Physical Education Theory and Methodology
Теорія та методика фізичного виховання

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

Original Scientific Articles. Assessment, Testing, and Measurement

Digitalization of "Timed Up and Go" Test to Increase the Control Efficiency in Inclusive Physical Education

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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: April 2, 2026
Published: May 30, 2026

DOI: 10.17309/tmfv.2026.3.13

Abstract

Objectives. The purpose of this study was to establish the reliability and validity of the "Timed Up and Go" (TUG) test for students with disabilities who have undergone lower limb amputation using an intelligent software-controlled hardware complex in inclusive physical education.

Materials and Methods. The study was conducted at the theoretical and empirical levels. The following methods were used: analysis, synthesis, systematization, generalization, measurement, and mathematical statistics. Measurements were performed using the TUG test. The study sample included first-year male students with a left lower limb amputation (n = 23), provided there were no acute conditions, open wounds, or complications.

Results. The results of the study are presented in the developed intelligent software-controlled hardware system for implementing the TUG test. The structural composition of the system includes Bluetooth-enabled wireless sensors placed on the student and along the entire TUG trajectory. The signals received by the Xsens DOT sensors are transmitted to the latest Arduino Uno R3 microcontroller. Information display and control are provided through the use of a Liquid Crystal Display. A distinctive feature of the complex is the use of IoT technologies for analytics and forecasting in inclusive physical education. Automated acquisition of TUG results enables the recording of numerous gait parameters in students with disabilities and lower limb amputation, such as the amplitude of central oscillations, reaction time, and step length, which cannot be recorded when TUG results are measured using a stopwatch.

Digital data processing transforms the reliability and validity of the TUG test from "average" when measured with a stopwatch to "high", ensuring accurate recording of numerous parameters down to the microsecond level.

Conclusions. The novelty of the developed intelligent programmable tool for implementing the "Get Up and Go" test ensures effective control in inclusive physical education and eliminates the influence of the human factor on test results.

Keywords: student, physical education, TUG test, control, reliability, validity.

Introduction

Inclusive education has become particularly relevant in Ukraine since the start of the full-scale russian invasion. As a result of rocket attacks and military operations, the number of students with disabilities in Ukrainian universities has increased significantly, creating new challenges for the education system (Klos, Blavt, & Kovalchuk, 2024).

According to statistics (Life In War, 2024), 65–70% of injuries in the russia-Ukraine war involve the limbs. Limb loss due to combat injuries among military personnel and civilians ranks among the leading causes of amputations

(Van Dongen et al., 2017). Over 17 months of full-scale war, approximately 50,000 Ukrainians have lost arms or legs (Radiosvoboda, 2024). Worldwide, amputation is one of the most common causes of disability: 30 million people globally live with the loss of a lower limb (Şahan & Erbahçeci, 2023).

The enormous number of wounds, injuries, and amputations sustained by students as a result of russian aggression necessitates the provision of conditions in higher education institutions for their full rehabilitation. Physical education, which fulfills this function, has taken on exceptional significance today, during the war in Ukraine.

Analysis of recent research and publications.

Studies have shown (Bastas et al., 2018; Eshraghi et al., 2018; Wong et al., 2020) that leg amputation leads to persistent functional impairments and significantly affects mobility (Premnath et al., 2021; Gaunaurd et al., 2020; Batten et al., 2019). It has been determined that a consequence of amputations is that the body shifts its center of mass during any activity (Eshraghi et al., 2018; Kark et al., 2012). This disrupts functional stabilization and dynamic stability (Bastas et al., 2018), which are important factors for safe mobility (Kendell et al., 2010). Consequently, movement patterns change (Vrieling et al., 2007; Premnath et al., 2021). It is argued (Kendell et al., 2010; Schmid et al., 2005; Chihuri, Youdan, & Wong, 2021) that this is particularly important for people with lower limb amputations, as they fall significantly more often (Vu et al., 2019; Dite, Connor, & Curtis, 2007). Therefore, gait restoration is recognized (Premnath et al., 2021; Gaunaurd et al., 2020; Batten et al., 2019) as the primary goal of post-amputation rehabilitation.

In higher education institutions, inclusive physical education is designed to support the rehabilitation process for students with disabilities (Karamani et al., 2024; Navas-Bonilla et al., 2025; Iedynak et al., 2025). Research focuses on the issue of the quality of inclusive PE (Penney et al., 2018; Kuntjoro et al., 2024; Marín-Suelves & Más, 2021).

