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Dynamics of physical development and functional capacity in youth aged 17-20 under the influence of aerobics

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Abstract. This study aimed to identify the characteristics of changes in indicators of physical development and functional capacity in young people resulting from the implementation of a specially designed aerobic programme. The research was conducted at Hryhorii Skovoroda University in Pereiaslav (Kyiv Region) over a ten-week period (3 February – 13 April 2025) and involved 40 students aged 17-21 years. The experimental design included three stages of measurement, which enabled an assessment of the dynamics of morphological and functional indicators in students under the influence of a structured aerobic training programme. The findings demonstrated a reduction in body mass by 1.1 kg, body mass index by 0.5 kg/m², waist circumference by 1.8 cm, and body fat percentage by 1.5%, indicating a decrease in central adiposity and optimisation of the somatic profile. Indicators of cardiovascular regulation also improved: resting heart rate decreased by 4.8 beats per minute, systolic blood pressure by 3.9 mmHg, and diastolic blood pressure by 2.5 mmHg, while the rate of heart rate recovery increased by 5.1 beats per minute. The Ruffier-Dixon index decreased by 3.8 points, reflecting enhanced reactivity and recovery capacity. Measures of physical fitness showed positive dynamics: the distance covered in the six-minute run increased by 154 m, standing long jump performance improved by 8.2 cm, muscular endurance increased by 4.1 repetitions, and the time for the 4×9 m shuttle run improved by 0.58 s. The set of observed changes confirms the effectiveness of the aerobic programme as a means of enhancing the overall physical capacity of students. The obtained data may be applied by physical education instructors, fitness programme trainers, specialists in sports medicine, and organisers of health-promoting activities in higher education institutions to optimise training sessions and to develop effective programmes for improving the physical fitness of young people

Keywords: waist circumference; adipose tissue; cardiovascular system; heart rate; arterial blood pressure; Ruffier-Dixon index; recovery rate

Introduction

The level of physical activity among young people demonstrates a persistent downward trend, which creates preconditions for impaired physical development and the gradual limitation of the body's functional capacities. The period of early adulthood is characterised by substantial changes in the cardiovascular, respiratory, and muscular systems; therefore, an adequate volume of motor activity is a necessary condition for maintaining an optimal functional state. High prevalence of insufficient activity in youth contributes to a decline in aerobic performance, deterioration of

morphofunctional indicators, and an increased risk of metabolic disorders. The further progression of these trends is capable of persistently reducing the adaptive capacity of the organism and promoting the early development of chronic functional disorders.

The physical development of young people is determined by the interaction of body composition components, which shape the individual capacity of the organism to respond to aerobic loads. In the study by D. Mohajan & H. Mohajan (2023), it was established that long-term

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regular performance of aerobic exercise contributes to an increase in oxygen consumption, which serves as an integral indicator of cardiorespiratory endurance. The authors demonstrated that improvements in aerobic capacity are driven by adaptive changes in the cardiovascular and respiratory systems and depend on the systematic nature and duration of the training stimulus. The physical status of students as a multidimensional characteristic of the organism was examined in the study by O. Pryimakov *et al.* (2024), which analysed the relationships between indicators of physical condition and the biological age of students in the context of physical education. The researchers found that anthropometric parameters and the level of physical fitness show strong correlations with biological age, allowing these variables to be regarded as informative markers of the organism's adaptive potential and the effectiveness of physical load. In the sample analysed by M. Mendoza-Muñoz *et al.* (2020), a comprehensive assessment of adolescent body composition was conducted, and the influence of the ratio of muscle and fat tissue on physical fitness indicators was determined. The results showed that a higher proportion of fat mass is associated with a reduction in aerobic endurance, whereas a greater muscular component ensures higher work efficiency and a more favourable functional response to physical load. The study by M. Bouamra *et al.* (2022) was aimed at comparing the effectiveness of different training regimes among young people with obesity, assessing changes in body composition, strength, endurance, and components of physical fitness. The obtained data demonstrated that combined programmes (aerobic plus resistance training), in contrast to monotonous training modalities, ensure a more substantial increase in muscle mass, a reduction in the fat component, and a more pronounced improvement in overall morphofunctional status.

The functional capacity of young people reflects the ability of the cardiovascular and respiratory systems to supply the organism with oxygen during prolonged aerobic work. Cardiorespiratory fitness was examined in the study by A.O. Agbaje *et al.* (2021) in conjunction with body composition components and vascular function, in particular, endothelial reactivity, arterial elasticity, and vascular stiffness. The researchers established an association between higher levels of cardiorespiratory endurance, better indicators of vascular function, and lower cardiometabolic risk, which reflects the systemic nature of aerobic adaptation. The responses of the cardiovascular and ventilatory systems were evaluated in the research of F.R. Mendonça *et al.* (2022), which compared the effectiveness of combined aerobic-strength programmes in enhancing the cardiorespiratory resilience of adolescents. The results demonstrated the development of more efficient cardiac and respiratory function, manifested in a lower physiological cost of exercise during standardised tests. In the study conducted by A. Liu (2023), the dynamics of external respiratory function and endurance indicators in students were analysed in response to regular participation in aerobic training. The author demonstrated that adaptation of the respiratory system directly depends on the systematic nature of training stimuli and determines the increase in overall aerobic capacity. The regulatory mechanisms of cardiorespiratory responses were further clarified by A.C. D'Souza *et al.* (2023), who showed that hormonal and neurohumoral

factors modulate cardiovascular, respiratory, and metabolic responses to physical exercise, thereby ensuring the stability of functional systems under conditions of aerobic work.

Aerobic programmes in the student population provide a combination of cyclic loading and controlled intensity, creating favourable conditions for the development of positive changes in morphofunctional and psychophysiological indicators. Analysis of the results obtained by A. Chekhovska (2023) confirmed that systematic participation in aerobics leads to an increase in the overall physical fitness of students, particularly through improvements in endurance and motor coordination. It was also emphasised that regular training exposure promotes more stable adaptive responses during physical exertion. The psychophysiological aspects of the effects of aerobics were analysed in the study by N. Chuprun & I. Yurchenko (2020), in which dance-based programmes were applied to assess their effectiveness in restoring regulatory mechanisms and reducing emotional tension. The results confirmed that the impact of aerobic exercise extends beyond motor qualities to the psychoemotional state, ensuring an increase in the functional resilience of students.

Previous studies have not provided a comprehensive analysis of the dynamics of physical development and functional capacity of students in response to structured aerobic programmes. This study aimed to determine the specific features of changes in the morphofunctional indicators of students following the implementation of specially organised aerobics classes. To achieve the stated aim, the following objectives were defined: to record the baseline level of physical development and functional status; to trace the dynamics of the indicators under the influence of the aerobic programme; and to characterise the relationships between morphological and functional parameters.

Materials and Methods

Research setting and sample characteristics

The study involved 40 full-time first- to third-year students of Hryhorii Skovoroda University in Pereiaslav, which served as the base for the experimental research. The mean age of the participants was 19.2 ± 1.1 years, with an age range from 17 to 21 years. This reflected the specific characteristics of the student population and, at the same time, imposed certain limitations on the generalisation of the obtained results to other age categories and social groups beyond the university environment. The gender composition of the sample was uneven: 28 females (70%) and 12 males (30%) participated in the study, which corresponded to the actual structure of physical education groups. For this reason, the results were analysed without division by sex. The experimental phase of the research lasted ten weeks (from 3 February to 13 April 2025) and included the active implementation of the aerobic training programme. During the subsequent two weeks (14-27 April 2025), generalisation, statistical processing, and analytical interpretation of the experimental results were carried out.

The formation of the sample was based on voluntary participation, taking into account predefined inclusion criteria (belonging to the main medical group; absence of acute diseases and decompensated chronic pathologies of the cardiovascular, respiratory, and musculoskeletal systems; regular attendance of physical education classes;

absence of systematic training outside the educational process) and exclusion criteria (the presence of medical contraindications to aerobic exercise; episodes of loss of consciousness or pre-syncope during the previous year; medical recommendations to limit physical activity). During the experiment, three participants withdrew from the study: one due to irregular attendance at training sessions and two due to temporary illnesses. These individuals were not included in the final sample size, and the data obtained from them were not considered in the subsequent analysis of results. The study complied with the guidelines of the European Commission (2021) and was approved by the local ethics committee of the Department of Physical Education of Hryhorii Skovoroda University in Pereiaslav (Protocol No. 1/2025-E dated 31 January 2025). All participants provided written informed consent to participate.

Prior to the start of the experiment, health status screening using a selfassessment questionnaire was conducted among 64 individuals. Based on the screening results and in accordance with the inclusion and exclusion criteria, a proportion of potential participants was excluded from further participation in the study. The questionnaire was developed by the author and consisted of seven questions. It was used as a screening tool to assess the safety of students' participation in the study without quantitative scoring of the results. The questions addressed general well-being, the presence of chronic diseases, possible complaints related to the cardiovascular system, episodes of loss of consciousness, subjective assessment of endurance, the level of additional physical activity, and the presence of medical recommendations to limit physical loads. Responses were provided using a five-point rating scale, "yes/no" options, and gradations of frequency or activity level. In particular, the questionnaire included questions such as: "How do you assess your overall health status?", "Do you have any chronic diseases that may limit physical activity?", and "Do you have any medical recommendations to restrict your level of physical activity?"

Characteristics of the developed training programme

The aerobic training programme was conducted three times per week in the afternoon (approximately from 16:00 to 17:30) under the supervision of a lecturer from the Department of Physical Education, with the participation of the researcher who provided methodological support and monitored compliance of the load with the planned regime. The duration of one session averaged 60-75 minutes (up to 80 minutes at certain stages), and the programme was implemented over a ten-week active phase, which ensured conditions for the development of stable adaptive changes. The preparatory part lasted 10-12 minutes and was aimed at the gradual activation of the cardiovascular and muscular systems. It included light jogging or rhythmic walking (2-3 minutes), a set of joint mobilisation exercises for the cervical, shoulder, elbow, hip, knee, and ankle joints (8-10 repetitions for each movement), as well as dynamic exercises aimed at mobility and stretching. Cones and markers were used to organise movement patterns and spatial orientation, which made it possible to vary movement trajectories and execution tempo.

The main part of the session lasted 40-55 minutes and provided the primary training effect. At the initial stages

of the programme, continuous aerobic loads of moderate intensity predominated, including jogging, sequences of aerobic steps, and simple dance combinations accompanied by music. In parallel, bodyweight exercises were performed, such as squats, lunges, jumps, and elements of skipping, which were carried out in sets or in a time-based format (20-40 seconds of work). During this phase, skipping ropes, cones, and exercise mats were actively used. As students adapted to the training load, the structure of the main part was progressively intensified through the inclusion of interval and circuit training formats. Variable running pace was applied, along with interval sets alternating between phases of active work and recovery, as well as circuit complexes consisting of 5-6 exercises (squats, lunges, star jumps, hops, skipping rope exercises, and plank holds). Each exercise was performed for 40-60 seconds with short transition pauses, and a total of 2-3 circuits were completed. Hoops, cones, skipping ropes, and gym mats were used to organise the circuit training. At the final stages of the programme, the main part could take the form of a prolonged continuous aerobic block lasting 35-45 minutes or be combined with an extended circuit training session with variations in work modes. This approach made it possible to increase the overall training volume without a sharp rise in intensity and ensured the development of general aerobic endurance and muscular endurance. The concluding part of the session lasted 8-10 minutes and was aimed at the gradual reduction of functional strain. It included breathing exercises, elements of active relaxation, and static stretching of the main muscle groups, with each position held for 15-20 seconds. Gym mats were used to perform these exercises.

Methods for assessing the morphofunctional status of students

The level of physical development was determined by recording a set of body structure indicators obtained using anthropometric and somatometric methods that characterised the morphological state of the organism. Body height and body mass, waist and hip circumferences, as well as approximate body composition, were measured. Body height was measured using a stationary stadiometer SECA 213 (Germany), and body mass was assessed using Tanita HD-380 electronic scales (Japan) with an accuracy of 0.1 kg. Based on the obtained data, body mass index (BMI) was calculated according to the standard formula:

$$BMI = \frac{m}{h^2}, \quad (1)$$

where m – body mass (kg); h – body height (m); BMI – body mass index (kg/m^2). In addition, indicators of central fat deposition (waist and hip circumferences) were recorded using a Gulik Tape measuring tape (USA) in accordance with the standard protocol: waist circumference was measured at the midpoint between the lower margin of the costal arch and the iliac crest, and hip circumference was measured at the level of the greatest gluteal protrusion. For an approximate assessment of body composition, a domestic bioimpedance analyser OMRON BF511 (Japan) was used, which measured the percentage of body fat, skeletal muscle mass, and phase angle. All anthropometric measurements were conducted by a lecturer from the

Department of Physical Education and the researcher, both of whom had received instruction to standardise measurement techniques.

Testing was performed in the morning (10:00-12:00), prior to training sessions, with participants wearing light sports clothing and no shoes. To improve accuracy, each measurement was recorded twice, and the mean value was calculated; if the difference exceeded 1%, a third control measurement was taken. Baseline testing was conducted before the start of the aerobic programme, and follow-up testing was carried out after the completion of the ten-week training cycle. No intermediate measurement was performed at week five, as morphological indicators change slowly and require a longer period to detect reliable differences. Measurement results were recorded in standardised observation protocols, which included the date of testing, testing conditions, recorded values, and the signature of the person conducting the measurements. Data from the bioimpedance analyser were additionally stored in digital format for subsequent statistical processing.

Functional capacity of the participants was assessed using a battery of tests evaluating aerobic performance, speed-strength and coordination abilities, as well as regulatory responses of the cardiovascular system (CVS). All measurements were conducted in the university sports hall at a fixed time of day (10:00-12:00) under the supervision of a lecturer from the Department of Physical Education and the researcher, who were responsible for organising the tests and ensuring technical control. Resting heart rate (HR), the Ruffier-Dixon index, and blood pressure (BP) were recorded by the university nurse following standard clinical protocols (Muntner *et al.*, 2019; American College of Sports Medicine, 2021).

Aerobic endurance was assessed using the six-minute run test, during which students covered the maximum possible distance over six minutes on a marked circuit. Results were recorded in metres using a CASIO HS-80TW stopwatch (Japan). The test was administered three times: before the start of the programme, after week five, and after week ten. Speed-strength capacity of the lower limbs was evaluated using the standing long jump. Two attempts were performed, and the best result was recorded using a Stanley PowerLock 5 m tape measure (USA). Muscular endurance was assessed by counting the number of correctly performed repetitions (squats or sit-ups) within 30 seconds, with technique monitored via video recording using a Sony HDR-CX405 digital camera (Sony Corporation, Japan). Coordination abilities were evaluated using the 4x9 m shuttle run, with times recorded to 0.1 s using the same stopwatch.

For a more detailed assessment of CVS function, resting HR and blood pressure were measured. Resting, exercise, and recovery heart rates were recorded using a Polar H10 chest heart-rate monitor (Polar Electro Oy, Finland), synchronised with a Polar Vantage M2 watch (Finland), which provided real-time display and recording of data. Maximum HR was calculated using the formula:

$$HR_{max} = 220 - age, \quad (2)$$

where HR_{max} – the estimated maximum heart rate (beats per minute, bpm); age – the participant's age in full years.

This allowed the determination of the target training zone within 60-75% of HR_{max} :

$$HR_{target} = HR_{max} \times 0.6 - 0.75, \quad (3)$$

where HR_{target} – the target heart rate (bpm) corresponding to the aerobic training zone; HR_{max} – the maximum allowable heart rate; 0.6-0.75 – the intensity range required to ensure predominantly aerobic energy supply. Heart rate recovery after one minute (HRR1) was used as an indicator of cardiovascular functional status and the efficiency of parasympathetic regulation following exercise. A greater reduction in HR during the first minute of rest reflects higher aerobic capacity and the body's ability to recover rapidly. HRR1 was calculated using the formula:

$$HRR1 = HR_{post} - HR_{1min}, \quad (4)$$

where HR_{post} – the heart rate immediately after exercise (bpm); HR_{1min} – the heart rate after one minute of rest (bpm). Blood pressure was measured using an automatic sphygmomanometer, OMRON M3 (Japan), after a five-minute rest, followed by the calculation of pulse pressure:

$$PP = BP_{syst} - BP_{diast}, \quad (5)$$

where BP_{syst} – the systolic blood pressure, representing the maximum pressure in the arteries during heart contraction (mmHg); BP_{diast} – the diastolic blood pressure, reflecting the minimum pressure during myocardial relaxation (mmHg); PP – the pulse pressure, the difference between systolic and diastolic pressures (mmHg). CVS function was also assessed using the Ruffier-Dixon index, which involved recording HR at rest, during the first 15 seconds after performing 30 squats in 45 seconds, and after one minute of recovery. The integral index was calculated as:

$$IR = \frac{(P_1 + P_2 + P_3) - 200}{10}, \quad (6)$$

where P_1 – the resting HR (bpm); P_2 – the HR during the first 15 seconds after exercise (bpm); P_3 – the HR during the first 15 seconds of the third minute of recovery (bpm). All functional tests were performed at three observation points: before the start of the programme, at week five, and at week ten. During the training process, exercise intensity was additionally monitored using a Polar Vantage M2 sports watch (Finland), which allowed HR to be maintained within the target aerobic zone and prevented exceeding the optimal load. Results were recorded in standardised protocols signed by the responsible personnel, and data from the heartrate monitor were stored digitally for subsequent statistical analysis.

Assessment standards and statistical processing of results

The interpretation of results was carried out in accordance with international standards for young adults aged 17-21 years, as recommended by the World Health Organization (2020) and the American College of Sports Medicine (2021), as well as physiological studies on heart rate and recovery speed (Vicente-Campos *et al.*, 2014; Hart, 2015; Fryar *et al.*, 2021). BMI values of

18.5-24.9 kg/m², waist circumference <94 cm in men and <80 cm in women, and waist-to-hip ratio (WHR) of 0.80-0.90 in men and 0.70-0.80 in women were considered normal, corresponding to a low risk of abdominal obesity (World Health Organization, 2020; Fryar *et al.*, 2021). Physiologically normal body fat content was defined as 10-20% in men and 18-28% in women (American College of Sports Medicine, 2021).

