



ORIGINAL SCIENTIFIC ARTICLE

## IMPLEMENTATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN TEST CONTROL OF LEG STRENGTH IN PHYSICAL EDUCATION OF STUDENTS

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

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Accepted for Publication: October 25, 2022

Published: November 30, 2022

DOI: 10.17309/tmfv.2022.3s.15

### Abstract

**The purpose of this study** was to experimentally substantiate the implementation of information and communication technologies in test control of leg strength in the process of physical education of students.

**Materials and methods.** The methods used to obtain empirical data included pedagogical experiment, pedagogical testing, mathematical methods for processing digital files, comparative statistical method, variance and correlation analysis. The study participants were 240 students aged 17–19 at the beginning of the study.

**Results.** A developed device for determining leg muscle strength, built based on the latest information and communication technologies, was presented. The developed design of the device involves the use of analog laser distance sensors the information from which is sent to the processing unit via wireless infrared communication devices and fed to the electronic computing device through an analog-to-digital converter. By calculating the authenticity of the test exercise used to control leg strength, the use of the developed device in practical activities was experimentally substantiated. According to the results of the correlation analysis, it was established that the authenticity of control using the developed device has reached a high level.

**Conclusions.** A qualitatively new approach to increasing the effectiveness of control in physical education of students was presented, which is implemented in the developed leg strength control device. The applied value of the results of the conducted research is that the device developed based on information and communication technologies provides a qualitatively new form of implementation of leg force control as well as processing and presentation of control information. The use of the device in the practice of physical education of students ensures the effectiveness and high efficiency of the control procedure, the result of which is the receipt of reliable data, which makes it possible to significantly improve the quality and intensify control of this process to ensure the effectiveness of physical education of students.

**Keywords:** testing, control, physical education, student, leg strength, device, information and communication technologies.

### Introduction

At the current stage of society's development, the development of higher education is conditioned by rapid changes dictated by the trends of the international educational space, the requirements of the educational services market, and the

demand for specialists who can meet the challenges and demands of the international labor market. In the context of the training of highly qualified specialists, physical education is defined as one of the priority directions in the pedagogical practice of a higher school (Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020; Shettar, Lathiwale, & Kulhalli, 2021).

The process of European integration increases the requirements for the organization of physical education of students and ensures its effectiveness. (Anikieiev, 2015). This

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necessitates the search for new means and methods, which involves their intensive modernization to move to a qualitatively new level of efficiency and scientific capacity. Information and communication technologies (ICT) are considered a powerful factor in increasing the effectiveness of physical education of students (Di Tore, Schiavo, & D'isanto, 2016; Koryahin, Mykytyuk, Turchyn, Blavt, Prystynskyi, & Stadnyk, 2021).

Prospective use of ICT in solving problems of the effectiveness of physical education of students is confirmed by active research activities. A significant number of publications are devoted to aspects of the use of modern ICT in physical education (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Koryahin, Blavt, Vanivska, & Stadnyk, 2020; Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020). ICT is considered an important component of the educational process (Gogoi, 2019), which provides the possibility of achieving the goals of physical education in the high-quality training of higher education students (Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Kozina, Ol'khovyy, & Temchenko, 2016; Shettar, Lathiwale, & Kulhalli, 2021).

Researchers have proposed a wide range of ICT use in physical education in health (Fisher, 2014; Alfrey, & Gard, 2014), education (Gogoi, 2019; Born, Nguyen, Grambow, Meffert, & Vogt, 2018; Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020) and training (Mullineaux, Bartlett, & Bennett, 2011; Koryahin, Iedynak, Blavt, Galamandjuk, Prozar, Zaikin, Veselovska, Golub, Kucher, & Gurtova, 2019; Serrien, Tassignon, Verschueren, Meeusen, & Baeyens, 2019) areas. It has been proven that the introduction of ICT makes it possible to effectively collect, process, and transmit information, qualitatively change the methods and organizational forms of physical education for students.

The expediency of introducing modern ICT into the process of physical education of students is substantiated. Several studies cover the dimension of the implementation of control in the pedagogical process of students physical education, which is based on theories, concepts, and approaches to its implementation at a qualitatively new level (Di Tore, Schiavo, & D'isanto, 2016; Gogoi, 2019; O'Brien, Philpott, Lester, Belton, Duncan, Donovan, Chambers, & Utesch, 2021).

