Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

Original scientific article

Using Programmable Device Installations to Control Students with Disabilities after Blast Traumatic Brain Injury in 10 Meter Walking Test

Oksana Blavt[1ABCD], Lesia Galamanzhuk[2BCD], Mykhailo Huska[2BCD], Gennadii Iedynak[2ABCD], Maryan Pityn[3BCD], Yurii Kachurak[1ABD], Volodymyr Faidevych[4BCD] and Rostyslav Turka[3BCD]

[1]Lviv Polytechnic National University
[2]Kamianets-Podilskyi Ivan Ohiienko National University
[3]Lviv State University of Physical Culture named after Ivan Boberskyj
[4]Lutsk National Technical University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Oksana Blavt, E-mail: oksanablavt@ukr.net
Accepted for Publication: June 10, 2024
Published: June 30, 2024

DOI: 10.17309/tmfv.2024.3.12

Abstract

Objectives. This study aimed to determine the degree of authenticity for the test implemented using a programmable installation for monitoring the functions of functional mobility, gait, and the state of the vestibular apparatus in students with disabilities who have sustained a blast traumatic brain injury.

Material and methods. The study included a total of 39 first-year students with disabilities after an explosive brain injury. The following methods were used: theoretical analysis of scientific and methodological literature, the method of technical modelling, pedagogical testing, pedagogical experiment, and methods of mathematical statistics. In order to ascertain the efficacy of the proposed intervention, a 10-meter walking test was conducted.

Results. The result of our study was the development using information systems and networks of a programmable device for the implementation of the 10-meter walking test, which is used to monitor the recovery of functional mobility, gait, and the state of the vestibular apparatus in students with disabilities after an explosive brain injury. The installation was based on a network of sensors organized according to the Arduino microcontroller platform. Acoustic, optical sensors, distance sensors, proximity sensors, presence sensors, and spatial position sensors have been placed to record the results of the test distance. The sensors, having received an information signal about the student passing the test, transmit it to the controller. In the controller, information is identified, processed, calculated and transferred to a personal computer, where it is displayed on the screen and reproduced graphically. The software ensures maintainability throughout the test, as well as efficiency of data processing, calculation of required parameters and their storage. Data processing is implemented using image analysis systems based on neural networks. According to the findings of testing and correlation analysis, indicators' authenticity degree for the used tests were established, which differed by the means of measuring the results. The level of correlation coefficient between the values for test reliability and validity in the case of fixing the test results using a stopwatch was not found to fall within the "low" and "acceptable" limits, while in the second case, when the results were fixed by a programmed control unit, it reached the "high" level.

Conclusions. The use of the developed programmable device in the practical work of inclusive PE provides convenience, functionality, objectivity and reliability of control in the process of rehabilitation of students with disabilities after an explosive craniocerebral injury. What is confirmed by the values of the test authenticity measure obtained during the experiment when fixing the results by the developed installation.

Keywords: students with disabilities, blast traumatic brain injury, physical education, testing, inclusion, control, authenticity.

Introduction

From February 24, 2022, Russia's full-scale aggression against Ukraine continues. In addition to protracted hostilities, the aggressor's army is shelling the civilian population daily. As a result, the number of people, including military personnel, children, and civilians, affected by the aggression of the Russian Federation with war injuries is permanently increasing (Dzyak et al., 2023).

Despite the lack of accurate statistical data for the period of the war in Ukraine, Ukraine has not yet encountered such a large number of complex injuries. Injuries as a result of war are characterized by considerable diversity, but according to data, 99% of victims have mine-explosive injuries, among which brain injuries are considered the most complex – blast traumatic brain injury (TBI) (U.S. Department of Veterans Affairs. Office of Research and Development, Veterans Health Administration, 2007).

According to (Chapman & Diaz-Arrastia, 2014), the number of blast TBI from blast wave action, which has no analogs in the clinic of peacetime diseases, is astounding. According to evidence (Mac Donald et al., 2014), among all injuries received during the war: 35-40% are head injuries, of which 80 % is blast TBI. According to data (VA research on Traumatic Brain Injury, 2019), the majority of blast TBIs associated with military actions and received by civilians are classified as mild.

Due to the fact that individuals with disabilities due to blast TBI are becoming students in increasing numbers, the higher school has found itself at the epicenter of serious challenges. The need to provide conditions for the restoration of the health status of students with disabilities after blast TBI in the process of education is growing due to the challenges of the long war, which determines the relevance of scientific intelligence.

The problem of improving the health status of students with disabilities after blast TBI becomes especially urgent given the fact that the timely restoration of the functions is a factor in preventing physical maladaptation of such students and ensuring the further ability to effectively perform their professional activities (Blavt & Gurtova, 2023; Hellweg & Johannes, 2008).

In higher education, the rehabilitation function of students with disabilities is considered in the context of inclusive PE (Rekaa, Hanisch, & Ytterhus, 2019). It has been studied (Haarbauer-Krupa et al., 2021) that the effectiveness of recovery after blast TBI depends on expertise, timeliness, qualified approaches, and a list of rehabilitation measures (Bramlett & Dietrich, 2015; Hellweg & Johannes, 2008). After analyzing the scientific literature, it was found that physical activity is considered an important means of rehabilitation after a blast TBI (Wise et al., 2012; Physical Activity Guidelines for Traumatic Brain Injury; Fulk & Nirider, 2014).