Functional standards stipulated that a resting heart rate of 60-80 bpm in men and 60-85 bpm in women corresponded to normal autonomic regulation (Hart, 2015). Blood pressure within the range 105-125/65-80 mmHg and pulse pressure of 35-50 mmHg were interpreted as indicators of physiological norm for young adults (World Health Organization, 2020). An HRR1 value of 15-24 bpm indicated normal recovery, whereas values above 25 bpm reflected a high level of physical fitness (Vicente-Campos *et al.*, 2014). The Ruffier-Dixon index within the range of 0-10 points was interpreted as indicating good or excellent functional status (American College of Sports Medicine, 2021). Assessment of physical fitness was based on generalised predictive norms for young adults: covering 1,100-1,400 m (men) and 900-1,200 m (women) in the six-minute run corresponded to an average or above-average level of aerobic endurance; standing long jump distances of 190-220 cm (men) and 150-180 cm (women) reflected an appropriate level of speed-strength capacity; completing 18-25 repetitions (men) and 15-22 repetitions (women) in 30 seconds indicated normal muscular endurance; and completing the 4x9 m shuttle run in 9.5-10.5 s (men) and 10.5-11.8 s (women) corresponded to age-appropriate coordination abilities (American College of Sports Medicine, 2021;

Fryar *et al.*, 2021).

Statistical analysis was performed using IBM SPSS Statistics 26.0 software (IBM Corp., USA). Normality of distribution was assessed using the Shapiro-Wilk test. Changes in anthropometric indicators at two time points were analysed using a paired Student's t-test or the Wilcoxon signed-rank test (for non-normal distributions). Functional parameters were evaluated using repeated measures analysis of variance (Repeated Measures ANOVA) or the Friedman test, depending on the distribution characteristics. Correlations between changes in morphological and functional parameters were determined using Spearman's rank correlation coefficient. Data are presented as $M \pm SD$, where M is the mean and SD the standard deviation; statistical significance was set at $p < 0.05$.

Results

Features of morphological adaptation in students to systematic aerobic training

Analysis of morphological changes following a ten-week aerobic programme revealed systematic positive adaptations in students' physical development. These were manifested in reductions in body mass and BMI, decreased abdominal fat accumulation, lower waist circumference and waist-to-hip ratio, and a reduction in body fat percentage. The most pronounced adaptive changes were observed in central fat indicators, reflecting the development of a favourable morphological profile under the influence of regular aerobic exercise. The overall pattern of morphological changes is illustrated in Figure 1, which presents mean values before and after the ten-week programme (BMI was calculated using formula (1)).

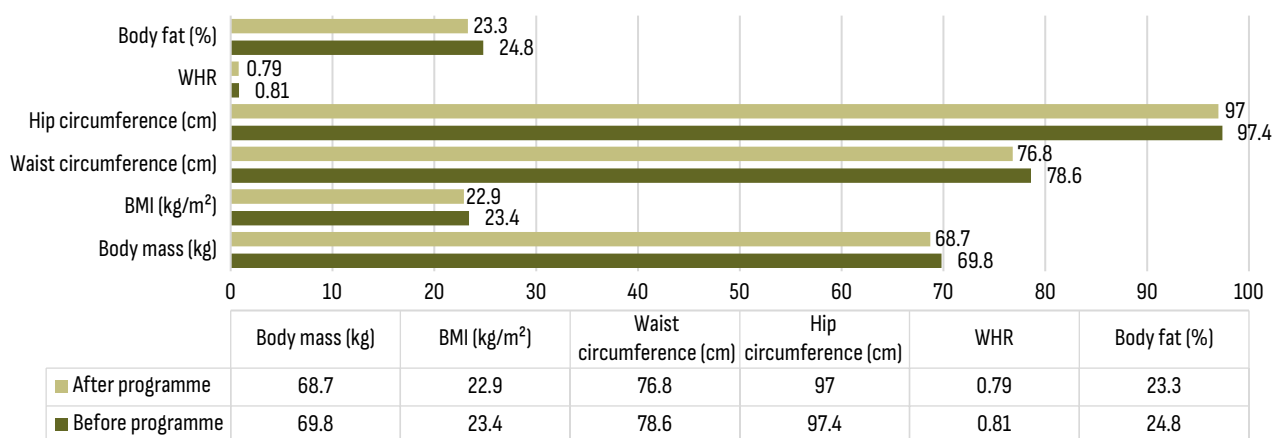


Figure 1. Dynamics of morphological indicators before and after the experiment

Source: created by the authors

The dynamics of morphological indicators after the ten-week programme demonstrated the development of coherent positive changes in the structure of students' physical development. The baseline profile of the sample was characterised by normal values for body mass (69.8 ± 7.4 kg), BMI (23.4 ± 2.1 kg/m²), and waist circumference (78.6 ± 5.8 cm), indicating that the majority of participants did not have excess body weight. This allows the observed changes to be interpreted as adaptive rather than corrective in nature. Following the completion of the

programme, body mass decreased to 68.7 ± 7.2 kg, and BMI fell to 22.9 ± 2.0 kg/m². Although these absolute changes were modest, they are physiologically consistent with moderate-intensity aerobic training, where fat substrates are primarily utilised while muscle mass is preserved. A reduction in body mass of 1.1 kg and a proportional decrease in BMI of 0.5 kg/m² align with the expected rate of fat loss in young adults of this age, without risking the loss of lean tissue.

The most pronounced changes were observed in indicators reflecting central adiposity. Waist circumference

decreased from 78.6 ± 5.8 to 76.8 ± 5.5 cm, a mean reduction of 1.8 cm. This change is clinically significant, as abdominal fat exhibits the highest metabolic activity and responds most readily to aerobic exercise. Despite the relatively short intervention period, a near 2 cm reduction in waist circumference indicates activation of lipolytic processes, increased fatty acid oxidation, and improved energy balance. By contrast, hip circumference remained largely stable (97.4 ± 6.2 cm to 97.0 ± 6.1 cm), consistent with typical patterns of morphological adaptation: gluteofemoral fat is more resistant to catabolic processes and changes more slowly than abdominal fat (Snijder *et al.*, 2003).

The waist-to-hip ratio, an integral marker of cardiometabolic risk, showed a statistically significant decrease from 0.81 ± 0.04 to 0.79 ± 0.04 . This improvement resulted from a greater reduction in waist circumference compared with the hips and indicates a shift in body composition towards lower central fat accumulation. While a WHR decrease of 0.02 units may appear minor in absolute terms, for a young adult sample, it represents a moderate but consistent optimisation of body proportions. Changes were also observed in body fat percentage, as measured by bioelectrical impedance analysis. At the start of the programme, the mean value was $24.8\% \pm 4.3\%$, decreasing to $23.3\% \pm 4.1\%$ by the end. A reduction of 1.5% is considered optimal for a ten-week, moderate-intensity programme (60-75 minutes, three times per week), reflecting enhanced oxidative metabolism and an increased contribution of fat substrates to energy expenditure. Standard deviation remained largely unchanged ($4.3 \rightarrow 4.1$), indicating a uniform response to training across the sample without marked individual variability.

Overall analysis of morphological dynamics revealed that waist circumference, WHR, and the fat component were the most responsive indicators to aerobic exercise. These measures capture the early phase of morphological remodelling, characterised by a reduction in central adiposity while preserving muscle mass and maintaining stability in peripheral anthropometric regions. In contrast, body mass and BMI exhibited only modest changes, which is typical for individuals with normal baseline characteristics and confirms that the programme intensity was appropriate without risk of inducing weight deficit. In summary, the ten-week aerobic programme produced a scientifically significant improvement in the morphological status of students, primarily through reductions in central adiposity. This pattern of adaptive changes has preventive significance, as the reduction of abdominal fat is directly associated with a lower cardiometabolic risk and the development of a more favourable somatic profile in young adults.

Changes in cardiovascular functional indicators

The results demonstrated a consistent positive trend across all major functional markers of the cardiovascular system, which was already apparent by the mid-point of the training cycle and became statistically and physiologically significant by the end of the programme. Comparison across the three observation points allowed the characterisation of adaptive changes induced by regular aerobic exercise performed within the target zone of 60-75% of HR_{max} . Final values of the indicators are presented in Table 1. Pulse pressure was calculated using formula 5), HRR1 using formula (4), and the Ruffier-Dixon index using formula (6).

Table 1. Cardiovascular system indicators at three observation points ($M \pm SD$)

Indicator	Before programme	5 th week	After programme
Resting HR (bpm)	74.2 ± 6.8	71.1 ± 6.2	69.4 ± 5.9
BP _{syst} (mmHg)	118.2 ± 8.4	116.5 ± 7.9	114.3 ± 7.5
BP _{diast} (mmHg)	74.1 ± 6.1	73.0 ± 5.8	71.6 ± 5.5
Pulse pressure (mmHg)	44.1 ± 4.7	43.5 ± 4.5	42.7 ± 4.3
HRR1, bpm	17.3 ± 3.6	19.8 ± 3.9	22.4 ± 4.1
Ruffier-Dixon index (points)	12.4 ± 3.1	10.2 ± 2.9	8.6 ± 2.7

Source: created by the authors

Resting heart rate demonstrated a gradual decline throughout the observation period. From a baseline of 74.2 ± 6.8 bpm, it decreased to 71.1 ± 6.2 bpm by the fifth week (-3.1 bpm) and to 69.4 ± 5.9 bpm at the end of the programme (-4.8 bpm relative to baseline). This reduction of approximately 6.5% indicates more efficient cardiac function, enhanced vagal control, and reduced sympathetic influence – a characteristic sign of improved aerobic fitness. The rate of decline in resting HR is physiologically appropriate for young adults with normal baseline health status. Blood pressure changes were more gradual but similarly directed. Systolic pressure decreased by 1.7 mmHg by the fifth week and by a total of 3.9 mmHg at the programme's conclusion. Diastolic pressure fell by 1.1 mmHg and 2.5 mmHg, respectively. Such changes, within a 2-4% range, can be interpreted as improvements in arterial tone and reduced peripheral resistance. Importantly, these reductions remained within age-appropriate norms, confirming the safety of the training intervention. Pulse

pressure decreased from 44.1 ± 4.7 to 42.7 ± 4.3 mmHg (-1.4 mmHg), indicating enhanced arterial wall elasticity. Since PP is a sensitive indicator of vascular stiffness, its reduction further supports an improvement in the haemodynamic profile.

The most pronounced adaptation was observed in HRR1 – the heart rate recovery during the first minute after exercise. HRR1 increased from 17.3 ± 3.6 to 19.8 ± 3.9 bpm ($+2.5$ bpm) by the fifth week and to 22.4 ± 4.1 bpm at the final stage ($+5.1$ bpm relative to baseline, an increase of 29.5%), providing clear evidence of the programme's effectiveness. This change reflects enhanced parasympathetic responsiveness, increased heart rate variability, and accelerated early-phase recovery – key markers of good aerobic fitness. The Ruffier-Dickson index demonstrated an equally significant positive trend. The baseline value was 12.4 ± 3.1 points. By the fifth week, it had decreased to 10.2 ± 2.9 points, a reduction of 2.2 points, or 17.7% of the initial level. By the end of the programme, the index had fallen to

8.6 ± 2.7 points (-3.8 points relative to baseline), representing a 30.6% reduction. This magnitude of change indicates improved cardiac functional response to standardised load, faster recovery processes, and more efficient cardiac function. Post-intervention values below 10 points correspond to a transition to the “good” functional category.

A comprehensive analysis of the data demonstrates that cardiovascular adaptations began by the programme's midpoint and had become systemic and stable by its conclusion. The most sensitive markers were HRR1, resting HR, and the Ruffier-Dickson index – parameters that directly reflect autonomic regulation, recovery efficiency, and aerobic conditioning. Slightly less pronounced, but stable, changes in BP and pulse pressure indicate a gradual improvement in vascular tone and overall haemodynamics. No pathological fluctuations or adverse reactions were recorded at any point, demonstrating the physiological appropriateness and safety of the programme. In summary, the ten-week aerobic intervention produced comprehensive improvements in the regulatory, haemodynamic, and recovery characteristics of the students' cardiovascular system. The observed changes indicate enhanced aerobic

capacity, more efficient cardiac function, and strengthened autonomic control. These outcomes have both health-promoting and preventive significance for young people aged 17-21 and confirm the high effectiveness of the proposed programme.

Impact of the aerobic programme on physical fitness and endurance

The analysis of physical fitness indicators at three observation points demonstrated a clear positive trend in adaptive changes resulting from the ten-week aerobic programme. Interim results at the fifth week already showed statistically significant progress in aerobic endurance, speed-strength abilities, muscular endurance, and coordination skills, which continued to develop by the end of the programme. Endurance assessment was conducted within the target training zone, calculated using formulas for maximum heart rate (formula (2)) and training heart rate (formula (3)), providing objective confirmation that the exercise intensity was appropriate. The final and interim results of the physical tests are presented in Table 2, summarising the key transformations in the students' physical fitness profile.

Table 2. Physical fitness indicators at three observation points ($M \pm SD$)

Indicator	Before programme	5 th week	After programme
Six-minute run, m	1,162 ± 118	1,234 ± 121	1,316 ± 127
Standing long jump, cm	183.4 ± 16.7	187.2 ± 17.3	191.6 ± 18.1
Muscular endurance (repetitions per 30 s)	21.3 ± 3.9	23.1 ± 4.0	25.4 ± 4.2
Shuttle run 4×9 m, s	10.86 ± 0.61	10.52 ± 0.57	10.28 ± 0.54

Source: created by the authors

Analysis of the data in Table 2 indicates that the most pronounced changes were observed in tests reflecting aerobic performance and overall physical fitness. In the six-minute run, the baseline distance was 1,162 ± 118 m. By the fifth week, this increased to 1,234 ± 121 m, demonstrating an early response of the aerobic system even to moderate training loads. After ten weeks, students achieved 1,316 ± 127 m, representing an improvement of 154 m from baseline. This progression reflects increases in stroke volume, mitochondrial density in muscle cells, improved efficiency of peripheral oxygen utilisation, and a reduction in the energy cost of submaximal exercise. Considering that the training sessions were conducted within the target aerobic HR zone, these results indicate that the exercise intensity was sufficient to induce aerobic adaptations and stimulate endurance development.

The standing long jump reflects the speed-strength capacity of the lower limbs, which is traditionally less responsive to aerobic interventions. Nevertheless, the data show a steady increase from 183.4 ± 16.7 cm to 191.6 ± 18.1 cm. The increase of approximately 8 cm can be attributed to the indirect effects of aerobic exercise on the functional state of the lower-limb muscles: regular cyclic movements enhance intermuscular coordination, improve muscular endurance, and optimise motor unit recruitment. The progression in the standing long jump is fully consistent with mechanisms of moderate strength adaptation, which accompany prolonged cyclic activity through increased elasticity of muscle-connective tissue structures and refinement of the technical execution of the movement.

In the muscular endurance test, which measured the number of correctly performed repetitions in 30 seconds, results gradually increased from 21.3 ± 3.9 to 25.4 ± 4.2 repetitions. This improvement indicates enhanced local endurance of the primary muscle groups of the trunk and lower limbs. It is well established that aerobic exercises enhance tissue buffering capacity, facilitate more efficient oxygen utilisation by muscles, and raise the fatigue threshold (McArdle *et al.*, 2015). Therefore, changes observed in this test reflect not only an overall improvement in functional resilience but also a systemic reorganisation of energy supply mechanisms towards greater reliance on oxidative processes, even during short-duration strength activities.

The indicator of speed and coordination, assessed using the 4×9 m shuttle run, also showed positive progression. The reduction in completion time from 10.86 ± 0.61 s to 10.28 ± 0.54 s indicates improvements in neuromuscular coordination, acceleration and deceleration capacity, and optimisation of movement skills during frequent changes of direction. Although this test is not directly aerobic, the overall increase in fitness and the reduction in recovery time (as confirmed by the HRR1 dynamics in the previous section) contributed to more efficient performance of the exercise.

In summary, the results indicate that the ten-week aerobic programme produced systemic improvements in the students' physical fitness. The most pronounced gains were observed in aerobic endurance, reflected in a substantial increase in the distance achieved during the six-minute run. Concurrently, the gradual improvements in standing long jump, muscular endurance, and speed-coordination

abilities demonstrate the comprehensive nature of the adaptive processes. These changes reflect enhanced oxygen utilisation, strengthening of the functional base of the musculoskeletal system, and improved neuromuscular regulation, collectively confirming the high efficacy of the programme in developing overall physical capacity and functional resilience in young adults.

Correlation analysis of morphological and functional changes

Correlation analysis revealed systematic relationships between morphological changes and functional cardiovascular adaptations induced by the ten-week aerobic training. The findings confirmed that reductions in body fat and optimisation of somatometric proportions have a direct physiological translation into improvements in endurance, recovery, and cardiac efficiency. These results are characteristic of training adaptation processes and allow the effectiveness of the programme to be evaluated not only by the end-point changes but also by the patterns of internal interrelationships. One of the strongest relationships identified in the study was the correlation between reductions in body fat and improvements in HRR1, which reached $r = -0.62$ ($p < 0.01$). The negative direction of the correlation indicates that the greater the decrease in body fat percentage, the larger the increase in HRR1. This aligns with evidence that reduction of the fat component decreases metabolic stress and improves heart rate variability (Brunetto *et al.*, 2008). Students exhibiting the most pronounced reductions in body fat (-1.5% to -1.8%) achieved HRR1 values of 23-24 bpm at the end of the programme, substantially higher than the group mean (22.4 ± 4.1 bpm). This relationship demonstrates that changes in the morphological profile have a direct impact on the autonomic regulation of cardiac function. Fat loss enhances baroreceptor sensitivity and accelerates parasympathetic recovery after exercise, explaining the observed increase in HRR1 (Brunetto *et al.*, 2008).

A similarly notable relationship was observed between reductions in waist circumference and increases in six-minute run distance ($r = -0.58$; $p < 0.01$). A decrease in waist circumference of 1.5-2.5 cm was accompanied by an increase in distance of 140-180 m, whereas students with less pronounced morphological changes showed gains of only 90-110 m. This relationship has a clear physiological basis: reduction of central adiposity lowers intra-abdominal pressure, improves diaphragmatic mobility, and reduces resistance during respiratory movements (Sonpeayung *et al.*, 2020). Reduction of abdominal adipose tissue simultaneously contributes to a decrease in peripheral vascular resistance and an improvement in muscle perfusion through restoration of endothelial function (Aronow, 2017). In practical sports terms, this means that changes in somatic profile alone can serve as a predictor of enhanced aerobic capacity, even when training volume remains constant.

A strong inverse correlation was observed between the Ruffier-Dickson index and six-minute run performance ($r = -0.66$; $p < 0.001$). This indicates that reductions in the index were closely associated with improvements in running distance. Students whose index decreased by more than 3 points increased their run distance by 150 m or more. Since the Ruffier-Dickson index integrates the heart's

response to exercise and the speed of recovery, improvement in this measure reflects an increase in stroke volume, economisation of cardiac activity, and enhanced aerobic capacity. Accordingly, the Ruffier-Dickson index proved to be a sensitive marker of training adaptation, capable of signalling functional progress even before changes in body mass or circumferences became evident.

