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# INCREASING THE RELIABILITY OF TEST CONTROL USING INFORMATION TECHNOLOGIES IN INCLUSIVE PHYSICAL EDUCATION

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**Abstract**

**The purpose of the study** was to determine the reliability and validity of a method developed on the basis of information technologies to control the strength endurance of the core muscles of students with disabilities.

**Materials and methods.** 38 students with disabilities, aged 18-23, who entered the first year of study at the university, voluntarily participated in the study. The studied sample consisted of students with a simple form of disorder in the musculoskeletal system, who have the ability to move independently and perform motor actions. An information-search approach to data collection was used at the theoretical level, and pedagogical testing and methods of mathematical statistics were used at the empirical level.

**Results.** A method for assessing the strength endurance of the core muscles developed on the basis of information technologies is presented. To implement the method, a network of sensors formed by analog and digital sensors, wireless infrared communication devices, information from which enters the programmable logic controller and is fed to the personal computer, is used. The software has been developed that implements immediate processing and presentation of test control results in real-time. Correlation analysis was used to calculate the indicators of test reliability and validity of fixing the results of tests using the method presented in this paper and the traditional method.

**Conclusions.** Experimental verification of the presented method for controlling the development of the core muscles of students with disabilities has proven its practical effectiveness. In conclusion, the numerical values of reliability and validity obtained using the automated method of countering are within the range of "above average," in contrast to the measurements made by the traditional method of control using a test exercise: the calculation of test reliability and validity revealed a level of "below average." The set of obtained numerical characteristics of empirical data proved the advantage of using the latest information technologies in inclusive physical education as a factor of its effectiveness. Achieving positive results in ensuring the proper level of health, full physical and psychological rehabilitation of higher education students with disabilities is considered as a practical value of implementing inclusion in a higher education institution.

**Keywords:** students, physical education, testing, inclusion, control, information technologies.

## Introduction

Problem statement. The change of modern accents in the interpretation of the concept of disability leads to the need to provide a comprehensive approach to creating conditions that would contribute to the full implementation of their inclusion in the higher education system. A direct component of the effectiveness of the level of inclusiveness is the development of new technologies in the educational process of a higher school, which are considered indicators of their importance (Page, Anderson, & Charteris, 2021).

Achieving positive results in ensuring the proper level of health, full physical and psychological rehabilitation of higher education students with disabilities is considered

as a practical value of implementing inclusion in a higher education institution (Goodwin, & Watkinson, 2000).

At the same time, full-fledged physical activity is often the first thing that a person with a disability loses as a result of a serious injury. Therefore, the function of ensuring both the physical and psychosocial development of students with disabilities is entrusted to inclusive physical education (PE) (Lidor, & Hutzler, 2019).

It was determined (Grenier, Patey, & Grenier-Burtis, 2022), that inclusive PE has significant potential for correcting and improving the motor skills of students with disabilities. Obtaining new scientific data on the formation of vital skills by means of PE will contribute to the further development of this field of knowledge, ensuring physical independence, reducing complications associated with health disorders, and enabling students with disabilities to successfully realize themselves in a regular academic environment.

We note that attention to the topic of disability has intensified today. Scientists agree (Blavt, 2022; Morley, Bailey, Tan, & Cooke, 2005; Tant, & Watelain, 2016), that PE is the most effective means of implementing inclusion in higher education.

At the same time, it has been proven (Qi, & Ha, 2012), that improving the health of students with disabilities during their studies is a necessary condition for overcoming inequality, gaining freedom and generally a new quality of life. It has been investigated (Koryahin, Blavt, Bakhmat, Guska, Ludovyk, Prozar, Bodnar, Kravets, & Bezgrebelnaya, 2019; Pocock, & Miyahara, 2018), that as an effective way to reduce the physical maladjustment of students with disabilities, their involvement in systematic PE classes is considered.

A distinctive feature of inclusive PE is its dynamism because there is a constant adaptation of this process to the individual characteristics of each student with a disability (Baglieri, Valle, Connor, & Gallagher, 2011; Keles, ten Braak, & Munthe, 2022). Instead, in certain scientific sources (Block, & Obrusnikova, 2007; Ruscitti, Thomas, & Bentley, 2017), inclusive PE is considered an individual program for the correction of physical development. According to sources (Gupta, 2021; Gogoi, 2019) an effective means of implementing this is the introduction of innovative technical developments, which are planned as a result of modernization to ensure the effectiveness of physical improvement. According to available research (Koryahin, Blavt, Vanivska, & Stadnyk, 2020; Varga, & Révész, 2023), the introduction of informative technologies (IT), which are a generator of progressive ideas and the optimal means of developing the innovative potential of inclusive PE.