Despite the broad presentation of the introduction issue of modern information technologies in the field of physical education, the specifics of ICT in the implementation of control of physical education of students, as a correlator of its effectiveness, is a dynamic issue, which provides an opportunity to highlight constructive ideas and outline the possibilities of their practical application.

Thus, the need for higher education to ensure the quality of physical education, as well as the insufficient provision of control in the process of physical education of students with the latest technologies, contradicts the objective necessity of educational practice, determined the choice of the topic of our research.

*The purpose of this study* is experimental substantiation to implement ICT in test control of leg strength in the process of physical education of students.

## Materials and methods

### Research methods

The methods used to obtain empirical data were the pedagogical experiment, pedagogical testing, mathematical methods for processing digital files, comparative statistical

method, variance, and correlation analysis. Technical modeling was used as a method of the empirical level of research. Pedagogical testing involved determining muscle strength traditionally and using a developed device.

Control of the level of leg strength development was implemented using the specialized test exercise "Chair" (Magill & Anderson, 2017). The expediency of using this test to control leg strength is because it is technically a fairly simple exercise that does not require additional equipment. The test involves maintaining a stable squat position, the knee angle is 90 degrees, and the hips should be parallel to the floor. A correctly methodically determined position is recorded and maintained. The time of maintaining a stable position of the body is recorded.

The study involved fixing the time of the correct execution of the test exercise in two ways: traditional – using a stopwatch and using the developed device presented in the study.

### Participants

The first and the second-year students from Lviv Polytechnic National University, Kamianets-Podilskyi National Ivan Ohiienko University, Lviv State University of Physical Culture named after Ivan Boberskyj and Kherson State University were selected for research. The study involved 240 students, their age at the beginning of the study was 17-19 years. It is important that the number of students in the research groups was sufficient for the demonstrable evaluation of the experiment's results. The requirements for the adequacy of the information volume at the level of  $p < 0.05$  were met.

The organization of the study took into account the provisions of the Declaration of Helsinki of the World Medical Association (WMA-2013) on the ethical principles of medical research with human participants; the research protocol was approved by the ethics committee of the Lviv Polytechnic National University.

### Organization of research

The experiment was implemented during two academic semesters. At the first stage of the research, all students of the studied sample made three attempts in a test to determine the level of leg strength development. The results were recorded using a stopwatch. The average result was determined based on the results of three attempts.

At the second stage of the study, all students who participated in the pedagogical experiment made three attempts in the test to determine the level of leg strength development. The results were recorded using the device developed and presented in the study.

After that, the reliability and validity indicators of the tests were calculated, the results of which were obtained at the first and second stages of the study. At the same time, the indicators obtained at the first stage of the study were used as a retest to determine test reliability and validity.

### Statistical analysis

Within descriptive statistics, the comparative-statistical method of determining of empirical authenticity of tests is

applied. To determine the empirical authenticity of the tests, variance and correlation analysis (between the obtained test results and the correlation criterion) were used. Quantitatively, the degree of authenticity of the tests is expressed using the reliability and validity coefficients, which are calculated using the intra-class correlation coefficient.

Using this analysis, correlation coefficients were calculated to establish numerical values of reliability and validity of the test for determining the level of leg strength development. The results obtained during the control are considered reliable if the test methods used are authentic, and its quantification is a criterion coefficient that quantifies the degree of test reliability and validity and is calculated using the intraclass correlation coefficient. The obtained numerical indicators of which are the basis of the conclusion about the meaning of the test (Magill, & Anderson, 2017).

The methods of mathematical statistics are used, it can be confirmed that the criteria of reliability and validity are adequately met. All statistical analysis was performed using SPSS Version 21.

## Results

The implemented experimental study was aimed at eliminating the dependence of subjectivity in the implementation of control of the assessment of the perception of a person who controls the level of leg strength development. By using ICT, they tried to achieve efficiency and objectivity of control. The result of the carried out scientific search was the developed device for controlling leg strength, as a component of physical training in the process of physical education of students.

Today, there are many ways to measure leg strength. We used the test exercise "Chair" because the exercise is easy to reproduce, does not require special equipment, and does not require time. In addition, this test can be used by students in independent work.

However, recording the stability of a certain body position: a right angle between the hip and the lower leg, as well as a right angle between the hips and the body, is associated with the probability of error. There is a possibility of an error in controlling the time of the correct execution of the test task, which makes it impossible and difficult to obtain reliable informative results.