It should be noted that scientists have a common belief (Kuntjoro et al., 2022; Page et al., 2021) that the main thing in the process of inclusive PE is compliance with the requirements of time (Blavt, Iedynak, Pereverzieva, Holub, & Melnyk, 2023). It has been studied that in the presence of modern technologies and equipment, the learning and PE process becomes more applied, motivating, actionable and diverse (Pellerin, Wilson, & Haegele, 2022; Blavt, Chaplinskyi et al., 2023).

There is a large list of studies on the feasibility and necessity (given the need to eliminate the influence of the human factor) of using information systems and networks, created on the basis of electronic technologies that are used in the PE process (Mykytyuk, Blavt et al., 2022; Varga & Révész, 2023; Gupta, 2021).

Purpose of the research is a determination of the degree of authenticity of the test implemented using a programmable installation for monitoring the functions of functional mobility, gait, and the state of the vestibular apparatus in students with disabilities after blast TBI.

Materials and Methods

Research Methods

The conducted research belongs to the randomized controlled type of empirical research. The experiment was implemented in two stages. The following methods were used: theoretical analysis of scientific and methodological literature, the method of technical modeling, pedagogical testing, pedagogical experiment, and methods of mathematical statistics.

The first stage consisted in the development of a programmable control unit using information systems and networks. For this, the method of technical modeling was used.

The second stage involved the implementation of a pedagogical experimen. The experiment consisted in the implementation of pedagogical testing, during which the control of functional mobility, gait, and the state of the vestibular apparatus (to determine functional mobility, gait, and vestibular function) was implemented in students of the studied sample.

The 10 Meter Walk Test was used in the study (Gafner, & Bruyneel, 2022). The appropriateness of choosing this test was that its use provides ease of control and assessment of measuring locomotor capacity in clinical and research settings (to measure locomotor capacity in clinical and research settings (de Baptista et al., 2020) which are recommended for monitoring the rehabilitation process for various diseases (Unver et al. 2017).

It is considered (Physiopedia), the scale properties (time in seconds or m/s) of the 10 Meter Walk Test make it a responsive test well suited to evaluating clinical interventions.

Test procedure. Equipment Required: a clear pathway with a set distance (6, 8, or 10 meters in length depending on distance tested). The student must walk 10 meters unaided, with the intervening 6 meters timed to account for acceleration and deceleration (Fig. 1). The time is recorded (to the nearest second) and the walking speed is calculated.

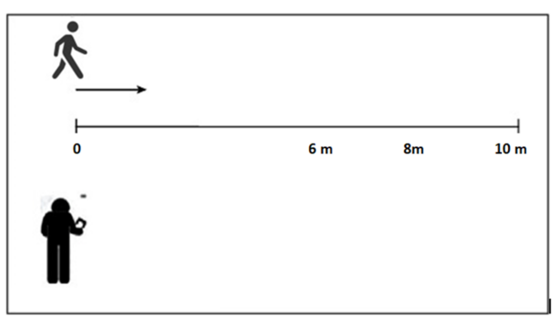

Fig. 1. Scheme of the test

The student walks without assistance for 10 meters, with the time measured for the intermediate 6 meters to allow for acceleration and deceleration Perform three trials and calculate the average of three trials. Scoring: The time (to the nearest second) is fixed.

Study Participants

39 students in the 1st year of studies with disabilities as a result of the blast TBI, were involved in the study from Lviv Polytechnic National University, Kamianets-Podilskyi Ivan Ohiienko National University, Lviv State University of Physical Culture named after Ivan Boberskyj and Lutsk National Technical University.

To implement the empirical part of the study, a research sample was formed. The selection of students for the experiment was randomized, taking into account personal consent to the collection and systematization of control information in an anonymized form for further statistical analysis. The gender factor was not taken into account, since no evidence of the influence of gender has been found on the quality indicators of the test.

The criteria for inclusion in the studied sample were the presence of the anamnesis of students with mild blast TBI disability, obtained as a result of the war, and being in a state of restoration of lost functions. The criteria that did not allow students with disabilities after blast TBI to participate in the study were the presence in the anamnesis of deformities and diseases affecting walking, the inability to move without aids (crutches, walking sticks), the presence of chronic health conditions and combined injuries.

The study was planned and carried out following the principles of bioethics set forth by the World Medical Association (WMA-2013) in the Helsinki Declaration "Ethical Principles of Medical Research Involving Humans" and UNESCO in the "General Declaration on Bioethics and Human Rights".

Research Organization

A comparative pedagogical experiment was carried out to determine the effectiveness of the means of control. As an experimental factor, a means of registering the results was used. In the first case, the registration of the results took place using a stopwatch and was carried out by the teacher.

Average time and speed of the walk (10 m) and mid-walk (6 m) obtained at a self-selected fast pace were analyzed. Participants were tested on the 10MWT twice: at baseline (test) and after seven days (retest). The outcome variable was mean speed. The results of the average arithmetic value of three attempts were used in the conclusions.

On the contrary, in the second case, the registration of the results took place using the programmable installation developed during the research, which ensured the calculation of all the necessary parameters automatically.

Statistical Analysis

Statistical analysis was used as a data analysis tool in our study. The obtained data from such an analysis became the basis of substantiated conclusions of the study of the degree of authenticity of the used test. In our case, such data served as the intraclass correlation coefficient, which is an indicator of the quality characteristics of the test as a measurement tool, namely its reliability and validity values. Intraclass correlation coefficient determined by correlation analysis.