It is believed (Rum et al., 2021) that the latest IT are non-invasive, portable and convenient ways of monitoring activities of persons with disabilities. One of the biggest challenges in using technological tools to assess the physical fitness outcomes of people with disabilities is that disability rarely affects two individuals in the same way, thus introducing greater intersubject variability relative to able-bodied individuals (Curran, & Frossard, 2012).

In addition, given that we are talking about persons with disabilities, IT can ensure objectivity and reliability of measurements given the degree of health impairment and related functional limitations (Cooper et al., 2018). So, considering the latter, let's single out a group of muscles – the muscles of the cortex, which are multifunctional in providing a numerous list of functional operations (Nanjwan, & Dada, 2018). Considering that the muscles of the cortex are involved in almost all movements of the human body, the study of the level of their development in the PE process of students with disabilities is of particular importance.

*Purpose of the research* in determining the reliability and validity of a method developed on the basis of IT to control the strength endurance of core muscles of students with disabilities.

## Materials and methods

### *Research methods*

The research has a theoretical-empirical systematic character. Such a combined approach was used to achieve a higher degree of validity and reliability. The topic is new, so data is difficult to collect. Because of the above, an information-search approach to data collection was used at the theoretical level of the research.

At the empirical stage, a mixed (quantitative-qualitative) approach to data collection was used, based on the fact that they alone are not absolute in their form. The technical modeling method was used to develop the control tool. The data were obtained as a result of a pedagogical experiment and the use of mathematical statistics methods for processing and interpreting the obtained results. The results are presented in the form of numbers from an accurate measurement.

Quantitative research of a descriptive-experimental nature involved the collection of experimental data during testing, which was carried out according to the standard procedure for performing test exercises. The results were recorded using a stopwatch and the developed device. Quantitative data analysis involved calculations performed using statistical methods to objectively measure reality.

The test used in the study were quantitative and easy to reproduce and repeat. It is considered that the use of a large number of tests for students with disabilities may cause fatigue. We tried to avoid this to exclude the dependence of test results on physiological factors. Given that the studied sample consisted of students with disabilities, fatigue may cause tremors and violation of the standardization of the test task.

A standardized and easily repeatable test "Keeping the legs at an angle in the supine position" was used. Test procedure. The student takes a position lying on his back, his hands are held on his chest in a crossed position, and his head lies on the floor. Performing the test involves lifting both legs up and holding them at an angle of 60 degrees (vertically). The upper part of the body should be kept on the floor. The time of holding a certain pose is fixed (Magill, & Anderson, 2017).

The execution procedure involved the start of the test task according to the sound signal provided by the device, during which the execution of the movement was initiated. When the student finished the test task, the device notified with a sound signal.

The test was performed twice in a row, to obtain the results of repeated measurements for each student of the studied sample. The average value of repeated measurements was used in the analysis.

*Study participants*

38 students with disabilities, aged 18-23, who entered the I-st year of study Lviv Polytechnic National University, Kamianets-Podilskyi Ivan Ohienko National University, Kryvyi Rih State Pedagogical University, Taras Shevchenko Regional Humanitarian Pedagogical Academy in Kremenets and Lutsk National Technical University, an equal number of girls and boys, voluntarily participated in the study.

We tried to achieve homogeneity of the studied sample, so students with uncomplicated forms of disorders in the musculoskeletal system were selected. Students with cognitive disabilities were not included in the study. The criteria for forming the study sample were as follows: absence of injuries, illnesses, or complications during the last month; the ability to independently complete the test task without external influence.

The study is characterized by certain limitations. First, the sample size is relatively small, and students with uncomplicated musculoskeletal disorders who do not need external support for movement were included. Secondly, there was a lack of information about other aspects of the disease, which can certainly affect the results of the test control.

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".

PE of students with disabilities involves ethical issues and lengthy procedures. After they agreed to participate, consent was obtained from their classmates and PE teachers. The limited number of participants in this study suggests obtaining information about group patterns rather than significant values.

Control of the studied parameters was carried out during studies at the university, during one calendar year, namely at the beginning of the study (october) and at the end of the study (may-june). The break between testing was 8 months. Participants performed two to three trials of each test.