The developed design of the device involves the use of analog laser distance sensors – high-precision laser sensors with a measurement range of no more than 1000 mm, which contain digital interfaces. Thanks to the use of short-range sensors, the quality of control increases. Analog laser distance sensors have high reliability, durability, stability, small dimensions, mass and power consumption, and compatibility with microelectronic devices for information processing at a low cost (Vistak, Dmytrah, Mykytyuk, Sushynskiy, Barylo, Prysiazhniuk, & Horbenko, 2017).

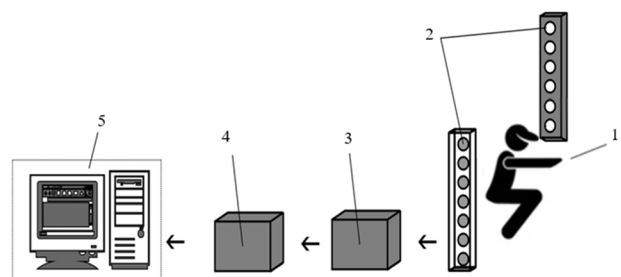
Sensors in the developed device are drawn on a ruler. The line of sensors is located vertically on both sides of the student performing the test exercise. Exercise signals are recorded by infrared receivers of non-contact analog laser distance sensors placed on the ruler.

Analog laser distance sensors can detect and calculate with high accuracy the position of objects made of any materials (Wojcik, Vistak, Mykytyuk, Politsanskyi, Diskovskiy,

Sushynskiy, Kremer, Prystay, Jaxylykova, & Shedreyeva, 2020). The principle of measurement by analog laser sensors is based on optical and ultrasonic methods of fixing the dependence of the time of passage of a light pulse on the distance between objects (Hotra, Mykytyuk, Diskovskiy, Barylo, & Vezyr, 2018). Control information is captured by the sensor's laser LED and photodiode, which is mounted in the controlled area in our development of the sensor line.

The laser beam of the sensor through the lens, directed at the student in the specified position of the test exercise, is reflected and focused on a line of photodiodes contained in the infrared radiation receiver, which forms information about the student's position in the form of discrete analysis. Photodiodes convert an optical signal to an electrical one (analog signal to digital). If the position of the student changes, the angle of reflection of the beam changes, and, therefore, the position of the reflected beam is fixed by a photodiode, which controls short-term deviations of the sensor values, avoiding the possibility of incorrect performance of the exercise.

To perform the exercise, the student takes a defined initial position and fixes it, placing himself between a line of sensors (fig. 1). Sensors placed in the line record the student's position and the time it takes to maintain a stable position. Non-contact analog laser distance sensors provide information about the position of the student in front of the sensor in the form of discrete analysis. The signal received by the sensor line is sent to the processing unit via wireless infrared communication devices. The processing unit processes the signal from the line of photodiodes and converts it into an analog signal, which, through an analog-to-digital converter, enters the electronic computing device for further processing.



**Fig. 1** Structural diagram of the design solution for leg strength control using the developed device, where: 1 – student, 2 – line of sensors, 3 – processing unit, 4 – analog-to-digital converter, 5 – electronic computing device

After the student changes the steady position of the body, the time of the exercise is fixed in digital units, convenient and understandable for perception. The obtained results are displayed using the LCD of the electronic computing device.

The developed device makes it possible to register the moment of the start of the exercise, the maintenance of a stable posture (performance process), and the moment of its end. In the electronic computing device, recording, visualization, and analysis of the received control results are also carried out, following the algorithm of the internal software.

**Table 1.** Authenticity of the test (rtt)

Curriculum	I		II		I		II		I		II	
	T	A	T	A	T	A	T	A	T	A	T	A
H	0,707	0,876	0,711	0,883	0,777	0,890	0,707	0,876	0,711	0,883	0,713	0,890
V	0,115	0,222	0,117	0,201	0,094	0,225	0,165	0,222	0,047	0,101	0,377	0,525

\*Note: H – reliability of the test, V – validity of the text; T – the traditional way, A – using the developed tool, I – first course of study, II – second year of study

The developed device uses an electronic computing device, but it is also possible to use a mobile telecommunication system that has a high-speed interface subsystem and in which the received signal is processed on a real-time scale.