All statistical analyses were performed using SPSS Version 22.0 (IBM Corporation).

Results

First of all, our experiment is based on the characteristics of blast TBI and the consequences for the body that accompanies it. It should be taken into account that BI, which occurs as a result of the action of a mine blast wave and has received the name blast TBI, is significantly different from that which occurs as a result of the action of other factors (impact, sports injuries, etc.) (Denby et al., 2020; Capizzi Woo & Verduzco-Gutierrez 2020).

Understanding the mechanisms of blast overpressure injury is important to finding ways to repair it (Nelson, Davenport, Sponheim, & Anderson, 2015). Therefore, in the PE process, it is necessary to take into account the impact of blast TBI on numerous vital functions, which can have a significant long-term impact on health (Bryden, Tilghman, & Hinds, 2019), since blast TBI is described as a chronic health condition (Haarbauer-Krupa, Pugh, Prager, Harmon, Wolfe, & Yaffe, 2021).

The peculiarity of blast TBI is that it can be accompanied by damage to the auditory and vestibular apparatus (Denby et al., 2020) and lead to a persistent vegetative state of disturbance in the activity of the central nervous system (Mac Donald et al., 2014). The result of such lesions is a motor deficit, consisting of a violation of body balance (DePalma, 2015), and a long-term motor deficit (Bramlett, & Dietrich, 2015). The result is a loss of stability and balance during walking and other locomotor movements (getting out of bed, chair, etc.) (Corwin et al., 2015).

Therefore, to ensure the efficiency and speed of recovery, specialists (Briskin, Odinets & Pityn, 2015) focus their attention on finding ways to effectively control this process, as a result of which tests become more and more diverse and complex to implement best practices for timeliness of intervention, monitoring and evaluation states after blast TBI (Haarbauer-Krupa et al., 2021).

The result of our research was the development, using information systems and networks, of a programmable installation for monitoring the restoration of functional mobility functions, gait, and the condition of the vestibular apparatus in students with disabilities after blast TBI.

The basis of the installation (Fig. 2) (Mykytyuk et al., 2024) was a sensor network organized based on the

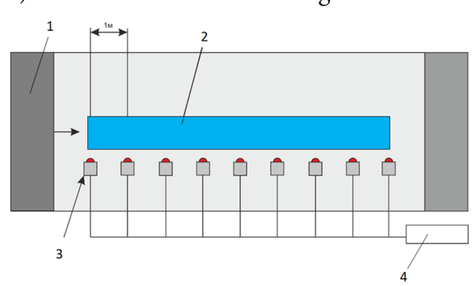

Fig. 2. Scheme programmable installation
(1 – start, 2 – track for passing the test, 3 – a system of sensors, 4 – data processing system)

Arduino microcontroller platform. Acoustic, optical, range, proximity, presence, and spatial position sensors are placed to record the test distance results (Mykytyuk, Blavt et al., 2022), which have different purposes in our installation. However, all sensors are assembled in a set, united by a common program for storing, processing, and displaying test data on a personal computer.

Sensors are placed at control points to record the beginning of the test process, the intermediate 6 meters, and the end of the test. In this way, it is possible to record whether a student walks 10 meters, without outside help, without losing balance, and at a constant speed. The determination of the time of movement between points is provided by the developed software.

A "smart system" with optical sensors is built into the device to measure the student's position in space when performing a test exercise that assesses the state of functional mobility and balance while walking. Such a system, with the help of a neural network, analyzes the position and movements of the student during the test and automatically records all the studied parameters and the presence of deviations from the norm.

In the developed installation, sensors are placed directly on the student's body. In this way, we ensure the reliability of the measurement of all parameters of coordination, balance, and functional mobility. A feature of the developed software installation is that such measurements can be carried out without sensors located at control points of the test distance.

The sensors, having received an information signal about the student passing the test, transmit it to the controller. In the controller, information is identified, processed, calculated, and transferred to the personal computer (PC). On a PC, the test results are displayed on the screen and reproduced graphically.

The software implements maintainability throughout the test, efficiency of data processing, calculation of necessary parameters, and storage. Data processing is implemented using image analysis systems based on neural networks.

The second stage involved the implementation of a comparative pedagogical experiment. According to the results of testing and correlation analysis (Table 1), indicators of the degree of authenticity of the used tests were established, which differed in the means of measuring the results.

Table 1. Degree of authenticity of the 10 Meter Walk Test for students with disabilities after blast TBI (n = 39)

rtt	S	PI	S	PI	S	PI	S	PI
reliability	0.588	0. 891	0.611	0.922	0.594	0.912	0.591	0.933
validity	0.215	0.218	0.616	0.609	0.220	0.618	0.223	0.601

* Note: S – fixing the results with a stopwatch, PI – fixing the results with a a programmable installation

The level of the correlation coefficient of the values of test reliability and validity in the first case (fixing the results with a stopwatch) was not at the limit of "low" and "acceptable", in the second case (fixing the results with a a programmable installation for monitoring) it reached the level of "high".

Discussion

Before the war, the issue of inclusion attracted considerable attention, however, as a result of the war, the issue of inclusive PE in higher education, given the humanitarian trends during emergencies (Congressional Research Service, 2019), gained special importance. The research conducted extends the data of previous studies (Blavt, Bodnar et al., 2023; Blavt, Iedynak et al., 2023) that the evolution of inclusive PE to meet the challenges of today, which are caused by Russia's long-term aggression against Ukraine requires the search for innovative solutions to ensure proper conditions for recovery after injuries of students with disabilities.