A moderate but statistically significant correlation was identified between BMI and muscular endurance ($r = -0.41$; $p < 0.05$). Students who reduced their BMI by 0.3-0.6 kg/m² exhibited greater increases in repetitions during the 30-second test (up to +5-7 repetitions). Physiologically, this can be attributed to a reduction in mechanical load on the musculoskeletal system and an improvement in the muscles' functional capacity to perform cyclic local efforts under conditions of reduced metabolic stress. This confirms that even a modest optimisation of body mass and height parameters can enhance overall physical capacity.

A cumulative analysis demonstrated that the strongest correlations were observed in measures sensitive to central adiposity – waist circumference, fat mass, and WHR. This underscores a fundamental principle of exercise physiology: central obesity is a key modifier of functional status and determines cardiovascular efficiency during aerobic exercise. The identified correlations indicate that morphological changes do not merely accompany training adaptations but actively shape them. Reduction of fat mass, particularly abdominal fat, is a determinant of increased endurance and accelerated recovery responses. In summary, the correlational analysis confirmed that the ten-week aerobic programme elicited coordinated improvements in both morphological and functional characteristics, with HRR1, the Ruffier-Dickson index, and six-minute run performance serving as the primary integrative markers of effectiveness. These relationships highlight the practical significance of optimising body composition as a prerequisite for enhancing aerobic performance and functional resilience in university students.

Discussion

The results demonstrate that the ten-week aerobic programme produced comprehensive positive changes in students' morphological and functional indicators. Moderate reductions were observed in body mass, BMI, waist circumference, and fat component, while peripheral anthropometric zones remained stable, indicating an early phase of central fat reduction. Cardiovascular parameters also improved: resting HR and blood pressure decreased, while HRR1 and the Ruffier-Dickson index reflected accelerated recovery processes. Simultaneously, aerobic endurance, muscular endurance, and coordination improved, confirming the systemic training effect of the programme.

Changes in morphological indicators following the ten-week programme were moderate but statistically significant: body mass decreased from 69.8 ± 7.4 to 68.7 ± 7.2 kg, BMI from 23.4 ± 2.1 to 22.9 ± 2.0 kg/m², waist circumference from 78.6 ± 5.8 to 76.8 ± 5.5 cm, and body fat percentage from $24.8\% \pm 4.3\%$ to $23.3\% \pm 4.1\%$. This pattern of morphological change is consistent with the findings of C. Lan *et al.* (2022), who reported that regular aerobic programmes in a student cohort contributed to reductions in body mass, BMI, and fat component,

particularly in measures of central adiposity. The authors highlighted that waist circumference is a sensitive marker of adaptation to systematic aerobic training, aligning with the dynamics observed in the present study. These trends also correspond with the conclusions of M.B. Batista *et al.* (2020), which indicated that body mass status and the degree of biological maturation determine aerobic capacity in young males. The authors found that BMI reduction is a typical response to moderate-intensity training in young individuals with an established somatic profile, reflecting the BMI dynamics observed in the 17-21-year-old cohort of the current study.

Similar findings have been reported by B.S. Chauhan & S. Kumar (2023), who evaluated the effects of regular aerobic exercise on the morphological characteristics of undergraduate students and found that systematic training produced a moderate reduction in body mass and BMI within the young adult cohort. These results are further corroborated by Y. Soyulu *et al.* (2023), who examined the effectiveness of two self-regulated aerobic training regimes in physically active young adults. Their study demonstrated that both regimes led to moderate decreases in body mass and fat tissue, consistent with the magnitude of morphological changes observed following the ten-week programme in the student cohort. By contrast, the changes observed in the present study were less pronounced than those reported by D. Djordjevic *et al.* (2021), who investigated the effects of aerobic exercise on body composition in children and adolescents. That study documented greater reductions in fat mass and faster morphological adaptation. The partial discrepancy can be attributed to age-related differences, as younger individuals exhibit greater metabolic plasticity and a more rapid response of adipose tissue to cyclical exercise.

The indicators of the cardiovascular system demonstrated a distinct positive trajectory: resting heart rate decreased from 74.2 ± 6.8 to 69.4 ± 5.9 bpm, systolic arterial pressure from 118.2 ± 8.4 to 114.3 ± 7.5 mmHg, and diastolic pressure from 74.1 ± 6.1 to 71.6 ± 5.5 mmHg. Notably, the HRR1 metric increased from 17.3 ± 3.6 to 22.4 ± 4.1 bpm. The Ruffier-Dixon index decreased from 12.4 ± 3.1 to 8.6 ± 2.7 points, indicating an improved cardiac response to standardised exercise. The observed changes in resting HR, HRR1, and the Ruffier-Dixon index align with the findings of J.M. Thomas *et al.* (2022), who highlighted the utility of HRR as a marker of cardiorespiratory fitness and the efficiency of autonomic cardiovascular regulation in young adults. The consistency in adaptive trends suggests that systematic moderate-intensity aerobic exercise enhances parasympathetic control of cardiac activity and optimises recovery processes following physical exertion. Similar patterns were reported by N. Armstrong & J. Welsman (2020), where regular cyclic exercise in young adults led to a gradual reduction in resting HR and improved cardiac reactivity to physical load. The agreement between these studies indicates that even relatively short interventions can initiate the early phase of cardiorespiratory adaptation.

The dynamics of HRR1 corresponded with trends observed by G. NavarroLomas *et al.* (2022), in which various training modalities in young adults increased heart rate variability and accelerated parasympathetic recovery. This similarity underscores the role of aerobic training in

establishing a more economical and controlled heart rhythm. Improvements in the Ruffier-Dixon index are also consistent with the conclusions of H.C.D. Souza *et al.* (2021), who demonstrated that enhanced cardiorespiratory fitness in young adults is accompanied by strengthened autonomic regulation and more efficient recovery following standardised exercise. The results partially align with those reported by R. Sloan *et al.* (2021), who observed more pronounced improvements in haemodynamic parameters and responses to orthostatic and psychological stimuli following aerobic training. The smaller magnitude of adaptive changes in the present study is likely due to the shorter programme duration and differences in the participants' baseline functional status.

The findings demonstrated a gradual enhancement of students' physical fitness over the ten-week aerobic programme: the six-minute run distance increased from $1,162 \pm 118$ m to $1,316 \pm 127$ m; the standing long jump improved from 183.4 ± 16.7 cm to 191.6 ± 18.1 cm; muscular endurance rose from 21.3 ± 3.9 to 25.4 ± 4.2 repetitions; and the 4×9 m shuttle run time decreased from 10.86 ± 0.61 s to 10.28 ± 0.54 s, indicating gains in endurance, strength, and coordination. Similar patterns were reported by C. Lourenço *et al.* (2025), who identified a relationship between weekly physical activity volume and students' fitness indicators, particularly endurance and strength. Comparable trends were also noted by M. Saputra *et al.* (2024), where comparisons of different forms of aerobic activity revealed improvements in overall physical performance and muscular endurance, consistent with the dynamics observed in the present sample.

In the study by A. Agus & F. Mukhtarsyah (2021), the effects of aerobic exercise on students' physical fitness were examined, showing that systematic aerobic training led to improvements in motor performance, particularly endurance, speed-strength characteristics, and coordination skills. These findings align with the observed changes in standing long jump performance and shuttle run times in the present sample. Data from B. Rogers *et al.* (2021) demonstrated that training intensity guided by heart rate variability reliably enhances aerobic performance. The increases in six-minute run distance and muscular endurance observed in this study are consistent with this trend. The overall improvement in endurance, strength, and coordination among students following the ten-week programme corresponds with the results reported by X. Yu (2025), where an aerobic dance intervention in university students simultaneously enhanced cardiorespiratory endurance, muscular qualities, and motor preparedness.

Correlation analysis revealed clear relationships between morphological and functional changes in the students. Reductions in fat mass were associated with increases in HRR1 ($r = -0.62$; $p < 0.01$), decreases in waist circumference correlated with gains in six-minute run distance ($r = -0.58$; $p < 0.01$), reductions in the Ruffier-Dixon index corresponded with improvements in aerobic endurance ($r = -0.66$; $p < 0.001$), and decreases in BMI were linked to increases in muscular endurance ($r = -0.41$; $p < 0.05$). A similar interrelationship between parameters is supported by the study of N.E. Wade *et al.* (2020), which examined associations between aerobic fitness and brain morphometric characteristics in young adults. The authors demonstrated

that superior physical fitness is linked to more efficient neurofunctional organisation, consistent with the observed association in the present sample between HRR1 and changes in the morphological profile. Results from D. Mongin *et al.* (2022) indicated that reductions in heart rate variability during exercise serve as a highly sensitive indicator of cardiorespiratory fitness. This mechanism aligns with the detected correlation between HRR1 and fat mass, as both indices reflect the efficiency of autonomic regulation.

In the study by J.A. Pérez-Ramírez *et al.* (2025), high-intensity interval programmes in schools led to improvements in adolescents' endurance and physical fitness. The association observed in the current sample between waist circumference and running distance corroborates the conclusion that changes in morphological profile directly influence aerobic performance. Similarly, T.G. Nguyen & O. Gomez (2024), in their research on models of aerobic control and the design principles of effective fitness systems, demonstrated that optimisation of morphological parameters – particularly the ratio of muscle to fat tissue – is a key mechanism for enhancing aerobic capacity. This finding aligns with the correlation observed in the student sample between reductions in BMI and gains in muscular endurance. The study by G.M.G. Bonuzzi *et al.* (2020), which examined the effects of aerobic exercise on the acquisition of complex motor skills, demonstrated that improvements in motor control are accompanied by functional changes in cardiorespiratory systems. A similar pattern was observed in the present study, where the Ruffier-Dickson index was closely associated with performance in the six-minute run.

In summary, the results of the study demonstrated consistent positive changes in students' morphological, functional, and physical indicators, aligning with the evidence reported in numerous scientific studies that confirm the effectiveness of structured aerobic interventions for young adult populations. The direction of adaptive responses – including reductions in fat mass, improvements in cardiovascular regulation, and increases in endurance and motor abilities – replicates findings from research conducted across various age groups and training contexts, underscoring the consistency of the observed effects with general patterns of aerobic adaptation.

Conclusions

The developed aerobic programme resulted in targeted improvements in students' morphological profiles: body mass decreased by 1.1 kg, BMI by 0.5 kg/m², waist

circumference by 1.8 cm, and body fat percentage by 1.5%. The most pronounced changes in waist circumference and fat mass indicate a reduction in central obesity – a key factor in cardiometabolic risk. This pattern of adaptation reflects the activation of lipolysis and a restructuring of energy metabolism without loss of muscle mass, which is a typical effect of regular aerobic exercise. The functional status of the cardiovascular system also improved: resting HR decreased by 4.8 bpm, systolic and diastolic blood pressure fell by 3.9 mmHg and 2.5 mmHg, respectively, and pulse pressure decreased by 1.4 mmHg. The HRR1 index increased by 5.1 bpm, while the Ruffier-Dickson index decreased by 3.8 points, indicating a substantial enhancement of parasympathetic control, improved cardiac efficiency, and more effective recovery processes. All observed changes are consistent with typical mechanisms of aerobic adaptation in young adults.

Physical fitness indicators improved across all tests: the six-minute run distance increased by 154 m, muscular endurance by 4.1 repetitions, standing long jump by 8.2 cm, and the 4×9 m shuttle run time decreased by 0.58 s. This pattern demonstrates gains in aerobic capacity, muscular endurance, speed-strength characteristics, and coordination, highlighting the effectiveness of the programme in developing multi-component motor fitness. Correlation analysis confirmed the interdependence of morphological and functional adaptations: reductions in fat mass were associated with increases in HRR1 ($r = -0.62$), decreases in waist circumference with improvements in six-minute run distance ($r = -0.58$), decreases in the Ruffier-Dickson index with enhanced running performance ($r = -0.66$), and reductions in BMI with gains in muscular endurance ($r = -0.41$). These findings indicate that morphological optimisation serves as a key determinant of functional progress, particularly in cardiovascular regulation and physical performance. Recommendations for future research include expanding sample sizes across age groups and involving multiple educational institutions to increase representativeness and enable comparative analyses.

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Динаміка фізичного розвитку та функціональних можливостей організму молоді 17-20 років під впливом аеробіки

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Анотація. Мета роботи – виявити особливості змін показників фізичного розвитку та функціональних можливостей молоді у результаті застосування розробленої аеробної програми. Дослідження проводилось на базі Переяславського університету імені Григорія Сковороди (Київська область) упродовж десяти тижнів (3 лютого – 13 квітня 2025 р.) із залученням 40 студентів віком 17-21 років. Експериментальне дослідження включало три етапи вимірювань, що дозволило оцінити динаміку морфологічних і функціональних показників у студентів під впливом структурованої аеробної програми. Результати дослідження засвідчили, що маса тіла зменшилася на 1,1 кг, індекс маси тіла – на 0,5 кг/м², окружність талії – на 1,8 см, а частка жирової тканини – на 1,5 %, що відображало редукцію центрального жиру та оптимізацію соматичного профілю. Показники серцево-судинної регуляції також покращилися: частота серцевих скорочень у спокої знизилася на 4,8 уд/хв, систолічний тиск – на 3,9 мм рт. ст., діастолічний – на 2,5 мм рт. ст., а швидкість відновлення частоти серцевих скорочень зросла на 5,1 уд/хв. Індекс Руф'є-Діксона зменшився на 3,8 бала, що свідчило про підвищення реактивності та відновних можливостей. Показники фізичної підготовленості демонстрували зростання: дистанція шестихвилинного бігу збільшилася на 154 м, стрибок у довжину – на 8,2 см, м'язова витривалість – на 4,1 повторення, а час човникового бігу 4×9 м покращився на 0,58 с. Сукупність отриманих змін підтверджує ефективність аеробної програми як засобу розвитку загальної фізичної дієздатності студентів. Отримані дані можуть бути використані викладачами фізичного виховання, тренерами фітнес-програм, фахівцями спортивної медицини та організаторами оздоровчих заходів у закладах вищої освіти для оптимізації навчально-тренувальних занять і розроблення ефективних програм фізичної підготовленості молоді

Ключові слова: окружність талії; жирова тканина; серцево-судинна система; частота серцевих скорочень; артеріальний тиск; індекс Руф'є-Діксона; швидкість відновлення



Analysis of the effectiveness of distance learning in physical education in higher education institutions

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Abstract. This study aimed to provide an empirical verification of the effectiveness of a comprehensive methodology for distance learning in the discipline of Physical Education within the educational process of students in the humanities (Faculty of Arts, Management, Pedagogy, and Psychology). The experimental phase of the research was conducted from February to May 2025 at Hryhorii Skovoroda University in Pereiaslav. To achieve the stated aim, a pedagogical experiment was carried out on a student sample ($N = 120$), which included assessments of physical fitness, questionnaire surveys, and correlation analysis using Student's t test to determine the statistical significance of differences between the experimental and control groups. The findings demonstrated that the comprehensive distance learning methodology, incorporating synchronous classes and systematic monitoring, ensured a statistically significant increase in objective indicators of physical fitness ($p < 0.01$ or $p < 0.001$), whereas such improvements were not observed within the traditional model of distance learning. Students in the experimental group exhibited substantial progress across all six evaluated indicators: overall satisfaction increased from 27% to 63%, perceived effectiveness from 23% to 75%, intrinsic motivation from 25% to 70%, independent organisation of learning from 33% to 80%, adequacy of physical workload from 45% to 85%, and the integral index of overall assessment rose from 17% to 55%. All observed shifts were statistically significant ($p < 0.001$), thereby confirming the sustained positive impact of the enhanced distance learning methodology. The obtained data indicate the statistically significant effectiveness of the tested distance learning methodology, which ensures positive dynamics in the development of students' physical qualities. A high degree of correlation was identified between the level of daily physical activity and indicators of endurance. In addition, quantitative analysis confirmed a substantial increase in the level of intrinsic motivation and satisfaction with learning in the experimental group. These findings are of practical significance for optimising the process of distance physical education in higher education institutions

Keywords: digital transformation; physical activity; health; demotivation; educational process; physical qualities

Introduction

The relevance of investigating the effectiveness of distance learning in physical education in higher education institutions is determined by a set of global and local factors that have significantly transformed the educational environment. The transition to a remote learning format, caused

by the COVID-19 pandemic and the war, has imposed new requirements on the higher education system regarding the adaptation of traditional academic disciplines, including physical education, to the digital space. Physical education in higher education institutions performs an

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important function in developing health-preserving competence and in maintaining students' physical and psychological well-being, which necessitates an analysis of the possibilities for ensuring its effectiveness under distance learning conditions. An insufficient level of physical activity among students is associated with a subsequent deterioration in cognitive functions and mental health, as confirmed, *inter alia*, by the research of E.A. Haapala *et al.* (2025), who considered childhood physical fitness as an indicator of future cognitive and psychological development. Thus, a need emerged not only to transfer the educational process to the online environment, but also to identify and analyse methodologies capable of ensuring the achievement of the discipline's objectives under conditions of physical separation between participants in the educational process. The transition to distance learning was predominantly compulsory rather than planned, which led to the application of diverse approaches requiring systematic analysis. Of particular relevance is the identification of didactic models, technological solutions, and organisational forms that are able to ensure high-quality learning outcomes, sustain learning motivation, and promote the development of students' physical qualities.

In academic discourse, considerable attention has been devoted to the general aspects of the impact of distance learning on higher education. D. Turnbull *et al.* (2021) examined universities' responses to the transition to e-learning during the COVID-19 pandemic and found that the success of institutional adaptation depended on technological preparedness and organisational flexibility. By contrast, B.N. Alarifi & S. Song (2024) compared online and face-to-face learning in higher education. Their study demonstrated that online learning provides flexibility and accessibility, but reduces social interaction and student engagement. M. Alenezi (2023) analysed digital learning and the formation of digital institutionalisation in higher education institutions, emphasising that the effective implementation of technologies enhances the quality of education and fosters the development of students' digital competences.

Meanwhile, I.G. Bondarenko *et al.* (2020) assessed the organisation of distance training for future specialists in physical education. The authors noted that the effectiveness of classes depends on the use of interactive methods and the monitoring of physical activity, thereby demonstrating the practical significance of the distance learning format in discipline-specific contexts. O.M. Nesterenko *et al.* (2024) analysed innovative approaches to teaching physical education in higher education institutions. Their study showed that the integration of digital simulators and online platforms enhances learning outcomes and contributes to the development of students' physical qualities. In the research of O. Mozolev (2022), the specific features of organising students' physical education under distance and blended learning conditions were described, with an emphasis on the necessity of adapting curricula to new circumstances.