The experimental justification of the use in practical activities of the developed device for controlling leg strength is presented in fig. 2. The authenticity of the leg strength control test was calculated. The determination of such a complex character of the test was used to obtain information about the degree of representativeness of the research procedure. For this purpose, the results of testing students of the 1st and 2nd years were registered traditionally and using the developed device.

According to calculations, the reliability coefficient of the test used in the study, the results of which were recorded in the traditional way using a stopwatch, is within the range of low and medium, which is considered acceptable. The validity coefficient obtained by the traditional method is within the low range. By changing the method of registering the results, we achieved that the authenticity of the test reached a high level.

In the obtained values of the measure of authenticity of the tests, there is a degree of change depending on the method of registering the results. Based on the obtained results, it can be concluded that the reliability of the same test depends on the way the results are recorded.

The effectiveness of using the device for controlling leg strength is ensured by: ease of use and compactness of the device, a comprehensive approach: the combination of the necessary analysis of the obtained control results with a visual form of presentation in the developed device is implemented by software. The use of the software enables simultaneous analysis of the test results of a group of students without loss of information. In addition, the software unifies and intensifies the receipt and processing of control results with the updating and correction of a large array of control information and its accumulation in an integrated database, in which their replication, processing, and interactive analysis using statistical and mathematical methods and algorithms are established.

## Discussion

Currently, the implementation of innovations is an important source of determining strategic directions for the development of higher education in Ukraine. This is positioned as an indicator of relevance and effectiveness and is embodied in specific, qualitatively new results of the educational process (Gogoi, 2019). We support scientific approaches (Koryahin, Mykytyuk, Turchyn, Blavt, Prystynskyi, & Stadnyk, 2021; Shettar, Lathiwale, & Kulhalli, 2021) that

modernization based on the introduction of ICT in physical education of higher schools is now a priority direction for ensuring modern progress in this process. It is significant that information becomes the foundation of the innovation process, and ICT provides the provision of this information at a modern scientific level (Gogoi, 2019; Estivalet, & Springer, 2009).

The conducted scientific research is due to the need to introduce innovations and fundamentally new approaches to the development of the theory of control in physical education. Which is consistent with available information (Ivashchenko, 2020; Ivashchenko, Khudolii, Iermakov, & Harkusha, 2017; Hasegawa, Fujii, Miura, Yokoyama, & Yamamoto, 2019;).

In modern science, attention is focused on the need to significantly improve the quality of scientific research and make radical changes in the organization and examination of the results of physical education (Khudolii et al., 2019; Zanevskyy, & Labartkava, 2020; Solohubova et al., 2020). Control of the results of physical education of students, which is positioned as a powerful mechanism of influence and management, is the basis of the effectiveness of physical education of students (Koryahin, Mykytyuk, Blavt, Dolnikova, & Stadnyk, 2020; Shettar, Lathiwale, & Kulhalli, 2021). The results of the study complement the data on pedagogical control in the physical education of students (Kozina, Ol'khovj, & Temchenko, 2016; Koryahin, Blavt, Vanivska, & Stadnyk, 2020; Edwards, 2010).

Data have been expanded that the effectiveness of the introduction of the latest technologies developed based on ICT in the physical education of students, which is determined by their accessibility to users, ease of use, and the degree of meeting the needs of this process (Di Tore, Schiavo, & D'isanto, 2016; Koryahin, Blavt, Vanivska, & Stadnyk, 2020). The importance of ensuring the objectivity and efficiency of control from a practical standpoint is determined by the importance of receiving and studying information about the state of the studied parameters during the physical education of students, as a factor in the effectiveness of this process (Kozina, Ol'khovj, & Temchenko, 2016; Shettar, Lathiwale, & Kulhalli, 2021). Added data on the optimization of physical education of students through the use of ICT and their capabilities in solving forecasting tasks, and designing classes based on objective control of physical education results (Bhat, Nazir, & Khan, 2018; Gogoi, 2019).

The applied value of the results of the conducted research is that the device developed based on ICT provides a qualitatively new form of implementation of leg force control, as well as processing and presentation of control information. Its novelty lies in the use of the potential of modern ICT, which provides a process of operational, rational, pur-

poseful obtaining of results for the effective implementation of control in the physical education of students.

