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Statistical evaluation of the effectiveness of an automated physical condition monitoring system for higher education students based on cloud scripts

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Статистичне оцінювання ефективності автоматизованої системи моніторингу фізичного стану здобувачів вищої освіти на базі хмарних скриптів

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Introduction

Obtaining a higher education is accompanied by significant academic workloads, which often lead to a critical decrease in the level of physical activity among young people. The problem of hypodynamia among students has reached a global scale. Specifically, in a fundamental systematic review by O. Castro et al. [1], it was demonstrated that the university environment is one of the highest risk factors for developing a sedentary lifestyle. Given this, traditional methods of physical education in higher education institutions (HEIs) require modernization through the integration of digital tools (Digital Health Interventions, DHI) directly into the everyday educational space.

An analysis of international scientific publications confirms the high effectiveness of applying digital and mobile technologies for correcting the behavioral patterns of students. According to a recent systematic review by Q. Zhou et al. [2], digital interventions have a decisive influence on changing the lifestyles of university students in the long term. The importance of this direction is supported by the study of S. Jiang et al. [3], which established a direct correlation between the level of eHealth literacy and physical activity. The role of smartphones and mobile applications as effective triggers for activity and healthy eating has been thoroughly proven in the works of N. Feter [4], K. Villinger [5], and Y. Wang [6]. The use of web-oriented tools and internet interventions, as noted by A. Murray et al. [7] and F. Yuan et al. [8], demonstrates significantly higher effectiveness in stimulating physical activity and improving the psychophysiological state of students compared to traditional informational

approaches. Modern studies by S. Bi et al. [9] mathematically prove that digital interventions significantly increase physical activity levels among college students. Furthermore, Y. Peng et al. [10] emphasize the importance of implementing algorithmic digital implementation intentions in the student environment, while J. Zhang et al. [11] focus on the gamification of mobile health interventions to improve not only physical but also mental health. The importance of general digitalization of the educational process from the perspective of students' perceptions is highlighted in the work of V. Potočan [12].

In the domestic scientific space, the issue of digitalizing physical education is also gaining particular relevance. Specifically, research by O.P. Nikolaichuk confirms the effectiveness of innovative strategies that combine digital monitoring and task personalization to increase the physical activity level of students under conditions of total digitalization [13]. The importance of implementing innovative technologies, fitness trackers, and digital platforms for tracking achievements and monitoring health status in Ukraine is highlighted in the works of P.Ye. Livak and co-authors [14]. At the same time, V. Bilohur et al. focus on the necessity of implementing digital technologies and skills in the field of physical education and sports, taking into account the modern European educational context [15]. The practical aspect of applying innovative technologies as a key factor in forming a healthy lifestyle among student youth, directly during physical education classes, is thoroughly covered in the study by T. Palahniuk and O. Kivernyk [16].

Despite the proven effectiveness of mobile applications and health trackers, most HEIs lack a unified corporate monitoring system that operates autonomously through

channels already familiar to students (e.g., corporate Google Workspace email). There is a critical lack of research regarding the effectiveness of using low-code tools (specifically cloud scripts) to create seamless, automated email interventions directly within the university's IT infrastructure, which would not require students to install third-party software.

The purpose of the research is to develop, scientifically substantiate, and statistically verify the effectiveness of an automated system for personalized monitoring and correction of university students' physical condition, implemented through cloud-based Google Apps Script tools and the Google Workspace ecosystem.

Object, materials and research methods

The experimental study was conducted at the Communal Institution of Higher Education "Kremenchuk Humanitarian and Technological Academy" within the framework of international scientific collaboration with the National University of Mar del Plata (Argentina). The total sample comprised 120 higher education students. To ensure representativeness and account for the interdisciplinary context, students from various fields of study were involved in the experiment, representing the following academic group codes: PE (future physical education specialists), EE (primary education), M (management), and Psy (psychology). Using simple randomization, the participants were divided into two equal groups: an experimental group (EG, $n = 60$) and a control group (CG, $n = 60$).

The architecture of the digital monitoring system was developed using the Google Workspace cloud ecosystem, which allowed for process optimization without the need for additional server resources. The accumulation of primary empirical data was initiated through a standardized input Google Form. The core of the information system was a master spreadsheet, in which an algorithm for instantaneous Body Mass Index (BMI) calculation

and automatic student profile categorization was implemented using built-in logical functions (Graph 1).