L. Moustakas & D. Robrade (2022) examined e-learning in the field of university sport and physical education during the COVID-19 pandemic. They emphasised that digital methods make it possible to maintain motivation and regularity of training even in a remote format, which indicates the promising future and relevance of using electronic technologies in sports education. By contrast,

J.K. Kohli *et al.* (2025) developed a scale to assess teachers' readiness for distance learning. The results demonstrated that a high level of e-readiness contributes to the effectiveness of the pedagogical process and facilitates the adoption of new technologies. B. Bashir & A.L. Lapshun (2025) explored the prospects of e-learning in higher education in the 2020s and beyond, emphasising that the integration of innovative digital platforms and technical solutions is crucial for improving educational quality and adapting to changes in teaching practices.

Despite the growing scholarly attention to this issue, several aspects remain insufficiently addressed in contemporary research. A substantial proportion of studies have focused on the general organisational parameters of the transition to distance learning or have relied on subjective evaluations by participants in the educational process. The issues of objectively measuring the effectiveness of distance learning in physical education on the basis of physical fitness indicators, the development of motor skills, and the comparison of these results with data obtained under traditional face-to-face instruction remain inadequately explored. Studies devoted to the training of specialists in physical education have also not fully considered the specific characteristics of teaching students in the humanities, for whom physical education functions as a general education discipline. Insufficiently investigated are the questions of the long-term impact of distance learning on students' levels of physical activity after returning to in-person instruction, as well as the need to take into account the conditions of local crisis events. In this context, there is a clear need for research aimed at determining the impact of distance learning in physical education on objective indicators of students' physical fitness in higher education institutions and at identifying methodological approaches capable of ensuring positive dynamics in these indicators.

This study aimed to conduct an experimental verification of the effectiveness of a comprehensive, author-developed methodology for distance learning in physical education for students of the Faculty of Arts, Management, Pedagogy, and Psychology at Hryhorii Skovoroda University in Pereiaslav. To achieve this aim, the following research objectives were defined: to assess the impact of the implemented methodology on students' physical fitness indicators; to examine the possibilities of using digital tools for monitoring physical activity through the application of fitness trackers; and to analyse students' levels of satisfaction, learning motivation, and engagement in the process of distance physical education classes.

Materials and Methods

The empirical study was conducted from February to May 2025 at Hryhorii Skovoroda University in Pereiaslav. The total sample comprised $N = 120$ first-year students with a mean age of 18.1 ± 0.4 years; the sample included 60 males and 60 females. The research was based on a pedagogical experiment. The inclusion criteria were enrolment in the first year of study, provision of informed consent to participate, an initial level of physical fitness, regular attendance of academic classes, and active participation in physical culture and health-related activities. The initial level of physical fitness was determined using standardised tests that assessed endurance, strength, speed-strength abilities,

and flexibility. The exclusion criteria included the presence of medical contraindications to physical activity, participation in professional sports clubs, and absence from more than 20% of distance learning classes. Participants were divided into a control group (CG, 60 students: 30 males and 30 females, mean age 18.2 ± 0.3 years) and an experimental group (EG, 60 students: 30 males and 30 females, mean age 18.0 ± 0.4 years), with comparable baseline levels of physical fitness. Full confidentiality was guaranteed to all participants. The study was conducted in accordance with international ethical standards, including the Code of Ethics of the American Sociological Association (1997) and the European Commission (2021) on ethics and data protection, and was approved by the university's ethics committee. To achieve the research objectives, a set of empirical methods was applied, including measurement, observation, testing, and comparison.

A formative experiment was conducted in which the CG was taught according to the traditional model of distance learning, which involved two classes per week, each lasting 60 minutes, delivered in the format of lectures and demonstrations. The EG followed a developed comprehensive methodology aimed at increasing students' physical activity. The methodology for the EG integrated three synchronous sessions per week via Google Meet (n.d.) (45-60 minutes each) and two asynchronous sessions on the Moodle (n.d.) platform, combined with structured physical exercises. Each session included the following stages: a warm-up (aerobic exercises, 10-15 minutes), a main part (strength and aerobic exercises, 25-35 minutes), and a cooldown (stretching). Load regulation was based on the FITT principles (frequency, intensity, time, and type of exercise), with exercise intensity maintained at 65-85% of the maximum heart rate. Individualisation was ensured through baseline test results, data obtained from fitness trackers worn daily by students throughout the experimental period, and subjective well-being indicators. The exercises were selected to ensure comprehensive physical development and safe performance in home-based conditions. The choice of a comprehensive methodology was determined by the need for interactive learning, personalisation of physical load in accordance with students' levels of physical fitness, and the possibility of real-time monitoring of physical activity, in contrast to the traditional model, which is predominantly based on passive perception of educational material.

For the objective assessment of physical fitness development, a measurement method was applied through standardised testing conducted at the beginning and at the end of the study. The testing included the standing long jump (speed-strength abilities), the Cooper test (endurance), the number of trunk lifts performed in

30 seconds (abdominal muscle strength), and the forward trunk bend (flexibility). To ensure objectivity, which is a critically important aspect of distance learning, students in the EG used portable fitness trackers, Xiaomi Smart Band 8 (China), for the daily measurement of physical activity indicators, specifically step counts. Questionnaire surveys were administered before the beginning and after the completion of the experiment. A single research instrument was applied, namely an author-developed questionnaire designed on the Google Forms platform (USA). It consisted of 12 items covering the level of interest in classes, motivation to perform exercises, and satisfaction with the organisation of distance learning. Sample questions included: "How capable are you of organising and monitoring your own learning?", "How satisfied are you with distance learning in physical education?", and "How would you assess the effectiveness of the lesson methodology?". A five-point Likert scale was employed, and the criterion for a high or positive assessment was established by combining the responses "high/very high" or "positive/very positive".

A set of statistical methods was applied for the processing of both subjective and objective data. The collection of subjective data (motivation and satisfaction) was carried out using the above-mentioned author-developed questionnaire. Prior to analysis, the normality of data distribution was verified using the Shapiro-Wilk test. The comparative method was used to assess the initial level of preparedness of the groups, the dynamics of improvement within the CG and EG, and the comparison of final results between the groups. Student's *t* test was applied to compare mean values, while the chi-square (χ^2) test was used for the analysis of categorical questionnaire data in order to determine the statistical significance of changes in the responses of the CG and EG before and after the experiment. The relationship between activity indicators obtained from fitness trackers and physical fitness indicators was assessed using Pearson's correlation coefficient. The processing of fitness tracker data involved averaging daily indicators over the entire experimental period. Statistical analysis was performed using Statistica 13 (USA). The level of statistical significance was set at $p < 0.05$, and the results are presented in the format $X \pm SD$.

Results and Discussion

Impact of the comprehensive methodology on students' physical fitness

The results of this comparison, illustrating changes in physical fitness parameters across four main aspects (speed-strength abilities, endurance, abdominal muscle strength, and flexibility) at the beginning and at the end of the experiment, are presented in Table 1 below.

Table 1. Comparative analysis of physical fitness indicators in the CG and EG at the beginning and at the end of the experiment

Indicator	Group	Beginning of the experiment ($X \pm SD$)	End of the experiment ($X \pm SD$)	Increase (%)	Student's <i>t</i> test	<i>p</i>
Standing long jump (cm)	CG (<i>n</i> = 60)	198.4\7.1	200.8\7.5	1.2	<i>t</i> = 0.89	<i>p</i> > 0.05
	EG (<i>n</i> = 60)	197.9\6.9	210.1\8.4	6.2	<i>t</i> = 4.12	<i>p</i> < 0.01
Cooper test (m)	CG (<i>n</i> = 60)	2,150\125	2,185\130	1.6	<i>t</i> = 1.05	<i>p</i> > 0.05
	EG (<i>n</i> = 60)	2,160\128	2,350\145	8.8	<i>t</i> = 5.78	<i>p</i> < 0.001

Table 1, Continued

Indicator	Group	Beginning of the experiment ($\bar{X} \pm SD$)	End of the experiment ($\bar{X} \pm SD$)	Increase (%)	Student's t test	p
Abdominal muscle strength (number of repetitions/30 s)	CG (n=60)	32.1\3.5	33.5\3.7	4.4	t=1.50	p > 0.05
	EG (n=60)	32.5\3.6	38.9\4.1	19.7	t=6.91	p < 0.001
Flexibility (forward trunk bend, cm)	CG (n=60)	8.5\1.2	8.8\1.3	3.5	t=0.75	p > 0.05
	EG (n=60)	8.3\1.1	10.4\1.4	25.3	t=5.15	p < 0.01

Source: created by the authors

A detailed analysis of the quantitative results presented in Table 1 made it possible to objectively evaluate the effectiveness of the comprehensive distance learning methodology in physical education implemented in the EG, in comparison with the traditional approach applied in the CG. The baseline testing data demonstrated that, at the beginning of the experiment, no statistically significant differences were observed between the CG and EG for any of the indicators (all $p > 0.05$). This confirms the homogeneity of the sample and its suitability for conducting a comparative study. The analysis of the results after the completion of the formative experiment revealed fundamentally different dynamics in the two groups. In the control group, which was taught according to the standard distance learning model with limited feedback, the increase in indicators was minimal and, importantly, statistically insignificant across all four dimensions ($p > 0.05$). For example, the standing long jump improved by only 1.2% (from 198.4\7.1 cm to 200.8\7.5 cm), while the Cooper test result increased by 1.6%, that is, from 2,150\125 m to 2,185\130 m.

In contrast, the experimental group, which applied the comprehensive methodology incorporating individualisation of physical load, synchronous sessions, and digital monitoring, demonstrated statistically significant and substantially greater improvements across all tested indicators. The most pronounced progress was observed in flexibility, where the increase reached 25.3%, namely from 8.3\1.1 cm to 10.4\1.4 cm ($p < 0.01$), and in abdominal muscle strength, which increased by 19.7%, from 32.5\3.6 to 38.9\4.1 repetitions per 30 seconds ($p < 0.001$). The marked improvement in abdominal muscle strength is particularly indicative, as this parameter is highly dependent on the regularity and intensity of the training process. This result is consistent with the findings of M. Sanz-Matesanz *et al.* (2024), who demonstrated that even a specialised physical training programme exerts a positive effect on both physical and cognitive performance. The endurance indicator (Cooper test) increased by 8.8%, specifically from 2,160\128 m to 2,350\145 m ($p < 0.001$), demonstrating the effectiveness of individualised running and cardio programmes, which were monitored using fitness trackers. Even in a metric traditionally challenging for distance learning, such as the standing long jump – which reflects the development of speed-strength abilities – an increase of 6.2% was recorded, with the mean value rising from 197.9\6.9 cm to 210.1\8.4 cm.

A comparison of the final results between the EG and the CG confirmed the statistical superiority of the comprehensive methodology applied in the EG. Across all four indicators, the final results of the EG were significantly higher than those of the CG, and these differences were highly significant. These findings demonstrate that the effectiveness of distance learning in physical education can be enhanced

to a level comparable with traditional approaches, provided that specialised methodological and technological solutions are employed. The use of technology for personalisation and real-time monitoring proved to be a key factor, which aligns with the projections of P.S. Aithal *et al.* (2024), who emphasised the growing role of technology in the future of higher education and the necessity of its implementation to improve learning quality. Furthermore, the outcomes of the experimental group highlighted the importance of active leadership and an innovative approach in educational management, a point also emphasised by G. Maheshwari *et al.* (2024), who analysed the impact of e-leadership on staff performance in higher education institutions.

In summary, the results of the pedagogical experiment not only demonstrated the superiority of the developed comprehensive methodology over the traditional distance learning model but also highlighted that approaches based on technological monitoring and individualisation can achieve substantial improvements in students' physical fitness even under remote learning conditions. In the context of barriers described by S.A.J. Phulpoto *et al.* (2024) regarding e-learning, the comprehensive methodology applied in the EG successfully overcame many of these obstacles, transforming technology from a potentially problematic element into an effective tool for the educational process.

The alignment of these findings with the conclusions of S.A.J. Phulpoto *et al.* (2024) illustrates improvements in teaching effectiveness within the context of e-learning at public universities in Pakistan. The authors emphasised that high achievements in e-learning systems are attainable only through the systematic elimination of organisational barriers, the provision of reliable digital infrastructure, and the creation of an environment in which educators receive support for the application of innovative approaches. Similarly, C. Tejada-Delgado *et al.* (2011), analysing cultural aspects of learning, highlighted the critical importance of aligning the educational environment with student expectations and ensuring regular, high-quality feedback to compensate for the absence of direct interaction. The success of distance learning, therefore, depends on the integration of technology, methodology, and psychology, which together form a new educational landscape. The present study corroborates these findings, demonstrating that a technologically and administratively supported model of remote learning can reliably produce significant improvements in students' academic achievements.

Digital monitoring of physical fitness in students of the Faculty of Arts, Management, Pedagogy, and Psychology at Hryhorii Skovoroda University in Pereiaslav

Contemporary academic discourse emphasises the necessity of digital transformation in higher education and the

integration of technologies to enhance learning effectiveness, particularly under distance learning conditions. The shift to online education, prompted by global crises, has highlighted a key challenge: maintaining the practical orientation of disciplines such as physical education without direct educator supervision. In this context, M. Akour & M. Alenezi (2022), analysing the future of higher education in the era of digital transformation, emphasised that the success of distance learning depends on the implementation of tools that allow the objectification of both the learning process and its outcomes. The use of portable

technologies and fitness trackers represents a key mechanism for addressing the problem of the absence of physical contact, enabling continuous measurement of students' physical activity. Additionally, the importance of a physical learning environment for distance learners in higher education is recognised as a critical factor influencing both psychological and physical well-being (Ng, 2021). Table 2 below presents the results of a correlation analysis between the average daily step count recorded for students in the EG during the experiment and the relative percentage increase (%) in their physical fitness indicators.

Table 2. Correlation analysis of the relationship between physical activity

Indicator of physical fitness increase	Pearson correlation coefficient (<i>r</i>)	Significance level (<i>p</i>)	Strength and direction of the relationship
Increase in standing long jump (%)	0.58	$p < 0.01$	Moderate, positive
Cooper test increase (%)	0.72	$p < 0.001$	High, positive
Increase in abdominal muscle strength (%)	0.65	$p < 0.01$	Moderate, positive
Flexibility increase (%)	0.41	$p < 0.05$	Weak, positive

Source: created by the authors

The analysis presented in Table 2 allows for the quantification of relationships between the objective measurement of physical activity in students of the EG (average daily step count) and the effectiveness of the applied comprehensive distance learning methodology, as expressed by the relative increase in physical fitness indicators. During the experimental period, the EG achieved an average of $9,850 \pm 1,120$ steps per day, considerably higher than the WHO-recommended 6,000-8,000 steps for maintaining health, indicating the success of the methodology in promoting physical activity (Elgin, 2025).

The Pearson correlation analysis demonstrated a direct and statistically significant relationship between average daily steps and improvements across all tested physical fitness qualities. The strongest correlation was observed between step count and endurance improvement (Cooper test), with a correlation coefficient of $r = 0.72$ ($p < 0.001$). This high correlation indicates that students who maintained higher levels of daily activity, as recorded by fitness trackers, achieved the greatest improvements in aerobic endurance. These results highlight the necessity of implementing objective monitoring of students' physical activity in distance education, providing a means to overcome limitations previously identified by N. Martynova & E. Kuzko (2021). Unlike the previously identified problem of insufficient supervision of practical activity, the applied methodology provided systematic and transparent monitoring of physical activity, which substantially enhanced the effectiveness of organising the learning process.

The increases in strength-related qualities, specifically abdominal muscle strength ($r = 0.65$, $p < 0.01$) and speed-strength abilities, as measured by the standing long jump ($r = 0.58$, $p < 0.01$), also showed a moderate but significant positive correlation with step count. This indicates that overall physical activity, even when non-specific (such as walking), serves as an important background factor in the development of these qualities within the context of the comprehensive training programme implemented in the EG. The strong correlation confirms that, in a distance

learning environment where the lecturer cannot continuously monitor exercise performance, maintaining high overall physical activity through tools such as fitness trackers is an effective mechanism for promoting performance outcomes. The weakest, although still statistically significant, correlation was observed between step count and improvements in flexibility ($r = 0.41$, $p < 0.05$). This finding is physiologically consistent: walking has a limited effect on flexibility, which primarily depends on the performance of specialised stretching exercises. Nevertheless, the positive correlation suggests that general physical activity and participation in the training regimen, even indirectly, contribute to improvements in this quality as well.

Overall, the results of the correlation analysis empirically support the necessity and effectiveness of using digital measurement tools (fitness trackers) to enhance both the objectivity and the outcomes of distance learning in physical education. It has been confirmed that technological monitoring and individualisation of physical load contribute to an increase in overall physical activity, which in turn leads to a significant improvement in physical fitness. Within the broader research context, for example, L. Zhang *et al.* (2022), who conducted a literature review on online learning during COVID-19, the present study adds concrete empirical evidence showing how technology can be used not only to deliver information but also to objectively monitor physical progress – a factor critical to maintaining quality in times of crisis. The findings also align with the recommendations of W. Ali (2020), who emphasised the need for a rapid and effective transition to remote learning, stressing that institutions must identify ways to ensure learning effectiveness. The methodology applied in the EG, based on continuous measurement and correlational analysis of data, demonstrated one such approach. The presence of significant correlations confirmed that individualised tasks, which required a specified level of daily activity, were successfully integrated into students' routines, resulting in a statistically significant increase in physical fitness indicators – an outcome not observed in the CG. This, in turn,

provides evidence of the effectiveness of the comprehensive methodology as a mechanism for overcoming the challenges of physical remoteness and maintaining the integrity of the physical education process in higher education institutions. The successful implementation of flipped classrooms in higher education during the pandemic, as examined by B. Divjak *et al.* (2022), further emphasises that independent student work – which forms the core of distance learning – can be highly effective if clearly structured and monitored, as was achieved here through digital measurement of physical activity.

Satisfaction indicators with online physical education in the control and experimental groups

The analysis of subjective data collected through the author-designed questionnaire allows for a comparison of the psychological and motivational profiles of students in the control group and the experimental group. To identify statistically significant differences between the groups for categorical variables (levels of satisfaction, motivation, and autonomy), the Chi-square test was applied. The results, together with the percentage distribution of responses, are presented in detail in Table 3.