Researchers see the solution to this issue in constructive and technological solutions based on the use of modern information technologies (Varga & Révész, 2023; Gupta, 2021; Cuthbert et al., 2014), which is currently is the most dynamic segment of software engineering development.

The effects of blast TBI remain a serious source of injury for armed forces and civilians in combat zones worldwide (Xiang et al., 2022). Blast injuries have been identified as a new entity with specific characteristics. Blast injuries have been identified as a novel entity with specific characteristics (Maas et al., 2008; Merritt et al., 2015). Physical activity is considered by experts as a powerful means of non-pharmacological recovery after blast TBI (Physical Activity Guidelines for Traumatic Brain Injury; Fulk & Nirider, 2014;

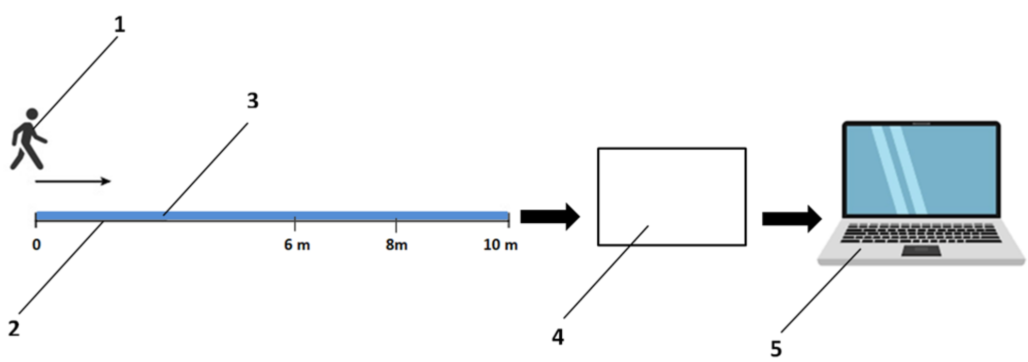

Fig. 3. Scheme using a programmable installation for 10 Meter Walk Test (1 – student, 2 – track for passing the test, 3 – a system of sensors that determine the time of passage of each section of the system to determine the speed and its changes during walking, 4 – controller, 5 – PC)

Johnson et al., 2023), control, as proven (Bland et al., 2011; Fure et al., 2021), having an exploratory and evaluative nature, is the basis of evidence-based rehabilitation The need for such studies is due to the lack of randomized trials establishing the effectiveness of rehabilitation after blast TBI (Xiang et al., 2022).

Tests that use the function of walking are quite widespread in the practice of monitoring the rehabilitation process in persons with amputations (Brooks et al., 2001), cardiovascular diseases (Bellet et al., 2012; Hanson et al., 2012; Casillas et al., 2013), with total hip arthroplasty (Yuksel, Unver, Kalkan, & Karatosun, 2021), brain injuries (SCIRE-PROJECT), in muscular dystrophy (Pizzato et al., 2016), in neurological diseases (Tyson & Connell, 2009) and even in children, during their development (de Baptista, et al., 2020).

A certain list of works is devoted to the determination of quality indicators of tests using walking for a certain distance in relation to various studied contingents. In particular, young healthy adults (Smith-Turchyn et al., 2021), persons with total hip arthroplasty (Yuksel et al., 2021), in typically developing children (de Baptista et al., 2020), persons with lower limb prostheses (Sawers et al., 2020). However, studies on the use of distance walking tests for students with disabilities after blast TBI have not yet been conducted.

On the other hand, we agree with our research on the use of test results to monitor the progression of disability. This was confirmed by previous studies (Pizzato et al., 2016).

The results of our previous research on the expediency of using technical means in the implementation of the control process in inclusive PE have been supplemented. Considering that specialists recommend repeating the test after certain periods (Pizzatoet al., 2016), the developed setup makes it possible to implement such control with the least loss of time.

Conclusions

Inclusive PE in times of war faces new challenges. As a result of the armed aggression of the Russian Federation, due to shelling and explosions, the structure of the contingent of students with disabilities was significantly affected: now students with disabilities after blast TBI are the largest contingent.

Blast TBI is considered a problem that goes beyond the scope of BI and is positioned as a multiple injuries, which is included in the concept of mine-explosive injury and requires a comprehensive approach in the implementation of the recovery process.

Developed with the use of information systems and networks, the programmable device for monitoring functional mobility, gait, and the state of the vestibular apparatus in students with disabilities after blast TBI integrates modern electronic technologies and a package of system application programs.

The use of the developed programmable installation in the practical work of inclusive PE provides convenience, functionality, objectivity, and reliability of control in the process of rehabilitation of students with disabilities after blast TBI. What is confirmed by the values of the measure of authenticity of the test obtained during the experiment in the case of fixing the results by the developed setup: The calculated values of the coefficients reach the "high" level, which allows us to assert the objectivity of the control of the studied parameters.

Conflicts of Interest

No conflicts of interest exist.

References

Dzyak, L.A., Mizyakina, K.V., Shulga, O.O., & Suk, B.M. (2023). *Protection of the brain with post-traumatic combat injuries.* Medical newspaper "Health of Ukraine of the 21st Century", 5-6, 541-542. https://health-ua.com/multimedia/userfiles/files/2023/ZU_5-6_2023/ZU_5-6_2023_32-33.pdf [in Ukrainian].