*Statistical analysis*

Statistical analysis was used as a process of data collection and analysis to identify research patterns and trends, the results of which became the basis of the research conclusions. Statistical correlation calculation was used to calculate test reliability. Reliability and validity were measured using intraclass correlation coefficients, standard error of measurement, and coefficient of variation. The reliability of the test was considered high when the intraclass correlation coefficient was 0.79-0.95, the validity – 0.6-1.0. The coefficient of variation, as the standard deviation divided by the mean, was additionally calculated for each trial and all trials combined (Vincent, 2005). All statistical analyzes were performed using SPSS Version 21, and p-values $< 0.05$ were considered statistically significant.

## Results

In order to carry out scientific research in a certain direction, let's specify the following. The normal functionality of the core muscles (local and global) ensures the preservation of segmental stability of the spine and its protection, good posture, correct curvature of the back, balance, and the health of the spine in general. In addition, the muscles of the cortex are involved in ensuring the vital functions of the body (breathing, posture control, urination, etc.) (Nanjwan, & Dada, 2018).

This was the basis of the scientific search for the research of the level of development of the muscles of the cortex. On the other hand, the issue of strength endurance development goes beyond motor readiness as a factor correlating the level of somatic health, physical capacity and individual lifestyle (Doma, Deakin, Schumann, & Bentley, 2019).

In the practice of inclusive PE, a test exercise for lowering the legs from a lying position is used to control strength endurance. However, with this method of control, there is a certain dependence of the subjective assessment of perception by the specialist who carries out the control, in the standardization of compliance with all methodological requirements of the test exercises that are set visually. Namely, fixing the corner and maintaining a stable position of the body and legs in the corner position. The possibility of errors also occurs when recording the results of the test exercise with a stopwatch. All of the above, respectively, reduces the reliability of the test, and, therefore, the degree of reliability of the control results.

To eliminate all the listed factors, a method of controlling the strength endurance of the core muscles has been developed (fig. 1).

The method of assessing the strength endurance of the core muscles is carried out as follows. A network of sensors is placed on the student's body. The sensor network is formed by analog and digital sensors (Wojcik et al., 2020). In the sensor network, signals are registered and identified when the student performs the test exercise. Using a network of sensors in the method provided an opportunity to monitor the change of any measurement parameters of the performance of the test task in real-time.

The received signal is sent to the programmable logic controller by wireless infrared communication devices. The function of the programmable logic controller is to manage all the structural elements that are used to implement the method and process the information coming from the sensor network: combining the sensor network, processing the information received from the sensors, and passing it on

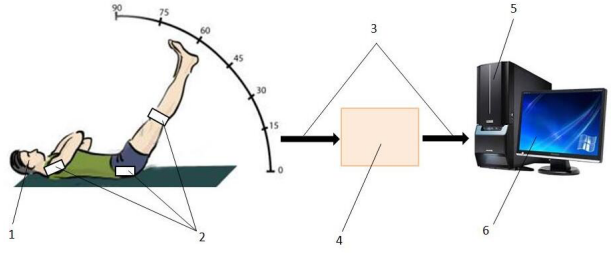


**Fig. 1.** Structural diagram of the method of assessing the strength endurance of the core muscles:1 – student, 2 – sensor network, 3 – wireless infrared communication devices, 4 – programmable logic controller, 5 – personal computer (PC), 6 – liquid crystal display

**Table 1.** The results and reliability of control test the strength endurance of the core muscles (n = 38)

| Statistical parameters | Test tasks and measurement results (s) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | at the beginning of the experiment | | | | at the end of the experiment | | | |
| | using the test exercises | | using the developed method | | using the test exercises | | using the developed method | |
| | female | male | female | male | female | male | female | male |
| M | 10.1 | 18.3 | 11.4 | 17.2 | 14.2 | 23.7 | 15.6 | 24.1 |
| S | 3.1 | 2.9 | 4.7 | 4.1 | 2.5 | 5.8 | 2.3 | 1.9 |
| V (%) | 46.2 | 47.1 | 45.1 | 43.3 | 38.2 | 37.2 | 28.2 | 27.6 |
| $r_{tt}$ | | | | | | | | |
| reliability | 0.601 | 0.690 | 0.921 | 0.881 | 0.655 | 0.642 | 0.902 | 0.858 |
| validity | 0.217 | 0.284 | 0.441 | 0.478 | 0.211 | 0.308 | 0.436 | 0.501 |

for processing on the PC. The programmable logic controller works in automatic mode and provides high measurement accuracy, long battery life, and the ability to seamlessly transfer information to a PC, thanks to which the high efficiency of control results and the informative presentation of results are achieved.