Table 3. Comparative analysis of students' subjective indicators of satisfaction and motivation in distance learning

No.	Questionnaire item	Criterion for a positive response	CG before (N=60)	CG after (N=60)	EG before (N=60)	EG after (N=60)	χ^2 (df=1)	p
1	How satisfied are you with distance learning in physical education?	High/medium level of satisfaction	18 (30%)	20 (33%)	16 (27%)	38 (63%)	27.9	$p < 0.001$
2	How would you assess the effectiveness of the lesson methodology?	Positive/very positive	15 (25%)	16 (27%)	14 (23%)	45 (75%)	35	$p < 0.001$
3	Evaluate your intrinsic motivation for physical education	High/very high level	17 (28%)	18 (30%)	15 (25%)	42 (70%)	22.5	$p < 0.001$
4	How capable are you of organising and monitoring your own learning?	High/very high level of autonomy	22 (37%)	24 (40%)	20 (33%)	48 (80%)	19.2	$p < 0.001$
5	Do you consider the physical load appropriate to your fitness level?	Yes (adequate)	28 (47%)	30 (50%)	27 (45%)	51 (85%)	18.7	$p < 0.001$
6	Would you like to continue learning in a distance format?	Yes (if the methodology is effective)	8 (13%)	9 (15%)	10 (17%)	33 (55%)	22.5	$p < 0.001$
7	How much support do you feel from the lecturer during classes?	High/medium level of support	25 (42%)	28 (47%)	24 (40%)	52 (87%)	26.8	$p < 0.001$
8	How easy was it to use digital tools (Moodle, Google Meet)?	Easy/very easy	35 (58%)	38 (63%)	34 (57%)	55 (92%)	15.6	$p < 0.001$
9	Did you receive sufficient feedback on exercise performance?	Yes (sufficient)	12 (20%)	14 (23%)	15 (25%)	40 (67%)	27.5	$p < 0.001$
10	Did you feel socially isolated during distance learning?	No (low level of isolation)	20 (33%)	22 (37%)	21 (35%)	49 (82%)	24.3	$p < 0.001$
11	Does the flexible class schedule meet your needs?	Fully/mostly meets	30 (50%)	32 (53%)	31 (52%)	54 (90%)	21.6	$p < 0.001$
12	Did the lessons contribute to an increase in your overall physical activity, according to your tracker?	Yes (contributed)	-	-	26 (43%)	53 (88%)	23.5	$p < 0.001$

Source: created by the authors

The data in Table 3 revealed a marked difference between the control and experimental groups in the dynamics of subjective indicators. For overall satisfaction with distance learning (Question 1), students in the CG exhibited minimal change (from 30% to 33%). In contrast, the EG showed a sharp increase in positive responses from 27% to 63%, which was statistically significant ($\chi^2 = 27.9, p < 0.001$). The high level of significance indicates a pronounced positive impact of the proposed methodology. This finding aligns with international research by P. Fidalgo *et al.* (2020), who emphasised that positive evaluations of distance learning depend on course structure quality, pedagogical support, and timely feedback.

A similar trend was observed for the assessment of methodology effectiveness (Question 2), where changes in the CG were minimal (25% \rightarrow 27%), whereas the EG demonstrated an increase from 23% to 75% ($\chi^2 = 35.0, p < 0.001$). This result reflects the subjectively perceived pedagogical effectiveness of the course. These findings are

consistent with those of S. Elfirdoussi *et al.* (2020), who found that students rated distance courses more positively when they included clear instructions and well-structured materials. Particularly noteworthy is the indicator of intrinsic motivation for physical education (Question 3), which is traditionally difficult to enhance in a distance learning format. In the CG, the indicator of intrinsic motivation remained almost unchanged (28% \rightarrow 30%), whereas in the EG it increased substantially from 25% to 70% ($\chi^2 = 22.5, p < 0.001$). This finding aligns with the results of M. Rizun & A. Strzelecki (2020), who demonstrated that motivation for online learning is strongly influenced by feelings of engagement, autonomy, and personalisation. The rise in motivation indicates an effective restructuring of the learning environment. The fourth indicator, students' ability to organise their own learning independently (Question 4), also revealed a significant gap. In the CG, growth was minimal (37% \rightarrow 40%), whereas in the EG, there was a dramatic increase from 33% to 80% ($\chi^2 = 19.2, p < 0.001$). The

improvement in autonomy supports the theoretical conclusion of M. Barak (2012) that organisational transformation should position students as active participants in the learning process. The fifth indicator, the perceived adequacy of the physical load (Question 5), reflected a balance between the objective difficulty of the exercises and the students' subjective capacity. The CG showed only a slight improvement (47% → 50%), whereas the EG increased from 45% to 85% ($\chi^2 = 18.7, p < 0.001$). This outcome aligns with the study by M. Allen *et al.* (2006), which concluded that the effectiveness of distance programmes depends on adapting the learning material to students' individual abilities. The sixth indicator, willingness to continue learning in a distance format (Question 6), demonstrated the clearest overall improvement. In the CG, changes were minimal (13% → 15%), while in the EG they were substantial, rising from 17% to 55% ($\chi^2 = 22.5, p < 0.001$). In turn, this indicates that the implemented methodology enhanced the motivational, emotional, and organisational aspects of learning, fostering a sustained desire to continue studying. This conclusion aligns with the findings of S.A. Aljawarneh (2020), who demonstrated that a key advantage of innovative ubiquitous learning tools is their ability to maintain prolonged student engagement.

Analysis of the additional questions (7-12) reinforces these conclusions. Regarding lecturer support (Question 7), the EG showed an increase from 40% to 87% ($\chi^2 = 26.8, p < 0.001$), highlighting the crucial role of synchronous communication and individualisation. Feedback provision (Question 9) also rose in the EG from 25% to 67% ($\chi^2 = 27.5, p < 0.001$), a factor recognised as essential for course quality by P. Fidalgo *et al.* (2020). Of particular note is the result concerning social isolation (Question 10), where the proportion of students in the EG reporting no feelings of isolation increased from 35% to 82% ($\chi^2 = 224.3, p < 0.001$), confirming the effectiveness of the methodology's interactive elements in promoting social engagement. Similarly, the indicator for contributing to overall physical activity (Question 12) rose in the EG to 88% ($\chi^2 = 223.5, p < 0.001$), supporting the efficacy of fitness trackers and individualised exercise loads. The experimental results are fully consistent with theoretical models of distance education and confirm that the effectiveness of online learning is determined by the quality of pedagogical decisions. At the same time, comparison with the study by I.A. Adeoye *et al.* (2020) shows that, in the absence of methodological preparation, even simple online tasks can become challenging. This provides grounds to interpret the present findings as evidence that the enhanced methodology significantly improves the effectiveness of distance learning. The comparative analysis of subjective indicators convincingly demonstrates the high effectiveness of the developed comprehensive distance-learning methodology for the EG. The substantial and statistically significant increases across all 12 questionnaire parameters (ranging from 15.6 to 35.0, $p < 0.001$) reflect improvements in satisfaction, intrinsic motivation, autonomy, perceived support, and the adequacy of workload. These findings indicate that the integration of synchronous communication and digital monitoring compensated for the limitations of the distance-learning format and fostered a new, more effective educational culture, aligning with the key theoretical positions of

M. Barak (2012) and P. Fidalgo *et al.* (2020) regarding the critical role of pedagogical support and student autonomy in online education.

Summarising the outcomes of the study, it is evident that the implementation of the developed comprehensive methodology for distance learning in physical education produced a systematic positive effect on all key components of the educational process in the experimental group. Observed changes include increases in student satisfaction, intrinsic motivation, and the development of autonomy, self-awareness, and responsibility for organising their own learning and physical activity. The combination of synchronous pedagogical guidance, structured learning content, and elements of digital monitoring created conditions to overcome characteristic limitations of the distance-learning format, such as reduced social interaction and insufficient feedback. The results confirm that the effectiveness of distance learning is determined not by the format itself, but by the quality of pedagogical decisions, their adaptability to student needs, and their ability to ensure active engagement in the learning process.

Conclusions

The empirical study, aimed at analysing the effectiveness of distance learning in physical education at a higher education institution, established and quantitatively confirmed the advantages of a comprehensive methodology that integrated digital monitoring technologies with individualised workloads over the traditional distance learning model. The research demonstrated that the application of this innovative approach produces a statistically significant improvement in objective measures of students' physical fitness and substantially enhances their subjective perception of the learning process. The results of the pedagogical investigation indicate that when distance learning is organised effectively, its outcomes are comparable to those of traditional face-to-face formats. Students in the EG showed statistically significant improvements across all tested indicators ($p < 0.01$ or $p < 0.001$), whereas increases in the CG were not statistically significant. The greatest improvements in the EG were observed in flexibility (25.3%) and abdominal muscle strength (19.7%), while endurance (Cooper Test) increased by 8.8%. These findings indicate that continuous digital monitoring and programme individualisation effectively stimulate the training process, which standard distance-learning arrangements do not provide.

Analysis of the data collected via fitness trackers in the EG revealed a direct and statistically significant correlation between the average daily step count and the gains in physical fitness indicators. The strongest correlation was observed with endurance ($r = 0.72, p < 0.001$), unequivocally confirming that objective measurement of physical activity is a significant factor in the development of physical abilities in the context of distance learning. Evaluation of the experimental results demonstrated a clear and consistent advantage of the experimental methodology over the traditional distance-learning format. All six indicators showed substantial improvement: in the experimental group, overall satisfaction increased from 27% to 63%, perceived effectiveness from 23% to 75%, intrinsic motivation from 25% to 70%, independent organisation of learning from 33% to 80%, adequacy of physical workload from 45% to 85%,

and the overall composite indicator rose from 17% to 55%. This dynamic confirms that the revised methodology had a marked positive effect on the emotional, motivational, and organisational aspects of distance learning.

The limitations of this study pertain to the sampling method, as a non-probability (convenience) sample was utilised, thereby restricting the direct extrapolation of the results to the broader population of higher education students. Furthermore, despite the implementation of fitness trackers, maintaining comprehensive oversight of exercise technique within a distance learning context remains a persistent challenge. Future research should focus on evaluating the long-term effects of the comprehensive

methodology on students' health-preserving competence and physical activity, employing a larger sample and comparing different models of digital monitoring, including mobile applications with AI-assisted correction.

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Conflict of Interest

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Аналіз ефективності дистанційного навчання з фізичної культури у закладах вищої освіти

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Анотація. Мета наукового дослідження полягала в емпіричній верифікації ефективності комплексної методики дистанційного навчання з дисципліни «Фізична культура» в освітньому процесі студентів гуманітарного профілю (факультет мистецтва, менеджменту, педагогіки і психології). Експериментальна частина дослідження була реалізована упродовж лютого-травня 2025 року на базі Університету Григорія Сковороди в Переяславі. Для досягнення мети був застосований педагогічний експеримент на вибірці студентів ($N = 120$), що включав тестування фізичної підготовленості, анкетування і кореляційний аналіз із використанням t критерію Стьюдента і тесту для встановлення статистичної значущості відмінностей між експериментальною та контрольною групами. Було встановлено, що комплексна методика дистанційного навчання із використанням синхронних занять і моніторингу забезпечувало статистично значущий приріст об'єктивних показників фізичної підготовленості ($p < 0,01$ або $p < 0,001$), що не спостерігалось у традиційній моделі дистанційного навчання. У студентів експериментальної групи зафіксовано суттєве покращення за всіма шістьма показниками: загальна задоволеність зростає з 27 % до 63 %, оцінка ефективності – з 23 % до 75 %, внутрішня мотивація – з 25 % до 70 %, самостійна організація навчання – з 33 % до 80 %, адекватність фізичного навантаження – з 45 % до 85 %, а інтегральний показник загальної оцінки підвищився з 17 % до 55 %. Усі зміни були статистично значущими ($p < 0,001$), що підтверджує стабільний позитивний вплив удосконаленої методики дистанційного навчання. Отримані дані свідчать про статистично значущу ефективність апробованої методики віддаленого навчання, яка забезпечує позитивну динаміку розвитку фізичних якостей студентів. Встановлено високий ступінь взаємозв'язку між рівнем щоденної фізичної активності та показниками стійкості. Крім того, кількісний аналіз підтвердив суттєве зростання рівня внутрішньої мотивації та задоволеності навчанням в експериментальній групі. Ці результати мають практичну значущість для оптимізації процесу дистанційного фізичного виховання у ЗВО

Ключові слова: цифрова трансформація; рухова активність; здоров'я; демотивація; освітній процес; фізичні якості



Optimisation of sports and physical education activities and physical training for students aged 14-16 through the integration of Olympic sports elements

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Abstract. The study aimed to investigate the impact of integrating the Olympic Education programme into school Olympic games and mass sporting events on the level of physical fitness and development of students. The research methodology included comparative analysis and a quasi-experimental study based at the V. Monomakh Lyceum in Pereiaslav and the I. Mazepa Academic Lyceum in Pereiaslav, involving 168 students between February and May, and the formation of an algorithm for organising mass sporting events based on elements of the Olympic Education programme. The study determined that each type of exercise has a different effect on the development of students' physical qualities. The implementation of the Olympic Education programme promotes the systematic combination of physical education lessons and extracurricular mass sporting events, ensuring the comprehensive development of schoolchildren through the integration of learning, physical activity and play. At the beginning of the experiment, the physical fitness of students in the experimental and control groups was relatively the same, with minor differences in cardiorespiratory endurance, strength, flexibility and coordination. After completing the Olympic Education programme, the experimental group demonstrated significant improvement in all indicators: the average distance in the 12-minute Cooper run was $2,070 \pm 200$ m compared to $1,850 \pm 210$ m in the control group, the number of push-ups in 1 minute increased to 30 ± 6 times compared to 24 ± 5 , flexibility in the sit-and-reach test reached 24 ± 5 cm compared to 19 ± 5 cm, and the shuttle run time (10x5 m) was 16.2 ± 1.8 seconds compared to 18.5 ± 2.1 seconds. These results indicate a significant increase in cardiorespiratory endurance, strength, flexibility, and speed-coordination of students who participated in gamified physical education classes. The results of the study can be used by physical education teachers and school administrators to plan and implement Olympic education programmes aimed at increasing students' physical activity

Keywords: teenagers; physical activity; mass sports activities; games; physical training; general secondary education institutions

Introduction

Olympic education is a tool for improving the effectiveness of mass sporting events in schools, as it shapes a value-based attitude towards physical culture, strengthens pupils' motivation to engage in regular sports activities and encourages them to lead an active lifestyle. Within the ed-

ucational process, it combines educational, upbringing and health aspects, ensuring the comprehensive development of schoolchildren. The inclusion of Olympic ideas and pedagogical technologies in the structure of physical education creates the basis for the growth of mass sporting events,

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increasing the level of student participation in sports clubs and developing internal motivation for self-improvement. This direction necessitates research-based justification of the role of Olympic education in improving mass sports activities in schools and determining effective ways to integrate it into the educational space.

In scientific discourse, researchers have actively studied this topic and outlined various approaches to interpreting its content, pedagogical functions, and role in shaping students' sports activities. V. Babalich *et al.* (2023) emphasised the role of physical culture trends that contribute to the modernisation of sports activities in schools and a gradual increase in the number of students participating in physical education and sports activities. The researchers pointed to such forms as health and training classes, mass sporting events, optional sections, and integrated physical education lessons with elements of fitness and game sports. The significance of encouraging young people to lead an active lifestyle is in line with the position of R. Kumar (2024), who described Olympic sport as a strategic resource for strengthening the nation through educational and training tools that are integrated into the school environment. The gradual formation of a sports culture within the school community helps to create conditions for the harmonious development of students, as well as the optimisation of mass sports activities by increasing motivation and participation.

J. Li & L. Yuan (2022) found that the introduction of Olympic education for primary and secondary school students, combined with the STEAM approach (Science, Technology, Engineering, Art, and Mathematics), promotes physical literacy and interest in sport. They also found that the effectiveness of the programme depends on the integration of interdisciplinary tasks and the active participation of teachers in the formation of sports skills and values. I. Lutsenko *et al.* (2025) demonstrated the effectiveness of innovative methods of teaching physical education in higher education institutions, emphasising the synergy of professional, physical and educational goals. These findings confirm the possibility of further introducing innovations into the school environment to optimise mass sports activities and expand the educational impact of Olympic ideas. The development of sport among young people is closely linked to the formation of a system for training athletes of different levels. M. Sattari *et al.* (2024) demonstrated the impact of involving educational structures in the development of elite sport, highlighting the significance of schools in the early identification and support of talented young people. This reinforces the argument regarding the function of Olympic education as a mechanism for increasing the sporting potential of society through basic and mass physical activity.

Furthermore, C. Fan *et al.* (2025) studied the success of a private sports school in China, demonstrating that institutional support, motivational programmes and maintaining team spirit can ensure the long-term participation of young people in sport. Despite the differences between private academies and regular schools, mechanisms for engaging and supporting student initiative have the potential to be adapted to mass sports activities within general secondary education. J.L. Rojas Torrijos (2024) explored how a scientific approach to sport can broaden coverage of the

Olympic Games by emphasising the integration of performance analysis, biomechanics, and sports science into media content. The researcher emphasised the importance of presenting evidence to improve public awareness of sporting achievements and the overall dynamics of large-scale sporting events. Despite the aspects highlighted by the above-mentioned authors, there is insufficient research into the mechanisms for implementing Olympic education in the daily practice of general education institutions. The study aimed to evaluate the effectiveness of implementing elements of the Olympic Education programme through school Olympic games and mass sporting events to improve physical fitness.

Materials and Methods

The study conducted a comparative analysis of various types of school Olympic games and mass sporting events, including short and middle-distance running, relay races, long jump and high jump, ball throwing, team games, and complex exercises for coordination and strength. These types of games were selected based on their accessibility, safety, and compliance with the methodological recommendations of the Olympic Education programme (International Olympic Committee, n.d.), and the analysis was based on criteria of physical fitness and participation in mass sporting events. An algorithm for organising mass sporting events was developed based on the Olympic Education programme, the methodological recommendations of the International Olympic Committee (International Olympic Committee, n.d.) and the existing experience of school Olympic programmes, incorporating safety, accessibility and the comprehensive development of students. The algorithm included the stages of planning the event, preparing participants and teachers, conducting a warm-up, the main part with various types of exercises and games, as well as the final stage with evaluation of results and summarising.

A quasi-experimental study was conducted between February and May 2024 in two lyceums in Pereiaslav, namely the V. Monomakh Lyceum and the I. Mazepa Academic Lyceum. The sample included 168 students aged 14 to 16 from the two selected lyceums. The inclusion criteria were age 14-16, regular attendance at physical education classes, no medical contraindications, and written consent from parents, while the exclusion criteria were chronic diseases or injuries of the musculoskeletal system, participation in professional sports sections, or refusal to participate further. The groups were formed in such a way that the overall percentage of attendance at physical education classes in both groups before the start of the study was 70%. The two groups included equal numbers of representatives from two schools. The experimental group studied according to the adapted Olympic Education programme, while the control group continued with standard physical education classes without an additional programme. Ethical research standards were adhered to in accordance with the Declaration of Helsinki (2013), and the voluntary participation of all participants and the confidentiality of their personal data were ensured.