The idea that the reliability of the same test depends on the way the results are recorded has been confirmed. At the same time, all specialists are unanimous in the fact that the leading means of implementing the aforementioned is the technological provision of the ICT-based control procedure, which is a step towards increasing the effectiveness of physical education to achieve a new quality.

## Conclusions

One of the priority directions of the development of modern higher education is the rethinking of the doctrine of physical education at the level of European quality, the corresponding modernization of its content, and optimization of its technical support to achieve new quality.

A qualitatively new approach to increasing the effectiveness of control in physical education of students is presented, which is implemented in the developed leg strength control device. The device, developed based on ICT, ensures the unification and intensification of obtaining and presenting control results. The use of the developed leg strength control device in the practice of physical education of students allows solving the problems of prompt, immediate obtaining and accumulation of objective information about the level of leg strength development.

Taking into account the possibility of carrying out a standardized test control procedure, which is a key factor in its objectivity; simplicity, convenience, accessibility, and the possibility of immediate obtaining control data, the use of a leg strength monitoring device developed based on ICT allows to reliably monitor the development of leg strength, which is confirmed by the obtained results of the authenticity of measurements, and to urgently and effectively analyze and interpret the received large volumes of quantitative control information.

The integration of ICT, which performs the functions of a toolkit for solving control tasks, has provided a qualitatively new technological advance in methodology and didactics, organization, and practical implementation of test control in the physical education of students.

## Conflict of interest

The authors state no conflict of interest.

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## УПРОВАДЖЕННЯ ІНФОРМАЦІЙНО-КОМУНІКАЦІЙНИХ ТЕХНОЛОГІЙ У ТЕСТОВИЙ КОНТРОЛЬ СИЛИ НІГ У ФІЗИЧНОМУ ВИХОВАННІ СТУДЕНТІВ

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Реферат. Стаття: 7 с., 1 табл., 1 рис., 28 джерел.

**Мета дослідження** полягала у експериментальному обґрунтуванні упровадження інформаційно-комунікаційних технологій у тестовий контроль сили ніг в процесі фізичного виховання студентів.

**Матеріали та методи.** Методами отримання емпіричних даних були педагогічний експеримент, педагогічне тестування, математичні методи обробки цифрових файлів, порівняльно-статистичний метод, дисперсійний та кореляційний аналіз. У дослідженні взяли участь 240 студентів, їх вік на початок дослідження становив 17-19 років.

**Результати.** Представлено розроблений пристрій для визначення сили м'язів ніг, побудований на основі новітніх інформаційно-комунікаційних технологій. Розроблена конструкція пристрою передбачає використання аналогових лазерних сенсорів відстані, інформація з яких бездротовими пристроями інфрачервоного зв'язку надходить

на блок обробки та через аналогово-цифровий перетворювач подається у електронно-обчислювальний пристрій. Обчисленням автентичності тестової вправи, яка використана для контролю сили ніг, експериментально обґрунтовано використання у практичній діяльності розробленого пристрою. За результатами кореляційного аналізу встановлено, що автентичність контролю з використанням розробленого пристрою досягла високого рівня.

**Висновки.** Представлено якісно новий підхід до підвищення ефективності контролю у фізичному вихованні студентів, що реалізовано у розробленому пристрої контролю сили ніг. Прикладне значення результатів проведеного дослідження полягає у тому, що розроблений на основі інформаційно-комунікаційних технологій пристрій забезпечує якісно нову форму реалізації контролю сили ніг, а також обробку й представлення інформації контролю. Використання у практиці фізичного виховання студентів пристрою забезпечує оперативність та високу ефективність процедури контролю, результатом яких є отримання достовірних даних що дають змогу істотно підвищити якість та інтенсифікувати контроль цього процесу задля забезпечення ефективності фізичного виховання студентів.

**Ключові слова:** контроль, фізичне виховання, студент, сила ніг, пристрій, інформаційно-комунікаційні технології.

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**Cite this article as:** Blavt, O., Iedynak, G., Pityn, M., Hlukhov, I., Guska, M., Stadnyk, V., Zaikin, A., & Karatnyk, I. (2022). Implementation of Information and Communication Technologies in Test Control of Leg Strength in Physical Education of Students. *Physical Education Theory and Methodology*, 22(3s), S110-S116. <https://doi.org/10.17309/tmfv.2022.3s.15>

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Received: 18.08.2022. Accepted: 25.10.2022. Published: 30.11.2022

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