From the programmable logic controller, the signal is transmitted to the PC by wireless infrared communication devices. The signals of the student's performance of the exercise are recorded and visualized on a PC using the developed software. It is possible to save the results for the necessary period in the database and observe their dynamics.

The developed method was tested in the PE practice of students with disabilities (Tab. 1).

It should be noted that in the testing of students with disabilities, the use of a network of sensors is another advantage, as they allow to obtain synthesized information and exclude the influence of tremor variability during the performance of test tasks (Camomilla, Bergamini, Fantozzi, & Vannozzi, 2018). Which, accordingly, can affect the results of the retest.

This was reflected in the reliability and validity coefficients of the test results using the developed control method. At the end of the experimental study, the indicators of these parameters reached digital values > 0.75, which proves the high level of reliability of the control results. Accordingly, with $r_{tt}$ = 0.60-0.69, the values of which are obtained using the traditional measurement method, the use of the test for individual evaluations is questionable.

The validity of measuring the strength endurance of the core muscles using the developed method was acceptable using the traditional control method and reached values in the range from 0.35 to 0.56, which are "above average" and "acceptable", respectively. Therefore, the test results obtained in this way can be considered reliable.

Taking into account the fact that a qualitative analysis of the phenomenon is impossible without the use of variation indicators, the coefficient of variation V(%) was calculated. A decrease in the coefficient of variation (up to 28%) at the second stage of measurements indicates the achievement of homogeneity of the population, and the average is a typical and reliable characteristic of it. We assume that the PE process and the use of the developed tool became the factor that ensured the effectiveness of the PE process. Thus, the reserves were used to improve the physical endurance of the core muscles of the students of the studied sample.

## Discussion

The urgency of considering the issue of the effectiveness of PE for students with disabilities takes on special importance in connection with the long-term hostilities on the territory of Ukraine, and, therefore, the permanent increase of persons with disabilities as a result of the war. The conducted scientific research is based on the fact that in Ukraine there is practically no experience in the practice of forming inclusive physical education in institutions of higher education, we believe that the development of this field of knowledge, as an inexpensive and effective means of health protection, should be one of the priority tasks of the modern educational policy of higher education. Our research expands scientific information on the importance of physical education in the process of eliminating health disorders of students with disabilities (Qi & Ha, 2012), using the basics of inclusive pedagogy (Alasim, 2021), innovative practices of pedagogical content (Baglieri & Bacon, 2020; Grenier, Patey, & Grenier-Burtis, 2022), physical therapy (Whitney, Moore, & Fry, 2017; Sawade, 2023). and integration of IT into this process (Mykytyuk, Blavt, Hnatchuk, Stechkevych, & Helzhynska, 2022).

The study is consistent with scientific data (Goodwin & Watkinson, 2000). regarding the need to focus efforts on the justification and creation of effective technologies of inclusive PE (Tant & Watelain, 2016), organized based on modern general scientific and special technologies of the theory (Pocock & Miyahara, 2018), methodology and practice of PE (Block, & Obrusnikova, 2007), using the latest achievements of IT (Blavt, Iedynak, Pityn, Hluhov, Guska, Stadnyk, Zaikin, & Karatnyk, 2022; Gogoi, 2019).

We tried to raise interest in the problem of effective use of IT network resources and provision of prompt access to information. According to the data (Curran & Frossard, 2012), the analysis of the PE process for people with disabilities is the most important in this process based on objective information.

An important aspect that limits the interpretation of results is the lack of standardization in control (Rum et al., 2021). In PE, control information obtained and analyzed with the help of IT is the prerogative of research and conclusions (Curran & Frossard, 2012; Klavina, 2011; Koryahin, Blavt, Vanivska, & Stadnyk, 2020). The practical significance of examining the development of core muscles in students with

disabilities is that these muscles provide fundamental movements that require targeted exposure because of impairment.

For the first time, a developed and practically tested latest technical method, created based on the latest IT, is presented to level the peculiarities and limitations that complicate the PE process of students with disabilities in a higher education institution. The obtained results are important for the modernization of PE content for students with disabilities in the direction of its individualization. Our research is consistent with the information (Ivashchenko, 2020; Chernenko et al., 2020), that continuous assessment, as a result of control, is the basis of understanding the development of motor skills during the period of PE.