U.S. Department of Veterans Affairs. Office of Research and Development, Veterans Health Administration. (2007). Single-topic issue on TBI and polytrauma. *J Rehabil Res Dev, 44*(7).

Chapman, J.C., & Diaz-Arrastia, R. (2014). Military traumatic brain injury: a review. *Alzheimers Dement,* 10, S97-S104. https://doi.org/10.1016/j.jalz.2014.04.012

Mac Donald, C.L., Johnson, A.M., Wierzechowski, L., Kassner, E., Stewart, T., Nelson, E.C., Werner, N.J., Zonies, D., Oh, J., Fang, R., & Brody, D.L. (2014). Prospectively assessed clinical outcomes in concussive blast vs nonblast blast TBI among evacuated US military personnel. *JAMA Neurol, 7*1(8), 994-1002. https://doi.org/10.1001/jamaneurol.2014.1114

VA research on Traumatic Brain Injury (TBI). (2019). *DVBIC: Defense and Veterans Brain Injury Center.* https://www.research.va.gov/topics/tbi.cfm

Blavt, O., & Gurtova, T. (2023). Postural Control Development of Students with Disabilities in the Process of Inclusive Physical Education. *Journal of Learning Theory and Methodology, 4*(3), 88-94. https://doi.org/10.17309/jltm.2023.3.03

Hellweg, S., & Johannes, S. (2008). Physiotherapy after traumatic brain injury: A systematic review of the literature. *Brain Injury, 22*(5), 365-373. https://doi.org/10.1080/02699050801998250

Rekaa, H., Hanisch, H., & Ytterhus, B. (2019). Inclusion in Physical Education: Teacher Attitudes and Student Experiences. A Systematic Review. *International Journal of Disability, Development and Education, 66*(1), 36-55. https://doi.org/10.1080/1034912X.2018.1435852

Haarbauer-Krupa, J., Pugh, M.J., Prager, E.M., Harmon, N., Wolfe, J., & Yaffe, K. (2021). Epidemiology of Chronic Effects of Traumatic Brain Injury. *J Neurotrauma, 38*(23), 3235-3247. https://doi.org/10.1001/10.1089/neu.2021.0062

Bramlett, H.M., & Dietrich, W.D. (2015). Long-term consequences of traumatic brain injury: current status of potential mechanisms of injury and neurological outcomes. *J Neurotrauma,* 32, 1834-1848. https://doi.org/10.1089/neu.2014.3352

Wise, E.K., Hoffman, J.M., Powell, J.M., Bombardier, C.H., & Bell, K.R. (2012) Benefits of exercise maintenance after traumatic brain injury. *Archives of physical medicine and rehabilitation, 93*(8), 1319-23. https://doi.org/10.1016/j.apmr.2012.05.009

Physical Activity Guidelines for Traumatic Brain Injury https://www.physio-pedia.com/Physical_Activity_Guidelines_for_Traumatic_Brain_Injury?

Fulk, G.D., & Nirider, C.D. (2014). *Traumatic brain injury.* In: O'Sullivan S. B., Schmitz T. J., Fulk G. D., editors: Physical rehabilitation. 6th edition, Philadelphia:FA Davis Co.

Kuntjoro, B.F.T., Soegiyanto, S., Setijono, H., & Suhiharto, S. (2022). Inclusion of students with disability in physical education: analysis of trends and best practices. *AJPESH, 2*(2), 88-94. https://doi.org/10.15294/ajpesh.v2i2.64840

Page, A., Anderson, J. & Charteris. J. (2021). Including students with disabilities in innovative learning environments: a model for inclusive practices. *International Journal of Inclusive Education,* 3. https://doi.org/10.1080/13603116.2021.1916105

Blavt, O., Iedynak, G., Pereverzieva, S., Holub, V., & Melnyk, S. (2023). Increasing the Reliability of Test Control Using Information Technologies in Inclusive Physical Education. *Physical Education Theory and Methodology, 23*(4), 607-613. https://doi.org/10.17309/tmfv.2023.4.16

Pellerin, S., Wilson, W. J., & Haegele, J. A. (2022). The experiences of students with disabilities in self-contained physical education. *Sport, Education and Society, 27*(1), 14-26. https://doi.org/10.1080/13573322.2020.1817732

Blavt, O., Chaplinskyi, R., Prozar, M., Pityn, M., Helzhynska, T., Dmytruk, V., Hrebik, O., & Kovalchuk, V. (2023). The Efficiency of the Application of Electronic Techniques in the Control of Dynamic Balance in the Process of Inclusive Physical Education. *Physical Education Theory and Methodology, 23*(5), 770-776. https://doi.org/10.17309/tmfv.2023.5.16

Mykytyuk, Z., Blavt, O., Hnatchuk, Ya., Stechkevych, O., & Helzhynska, T. (2022). Intensification of Back Muscle Strength Testing in Physical Education of Students by Applying Information and Communication Technologies. *Physical Education Theory and Methodology,* 22(2), 216-222. https://doi.org/10.17309/tmfv.2022.2.10

Varga, A., & Révész, L. (2023). Impact of applying information and communication technology tools in physical education classes. *Informatics,* 10, 20. https://doi.org/10.3390/informatics10010020

Gupta, R. (2021). *Information and Communication Technology in Physical Education.* Friends Publications.