A position has become established in the scientific discourse according to which judgments about the effectiveness of physical education for students with disabilities are formed based on the results of test-based assessment (Blavt et al., 2024a; Maher, van Rossum, & Morley, 2023; Fuentes-Nieto, López Pastor, & Palacios-Picos, 2022). The factors contributing to the effectiveness of assessment in physical education are recognized as the objectivity of evaluation, the timeliness of results, the specificity of the assessment, and the suitability of tests for a specific population (Marín-Suelves & Más, 2021; Moura et al., 2021; Iedynak et al., 2025; Blavt et al., 2024b).

It has been demonstrated (Archer, & Ellis, 2024; Fuentes-Nieto, López Pastor, & Palacios-Picos, 2022) that the challenge of ensuring the effectiveness of assessment in inclusive physical education cannot be resolved today without the use of modern innovative technologies. Such technologies allow for the transformation of subjective assessment into a precise process of quality control management in physical education (Müller & Wagner, 2025; Kuntjoro et al., 2024).

Based on data from the scientific literature, it has been established that the problem of monitoring the body's dynamic stability and the dynamics of its normalization under the influence of inclusive physical education for students with disabilities involving amputation remains entirely unresolved. In general, researchers note (Eshraghi et al., 2018; Lythgo, Marmaras, & Connor, 2010; Maikos et al., 2024) the limited progress in improving the rehabilitation process for individuals with disabilities involving amputation across various populations, aimed at enhancing gait and balance.

The need to ensure the effectiveness of the rehabilitation process based on the results of gait parameter testing during inclusive physical education for students with disabilities involving lower limb amputation prompted us to conduct this experimental study.

The purpose of the study was to establish the level of reliability and validity of the Timed Up and Go (TUG) test for students with disabilities involving lower limb amputation using an intelligent software-controlled hardware complex in the process of inclusive physical education.

Materials and methods

Research methods

The experimental study was conducted at both the theoretical and empirical levels. The theoretical level established the foundation for justifying the concept of scientific research.

Based on the results of the analysis and synthesis of existing experience, the logic for further research was developed, and key components were identified. Through abstraction, secondary factors were eliminated to focus on gait biomechanics. Through concretization, general principles of inclusion were applied to the specific conditions of higher education. Through induction, a transition was made from individual facts to general conclusions regarding the effectiveness of testing using a specific methodology. Deduction was used to apply general laws of pedagogy to a specific case – physical education for students with disabilities involving lower limb amputation.

At the empirical level, technical modeling was used to create an intelligent software-controlled hardware system. A natural pedagogical experiment was organized to test the hypothesis regarding the improvement of gait parameter monitoring. Testing was conducted using the TUG test. The TUG test is a reliable, cost-effective, safe, and time-efficient way to evaluate overall functional mobility with high correlation with other proven tests that measure pure balance and gait performance (Shirley Ryan Abilitylab).

The test procedure. The TUG test requires the student to rise from a standard armchair, walk to a marker 3 meters away, turn, walk back, and sit down again (Fig. 1). It is a simple, quick assessment that measures functional mobility, dynamic balance, and fall risk.

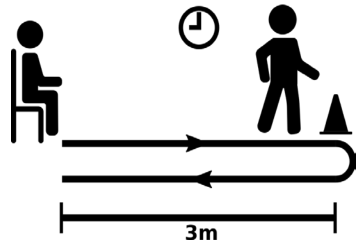

Fig. 1. Scheme of the TUG test (NeuroToolKit)

Study participants

The study sample consisted of male first-year students (23) with disabilities who had a left-sided transtibial amputation of the left lower limb. The sample was composed of individuals who had no clinical contraindications, such as acute conditions or inflammatory processes of the stump. Informed consent was obtained from the study participants.

The selection of participants with a left-sided limb deficiency was driven by the need to ensure homogeneity in the study sample. The selection criterion was the ability to walk independently with crutches and perform basic daily activities without external support.

Since the knee joint in the students of the study sample is intact, which significantly facilitates prosthesis control and ensures a higher level of mobility, the participants' functional status was characterized by the ability to perform self-care and move confidently using assistive devices (crutches).

Given that sample size affects conclusions in identifying study effects, recommendations were taken into account (Kemal, 2020). The results should be interpreted with consideration of the limited sample size, which is typical for the pilot phases of implementing innovative monitoring systems (Baumgartner et al., 2015).

The experiment is conducted with the anonymous written consent of the students. Students who agreed to participate in the study were given the right to withdraw from it at any time during its conduct.