## Conclusions

The implementation of IT in inclusive physical education is considered an optimal means of developing the innovative potential of this process. To receive high-quality physical education that meets students with disabilities needs, which will ensure the improvement of their physical condition based on the improvement of impaired motility, implies the presence of permanent control, which is the basis of individual correction of classes.

The paper presents a method of controlling the strength endurance of the core muscles developed on the basis of the latest IT, which are proposed to be used in the physical education of students with disabilities. The expediency of researching the development of core muscles is due to their role and importance in ensuring the vital functions of the body and performing isometric or dynamic stabilization during movements. The proposed method ensures immediate acquisition of objective control data, without creating any restrictions for the implementation of motor tasks of students with disabilities. The integration of the latest IT in the test control of students with disabilities ensures the elimination of a number of problematic factors of the current control based on automatic monitoring of changes in the measurement parameters of the test task in real-time.

Experimental verification of the presented method of controlling the development of the core muscles of students with disabilities has proven its practical effectiveness. In conclusion, the numerical values of reliability and validity obtained using the automated method of control are within the range of "above average", in contrast to the measurements made by the traditional method of control using a test exercise: the calculation of test reliability and validity revealed a level of "below average" and "accepted".

The set of obtained numerical characteristics of empirical data proved the advantage of using the latest IT in inclusive physical education as a factor of its effectiveness. At the same time, determining the level of reliability and validity of the test used to control the strength endurance of the core muscles in the traditional way proved the low level of these indicators.

In general, the scientific potential of equipping the test process with the use of the latest IT ensures a high level of control and evaluation of the studied parameters for a limited period of physical education of students with disabilities.

## Conflicts of interest

No conflicts of interest exist.

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# ПІДВИЩЕННЯ НАЙДІЙНОСТІ ТЕСТОВОГО КОНТРОЛЮ ІНФОРМАЦІЙНИМИ ТЕХНОЛОГІЯМИ У ІНКЛЮЗИВНОМУ ФІЗИЧНОМУ ВИХОВАННІ

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

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**Мета дослідження** полягала у визначенні надійності та валідності розробленого засобу на основі інформаційних технологій для контролю силової витривалості м'язів кора здобувачів вищої освіти з інвалідністю.

**Матеріал та методи.** У дослідженні добровільно взяли участь 38 здобувачів вищої освіти з інвалідністю, віком 18-23 роки, які вступили на І-ший курс навчання університету. Досліджувану вибірку склали здобувачі вищої освіти із нескладною формою порушень в опорно-руховому апараті, які володіють навичкою самостійного пересування та здійснення рухових дій. Використано інформаційно-пошуковий підхід до збору даних на теоретичному рівні та педагогічне тестування й методи математичної статистики – на емпіричному.

**Результати.** Представлено на основі інформаційних технологій розроблений спосіб контролю силової витривалості м'язів кора. Для реалізації способу використано мережу сенсорів, сформованої аналоговими та цифровими сенсорами, бездротові пристрої інфрачервоного зв'язку, інформація з яких поступає на програмований логічний контролер та подається на персональний комп'ютер. Розроблено програмне забезпечення, яким реалізують негайну обробку та представлення результатів тестового контролю в режимі реального часу. Кореляційним аналізом здійснено обчислення показників тестової надійності та валідності фіксації результатів виконання тестів з використанням представленого у роботі способу та традиційним способом.

**Висновки.** Експериментальною перевіркою представленого способу контролю розвитку м'язів кора здобувачів вищої освіти з інвалідністю засвідчено його практичну ефективність. У підсумку, числові значення надійності та валідності, які отримано з використанням автоматизованого способу контролю знаходяться у межах «вище середнього», на відміну від вимірювань, здійснених традиційним способом контролю з використанням тестової вправи: обчислення тестової надійності та валідності виявило рівень «нижче середнього». Сукупністю отриманих числових характеристик емпіричних даних доведено перевагу використання новітніх інформаційних технологій у інклюзивному фізичному вихованні як чинника його ефективності. Досягнення позитивних результатів у забезпеченні належного рівня здоров'я, повної фізичної та психологічної реабілітації здобувачів вищої освіти з інвалідністю розглядаємо як практичну цінність реалізації інклюзії у закладі вищої освіти.

**Ключові слова:** здобувачів вищої освіти з інвалідністю, фізичне виховання, тестування, інклюзія, контроль, інформаційні технології.

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