The methodological basis for developing the intervention content was the developed digital "Knowledge Base". Its structure was established in strict accordance with the current biomedical protocols of the World Health Organization (WHO), as detailed in the study by F.C. Bull et al. [17]. The content was differentiated into four vectors: water balance (hydration), physical activity, nutritional profile (diet), and circadian rhythm hygiene (sleep). The array of recommendations was algorithmically segmented according to the participants' established BMI categories (Graph 2).

The formative intervention procedure was fully automated within the Google Apps Script runtime environment. The core of the logic was a script designed to cyclically scan the database, identify the current BMI category of each student in the experimental group, and automatically generate personalized emails. The content of these communications was dynamically adapted according to the specific week of the experiment and the unique needs of the corresponding nominal group.

To minimize researcher bias and ensure the continuity of standardized data collection, the control phase (monthly monitoring) was also migrated to an autonomous mode. To achieve this, a time-driven trigger was integrated into the system architecture. This software module initiated the distribution of monitoring forms at precisely defined intervals (specifically, on the 28th of each month) without any direct intervention from the process administrator.

Statistical processing and visualization of empirical datasets were performed in the specialized jamovi 2.6.44 software. Given the study design, which involved the transformation of continuous anthropometric variables (BMI) into categorical (nominal) variables ("Normal," "Overweight," "Obesity"), the application of non-parametric mathematical criteria was methodologically justified. This approach was necessitated by the need to ensure the relevance of calculations to the nature

1	Email Address	Full Name	Group_ID	Height	Body Weight	Initial_BMI	BMI_Category_Initial
2	st55@pu.org.ua	Student_55	Psy-11B	168	86,4	30,6	Obesity
3	st84@pu.org.ua	Student_84	PE-41B	174	72,7	24,0	Normal
4	st40@pu.org.ua	Student_40	M-11B	170	76,6	26,5	Overweight
5	st62@pu.org.ua	Student_62	EE-21B	173	64,3	21,5	Normal
6	st95@pu.org.ua	Student_95	PE-31B	183	90,8	27,1	Overweight
7	st89@pu.org.ua	Student_89	Psy-11B	177	72,4	23,1	Normal
8	st105@pu.org.ua	Student_105	Psy-21B	183	98,5	29,4	Overweight
9	st87@pu.org.ua	Student_87	PE-41B	163	54,7	20,6	Normal
10	st51@pu.org.ua	Student_51	PE-41B	164	69,9	26,0	Overweight
11	st116@pu.org.ua	Student_116	Psy-11B	172	95,9	32,4	Obesity
12	st9@pu.org.ua	Student_9	Psy-21B	187	81,1	23,2	Normal
13	st16@pu.org.ua	Student_16	PE-21B	171	59,1	20,2	Normal
14	st107@pu.org.ua	Student_107	EE-41B	185	96,9	28,3	Overweight
15	st28@pu.org.ua	Student_28	PE-31B	179	76,9	24,0	Normal

Graph 1. Fragment of the initial database with automatically calculated BMI parameters

Week_Number	BMI_Category	Subject_Line	Email_Body_Content
1	1 Normal	Week 1: Hydration and Performance	Dear student, to maintain high physical and cognitive performance, drink at least 30 ml of water per 1 kg of body weight daily. Stay hydrated!
2	1 Overweight	Week 1: Metabolic Activation	Dear student, to activate your metabolism and improve digestion, start your morning with a glass of warm water 20 minutes before breakfast.
3	1 Obesity	Week 1: Calorie Control Strategy	Dear student, drinking a glass of water 20 minutes before each meal helps naturally reduce portion sizes and prevents overeating.
4	2 Normal	Week 2: Aerobic Endurance	Dear student, aim for 150 minutes of moderate-intensity aerobic activity per week (e.g., brisk walking or cycling) to strengthen your heart.
5	2 Overweight	Week 2: Fat Burning Activity	Dear student, try 40 minutes of brisk walking 4-5 times a week. Keeping a steady pace is more important for fat oxidation than high intensity.
6	2 Obesity	Week 2: Low-Impact Movement	Dear student, focus on low-impact activities like swimming or stationary cycling for 30 minutes to protect your joints while staying active.
7	3 Normal	Week 3: The Healthy Plate Rule	Dear student, follow the WHO "Healthy Plate" model: 50% vegetables, 25% whole grains, and 25% lean protein for optimal energy balance.
8	3 Overweight	Week 3: Fiber and Satiety	Dear student, increase your intake of dietary fiber (vegetables, legumes, whole grains). This helps you stay full longer and controls insulin levels.
9	3 Obesity	Week 3: Eliminating Added Sugars	Dear student, try to completely eliminate sugar-sweetened beverages and highly processed snacks. This is the fastest way to improve metabolic health.
10	4 Normal	Week 4: Recovery and Sleep	Dear student, high-quality sleep (7-9 hours) is essential for muscle recovery and hormonal balance. Try to maintain a consistent sleep schedule.
11	4 Overweight	Week 4: Cortisol and Weight	Dear student, lack of sleep increases cortisol levels, which promotes fat storage. Aim to be in bed by 11:00 PM for optimal hormonal recovery.
12	4 Obesity	Week 4: Circadian Rhythms	Dear student, establishing a regular sleep-wake cycle helps regulate hunger hormones (ghrelin and leptin), making it easier to manage weight.