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».

The sample size corresponds to a pilot-stage study focused on testing the applicability of the proposed monitoring approach.

Research organization

The study involved a comparison of methods for recording TUG results for students with lower limb amputations. The experimental work was based on a comparative analysis of two approaches to recording TUG results for students with lower limb amputations. A comparison was conducted between recording TUG results using a stopwatch and using a smart software-controlled hardware system.

A stopwatch was used to record the time taken to complete the TUG test. An intelligent software-controlled hardware system was used to record center oscillation amplitude, reaction time and stride length.

The students in the study sample were given detailed instructions on how to perform the test. The study was conducted in two sessions, during which the students completed two trials each.

Statistical analysis

Statistical information was obtained from the results of descriptive statistics. The reliability and validity of the methods were assessed using correlation analysis with correlation coefficient (rtt) (Mishra et al., 2019).

Mathematical statistics methods were used to process, analyze, and interpret the experimental data using SPSS Version 22.0 (IBM Corporation).

Results

We present the results of our research in the form of a custom-designed, software-controlled hardware system for implementing the TUG. The primary objective in developing the system was to record various gait parameters of students with lower-limb amputations and analyze them in real time.

The system's structural composition includes Bluetooth-enabled wireless sensors, which are placed on the student and along the entire TUG trajectory. The main computing module is a microcontroller that processes sensor data and performs real-time configuration. We display monitoring information using an LCD (Liquid Crystal Display), which serves as the main interface.

A schematic diagram of the connection of all elements of the intelligent software-controlled hardware complex has been developed, ensuring their proper interaction (Fig. 2). The system utilizes Bluetooth-enabled wireless sensors; the Xsens DOT (Mykytyuk et al., 2025) was selected, which consists of sensor modules that can be attached to the student's body segments to collect 3D data during the TUG test. Xsens DOT sensors provide detailed information about movement, including orientation, acceleration, angular velocity, step frequency, and more, enabling comprehensive and accurate motion analysis through real-time data streaming.

Xsens DOT implements an algorithm for fusing the student's motion sensors during the TUG test. Xsens DOT is resistant to magnetic field interference and equipped with the latest signal processing technology, easily enabling integration with mobile devices and compatibility with various software platforms.

The Arduino Uno microcontroller, the latest R3 model, was selected as the main computing module for the intelligent software-controlled hardware system to implement the TUG. The Arduino Uno has sufficient technical specifications to implement control algorithms and process data from sensors, as well as a simple programming structure and an easy-to-use USB interface for uploading. Communication between complex elements is provided by infrared communication lines.

The software for the intelligent software-controlled hardware complex for implementing TUG was developed using the Arduino IDE. A key feature of the complex is the use of IoT technologies. Consequently, connectivity to cloud platforms has been implemented, opening new possibilities for analytics, forecasting programs for inclusive physical education for students with disabilities, and optimizing energy consumption. It provides instant biofeedback, which is critical in rehabilitation for correcting a student's movements in real time. Thanks to the high measurement resolution (0.001 s), the student can feel the difference even in slight changes in walking pace.

Thus, the automated collection of TUG results provides numerous gait parameters for students with lower-limb amputations, such as center oscillation amplitude, reaction time and stride length, which cannot be recorded when TUG results are manually recorded by a teacher.

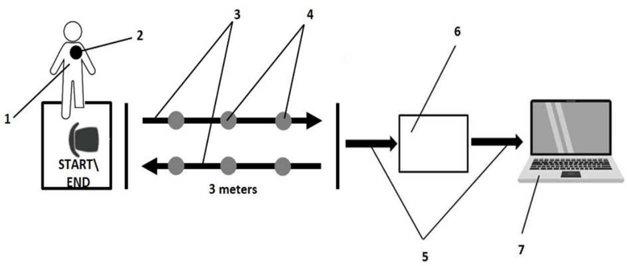

Fig. 2. Scheme of TUG test implementation using a: 1 – student, 2 – sensor modules, 3 – TUG test trajectory, 4 – Xsens DOT sensors, 5 – infrared communication lines, 6 – Arduino Uno microcontroller; 7 – PC

In the second stage of the empirical study the TUG was establish of the level of reliability and validity. The results are presented in Table 1-2.

According to the numerical data obtained from the intellectual software-controlled hardware complex, the TUG reliability (0,838-0,903) and validity (0,558-0.605) level is high. The detection of TUG performance results is carried out at the speed of the microprocessor, which ensures measurement accuracy down to the microsecond. The digitization of the process effectively «cleans» the data, ensuring the reliability of the test results.