Gafner, S.C., & Bruyneel, A.-V. (2022). Test de 10 mètres de marche. *Kinésithérapie, la Revue,* 22, 248-249. https://doi.org/10.1016/j.kine.2022.05.001

de Baptista, C.R.J.A., Vicente, A.M., Souza, M.A., Cardoso, J., Ramalho, V.M., & Mattiello-Sverzut, A.C. (2020). Methods of 10-Meter Walk Test and Repercussions for Reliability Obtained in Typically Developing Children. *Rehabil Res Pract,* 20, 4209812. https://doi.org/10.1155/2020/4209812

Unver, B., Baris, R.H., Yuksel, E., Cekmece, S., Kalkan, S., & Karatosun, V. (2017). Reliability of 4-meter and 10-meter walk tests after lower extremity surgery. *Disabil Rehabil, 39*(25), 2572-2576. https://doi.org/10.1080/09638288.2016.1236153

Physiopedia: 10 Metre Walk Test. Available at: https://www.physio-pedia.com/10_Metre_Walk_Test

Denby, E., Murphy, D., Busuttil, W., Sakel, M., & Wilkinson, D. (2020). Neuropsychiatric outcomes in UK military veterans with mild traumatic brain injury and vestibular dysfunction. *J. Head Trauma Rehabil,* 35, 57-65. https://doi.org/10.1097/HTR.0000000000000468

Capizzi, A., Woo, J., & Verduzco-Gutierrez, M. (2020). Traumatic brain injury: an overview of epidemiology, pathophysiology, and medical management. *Med. Clin. North Am,* 104, 213-238. https://doi.org/10.1016/j.mcna.2019.11.001

Nelson, N.W., Davenport, N.D., Sponheim, S.R., & Anderson, C.R. (2015). *Blast-Related Mild Blast TBI: Neuropsychological Evaluation and Findings.* In: Kobeissy FH, editor. Brain Neurotrauma: Molecular, Neuropsychological, and Rehabilitation Aspects. Boca Raton (FL): CRC Press/Taylor & Francis

Bryden, D. W., Tilghman, J. I., & Hinds, S. R. (2019). Blast-Related Traumatic Brain Injury: Current Concepts and Research Considerations. *Journal of Experimental Neuroscience,* 13, 117906951987221. https://doi.org/10.1177/1179069519872213

DePalma, R.G. (2015). *Combat TBI: History, Epidemiology, and Injury Modes.* In: Kobeissy FH, editor. Brain Neurotrauma: Molecular, Neuropsychological, and Rehabilitation Aspects. Boca Raton (FL): CRC Press/Taylor & Francis. https://doi.org/10.1201/b18126-3

Corwin, D.J., Wiebe, D.J., Zonfrillo, M.R., Grady, M.F., Robinson, R.L, Goodman, A.M., & Master, C.L. (2015). Vestibular deficits following youth concussion. *J. Pediatr,* 166, 1221-1225. https://doi.org/10.1016/j.jpeds.2015.01.039

Briskin, Y., Odinets, T., Pityn, M. (2015). Influence of the problem-oriented program of physical rehabilitation on the type of attitude to the disease in women with postmastektomy syndrome. *Journal of Physical Education and Sport, 16*(1), 33-37. https://doi.org/10.7752/jpes.2016.01006

Mykytyuk, Z.M., Barylo, H.I., Kremer, I.P., Kachurak, Y.M. & Shymchyshyn, O.Y. (2024). Sensitive liquid crystal composites for optical sensors. *Molecular Crystals and Liquid Crystals, 768*(2), 1-8. https://doi.org/10.1080/15421406.2023.2235865

Mykytyuk, Z., Blavt, O., Kachurak, Y., Stadnyk, V., Gurtova, T, Diskovskyi, I, & Barylo, N. (2022). Hardware and software system for control of complex sensorimotor response and coordination parameters during physical training. *Advanced trends in radioelectronics, telecommunications and computer engineering: proceedings 16th International conference (IEEE TCSET),* 606-609. https://doi.org/10.1109/TCSET55632.2022.9766915

Congressional Research Service. (2019). T*he Individuals with Disabilities Education Act (IDEA), Part B: Key statutory and regulatory provisions.* CRS Report. https://crsreports.congress.gov/product/pdf/R/R41833

Blavt, O., Bodnar, A., Mykhalskyi, A., Gurtova, T., & Tsovkh, L. (2023). Application of Electronic Means in Endurance Coordination Testing of Students with Disabilities Who are War Veterans. *Physical Education Theory and Methodology,* 23(3), 397-403. https://doi.org/10.17309/tmfv.2023.3.12

Blavt, O., Iedynak, G., Galamanzhuk, L., Zhygulova, E., Mykhalska, Yu., Khomych, A., & Sovtisik, D. (2023). Test Control of Inclusive Physical Education: Assessment Using the Newest Electronics. *Physical Education Theory* *and Methodology, 23*(6), 940-946. https://doi.org/10.17309/tmfv.2023.6.17

Cuthbert, J.P., Staniszewski, K., Hays, K., Gerber, D., Natale, A., & O'Dell, D. (2014). Virtual reality-based therapy for the treatment of balance deficits in patients receiving inpatient rehabilitation for traumatic brain injury. *Brain Inj. 28*(2), 181-8. https://doi.org/10.3109/02699052.2013.860475