Graph 2. Fragment of the structure of the recommendation knowledge base (WHO_Protocols) with segmented content by BMI categories

of categorical data, as well as a deliberate decision to avoid over-mathematization of the conclusions by using complex parametric models that are not optimal for the chosen scale types.

To verify the initial homogeneity of the sample, the Pearson's χ^2 -test was applied. The dynamics of intra-group changes (shift analysis in the experimental group) were recorded using the Wilcoxon signed-rank test. The strength and direction of the relationship between students' level of digital engagement (the number of processed email interventions) and physiological outcomes were evaluated using the Spearman's rank correlation coefficient (r_s).

The methodological framework of the study and the interpretation of digital health intervention principles were discussed within the framework of international scientific collaboration with a representative of the National University of Mar del Plata (Argentina).

Research results

At the initial stage of the study, a baseline assessment of the anthropometric indicators of the higher education students was conducted to determine the starting level and verify the baseline equivalence of the formed groups. The system's algorithm automatically calculated and classified 120 participants into the corresponding BMI categories. A statistical test of the hypothesis regarding the absence of significant differences between the experimental (EG) and control (CG) groups at the start of the experiment, using the Pearson's χ^2 -test, confirmed a high level of sample homogeneity ($\chi^2 = 1.18$; $p > .05$),

as detailed in the cross-tabulation results (Graph 3). This objectively confirms the validity of the sample formation and the identity of the starting conditions prior to the implementation of the digital interventions.

Throughout the semester, the students in the experimental group were subjected to the systematic influence of the automated distribution system. The practical implementation of the intervention consisted of the automatic generation and delivery of personalized recommendations to the students' corporate email accounts, tailored to their individual health profiles and the current week of the program (Graph 4).

This format of digital interaction ensures the continuity of information support within a communication environment natural to students, thereby eliminating the need for third-party applications and avoiding additional administrative burden on the teaching staff.

To evaluate the effectiveness of the implemented cloud-based system, a comparative analysis of baseline and final data was conducted. Calculations using the Wilcoxon signed-rank test for related samples revealed a statistically significant positive shift in the experimental group, as confirmed by computations in the jamovi 2.6.44 environment (Graph 5).

A statistically significant reduction in students' body mass was recorded, accompanied by structural changes in category distribution: a pronounced trend of participants transitioning from the "Overweight" and "Obesity" groups to the "Normal" category was observed (Graph 6).

At the same time, the anthropometric indicators of the control group members, who did not receive automated support, remained relatively stable, with minor fluctuations within the range of statistical error.

To determine the degree of influence that the intensity of digital interaction had on physiological outcomes, a correlation analysis was performed. The variables considered

Contingency Tables

BMI_Category	Group_Assigned		Total
	EG	CG	
Obesity	8	12	20
Normal	39	34	73
Overweight	13	14	27
Total	60	60	120

χ^2 Tests

	Value	df	p
χ^2	1.18	2	0.554
N	120		

Graph 3. Baseline Chi-square test results for experimental and control group homogeneity

Week 10: Joint-Friendly Activity

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Dear Student_55,

consistency is your best tool. Focus on continuous, joint-friendly movements like stationary cycling or water aerobics to build stamina safely.

