in the BCI-rehabilitation process. *Procedia Computer Science*, *169*(2019), 677–685. https://doi.org/10.1016/j.procs.2020.02.184