In contrast, the use of a stopwatch reduces the test's validity and reliability to average values and levels deemed «acceptable for use». This is entirely expected, as the instructor's reaction is not constant and varies depending on fatigue, attention, and anticipation of the moment, leading to random errors in recording TUG results.

In addition, in manual mode, it is not possible to record and analyze numerous gait parameters (center oscillation amplitude, reaction time, stride length), that provide information about the progress of rehabilitation for students with disabilities involving lower limb amputation.

Discussion

Our study is based on the premise that the use of innovative technologies in physical education monitoring eliminates the influence of the human factor, ensuring high-quality monitoring and ease of use (Tohănean et al., 2025; Müller & Wagner, 2025; Blavt et al., 2024a). Consequently, the data (Navas-Bonilla et al., 2025; Karamani et al., 2024; Fuentes-Nieto, López Pastor, & Palacios-Picos, 2022) have been expanded, showing that improving the quality of monitoring holds significant potential for enhancing the quality of inclusive physical education.

The body of evidence has expanded (Hafner & Sanders, 2014; Clemens et al., 2020; Rietman, Postema, & Geertzen, 2002), indicating that the collection and use of objective data form the basis for objectively adjusting rehabilitation interventions following lower limb loss. At the same time, identifying mechanisms for correcting gait asymmetry

Table 1. The reliability and validity level of the TUG test for students with disabilities involving lower limb amputation using intellectual software-controlled hardware complex (n – 23)

Control parameter		(X ± m)	As	Me	V	(X ± m)	As	Me	V
Total test time (s)		16.5 ± 2.04	0.36	16.1	22.4	16.1 ± 1.96	0.38	15.9	22.1
Center oscillation amplitude (ms)	Straight-line gait	272.6 ± 12.7	2.99	270.8	24.5	265.8 ± 13.6	1.99	265.6	23.7
	Turning 180°	670.4 ± 22.3	8.91	670.8	25.3	645.7 ± 15.2	5.41	646.1	25.3
	Sit-to-Stand	420.1 ± 26.7	5.72	419.5	24.6	401.6 ± 21.3	3.82	400.8	24.5
	Stand-to-Sit	511.3 ± 21.2	9.1	509.5	22.5	515.7 ± 23.6	4.29	516.1	23.7
Step time (left, s)		0.45 ± 0.09	0.19	0.431	20.1	0.43 ± 0.11	0.18	0.415	22.3
Reaction time (ms)		730.4 ± 33.5	9.32	734.2	25.4	723.7 ± 29.2	7.29	725.1	24.5
Steps (number)		18.2 ± 2.3	0.72	18.5.	23.6	18.7 ± 2.9	0.39	17.5	21.5
Stride length (sm)		32.1 ± 2.01	0.88	32.5	25.1	31.5 ± 2.32	0.91	31.9	22.3
Velocity (m/s)		0.375 ± 0.034	0.17	0.373	21.4	0.372 ± 0.066	0.13	0.370	22.7
Reliability (rtt)			0, 838				0,902		
Validity (rtt)			0,558				0,612		

Table 2. The reliability and validity level of the TUG test for students with disabilities involving lower limb amputation using a stopwatch (n – 23)

Control parameter	(X ± m)	As	Me	V	(X ± m)	As	Me	V
Total test time (s)	17.4 ± 3.05	0.41	17.7	28.2	17.2 ± 2.88	0.44	17.4	27.9
Steps (number)	19.3 ± 2.6	0.62	19.1	30.1	19.1 ± 2.6	0.41	19.3	29.1
Stride length (sm)	31.1 ± 1.74	0.71	31.3	28.5	32.9 ± 2.55	0.68	32.7	31.1
Velocity (m/s)	0.341 ± 0.071	0.41	0.343	29.2	0.361 ± 0.083	0.43	0.365	28.5
Reliability (rtt)		0,512				0, 610		
Validity (rtt)		0,199				0,204		

following lower limb amputation can serve as a guide for understanding optimal strategies for the rehabilitation process (Maikos et al., 2024).