Xiang, L., Bansal, S., Wu, A. Y., & Roberts, T.L. (2022). Pathway of care for visual and vestibular rehabilitation after mild traumatic brain injury: a critical review. *Brain Injury, 36*(8), 911-920. https://doi.org/10.1080/02699052.2022.2105399

Maas, A.I., Stocchetti, N., & Bullock, R. (2008). Moderate and severe traumatic brain injury in adults. *The Lancet. Neurology, 7*(8), 728-741. https://doi.org/10.1016/S1474-4422(08)70164-9

Merritt, V.C., Lange, R.T., & French, L.M. (2015). Resilience and symptom reporting following mild traumatic brain injury in mil-itary service members. *Brain Injury, 29*(11), 1325-1336. https://doi.org/10.3109/02699052.2015.1043948

Johnson, L., Williams, G., Sherrington, C., Pilli, K., Chagpar, S., Auchettl, A., Beard, J., Gill, R., Vassallo, G., Rushworth, N., Tweedy, S., Simpson, G., Scheinberg, A,, Clanchy, K., Tiedemann, A, & Hassett, L. (2023). The effect of physical activity on health outcomes in people with moderate-to-severe traumatic brain injury: a rapid systematic review with meta-analysis. *BMC Public Health, 9, 23*(1), 63. https://doi.org/10.1186/s12889-022-14935-7

Bland, D.C., Zampieri, C., & Damiano, D.L. (2011) Effectiveness of physical therapy for improving gait and balance in individuals with traumatic brain injury: A systematic review. *Brain Injury,* 25, 7-8, 664-679. https://doi.org/10.3109/02699052.2011.576306

Fure, S.C., Howe, E.I., Andelic, N., Brunborg, C., Sveen, U., Røe, C., Rike, P. O., Olsen, A., Spjelkavik, Ø., Ugelstad, H., & Lu, J. (2021). Cognitive and vocational rehabilitation after mild-to-moderate traumatic brain injury: a randomised controlled trial. *Annals of physical and rehabilitation medicine, 1, 64*(5). https://doi.org/10.1016/j.rehab.2021.101538

Brooks, D., Parsons, J., Hunter, J.P., Devlin, M., & Walker, J. (2001) The 2-minute walk test as a measure of functional improvement in persons with lower limb amputation. *Archives of Physical Medicine and Rehabilitation, 82*(10), 1478-1483. https://doi.org/10.1053/apmr.2001.25153

Bellet, R.N., Adams, L., & Morris, N.R. (2012). The 6-minute walk test in outpatient cardiac rehabilitation: validity, reliability and responsiveness-a systematic review. *Physiotherapy, 98*(4), 277-86. https://doi.org/10.1016/j.physio.2011.11.003

Hanson, L.C., McBurney, H., & Taylor, N.F. (2012). The retest reliability of the six-minute walk test in patients referred to a cardiac rehabilitation programme. *Physiother Res Int, 17*(1), 55-61. https://doi.org/10.1002/pri.513

Casillas, J.M., Hannequin, A., Besson, D., Benaïm, S., Krawcow, C., Laurent, Y., & Gremeaux, V. (2013). Walking tests during the exercise training: specific use for the cardiac rehabilitation. *Ann Phys Rehabil Med, 56*(7-8), 561-75. https://doi.org/10.1016/j.rehab.2013.09.003

Yuksel, E., Unver, B., Kalkan, S., & Karatosun, V. (2021). Reliability and minimal detectable change of the 2-minute walk test and Timed Up and Go test in patients with total hip arthroplasty. *Hip Int, 31*(1), 43-49. https://doi.org/10.1177/1120700019888614

SCIREPROJECT Available at: https://scireproject.com/about-scire-project/

Pizzato, T.M., de Jesus, C.R., & de Baptista, A. (2016). Prediction of Loss of Gait in Duchenne Muscular Dystrophy Using the Ten Meter Walking Test Rates. *Journal of Genetic Syndromes & Gene Therapy, 7*(4), 1000306. https://doi.org/10.4172/2157-7412.1000306

Tyson, S., & Connell, L. (2009). The psychometric properties and clinical utility of measures of walking and mobility in neurological conditions: a systematic review. *Clin Rehabil, 23*(11), 1018-1033. https://doi.org/10.1177/0269215509339004

Smith-Turchyn, J., Adams, S. C., & Sabiston, C. M. (2021). Testing of a Self-administered 6-Minute Walk Test Using Technology: Usability, Reliability and Validity Study. JMIR Rehabilitation and Assistive Technologies, 8(3), e22818. https://doi.org/10.2196/22818

Sawers, A., Kim, J., Balkman, G., & Hafner, B.J. (2020). Interrater and Test-Retest Reliability of Performance-Based Clinical Tests Administered to Established Users of Lower Limb Prostheses. *Phys Ther, 100*(7), 1206-1216. https://doi.org/10.1093/ptj/pzaa063

Застосування здобувачами вищої освіти з інвалідністю після вибухової черепно-мозкової травми установки для контролю у 10-метровому тесті ходьби

Оксана Блавт[1ABCD], Леся Галаманжук[2BCD], Михайло Гуска[2BCD], Геннадій Єдинак[2ABCD], Мар'ян Пітин[3BCD], Юрій Качурак[1ABD], Володимир Файдевич[4BCD], Ростислав Турка[3BCD]

[1]Національний університет "Львівська політехніка"
[2]Кам'янець-Подільський національний університет імені Івана Огієнка
[3]Львівський державний університет фізичної культури імені Івана Боберського
[4]Луцький національний технічний університет

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 9 с., 1 табл., 3 рис., 55 джерел.