Best regards,
Monitoring Team
Kremenchuk Humanitarian and Technological Academy

Graph 4. Interface of the personalized health recommendation delivery via corporate email

Paired Samples T-Test

			Statistic	p	Mean difference	SE difference	Effect Size
Initial_BMI	Final_BMI	Wilcoxon W	4856*	<.001	0.700	0.0604	Rank biserial correlation
							0.813

Note. H₀: $\mu_{\text{Measure 1}} - \mu_{\text{Measure 2}} \neq 0$

* 17 pair(s) of values were tied

Graph 5. Results of the Wilcoxon signed-rank test indicating a significant reduction in BMI within the experimental group ($p < .001$, $r_b = 0.813$)

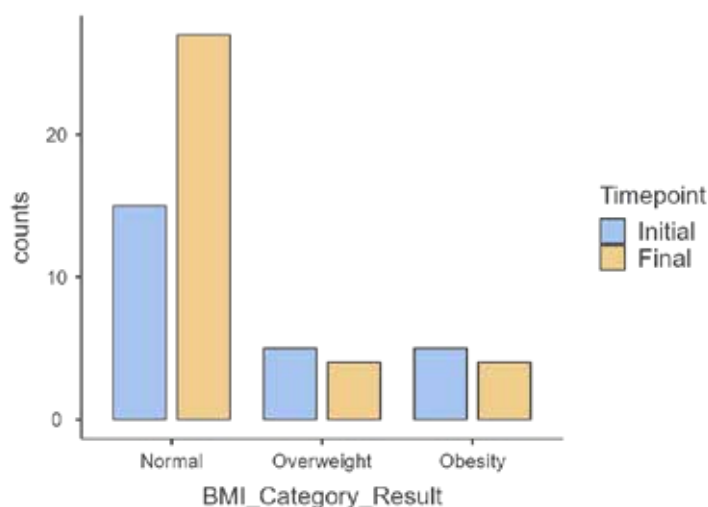
were the digital engagement index (the number of monthly monitoring forms completed and emails processed by the student) and the absolute indicator of BMI reduction.

The calculation of the Spearman's rank correlation coefficient demonstrated the presence of a strong direct statistical relationship between the studied parameters ($r_s = 0.744$; $p < .001$), which is illustrated in the correlation matrix (Graph 7).

The obtained data empirically prove the working hypothesis: the higher the level of systematic interaction between the student and the developed IT infrastructure, the more intensive the dynamics of their physical condition normalization (Graph 8).

Discussion of research results

The empirical data obtained provide grounds to assert that the integration of digital interventions directly into the communication channels familiar to students (corporate email) is an effective tool for physical condition correction. Unlike traditional approaches, which require the installation of additional mobile applications and often encounter the problem of rapid user motivation loss, the use of cloud scripts ensured stable, non-intrusive algorithmic support. The recorded statistically significant BMI reduction in the experimental group ($p < .001$) indicates that personalized content, adapted to the student's current

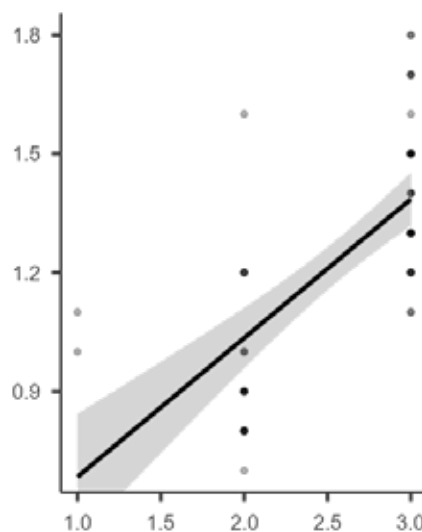


Graph 6. Distribution of BMI categories in the experimental group before and after the intervention

Correlation Matrix			
		Forms_Completed	BMI_Reduction
Forms_Completed	Spearman's rho	—	
	df	—	
	p-value	—	
BMI_Reduction	Spearman's rho	0.744***	—
	df	58	—
	p-value	<.001	—

Note. * $p < .05$, ** $p < .01$, *** $p < .001$

Graph 7. Spearman's rank correlation matrix between digital engagement and BMI reduction



Graph 8. Scatter plot with regression line illustrating the relationship between participation frequency and physiological outcome

physiological state, is capable of forming sustainable healthy behavior patterns without direct administrative or pedagogical pressure.