We were guided by the information (Kendell et al., 2010; Salih, Peel & Burgess 2016; Griffiths, Diment, Granat, 2021) that current assessment methods do not allow for characterizing the dynamic stability of individuals with lower limb amputations during walking. At the same time, as noted (Schmid et al., 2005; Rietman, Postema, & Geertzen, 2002; Bastas et al., 2018), one of the goals of gait rehabilitation after amputation is to restore step symmetry and variability (Sinitski et al., 2021; Vrieling et al., 2009) and gait stability on various surfaces (Premnath et al., 2021; Kark et al., 2012), including descents and ascents (Sturk et al., 2019; Vrieling et al., 2009; Lythgo, Marmaras, & Connor, 2010), walking speed (Gaunaurd et al., 2020; Batten et al., 2019), and step count (Chihuri, Youdan, & Wong, 2021).

Our study expands on the findings that artificial intelligence systems (Lex et al., 2023; Griffiths, Diment, Granat, 2021; Mahoney & Rhudy, 2019), electronic technologies (Jarchi et al., 2018; Chen et al., 2016; Kim et al., 2020), virtual reality (Şahan & Erbahçeci, 2023; Hao et al., 2023), and augmented reality (Vinolo Gil et al., 2021) are transforming the monitoring process in the implementation of rehabilitation for amputation, offering unprecedented accuracy in assessment.

Research (Grace Gaerlan et al., 2012) has shown that the TUG is reliable and valid for the quantitative assessment of functional mobility and for tracking clinical changes in walking ability. To date, the TUG has been validated for elderly individuals (Podsiadlo & Richardson, 1991; Alexandre et al., 2012; Herman, Giladi, & Hausdorff, 2011), in older adults with impaired mobility (Botolfsen et al., 2006), in patients with total hip arthroplasty (Yuksel et al., 2021; Özden, Coşkun, & Bakırhan, 2020); in frail and non-frail patients with prostate cancer (Feyzioğlu et al., 2025); in patients with knee osteoarthritis (Nalbant, Unver, & Karatosun, 2022); for children with Down syndrome (Martin et al., 2017; Nicolini-Panisson, & Donadio, 2014); in knee osteoarthritis (Gacto-Sánchez et al., 2023); in people with Parkinson's disease (Huang et al., 2011; Vance et al., 2015); in children (Verbecque et al., 2019); in children with cerebral palsy (Besios et al., 2018); in multiple sclerosis patients (Kalron, Dolev, & Givon, 2017; Hershkovitz et al., 2019); in older adults living with dementia (Chan et al., 2024).

To date, the TUG has been used for elderly patients with a lower limb amputation (Schoppen et al., 1999; Dite, Connor, & Curtis, 2007). The level of validation of individual tests for individuals with disabilities who have lower limb amputations has been determined: the Berg Balance Scale (Major, Fatone, & Roth, 2013), the Houghton Scale (Wong, Gibbs, & Chen, 2016), and the 2-Minute Walk Test (Wong et al., 2020).

However, no studies have assessed walking skills in a population of students with lower limb amputations. In our study, we were guided by the finding (Chen et al., 2016) that «gait analysis using wearable sensors must be evaluated in the target patient population to prove its clinical value, since algorithms developed from control subject data may not be generalizable to pathological gait».

For the first time, it has been substantiated and experimentally confirmed that the use of an intelligent software-controlled hardware system to record TUG results in students with lower limb amputations significantly enhances its validation.

The obtained detailed gait parameters (center oscillation amplitude, reaction time, stride length) extend the analytical capacity of the TUG test beyond time-based assessment. These parameters enable differentiation of motor deficits in students with lower limb amputation, particularly in terms of movement stability, coordination, and temporal organization of gait. This creates a basis for targeted pedagogical interventions in inclusive physical education, where exercise selection, load distribution, and corrective tasks can be individualized according to specific gait characteristics rather than general performance indicators. Thus, digitalization of the TUG transforms it from a screening tool into an instrument of pedagogical control and decision-making.

The results of our previous studies regarding the appropriateness of using technology to monitor inclusive physical education as a factor in ensuring its effectiveness have been confirmed (Blavt et al., 2024a; Blavt et al., 2024b).

Conclusions

The increasing number of students with disabilities resulting from lower limb amputations caused by prolonged hostilities in Ukraine necessitates improving the quality of their rehabilitation within the university course on inclusive physical education. This requires the use of modern innovative technologies in the monitoring process as a factor ensuring the effectiveness of the rehabilitation process.

An intelligent, software-controlled hardware system has been developed for the implementation of the TUG. Its structure integrates Xsens DOT sensors placed on the student's limbs and along the test trajectory, an Arduino Uno microcontroller of the latest R3 model, and an LCD display with an I^2C interface, which allows for the real-time display of current movement parameters. A distinctive feature of the system is the use of IoT technologies to connect to cloud platforms for analytics and forecasting.