Before the initiation of the experiment, schoolteachers underwent two days of training on how to integrate school games and elements of the Olympic Education programme

into physical education lessons. For 16 weeks (from February to May 2024), students in the experimental group participated in two 60-minute classes per week, which included a warm-up, a main part with aerobic, strength and coordination exercises, and a cool-down. Students in the control group continued with standard physical education classes with the same frequency and duration, but without the thematic component. The assessment was conducted in several stages: pre-intervention testing in January 2024 included measurements of physical indicators (12-minute Cooper run, number of push-ups in 1 minute, sit-and-reach test for flexibility, shuttle run for coordination). Final testing was conducted in May 2024, and additional data on class attendance was collected. The results were processed by comparing pre- and post-intervention indicators within the group and between schools using paired and intergroup *t* tests for categorical changes in the level of participation in activities.

Results

The Olympic Education programme was developed by the International Olympic Committee (International Olympic Committee, n.d.) to promote Olympic values among young people and integrate them into the educational process in schools around the world. It involves a gradual increase in the complexity of tasks and physical activity, adapted to the level of training of students, as well as systematic monitoring of results and support. The programme can be effectively implemented in schools both within physical education lessons and through extracurricular sports and mass events. Its structure provides for the adaptation of tasks to the level of physical training of students, the safety of exercises and the integration of Olympic values into the educational process. Relays, team games and tournaments are organised in an accessible and interactive way. Table 1 shows a comparative analysis of the main types of school Olympic Games according to various criteria.

Table 1. Comparative analysis of types of school Olympic Games

Types of Olympic Games	Physical training	Involvement in mass sporting events
Short-distance running (60-100 metres)	Develops explosive speed, starting technique, and reaction to the signal	Used in school athletics competitions, "Fast Sprint" competitions
Middle-distance running (200-400 metres)	Improves cardiovascular endurance, leg strength and proper breathing	Participation in interclass and interschool cross-country competitions, "Spring Run"
Relay races	Contributes to the development of speed, coordination and baton passing skills	Organisation of class and school relays for Olympic Week
Long jump	Increases leg strength, range of motion and coordination during the run-up	Used in school athletics competitions and Olympic festivals
High jump	Develops leg strength, flexibility and jumping technique	Used in intra-school tournaments, Olympic days
Ball throwing	Develops hand strength, precision and coordination	Organisation of school competitions for accuracy and distance of throw, "Athletics Day"
Team games (football, basketball, volleyball)	Develops endurance, speed, strength, tactical thinking and teamwork	Holding tournaments between classes and schools, "Olympic Cup"
Comprehensive exercises for coordination and strength	Combine squats, push-ups, planks, balance exercises, and yoga elements.	Used in school sports holiday programmes, Olympic Health Day, and training complexes

Source: compiled by the authors based on the International Olympic Committee (n.d.)

Analysis of the table showed that different types of school Olympic Games combine various aspects of physical education and can be effectively integrated into the educational process to optimise mass sports activities. Short and medium distance running develops speed and endurance, relay races and team games improve coordination, endurance, team spirit and responsibility, long jump and high jump, ball throwing develop strength, accuracy, movement technique, and complex coordination and strength exercises stimulate self-discipline, attentiveness and progress in performance. The combination of these activities ensures the comprehensive development of students and involves a wide audience of schoolchildren in systematic participation in mass sporting events. In addition, adjusting the schedule of classes and sporting events in accordance with the rules of instruction ensures stable physical activity for students, prevents overexertion and reduces the risk of injury during exercise. This approach ensures even distribution of workload throughout the week, which contributes to the safe and effective

development of students' physical skills in the learning process. From the point of view of improving physical fitness and preventing injuries, comprehensive planning of sports activities is effective. The use of a structured schedule and adherence to instruction rules creates favourable conditions for the development of strength, endurance, flexibility and coordination, while at the same time forming safe exercise habits in students.

To systematise the work of teachers and students, ensure the safe and effective conduct of events, and promote the consistent development of students, it is recommended to use the algorithm for organising mass sporting events under the Olympic Education programme. It maintains high motivation to participate, can be used to assess progress, optimises the use of equipment and resources, and ensures the integration of Olympic values into the learning process. Table 2 illustrates a step-by-step algorithm for organising mass sporting events using elements of the Olympic Education programme, with detailed instructions, tools and sports equipment used for each stage.

Table 2. Algorithm for the step-by-step organisation of mass sporting events using elements of the Olympic Education programme

Stage	Steps	Tools	Sports equipment
Event planning	Define the goals and format of the event, select types of exercises and games, and consider safety and accessibility	Event plan, IOC methodological recommendations, schedule templates	–
Preparation of participants and teachers	Conduct training for teachers and students, familiarise them with the rules and safety procedures	Instructional materials, presentations, demonstration videos	–
Warm-up and introduction	A set of light aerobic and flexibility exercises, familiarise students with the technique	Methodological recommendations, value charts, and a timer	Balls, skipping ropes, cones, and stretching mats
Main part (exercises and games)	Performing planned exercises and games: short and medium distance running, relay races, long jump/high jump, ball throwing, team games, complex exercises for coordination and strength; compliance with safety rules	Event programme, instruction cards, timer, stopwatch	Balls, batons, dumbbells, cones, mats, and throwing balls
Final stage (assessment)	Evaluate the results of physical exercises, discuss achievements and difficulties, and summarise the results	Results protocols, standardised physical fitness tests	–

Note: IOC (International Olympic Committee)

Source: compiled by the authors based on research

In practice, the algorithm for organising mass sporting events under the Olympic Education programme should ensure systematic and consistent work for both students and physical education teachers. For students, it creates a clear structure for participation in various types of physical activity, encourages the priority on personal results and progress, and stimulates motivation through participation in competitions, relays, team games and complex exercises to develop coordination, strength, endurance and flexibility. Students can participate in short and medium distance running, relay races, long and high jumps, ball throwing, team games such as football, basketball or volleyball, as well as specially designed complex exercises to develop physical qualities and coordination. Each stage includes a warm-up with light cardio and flexibility exercises, a main part with planned exercises and games, and a final stage with evaluation of results. The algorithm involves regular repetition of activities with a gradual increase in the complexity and intensity of the load, which helps to avoid overload and injury and ensures noticeable progress in physical fitness.

For teachers, the algorithm is a methodological tool that helps them plan lessons, monitor the safety of exercises, assess students' achievements, and adjust the programme according to their level of preparation and individual needs. Teachers should conduct a briefing before the start of the event, familiarise students with safety rules, and organise compliance with the exercise regime, alternating types of activity and adapting loads for students with different levels of physical fitness. Motivational support, encouragement of teamwork and individual achievements are emphasised, which promotes a positive attitude towards physical activity and forms healthy habits. The algorithm can be used to allocate time and resources more effectively, optimise the use of sports equipment, monitor results, and foster a sense of achievement and success in students.

The algorithm also provides for various types of activities. Short and medium distance running can be organised in the form of class or interclass sprints and cross-country races, relays can be held with mutual team support, and

long jump and high jump can be held as individual or team competitions with technique and result assessment. Ball throwing can be used to develop accuracy and strength, and complex coordination and strength exercises can be conducted in the form of station training with alternating types of activity. Team games develop tactical thinking, interaction and leadership skills, and build team spirit. Each event should end with a summary, analysis of achievements and discussion of the experience gained.

For effective application of the algorithm, it is recommended to use available sports equipment such as balls, skipping ropes, cones, relay batons, stretching mats and minimal equipment for strength exercises. It is also necessary to ensure that the intensity of the load varies, to combine aerobic and strength exercises, and to integrate flexibility and coordination exercises into the warm-up and cool-down parts of the session. Teachers should regularly record students' results and use standardised physical fitness tests to assess progress, adjust the programme and maintain positive development dynamics. The assessment of students' physical development, motivation and participation in sports activities is interrelated, as the level of physical fitness directly affects the ability and desire to participate in various types of sports activities, while motivation determines the regularity and activity of participation, and systematic involvement in activities, in turn, stimulates the development of physical qualities and reinforces a positive attitude towards sport, creating a cyclical effect of mutual reinforcement of these components in the process of forming Olympic values. Thus, the algorithm works as a comprehensive tool that ensures structured, safe and effective organisation of mass sporting events, while providing educators with clear methodological guidelines for planning, conducting and evaluating results. An empirical study was conducted to evaluate the effectiveness of the described algorithm using elements of the Olympic Education programme. Table 3 shows the results of pre-intervention testing of the physical fitness of the experimental and control groups.

Table 3. Results of pre-intervention testing of students in the experimental and control groups

Indicator	Units of measurement	Experimental group (M ± SD)	Control group (M ± SD)
12-minute Cooper run	m	1,780 ± 210	1,805 ± 215
Push-ups in 1 minute	several times	20 ± 4	21 ± 5
“Sit-and-reach” test	cm	16 ± 4	17 ± 5
Shuttle run (10×5 m)	s	19.2 ± 2.3	19.0 ± 2.2
Class attendance	%	70	70

Source: compiled by the author based on a quasi-experimental study

Analysis of the pre-intervention test results showed that both groups of students had a relatively similar level of physical fitness, but the control group demonstrated slightly higher scores in some tests. The average distance in the 12-minute Cooper run in the experimental group was 1,780 m, while in the control group it was 1,805 m, which indicates slightly better cardiorespiratory endurance in the control group. The number of push-ups in 1 minute was 20 in the experimental group, and 21 in the control group, i.e. the upper body strength was almost the same, with a slight advantage for the control group. The sit-and-reach test for flexibility showed 16 cm in the experimental group and 17 cm in the control group, indicating a similar level of muscle elasticity and joint mobility. The shuttle run (10×5 m) results showed 19.2 seconds in the experimental group and 19.0 seconds in the control group, reflecting almost the same level of coordination and speed

abilities in both groups. Overall, these indicators show that the physical fitness of students in both groups was approximately the same, which created favourable conditions for an objective assessment of the programme’s impact on the further development of physical activity and sports skills. An experiment was conducted with classes based on an algorithm with elements of the Olympic Education programme, which included a warm-up, main and final parts aimed at increasing student motivation and activity. Post-intervention testing showed that the experimental group significantly improved their performance, while the control group showed only minor changes. Table 4 shows the average values of physical performance, class attendance and participation in mass sporting events of students in the experimental and control groups before and after the implementation of the Olympic Education programme.

Table 4. Results of assessment of students in the experimental and control groups before and after testing

Indicator	Units of measurement	Experimental group	Control group
12-minute Cooper run	m	2,070 ± 200	1,850 ± 210
Push-ups in 1 minute	times	30 ± 6	24 ± 5
“Sit-and-reach” test	cm	24 ± 5	19 ± 5
Shuttle run (10×5 m)	s	16.2 ± 1.8	18.5 ± 2.1
Class attendance	%	92	72

Source: compiled by the author based on a quasi-experimental study

Analysis of post-intervention results showed that students in the experimental group significantly improved their physical fitness in all indicators compared to the control group. The average distance for the 12-minute Cooper run in the experimental group was 2,070 ± 200 m, while in the control group it was 1,850 ± 210 m, indicating significantly higher cardiorespiratory endurance. The number of push-ups per minute in the experimental group reached 30 ± 6 times, in the control group 24 ± 5 times, demonstrating better upper body strength in the experimental group. The sit-and-reach test showed an average flexibility level of 24 ± 5 cm in the experimental group versus 19 ± 5 cm in the control group, indicating higher muscle elasticity and joint mobility. The shuttle run (10×5 m) results in the experimental group were 16.2 ± 1.8 seconds, in the control group – 18.5 ± 2.1 seconds, reflecting higher coordination and speed abilities of students who participated in the Olympic Education programme. Attendance among students in the experimental group was 92%, while in the control group it was 72%, indicating more active participation of the first group in the learning process. Overall, these data confirm the effectiveness of the gamified approach and the integration of game elements into physical education classes to improve the physical fitness and sports skills of

schoolchildren. Thus, after the programme was implemented, the experimental group demonstrated an improvement in all indicators of physical development, motivation and involvement in sports activities compared to the control group, which proves the effectiveness of “Olympic education” in promoting physical activity and Olympic values among secondary school students.

Discussion

The implementation of the Olympic programme contributes to the optimisation of mass sports activities in general secondary education institutions and increases the organisation of students to participate in extracurricular sports events. The growing interest and motivation for Olympic ideas, which is reflected in an increased number of class attendances and an expansion of the range of mass sporting events, indicates that pedagogical interventions based on Olympic values stimulate collective physical activity among schoolchildren. These results are consistent with the findings of a study by A. Abdrassilov *et al.* (2023), which confirmed that the proper organisation of sports education clusters increases the level of youth participation in collective forms of activity due to increased internal interest. The study demonstrated the importance of a pedagogical value

base for maintaining a sustained interest in physical education. The identified increase in the motivational component among schoolchildren corresponds to the conclusions of G. Alardani (2023), in which the quality of sports management in educational institutions influences the activation of sports initiatives among students. Proper organisation and value orientation of educational programmes create conditions for the formation of sustained interest in physical activity among students. The results reflect the position of V. Bilogur & R. Andriukaitiene (2021) and J.E. Yu (2022) that competent management of sports education in crisis conditions does not ensure a mechanical increase in the number of events, but rather the formation of an environment that supports sustainable physical activity practices among students. The data reproduce the trend described by J. Choi *et al.* (2025), where the historical evolution of elite sport has shown that the transmission of Olympic traditions contributes to the formation of generations of young athletes with a high level of sports culture. The improvement in children's participation in mass sports initiatives coincides with the research of X. Zhan *et al.* (2021) and P.H. Chowdary & P. Thapar (2025), determining that statistical analysis and sports technologies have an impact on the younger generation's growing interest in Olympic disciplines. Injuries negatively affect the physical development, academic performance and participation of students in sports activities, while the systematic organisation of the educational environment positively contributes to their prevention. This statement is consistent with the findings of M. Li *et al.* (2025), determining that the systematic organisation of the educational environment has a positive effect on the prevention of sports injuries among students. This proved that the combination of pedagogical control and Olympic principles of safe training contributes to the preservation of students' physical health.

A. Martín-Rodríguez & R. Madrigal-Cerezo (2025) and M. Whitehead (2020) demonstrated that Olympic values stimulate more active participation of students in classes and increase the effectiveness of motor skill acquisition. The study noted that student participation in classes was higher in the experimental group compared to the control group, which indicates more active involvement of the first group in the learning process and regular attendance at training sessions. This correlates with the findings of W. Ning *et al.* (2022), in which preparation for sporting events creates a lasting educational and cultural effect of increased public interest in sport. There is also consistency with the findings of M.J. Schmid *et al.* (2022), determining that early acquisition of sports social-value norms can shape sustainable life strategies. The results obtained corresponded to the observations of A.B. Tamayo *et al.* (2024) analysed the significance of Olympic values among schoolchildren in Chile and Argentina. Awareness and acceptance of Olympic principles stimulate social activity and positive interaction in sporting events, confirming the possibility of transmitting these values to young audiences in general secondary education institutions. The increase in the effectiveness of mass sports activities is reflected not only in the increased activity of students, but also in the more rational use of sports facilities and equipment. This effect is consistent with the findings of N. Atghia (2022), comparing the use of sports facilities at universities in Iran and Canada

and noted that the introduction of structured training programmes and systematic planning of sporting events contributes to the optimisation of resources and more effective engagement of participants. The integration of Olympic principles has made it possible to plan sports activities addressing the available equipment and infrastructure, ensuring an even distribution of use of sports halls and fields.

This correlated with the findings of H.M. Mason *et al.* (2024), who analysed the importance of instruction in conducting mass sporting events and noted that the adaptation of programmes depends on the positive outcome of this stage. Adjusting the schedule of classes and sporting events to incorporate the rules of instruction ensures stable student activity and reduces the risk of fatigue and injury. In terms of improving physical fitness and preventing injuries, the results confirm the effectiveness of a comprehensive approach to planning sports classes. According to the results of the 12-minute Cooper run, students in the experimental group covered an average of $2,070 \pm 200$ m, while the control group covered $1,850 \pm 210$ m. This indicates significantly higher cardiorespiratory endurance in students who participated in the Olympic Education programme, which is consistent with the findings of L. Ye & P. Di (2021) studied the regulation and control of injuries and fatigue in Winter Olympic athletes. The study established that a gradual increase in load, the use of various forms of physical activity and the alternation of sports increase students' motivation and contribute to the development of physical qualities. This approach coincides with the conclusions of Y. Zhou *et al.* (2021) and C. Xia & X. Lei (2023), who studied the optimisation of post-competition methods for high-level athletes and noted that variability and adaptation of loads increase the effectiveness of training and prevent overtraining. Students participating in structured cycles of sports activities demonstrate more consistent progress in physical fitness, confirming the advisability of gradually increasing activity levels.

Attendance in the experimental group increased to 92%, and participation in mass sporting events to 85%, indicating an increase in student motivation and engagement because of the programme. This is consistent with the findings of K. Tang (2023), determining that the organisation of mass sporting events under the Olympic Education programme ensures systematic and consistent work by teachers and students. The integration of sports equipment can improve the efficiency of tracking student participation in mass sporting events, planning team rotations, and optimising sports equipment use. The use of the algorithm ensures efficient allocation of time and resources, optimises sports equipment, monitors results and fosters a sense of achievement, success and high moral consciousness in schoolchildren. This result coincided with the conclusions of X. Xu *et al.* (2024) and A. Fengyingna *et al.* (2024), determining that regular repetition of activities with a gradual increase in the complexity and intensity of loads can mitigate overload and injury and ensuring progress in physical training. The results of post-intervention testing showed that improvements in physical fitness in the experimental group were statistically significant ($p < 0.05$) compared to the control group, in which the changes were insignificant. Thus, structured sports programmes increase the overall effectiveness of organising mass sporting events in

educational institutions. This contributes to the formation of a stable motivation for regular physical activity in students, the development of a sports culture and a responsible attitude towards personal health.

Conclusions

An analysis of the types of school Olympic Games demonstrated that each format has its own impact on students' physical fitness. Short and medium distance running helps improve speed, endurance and cardiovascular function. Relays and team games develop coordination, team spirit and responsibility for results. Jumping exercises and ball throwing contribute to the development of strength, physical exercise technique and self-discipline. Complex exercises integrate various motor skills and develop attentiveness and control of movements. The use of interactive and extracurricular formats increases student motivation and engagement, promotes the assimilation of Olympic values, and supports regular physical activity, ensuring the comprehensive development of schoolchildren.

Testing conducted after the programme's implementation showed that the experimental group significantly outperformed the control group in all physical fitness indicators: the average distance in the 12-minute Cooper run was $2,070 \pm 200$ m versus $1,850 \pm 210$ m, and push-ups in 1 minute were 30 ± 6 times versus 24 ± 5 . Flexibility in the sit-and-reach test in the experimental group reached 24 ± 5 cm, while in the control group it was 19 ± 5 cm, and the shuttle run (10×5 m) time was 16.2 ± 1.8 s compared to 18.5 ± 2.1 s.