An important advantage of the developed architecture is its construction based on the principles of low-code technologies. Utilizing the Google Apps Script ecosystem eliminates the need for deploying complex server infrastructures, making this tool optimal for rapid implementation into the educational process. The demonstrated model is characterized by a high level of scalability and can be integrated as a core module of health-preserving monitoring into the unified digital environment of the “Kremenchuk Humanitarian and Technological Academy”. Such a technological approach allows for the development of an internal institutional ecosystem to support students, automating routine data collection processes and optimizing the time resources of the institution's teaching staff. This confirms the readiness of the academic infrastructure for the implementation of highly effective low-code solutions without the need for third-party platforms.

To verify the effectiveness of the formative intervention, a set of classical non-parametric criteria was deliberately applied. This allowed for obtaining valid, reliable, and easily reproducible results while avoiding overloading pedagogical research with overly complex statistical constructs. The chosen experimental design ensures the transparency of the conclusions and makes the methodology accessible for adaptation in other higher education institutions.

Despite the high statistical significance of the results obtained, the study has certain objective limitations. A determining factor is the use of anthropometric data, which students provided independently through electronic monitoring forms. Although authorization via corporate accounts minimizes the risks of intentional falsification, the absolute accuracy of the indicators partially depends on the participants' integrity. Furthermore, the duration of the formative stage, limited to one academic semester, allows for the assessment of only the short-term and medium-term impacts of the interventions. To conduct an in-depth study of the effect of prolonged result retention, organizing further longitudinal research is necessary.

Prospects for further research

A promising avenue for further scientific exploration in this field involves expanding the system's functionality through API integration with personal wearable devices (fitness trackers, smartwatches). This will allow for the mitigation of issues related to manual data entry and facilitate a transition toward the concept of continuous, objective monitoring of student health.

Conclusions

In the course of this study, an automated system for monitoring the physical condition of higher education students was developed and successfully tested. It has been proven that the use of low-code tools (Google Apps Script) allows for the creation of an autonomous digital ecosystem capable of continuous data collection, physiological indicator calculation (BMI), and the generation

of algorithmic feedback without the need for complex server solutions.

The effectiveness of the implemented personalized email interventions has been statistically verified. The application of the Wilcoxon signed-rank test demonstrated a significant reduction in the Body Mass Index of students in the experimental group ($p < .001$). The final comparison of results using the Pearson's χ^2 test confirmed the significant superiority of the experimental sample over the control group ($p < .05$), which proves the advantage of algorithmic support over traditional forms of physical education.

It was empirically established that a strong direct correlation ($r_s = 0.744$; $p < .001$) exists between students' level of digital engagement and the dynamics of their weight normalization. This confirms the thesis that systematic interaction with digital prompts within a familiar communication environment is a determining factor in shaping health-preserving behavior.

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Purpose is to develop, scientifically substantiate, and statistically verify the effectiveness of an automated system for personalized monitoring and correction of higher education students' physical condition based on cloud low-code technologies integrated into the Google Workspace ecosystem.

Materials and methods. The experimental study was conducted at the Communal Institution of Higher Education “Kremenchuk Humanitarian and Technological Academy” within the framework of international scientific collaboration with the National University of Mar del Plata (Argentina). A total of 120 higher education students were randomly assigned to an experimental group (EG, $n = 60$) and a control group (CG, $n = 60$). The monitoring system was developed using Google Workspace and Google Apps Script. Statistical analysis was performed using jamovi 2.6.44 software with Pearson's chi-square test, the Wilcoxon signed-rank test, and Spearman's rank correlation coefficient.

Results. The personalized automated intervention significantly improved students' physical condition. A statistically significant reduction in BMI was observed in the experimental group (Wilcoxon $W = 4856$, $p < .001$, $r_s = 0.813$), whereas no meaningful changes were found in the control group. A strong positive correlation was identified between students' digital engagement and BMI reduction ($r_s = 0.744$, $p < .001$), confirming the effectiveness of systematic personalized digital support.

Conclusions. The developed cloud-based monitoring system proved to be an effective, scalable, and cost-efficient tool for supporting students' health-preserving behavior. The integration of Google Apps Script into the institutional digital environment enables continuous monitoring, automated personalized feedback, and optimization of teachers' workload without requiring additional software or server infrastructure.

Key words: digital interventions, body mass index (BMI), Google Apps Script, physical condition monitoring, higher education.