An analysis of the reliability and validity of the TUG test among students with disabilities involving lower limb amputations confirmed a significant advantage of using the digital system for gait monitoring. Its application ensured a «high» level of reliability and validity of the methodology. At the same time, the use of the digital instrument allows for the recording of numerical gait parameters that cannot be obtained manually. In contrast, the use of a traditional stopwatch yielded only «average» and «acceptable» levels of reliability and validity for the TUG. This allows the digitized TUG to be considered a precision (high-accuracy) assessment tool with a high level of functionality, reliability, and effectiveness.

The study demonstrates that detailed digital recording of TUG parameters allows identifying specific characteristics of gait organization (e.g., instability phases, delayed motor response, asymmetry), which are not detectable using traditional timing methods. These characteristics can serve as a basis for targeted correction within the process of inclusive physical education.

The findings should be interpreted with caution due to the limited sample size and the specificity of the participant group.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

AI Transparency Statement

The author declares that no generative AI or AI-assisted technologies were used in the writing, editing, or preparation of this manuscript.

Funding statement

This research received no external funding
The authors received no financial support for the research, authorship, and publication of this article.

Clarified Ethics Approval

This study was approved by the Research Ethics Committee Міжнародного Kamianets-Podilskyi National Ivan Ohiienko University (KPNU 2025-015) before the start of the study.

Conflicts of interest

No conflicts of interest exist.

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Цифровізація тесту «встань та іди» для підвищення ефективності контролю у інклюзивному фізичному вихованні

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

Реферат. Стаття: 10 с., 2 табл., 2 рис., 76 джерел.

Мета дослідження – установлення рівня надійності та валідності тесту «Встань та іди» для студентів з інвалідністю з ампутацією нижньої кінцівки з використанням інтелектуального програмно-керованого апаратного комплексу у процесі інклюзивного фізичного виховання.

Матеріал та методи. Дослідження реалізовано на теоретичному та емпіричному рівні. використано методи: аналізу, синтезу, систематизації, узагальнення, вимірювання та математичної статистики. Вимірювання реалізовано з використанням тесту «Встань та іди». У досліджувану вибірку увійшли 23 студенти I-го курсу навчання (чоловіки) з лівобічною транстібіальною ампутацією нижньої лівої кінцівки за умови відсутності гострих станів, відкритих ран чи ускладнень.

Результати. Результати здійсненого наукового пошуку представляємо у розробленому інтелектуальному програмно-керованому апаратному комплексі для реалізації тесту «Встань та іди». Структурна композиція комплексу включає: бездротові датчики з підтримкою Bluetooth, які розміщуємо на студентові та по всій траєкторії виконання тесту «Встань та іди». Сигнали, отримані датчиками Xsens DOT, передаються на мікроконтролер Arduino Uno останньої моделі R3. Представлення інформації контролю забезпечуємо використанням РК-дисплей Liquid Crystal Display. Визначною особливістю комплексу є використання IoT-технологій для аналітики та прогнозування інклюзивного фізичного виховання. Автоматизоване отримання результатів тесту «Встань та іди» забезпечує отримання численних параметрів ходи студентів з інвалідністю з ампутацією нижньої кінцівки як амплітуда коливань центру, час реакції та довжина кроку, які не можливо зафіксувати з фіксацією результатів, секундоміром.

Цифрова обробка даних трансформує рівень надійності та валідності тесту «Встань та іди» з «середнього» при вимірюванні секундоміром, до «високого», що забезпечує точність фіксації числених параметрів до мікросекунд.

Висновки. Новизна розробленого інтелектуального програмованого інструменту для реалізації тесту «Встань та іди», полягає у забезпеченні ефективності контролю у інклюзивному фізичному вихованні та усунення впливу людського фактору на результати тестування.

Ключові слова: студенти, фізичне виховання, тест «Встань та іди», контроль, надійність, валідність.

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Cite this article as: Blavt, O., Galamanzhuk, L., Iedynak, G., Larysa, K., Banakh, V., Faidevych, V., Holub , V., & Stadnyk, V. (2026). Digitalization of "Timed Up and Go" Test to Increase the Control Efficiency in Inclusive Physical Education. *Physical Education Theory and Methodology, 26*(3), 518-527. https://doi.org/10.17309/tmfv.2026.3.13

Received: 15.03.2026. Accepted: 02.04.2026. Published: 30.05.2026