These results indicate a higher level of cardiorespiratory endurance, strength, flexibility and coordination in students who participated in the Olympic Education programme.

The algorithm for organising mass sporting events under the Olympic Education programme ensures systematic and consistent work by teachers and students, creating a clear structure for participation in physical activity and the development of team skills. It involves planning the event, preparing participants, warming up with aerobic and flexibility exercises, the main part with running, relays, jumping, ball throwing and team games, as well as the final stage with evaluation of results and reflection. Following the algorithm increases motivation, promotes the development of physical qualities, and provides teachers with methodological support for monitoring the safety and effectiveness of events. The prospect for further research on the analysis of the effectiveness of using interactive digital platforms and mobile applications to increase motivation and systematic participation of students in mass sports events under the Olympic Education programme.

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Conflict of Interest

None.

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Оптимізація спортивно-масової діяльності та фізичної підготовки учнів 14-16 років засобами інтеграції елементів Олімпійського спорту

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Анотація. Метою дослідження було дослідити вплив інтеграції програми «Олімпійська освіта» в шкільні олімпійські ігри та спортивно-масові заходи на рівень фізичної підготовки та розвиток учнів. Методологія дослідження включала порівняльний аналіз, квазіекспериментальне дослідження на базі Переяславського ліцею ім. В. Мономаха та Переяславського академічного ліцею ім. І. Мазепи, за участю 168 учнів в період з лютого по травень 2024 року та формування алгоритму організації спортивно-масових заходів на основі елементів програми «Олімпійська освіта». Було досліджено, що кожен вид вправ по-різному впливає на розвиток фізичних якостей учнів. Реалізація програми «Олімпійська освіта» сприяє систематичному поєднанню уроків фізичної культури та позакласних спортивно-масових заходів, забезпечуючи комплексний розвиток школярів через інтеграцію навчання, рухової активності та ігрової діяльності. На початку експерименту фізична підготовка учнів експериментальної та контрольної груп була порівняно однаковою, з незначними відмінностями у показниках кардіореспіраторної витривалості, сили, гнучкості та координації. Після проведення занять за програмою «Олімпійська освіта» експериментальна група продемонструвала суттєве покращення всіх показників: середня дистанція за 12-хвилинним бігом Купера становила $2\,070 \pm 200$ м проти $1\,850 \pm 210$ м у контрольній групі, кількість віджимань за 1 хвилину зросла до 30 ± 6 разів проти 24 ± 5 , гнучкість за тестом «sit-and-reach» досягла 24 ± 5 см проти 19 ± 5 см, а час шатл-рану (10×5 м) склав 16.2 ± 1.8 с порівняно з 18.5 ± 2.1 с. Ці результати свідчать про значне підвищення кардіореспіраторної витривалості, сили, гнучкості та швидкості-координації учнів, які брали участь у гейміфікованих фізкультурних заняттях. Результати дослідження можуть використовувати вчителі фізичної культури та адміністрації шкіл для планування та впровадження програм «Олімпійська освіта», спрямованих на підвищення фізичної активності учнів.

Ключові слова: підлітки; рухова активність; спортивно-масова робота; ігри; фізична підготовка, заклади загальної середньої освіти



The role of fitness programmes in the prevention of cardiovascular diseases among pupils in general secondary education institutions

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Abstract. The aim of the study was to determine the impact of a school fitness programme on the functional indicators of the cardiovascular system of pupils in general secondary education institutions. The study was conducted at Uman Lyceum No. 3 (Ukraine) from 31 March to 25 May 2025 and involved the implementation of an eight-week fitness programme with sequential measurements of pupils' cardiovascular system indicators to assess its effectiveness. It was found that the resting heart rate decreased from 84.6 ± 6.8 to 76.1 ± 6.2 beats per minute (-10%), indicating an increase in parasympathetic regulation. Systolic pressure decreased from 114.2 ± 8.5 to 110.4 ± 7.9 mm Hg (-3.3%), and diastolic pressure decreased from 72.8 ± 6.9 to 70.2 ± 6.4 mm Hg (-3.6%), indicating a decrease in peripheral resistance. At the same time, stroke volume increased from 70.4 ± 12.2 to 78.5 ± 11.8 ml (+11.5%), reflecting an improvement in the pumping function of the heart. A significant decrease in integral indicators was observed: the Robinson index decreased from 96.0 to 83.6 conventional units (-13%), the Ruffier index decreased from 10.8 to 8.6 conventional units (-20.4%), the functional change index from 2.87 to 2.41 conventional units (-16%) and the endurance coefficient from 20.7 to 17.4 conventional units (-15.9%) – indicated an increase in adaptive reserves and the effectiveness of cardiovascular system regulation. The data obtained confirmed that the eight-week fitness programme ensured the formation of stable aerobic adaptation, improvement of frequency and haemodynamic parameters, and an increase in cardiorespiratory reserves, which reduces the risk of early cardiovascular disorders. The results can be used by physical education teachers, school medical workers, and physical therapy specialists to develop and implement effective fitness programmes aimed at strengthening the cardiovascular health of children and adolescents in educational institutions

Keywords: cardiorespiratory adaptations; endurance; haemodynamic parameters; blood pressure; aerobic performance; adolescents; secondary school

Introduction

The incidence of cardiovascular disorders in the paediatric population shows a steady upward trend, which is associated with a decrease in daily physical activity and an increase in the prevalence of risk factors such as excess weight, high blood pressure and low exercise tolerance. According to the World Health Organization (2024), 81% of adolescents aged 11-17 do not meet the recommended level of daily physical activity (60 minutes of moderate or vigorous physical activity every day), which hinders the

formation of stable adaptive responses of the cardiovascular system. The school environment is a key space for systematising physical activity, so insufficient attention to the implementation of targeted physical training programmes can contribute to a deterioration in functional indicators, an increase in cardiometabolic risks and the progression of early vascular changes.

Organised forms of physical activity in the school environment play an important role in the development of

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cardiorespiratory adaptations in children and adolescents. A randomised study conducted by C. Meng *et al.* (2022) found improvements in body composition and cardiorespiratory endurance after the introduction of a school programme of high-intensity interval training. In addition, a reduction in cardiometabolic markers in obese adolescents was demonstrated. An analysis of the impact of increased physical activity in the school environment conducted by T. Jagomast *et al.* (2023) showed a significant improvement in endothelial function and an increase in the physical performance of students. The scientists recorded positive dynamics in cognitive indicators, which is consistent with the strengthening of cardiovascular regulation mechanisms. According to D.V. Dychko *et al.* (2025), the effectiveness of a health-improving exercise complex for adolescents was confirmed by an improvement in haemodynamic parameters. In addition, the authors showed an increase in exercise tolerance. In children living in war conditions, after participating in a fitness programme, a decrease in heart rate (HR) and an improvement in overall physical condition were recorded, as shown in a study by A. Hakman *et al.* (2025). The authors noted the normalisation of a number of functional indicators of the cardiovascular system (CVS), confirming its positive adaptive response to training.

Intervention programmes within school physical education are considered a tool for preventing early vascular dysfunction in the paediatric population. A systematic review conducted by S.E. Neil-Sztramko *et al.* (2021) demonstrated an increase in physical activity levels and improved cardiorespiratory performance among students. The researchers recorded consistent positive effects in terms of improving overall physical fitness. The effectiveness of a randomised school exercise programme, demonstrated by S. Ketelhut *et al.* (2020), confirms that a targeted increase in physical activity at school contributes to lower blood pressure and improved vascular elasticity, reflecting an increase in exercise tolerance. Ukrainian scientific material confirms the effectiveness of multicomponent physiotherapy programmes, with V.E. Pyurko & S.M. Kazakova (2020) showing improvements in systemic signs of cardiovascular regulation in schoolchildren. The study proved the impact of comprehensive training approaches on the functional reserves of the body. Programmes aimed at students with cardiorespiratory disorders showed an increase in functional and adaptive indicators. In addition, the effectiveness of the comprehensive application of multidirectional physical training methods was confirmed.

A comprehensive assessment of the functional state of the cardiovascular system in schoolchildren allows to establish links between physical development, motor activity, and the risk of vascular disorders. A study of Ukrainian schoolchildren conducted by S. Kots *et al.* (2022) revealed abnormalities in heart rate and heart rate variability in children aged 11-12 years. A correlation between functional parameters and physical fitness was also found. Additional data on the circulatory characteristics of school-age pupils, provided by S. Kots & V. Kots (2023), demonstrated the variability of cardiovascular regulation depending on somatic characteristics, which emphasises the role of physical activity in stabilising haemodynamic reactions. In a scientific paper prepared by V. Ivanochko *et al.* (2024), a positive effect of differentiated physical training methods on the

functional indicators of the cardiovascular system of female students aged 17-22 was recorded, which indicates the effectiveness of using multidirectional training approaches to improve the body's adaptive capabilities.

It should be noted that previous studies have not sufficiently revealed the impact of structured fitness programmes in the school environment on complex indicators of cardiovascular system functioning, focusing mainly on individual physiological parameters or short-term interventions. The aim of the study was to evaluate the effectiveness of a school fitness programme in improving the functional parameters of the cardiovascular system of learners. The objectives of the study were to develop a structured fitness programme for the school environment; to determine the baseline state of cardiorespiratory and haemodynamic indicators; to analyse changes in these parameters under the influence of the programme; and to establish relationships between the level of physical fitness and the dynamics of cardiovascular responses.

Materials and Methods

The study was organised as a quasi-experimental design with repeated measurements, which made it possible to trace the dynamics of pupils' cardiovascular system functional indicators under the influence of a structured fitness programme. The study was conducted at Uman Lyceum No. 3 (Uman, Cherkasy region), which provided the necessary conditions for the implementation of the fitness programme, screening measurements and repeated functional assessments. The educational institution has adequate sports infrastructure, including a sports hall, equipped playgrounds and the possibility of organising group classes within the framework of physical education lessons. The research stage lasted from 31 March to 25 May 2025, which was eight full weeks without breaks for holidays. The choice of this time and organisational interval was dictated by the need to ensure the continuity of the training process, minimise the impact of external educational and seasonal fluctuations, and allow sufficient time for the manifestation of primary cardiorespiratory and haemodynamic adaptations in school-age youth.

The study involved pupils from a general secondary school who were in grades 7-8. The total sample consisted of 42 pupils, including 21 boys (50.0%) and 21 girls (50.0%). The age range of the respondents was 12-14 years, with an average age of 13.1 ± 0.6 years. The choice of this age group was justified by the fact that this period is characterised by intensive formation of the cardiorespiratory system, which increases sensitivity to training influences; accordingly, it is at this age that changes in haemodynamic parameters and exercise tolerance are most pronounced (Meng *et al.*, 2022; Jagomast *et al.*, 2023). In addition, pupils in grades 7-8 are characterised by stable attendance and a sufficient level of physical fitness, which ensured the possibility of implementing a comprehensive eight-week fitness programme. The sample was formed using a special selection method, as all pupils from two parallel classes who met the medical and organisational criteria were involved. Information about participation was provided by class teachers and physical education teachers, who explained the structure, purpose and conditions of the study at parent-teacher meetings and class hours, after which parents provided written informed

consent. The subjects were recruited directly at the educational institution, where students received explanations about the measurement procedure and participation in the fitness programme. The sample included pupils who belonged to the appropriate age group, had no contraindications to physical exercise, regularly attended physical education classes and were able to perform the proposed exercises. Children with acute or chronic diseases in the acute stage, cardiovascular pathologies that limit physical activity, orthopaedic limitations, a significant number of absences, or unwillingness to participate in the experiment were not included. Throughout the research period, the sample remained complete, and no participants were excluded before the end of the eight-week programme and final measurements.

No gender comparison was made, as the analysis was performed for a combined sample of pupils regardless of gender. The level of physical fitness of the participants at the time of inclusion in the study was heterogeneous: 12 pupils (28.6%) regularly attended sports clubs, the most common of which were football, volleyball and athletics. The remaining 30 pupils (71.4%) were limited to

physical education classes and did not participate in additional training sessions. This difference in baseline physical activity was taken into account when planning the physical load, as the fitness programme provided for a universal basic level of intensity with the possibility of individual regulation of the pace and amplitude of movements. Further analysis was based on average values, which ensured a comprehensive reflection of the physiological characteristics of the group, regardless of the different levels of fitness of individual participants.

Description of the fitness program. The fitness program was developed taking into account the age and functional characteristics of students aged 12-14 and included a combination of aerobic, strength, coordination, and functional exercises aimed at developing cardiorespiratory adaptations. Classes were held three times a week as part of physical education lessons, with each lesson lasting 40-45 minutes. Each class included three structural components: preparatory, main, and final parts. A detailed description of the fitness program, including a list of exercises, their duration, mode of execution, and necessary equipment, is provided in Table 1.

Table 1. Structure of the fitness programme

Exercise content	Duration	Intensity / repetitions	Equipment
Warm-up section			
Jogging; walking with changes in pace; arm and leg swings; coordination exercises; mobilisation of the shoulder and hip joints	7-8 min	Moderate intensity, with a gradual increase in heart rate	No equipment
Main section (circuit training)			
A complex of 8-10 stations; a combination of strength, aerobic, and coordination exercises	28-32 min	30-40 seconds of work / 20-25 seconds of rest, 3 circuits	Mats, elastic bands, markers, gym benches
Squats (standard or with reduced range of motion for easier performance)	30-40 s	Steady pace	No equipment
Forward / backward lunges	30-40 s	Alternating legs	No equipment
Press-ups (full or with support on a bench)	30-40 s	8-15 repetitions depending on the level of physical fitness	Floor / bench
"Plank" (classic or knee-supported modification)	30-40 s	Static hold	Exercise mat
"Burpee" (full or simplified version)	30-40 s	Continuous execution	No equipment
Jumping jacks	30-40 s	Moderate pace	No equipment
Running on the spot with high knee lift	30-40 s	Maintenance of technique and pace	No equipment
Coordination exercises (stepping over markers, work on a coordination "ladder")	30-40 s	High pace with an emphasis on accuracy	Markers / coordination "ladder"
Concluding part			
Breathing exercises; static stretching of the main muscle groups (quadriceps, hamstrings, calf muscles, pectoral muscles)	4-5 min	Low intensity	Mats
Individual modifications			
Easier squats; press-ups with support; plank on the knees; reduced pace of aerobic exercises	-	As required by the pupils	Benches, mats

Source: made by the authors

The training load design strategy involved a gradual increase in intensity: during the first two weeks, emphasis was placed on technique and a moderate pace; in weeks 3-5, execution speed increased and rest intervals were shortened; and in weeks 6-8, alternating high and moderate intensities was applied to stimulate both aerobic and anaerobic components of endurance. Individualisation of the load was implemented in cases where pupils demonstrated lower tolerance to physical activity. Adjustments were made according to the pupils' capabilities and under continuous supervision by the teacher.

The programme was delivered by a physical education teacher at Uman Lyceum No. 3, who monitored correct technique, exercise safety, adherence to prescribed intensity and rest intervals, as well as the pupils' functional status. All pupils had free access to room-temperature drinking water in individual bottles and were allowed to drink according to personal need during the session, which supported hydration and helped prevent fatigue. Classes were conducted in the lyceum sports hall, ensuring appropriate sanitary, hygienic, and safety conditions for implementation of the fitness programme.

The functional state of the pupils' cardiovascular system was assessed in a comprehensive format, recording parameters at rest, during training sessions, and under conditions of cognitive load. All measurements were taken in the sports hall of Uman Lyceum No. 3 and in the school's medical office by the physical education teacher and the school nurse. Before each procedure, pupils underwent a ten-minute adaptation to a resting state. Comprehensive testing was performed three times: before the start of the program (week 0), during the intermediate period (week 4), and after the completion of the program (week 8). All recorded values of functional indicators within each measurement point were averaged after two consecutive measurements to minimise random error. At the same time, the heart rate indicators during training loads were recorded at each session, after which the average daily values for weekly dynamics were calculated and included in the analysis at the corresponding control points. Blood pressure (BP) was determined using the Korotkoff method with a mechanical tonometer AND UA-200 (Japan). Measurements were taken in a sitting position twice at two-minute intervals. Pulse pressure was calculated based on systolic blood pressure and diastolic blood pressure:

$$PP = BP_{max} - BP_{min}, \quad (1)$$

where PP – pulse pressure; BP_{max} – systolic blood pressure; BP_{min} – diastolic blood pressure. Heart rate was recorded using a Beurer PM 25 heart rate monitor (Germany) or by palpation of the radial artery. Based on heart rate and blood pressure values, the Robinson index was determined, which characterises the level of strain on the cardiovascular system:

$$RI = \frac{HR \times BP_{max}}{100}, \quad (2)$$

where RI – Robinson index; HR – heart rate; BP_{max} – systolic blood pressure. Functional reserves were assessed using the Ruffier test, which involved three measurements of heart rate: at rest, immediately after performing squats, and after one minute of recovery. The Ruffier index was calculated using the formula:

$$RI = \frac{4 \times (P1 + P2 + P3) - 200}{10}, \quad (3)$$

where RI – Ruffier index; $P1$ – heart rate at rest; $P2$ – heart rate immediately after exercise; $P3$ – heart rate after one minute of recovery; 200 – normative correction (integral threshold of the sum of heart rate values). In addition, the functional changes index (FCI) was determined, which integrates heart rate, blood pressure, and anthropometric characteristics, as well as the adaptive potential of the cardiovascular system, which characterises the effectiveness of regulatory mechanisms. The endurance coefficient was calculated using Kvas's formula:

$$EC = \frac{HR \times 100}{BP_{max} - BP_{min}}, \quad (4)$$

where EC – endurance coefficient; HR – heart rate during recovery (after 1 or 2 minutes following exercise); BP_{max} and BP_{min} – blood pressure values. Stroke volume (SV) was determined using an empirical formula recommended for the adolescent age group:

$$SV = PP \times 1.7, \quad (5)$$

where SV – systolic (stroke) blood volume, ml; PP – pulse pressure, mmHg; 1.7 – empirical age-related coefficient. Based on the calculated SV value, cardiac output (CO) was determined using the formula:

$$CO = SV \times HR, \quad (6)$$

where CO – cardiac output, ml/min; SV – stroke volume, ml; HR – heart rate per minute. The SV and CO indicators reflected the efficiency of the heart's pumping function and the dynamics of haemodynamic adaptations in response to physical exercise. Cardiac activity indicators during training sessions were recorded using Xiaomi Mi Band 7 (China) fitness bracelets equipped with an optical photoplethysmography sensor. HR was recorded at the fifth, fifteenth and final minutes of the main part of the training session, as well as one minute after the completion of the exercises using the circuit training method to assess the speed of recovery. The indicators were recorded by the physical education teacher, who read the information from the bracelet screens and entered it into the control observation protocols. The combination of all these indicators provided a comprehensive assessment of the functional state of the pupils' cardiovascular system, covering haemodynamic parameters, adaptive reserves and the immediate physiological response to exercise.