Здобуття вищої освіти в умовах сучасних академічних викликів часто супроводжується значним зниженням рухової активності студентської молоді, що актуалізує проблему пошуку нових інструментів здоров'язбереження/

Метою цієї роботи є розробка та статистична верифікація ефективності автоматизованої системи персоналізованого моніторингу та корекції фізичного стану здобувачів вищої освіти на основі інтеграції хмарних low-code інструментів в інституційну IT-інфраструктуру.

Матеріали та методи. Дослідно-експериментальна робота реалізована на базі Кременчуцької гуманітарно-технологічної академії. Загальний обсяг вибіркової сукупності становив 120 здобувачів вищої освіти, які були розподілені шляхом простої рандомізації на дві рівномірні групи: експериментальну (ЕГ, $n = 60$) та контрольну (КГ, $n = 60$). Методологічне обґрунтування дослідження та інтерпретація принципів цифрових здоров'язбережувальних інтервенцій здійснювалися в межах міжнародної наукової співпраці між закладами вищої освіти України та Аргентини. Цифрова архітектура моніторингу була побудована в екосистемі Google Workspace, що дозволило оптимізувати процес збору даних без залучення зовнішніх серверних потужностей. Ядром системи виступила зведена електронна таблиця з автоматизованим алгоритмом розрахунку індексу маси тіла (ІМТ) та категоризації профілів здоров'я. Процедура втручання базувалася на використанні Google Apps Script, що забезпечило автономну циклічну розсилку персоналізованих email-рекомендацій, сформованих відповідно до актуальних медико-біологічних протоколів ВООЗ (водний баланс, нутриціологічний профіль, рухова активність та гігієна сну). Корекція контенту повідомлень здійснювалася динамічно, зважаючи на індивідуальні антропометричні показники кожного студента та поточний тиждень програми. Для статистичного аналізу емпіричних даних використовувалося програмне середовище jamovi 2.6.44. З огляду на специфіку даних застосовано комплекс класичних непараметричних критеріїв: Т-критерій Вілкоксона для аналізу внутрішньогрупового зсуву антропометричних показників та ранговий коефіцієнт кореляції Спірмена для оцінки взаємозв'язку між рівнем цифрової залученості здобувачів (активністю опрацювання інтервенцій) та результативністю нормалізації маси тіла.

Результати. На старті експерименту за допомогою критерію χ^2 -Пірсона підтверджено вихідну однорідність груп. Протягом семестрового впровадження системи було зафіксовано статистично значуще зниження ІМТ в експериментальній групі, що підтверджено розрахунками за Т-критерієм Вілкоксона (Wilcoxon $W = 4856$, $p < .001$, $r_b = 0.813$). Спостерігалася виражена позитивна тенденція до переходу учасників із категорій «Надлишкова вага» та «Ожиріння» до категорії «Норма». Водночас антропометричні показники представників контрольної групи, які не отримували алгоритмізованої підтримки, залишилися відносно стабільними. Кореляційний аналіз продемонстрував наявність сильного прямого статистичного зв'язку між індексом цифрової залученості здобувачів та динамікою редукції ІМТ ($r_s = 0.744$; $p < .001$), що математично обґрунтовує високу ефективність систематичної взаємодії з цифровими підказками у звичному для студентів комунікаційному середовищі.

Висновки. Проведене дослідження доводить, що використання хмарних low-code інструментів (Google Apps Script) є дієвим та економічно доцільним рішенням для створення автономних здоров'язбережувальних екосистем у вищій школі. Розроблена архітектура дозволяє автоматизувати рутинні процеси моніторингу та персоналізованого супроводу студентів без створення додаткового адміністративного навантаження на науково-педагогічний склад. Модель демонструє високий рівень масштабованості та може бути інтегрована в загальну IT-інфраструктуру академії як базовий модуль постійного медико-педагогічного супроводу. Подальші дослідження спрямовано на розширення функціоналу системи шляхом інтеграції з персональними смарт-пристроями для переходу до концепції безперервного об'єктивного моніторингу здоров'я молоді.

Ключові слова: цифрові інтервенції, індекс маси тіла (ІМТ), Google Apps Script, моніторинг фізичного стану, вища освіта.

Conflict of interest: absent.

Конфлікт інтересів: відсутній.

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Дата першого надходження статті до видання: 06.07.2026

Дата прийняття статті до друку після рецензування: 31.08.2026

Дата публікації (оприлюднення) статті: 28.10.2026