Мета дослідження – визначити ступінь автентичності у 10-метровому тесті ходьби, реалізованого з використанням розробленої програмованої установки контролю відновлення функцій функціональної рухливості, ходи та стану вестибулярного апарату у здобувачів вищої освіти з інвалідністю після вибухової черепно-мозкової травми.

Матеріал та методи. 39 студентів І курсу з інвалідністю після вибухової черепно-мозкової травми. Використано такі методи: теоретичний аналіз науково-методичної літератури, метод технічного моделювання, педагогічне тестування, педагогічний експеримент, методи математичної статистики. У дослідженні застосовано 10-метровий тест ходьби.

Результати. Результатом нашого дослідження стала розробка з використанням інформаційних систем та мереж програмованої установки для реалізації 10-метрового тесту ходьби, який застосовується для контролю відновлення функцій функціональної рухливості, ходи та стану вестибулярного апарату у студентів з інвалідністю після вибухової черепно-мозкової травми. Основою установки стала мережа сенсорів, яку організували на базі мікроконтролерної платформи Arduino. Для фіксації результатів по дистанції проходження тесту було розміщено акустичні, оптичні датчики, датчики дальності, наближення, присутності та положення у просторі. Датчики, отримавши інформаційний сигнал про проходження тесту передають його на контролер. У контролері інформація індифікується, обробляється, обчислюється та передається на персональний комп'ютер, де відображаються на екрані та відтворюються графічно. Програмне забезпечення реалізує супроводження впродовж усього тесту, ефективність обробки даних, обчислення необхідних параметрів та їхнє зберігання. Обробка даних здійснюється з використанням систем аналізу зображень на основі нейромереж. За результатами тестування та кореляційного аналізу було установлено показники міри автентичності використаних тестів, які відрізнялись засобами вимірювання результатів. Рівень коефіцієнта кореляції значень тестової надійності та валідності у разі фіксації результатів тестування з використанням секундоміра перебував не межі "низької" та "прийнятної", у другому, коли фіксували результати програмованою установкою контролю, – досягав рівня "високий".

Висновки. Використанням у практичній роботі інклюзивного фізичного виховання розробленої програмованої установки контролю забезпечують зручність, функціональність, об'єктивність та достовірність контролю у процесі реабілітації здобувачів вищої освіти з інвалідністю після вибухової черепно-мозкової травми. Що підтверджується отриманими в процесі експерименту значень міри автентичності тесту у разі фіксації результатів розробленою програмованою установкою.

Ключові слова: здобувачі вищої освіти з інвалідністю, вибухова черепно-мозкова травма, фізичне виховання, тестування, інклюзія, контроль, автентичність.

Information about the authors:

Blavt, Oksana: oksanablavt@ukr.net; https://orcid.org/0000-0001-5526-9339; Department of Physical Education, Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine.

Galamanzhuk, Lesia: astralesg@gmail.com; https://orcid.org/0000-0001-9359-7261; Department of Theory and Methods of Preschool Education, Kamianets-Podilskyi Ivan Ohiienko National University, Ohiienko St, 62, Kamianets-Podilskyi, 32300, Ukraine.

Huska, Mykhailo: huskam@ukr.net; https://orcid.org/0000-0002-7068-5493; Department of Sports and Sports Games, Kamianets-Podilskyi Ivan Ohiienko National University, Ohiienko St, 62, Kamianets-Podilskyi, 32300, Ukraine.

Iedynak, Gennadii: yedinak.g.a@gmail.com; https://orcid.org/0000-0002-6865-0099; Department of Theory and Methods of Physical Education, Kamianets-Podilskyi Ivan Ohiienko National University, Ohiienko St, 62, Kamianets-Podilskyi, 32300, Ukraine.

Pityn, Maryan: pityn7@gmail.com; https://orcid.org/0000-0002-3537-4745; Department of Sports Theory and Physical Culture, Lviv State University of Physical Culture named after Ivan Boberskyj, Kostiushka St, 11, Lviv, 79007, Ukraine.

Kachurak, Yurii: yurii.kachurak@lpnu.ua; https://orcid.org/0000-0003-1437-3943; Department of Electronic Devices, Lviv Polytechnic National University, Bandera St, 12, Lviv, 79013, Ukraine.

Faidevych, Volodymyr: odiafadya@gmail.com; https://orcid.org/0000-0001-8432-3074; Department of Physical Culture, Sports and Health, Lutsk National Technical University, Lvivska St, 75, Lutsk, 43018, Ukraine.

Turka, Rostyslav: rostyslavturka@ukr.net; https://orcid.org/0000-0001-6840-8692; Department of Fitness and Recreation, Lviv State University of Physical Culture named after Ivan Boberskyj, Kostiushka St, 11, Lviv, 79007, Ukraine.

Cite this article as: Blavt, O., Galamanzhuk, L., Huska, M., Iedynak, G., Pityn, M., Kachurak, Y., Faidevych, V., & Turka, R. (2024). Using Programmable Device Installations to Control Students with Disabilities after Blast Traumatic Brain Injury in 10 Meter Walking Test. *Physical Education Theory and Methodology, 24*(3), 433-441. https://doi.org/10.17309/tmfv.2024.3.12

Received: 20.05.2024. Accepted: 10.06.2024. Published: 30.06.2024