For the correct interpretation of the data obtained, generally accepted age standards for adolescents aged 12-14 were used. The normal range of heart rate at rest is 60-100 beats per minute, depending on the level of physical activity, while the optimal blood pressure values are 105-125 mmHg for BP_{max} and 65-80 mm Hg for BP_{min} . Pulse pressure is usually within the range of 30-50 mmHg. The Robinson index in this age group corresponds to the functional optimum at values of 70-90 conventional units, and the Ruffier index assesses functional reserves as good at values < 6 conventional units, average at 6-10, and satisfactory at 10-15. For the functional change index, values of 2.0-2.5 are considered optimal, and 2.6-3.0 are considered borderline. The endurance coefficient is favourable at values <17 conventional units, average at 17-20, and reduced at >20. The norm for systolic blood volume is 65-90 ml, and for cardiac output – 4.5-6.5 l/min, which corresponds to the typical limits of age-related cardiorespiratory performance.

Statistical data processing. Statistical data processing was performed using IBM SPSS Statistics 29.0 software. Descriptive statistics were presented as mean and standard deviation ($M \pm SD$). The dynamics of indicators at three control points (at 0, 4, and 8 weeks) were assessed using repeated measures analysis of variance (Repeated Measures ANOVA) or the Friedman test for abnormal distribution. Paired comparisons between stages were performed using Student's t test for dependent samples or Wilcoxon's test. In addition to the absolute values of the indicators, the results also included the relative change (Δ), which was defined as the difference between the values at weeks 8 and 0, expressed as a percentage of the baseline level. This indicator allowed for a quantitative assessment of the intensity of the training effect and ensured the comparability of changes

between different physiological parameters. Correlation analysis was performed using Pearson's or Spearman's coefficients, depending on the nature of the distribution. The level of statistical significance was set at $p < 0.05$.

The study complied with ethical standards for working with minors and was conducted in accordance with the European Commission's Guidelines on Ethics and Data Protection (European Commission, 2021) and the ICC/ESOMAR International Code of Market, Public and Social Research (2025). The study was approved by the administration of Uman Lyceum No. 3. The participation of pupils was voluntary and confirmed by the written informed consent of their parents, who received the necessary information about the content of the programme, the workload and the procedure for processing personal data. During the study, safety measures, pedagogical and medical supervision were provided, and all personal and physiological

data were stored in an anonymised form on secure media in accordance with European requirements for ethics and confidentiality. Pupils had the right to withdraw from participation at any time without any consequences for the educational process.

Results

Baseline indicators of the functional state of the cardiovascular system of pupils

The baseline cardiovascular indicators of the pupils demonstrated a combination of normative haemodynamic values and markers of insufficient training, which is typical of adolescents with irregular physical activity. The integral and calculated indices obtained using formulas (1-6) reflected moderate myocardial strain, low efficiency of heart rate regulation, and a borderline level of functional reserves. The summarised results are presented in Table 2.

Table 2. Baseline indicators of the functional state of the cardiovascular system of pupils ($n = 42$)

Indicator	$M \pm SD$	Interpretation relative to normative values
HR, beats/min	84.6 \pm 6.8	within the normal range
BP _{max} , mmHg	114.2 \pm 8.5	within the normal range
BP _{min} , mmHg	72.8 \pm 6.9	within the normal range
PP, mmHg	41.4 \pm 7.2	within the normal range
Robinson index, conventional units	96.0 \pm 11.3	increased myocardial strain
Ruffier index, conventional units	10.8 \pm 1.9	borderline level of reserves
Functional changes index, conventional units	2.87 \pm 0.41	borderline level of adaptation
EC, conventional units	20.7 \pm 3.9	lower endurance (values above the normative range)
SV, ml	70.4 \pm 12.2	lower limit of the normal range
Cardiac output, ml/min	5,948 \pm 1,010	within the normal range, high variability

Source: compiled by the authors

The obtained results indicate that the baseline physiological state of the pupils' cardiovascular system corresponded to age-related norms in terms of the main hemodynamic indicators; however, it was characterised by a number of markers of insufficient training. This is typical for children aged 12-14 years who do not participate in regular sports activities and receive only standard physical load within the school curriculum. The first indicator of cardiovascular system fitness is resting heart rate. The mean heart rate value was 84.6 \pm 6.8 beats per minute, which corresponds to the age norm. Such values are most often observed in schoolchildren with a reduced level of aerobic fitness, when the cardiac muscle works less economically and the activity of the sympathetic division of the autonomic nervous system predominates over the parasympathetic one. In sports physiology, such characteristics are considered a potential prerequisite for a pronounced training effect, since regular exercise leads to a reduction in resting heart rate and an increase in heart rate variability (Meng *et al.*, 2022). Blood pressure indicators demonstrated the absence of hypertensive or hypotensive deviations in the group: the mean systolic blood pressure value was 114.2 \pm 8.5 mmHg, and diastolic blood pressure was 72.8 \pm 6.9 mmHg. These data are consistent with age-related norms; however, significant variability in diastolic pressure may indicate different degrees of structural maturity of the vascular bed, which is characteristic of adolescents during a period of intensive somatic growth. Pulse pressure (41.4 \pm 7.2 mmHg) was within the physiological norm and indicated preserved

elasticity of the arterial wall. However, variability was also substantial in this parameter, which points to heterogeneity of vascular reactivity within the studied cohort.

A deeper characterisation of cardiac hemodynamics is provided by the Robinson index, which reflects the level of myocardial tension at rest. Its values (96.0 \pm 11.3 conventional units) exceeded the optimal range, indicating increased functional load on the heart even in the absence of physical exertion. Such values are typical for children with low aerobic endurance or increased psycho-emotional stress, which may also cause activation of the sympathetic nervous system. The Ruffier index (10.8 \pm 1.9 conventional units), which assesses the ability of the cardiovascular system to adapt to physical load and recover after it, corresponded to a borderline level. This means that adaptive reserves in most pupils were average or below average. These trends are further confirmed by the Functional Changes Index (2.87 \pm 0.41 conventional units), the values of which are characteristic of insufficiently trained children and indicate a reduced level of regulatory capabilities of the cardiovascular system.

The endurance coefficient (20.7 \pm 3.9 conventional units) was also higher than optimal. Since, according to the Kvas method, higher endurance coefficient values indicate lower endurance, these results point to insufficient physical capacity of the pupils. In physical education and sports practice, this is considered an important argument for the appropriateness of using programmes aimed at developing general endurance. Indicators of the

heart's pumping function – systolic and cardiac output – complement the overall characterisation of physiological status. SV (70.4 ± 12.2 ml) was at the lower limit of the age norm, indicating relatively low contractile strength of the left ventricle. Cardiac output ($5,948 \pm 1,010$ ml/min), although within the normal range, demonstrated substantial variability, which indicates differences in aerobic potential among pupils.

Since the analysis was performed on the basis of arithmetic mean values of functional indicators obtained from the entire sample of pupils, the identified profile of the baseline state of the cardiovascular system reflected a general tendency toward insufficient training, typical of adolescents with a predominantly sedentary lifestyle. Despite individual differences in the level of daily physical activity, the integrated mean values indicated a combination of normative blood pressure and cardiac output parameters with borderline and strained adaptation indicators, specifically elevated heart rate, a high Robinson index, a borderline Ruffier index, lower stroke volume, and an increased endurance coefficient. Such an averaged physiological profile

confirmed an insufficient level of cardiorespiratory fitness and limited reserve capacities of the cardiovascular system, which created prerequisites for the formation of pronounced positive adaptive changes under the influence of a structured fitness programme.

Changes in indicators at the fourth week of fitness programme implementation

The interim assessment of the functional state of the pupils' cardiovascular system at the fourth week of the fitness programme made it possible to identify early training adaptations that develop in response to systematic physical loads. The first four weeks represent a period of initial physiological restructuring, during which neurohumoral mechanisms are normalised, myocardial strain is reduced, and vascular tone improves (Baumgartner *et al.*, 2020). As the analysis was based on averaged group values, the results presented in Table 3 reflect the integral response of the pupils' cardiovascular system to the physical training programme. The calculated parameters were determined using formulas (1-6).

Table 3. Cardiovascular system indicators at the fourth week of the experiment ($n = 42$)

Indicator	Week 4 ($M \pm SD$)	Change from baseline
HR, beats/min	80.2 ± 6.1	↓ 5.2%
BPmax, mmHg	112.5 ± 8.1	↓ 1.7 mmHg
BPmin, mmHg	71.5 ± 6.4	↓ 1.3 mmHg
PP, mmHg	41.0 ± 7.0	↓ 0.4 mmHg
Robinson index, conventional units	89.9 ± 10.2	↓ 6.4%
Ruffier index, conventional units	9.5 ± 1.7	↓ 12.0%
Functional changes index, conventional units	2.65 ± 0.38	↓ 7.7%
EC, conventional units	19.1 ± 3.4	↓ 7.7%
SV, ml	74.2 ± 11.5	↑ 5.4%
Cardiac output, ml/min	$5,940 \pm 998$	↓ 0.1%

Source: compiled by the authors

Interim results indicate the formation of early positive adaptations of the cardiovascular system in response to regular fitness training. The most noticeable change was in resting heart rate, which decreased from 84.6 to 80.2 beats per minute ($p < 0.05$). A 5.2% decrease in HR indicates increased vagal control and decreased basal sympathetic influence, which is a marker of improved cardiac efficiency. In pedagogical physiology, this change is one of the most sensitive indicators of early training adaptation, since HR is the first to respond to systematic aerobic exercise. Blood pressure indicators changed less significantly, which corresponds to the typical physiological response of adolescents during training. Systolic pressure decreased to 112.5 ± 8.1 mm Hg ($p < 0.05$), indicating a decrease in peripheral vascular resistance and improved elasticity of the arterial bed. Diastolic pressure showed a slight, statistically insignificant decrease ($p > 0.05$), which is typical for the initial phase of adaptation, when central haemodynamic mechanisms change faster than peripheral ones. Pulse pressure remained stable (41.0 mm Hg), indicating no significant changes in vascular stiffness and stroke volume at this stage of the programme. This was expected, as structural changes in the arterial wall and significant changes in stroke volume are mainly formed after 6-10 weeks of training.

A decrease in the Robinson index to 89.9 ± 10.2 conventional units ($p < 0.05$) reflected a reduction in myocardial tension and a decrease in the heart's oxygen demand at rest. This reaction is critically important for pupils with borderline or elevated baseline Robinson index values, as it reflects the transition of the cardiovascular system to a more economical mode of functioning. The decrease in the Ruffier index was particularly pronounced, from 10.8 to 9.5 conventional units ($p < 0.01$). The Ruffier index is one of the indicators of adaptation to physical activity, as it integrates three HR values: before exercise, immediately after exercise, and after one minute of recovery. An improvement in Ruffier index indicates faster heart rate recovery, increased myocardial contractility, and reduced metabolic stress. In fact, it is one of the most important markers of endurance progress in school age. A decrease in the functional change index to 2.65 ± 0.38 cond. units ($p < 0.05$) reflects the improvement of the regulatory mechanisms of the cardiovascular system and improved adaptation to physical activity. The FCI responds to training more slowly than the HR or Robinson index, so its early changes indicate a high potential for further positive adaptations.

The endurance coefficient decreased from 20.7 to 19.1 conventional units ($p < 0.05$), indicating an improvement in the body's aerobic capacity. According to Kvas's

methodology, lower EC values are a sign of more efficient heart function during physical activity. This emphasises that even during the first four weeks of the programme, significant improvements in recovery speed and overall resistance to exercise were observed. The indicators of the heart's pumping function showed positive trends: systolic blood volume increased by 5.4% ($p < 0.05$), which means an increase in the force of heart contractions. Minute blood volume remained virtually unchanged ($p > 0.05$), due to the compensatory relationship between SV and HR: the decrease in heart rate was compensated by an increase in stroke volume. This mechanism is characteristic of the economisation of heart activity during the early phases of aerobic adaptation.

Summarising the results, it can be noted that the fourth week was a stage of formation of early stable adaptations of the cardiovascular system. The decrease in HR and Robinson's index reflected a decrease in myocardial tension and an increase in the efficiency of cardiac activity, while the improvement in the Ruffier index and endurance coefficient indicated a strengthening of functional reserves and faster recovery after exercise. The increase in stroke volume demonstrated an improvement in the efficiency of the heart's pumping function, and stable blood pressure and pulse pressure readings confirmed a balanced vascular response. Taken together, these changes indicate that by the fourth week, the pupils' bodies had transitioned to a more economical

and coordinated cardiovascular system, laying the foundation for further progress in the final stage of the programme.

Final dynamics of indicators after the eighth week

The final stage of the eight-week fitness programme demonstrated the most pronounced adaptive changes in the functioning of the pupils' cardiovascular system, indicating a transition from the stage of initial responses to a phase of structured and stable physiological adaptation. Analysis of the final indicators made it possible to assess the magnitude of the training effect, the sequence of changes, and their functional significance. All presented results reflect averaged sample values (calculated using formulas (1-6)) and include a statistical comparison between the baseline stage (week 0) and the completion of the programme (week 8) (Table 4). For an in-depth interpretation of the overall trajectory of cardiovascular system adaptations, key integral indicators of fitness – resting heart rate, Robinson index, and Ruffier index – were graphically represented at three control points (0, 4, and 8 weeks). The combined presentation of these three indicators allows for a comprehensive assessment of changes in autonomic regulation, myocardial economy, and recovery capacity. The graphical dynamics allow for a visual comparison of the speed and direction of changes, which were mathematically confirmed by statistical analysis ($p < 0.001$) (Fig. 1).

Table 4. Final dynamics of cardiovascular system indicators after eight weeks of the programme ($n = 42$)

Indicator	Week 0 $M \pm SD$	Week 8 $M \pm SD$	Δ change (%)	p
HR, beats/min	84.6 \pm 6.8	76.1 \pm 6.2	-10.0%	< 0.001
BPmax, mmHg	114.2 \pm 8.5	110.4 \pm 7.9	-3.3%	= 0.041
BPmin, mmHg	72.8 \pm 6.9	70.2 \pm 6.4	-3.6%	= 0.038
PP, mmHg	41.4 \pm 7.2	40.2 \pm 6.8	-2.9%	= 0.112
Robinson index, conventional units	96.0 \pm 11.3	83.6 \pm 10.4	-13.0%	< 0.001
Ruffier index, conventional units	10.8 \pm 1.9	8.6 \pm 1.5	-20.4%	< 0.001
Functional changes index, conventional units	2.87 \pm 0.41	2.41 \pm 0.38	-16.0%	< 0.001
EC, conventional units	20.7 \pm 3.9	17.4 \pm 3.3	-15.9%	< 0.001
SV, ml	70.4 \pm 12.2	78.5 \pm 11.8	+11.5%	< 0.001
Cardiac output, ml/min	5,948 \pm 1,010	5,975 \pm 980	+0.5%	= 0.612

Source: compiled by the authors

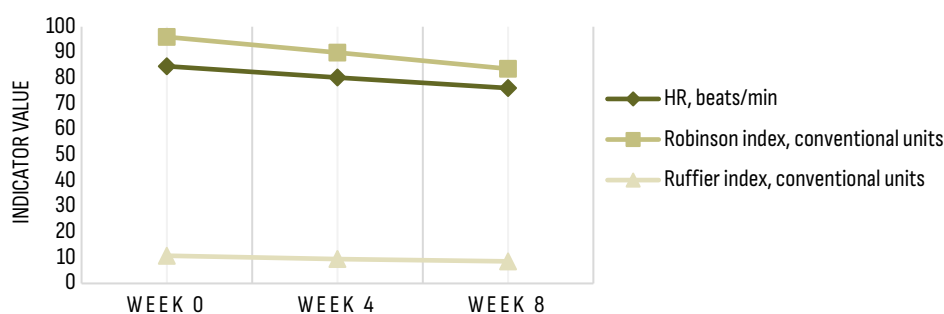


Figure 1. Dynamics of heart rate, the Robinson index, and the Ruffier index

Source: created by the authors based on the received data

Figure 1 shows a consistent and pronounced decrease in all three indicators over the eight-week period. The heart rate curve demonstrates a steady reduction from 84.6 to 76.1 beats per minute, reflecting the development of a more economical mode of cardiac function and enhanced

parasympathetic regulation. The parallel decrease in the Robinson index (-13%) confirms a reduction in myocardial strain and an increase in stroke volume. The most rapid dynamics are observed for the Ruffier index (-20.4%), indicating improved recovery capacity and adaptation to

physical load. Taken together, these changes indicate that the cardiovascular system shifted to a more efficient mode of functioning, characteristic of the development of stable aerobic adaptation. As haemodynamic parameters are among the most sensitive markers of adaptation to physical exercise, a graphical comparison of systolic blood

pressure, diastolic blood pressure, and pulse pressure was performed across three time points. This comprehensive presentation makes it possible to assess not only changes in pressure values but also their interaction, including the degree of peripheral resistance, vascular wall stability, and arterial elasticity (Fig. 2).

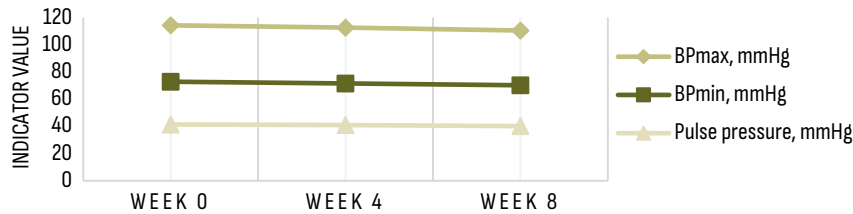


Figure 2. Dynamics of BP_{max}, BP_{min}, and pulse pressure

Source: created by the authors

The graphical data demonstrate a gradual decrease in BP_{max} and BP_{min}, indicating an improvement in vascular tone and optimisation of haemodynamics. A moderate reduction in systolic blood pressure (-3.3%) and diastolic blood pressure (-3.6%) reflects a decrease in total peripheral resistance, which is characteristic of pupils who begin to engage in regular physical exercise. Pulse pressure, by contrast, remains stable, confirming the absence of excessive load on the arterial wall and normal vascular elasticity.

Such stability is an important indicator of safe adaptation to training loads in adolescents. To assess the efficiency of cardiac output and the heart's ability to maintain an adequate level of systemic perfusion, a graphical comparison of stroke volume, cardiac output, and the endurance coefficient was performed. The combination of these indicators within Figure 3 makes it possible to identify the relationship between stroke volume, heart rate, and the overall efficiency of the myocardium's pumping function.

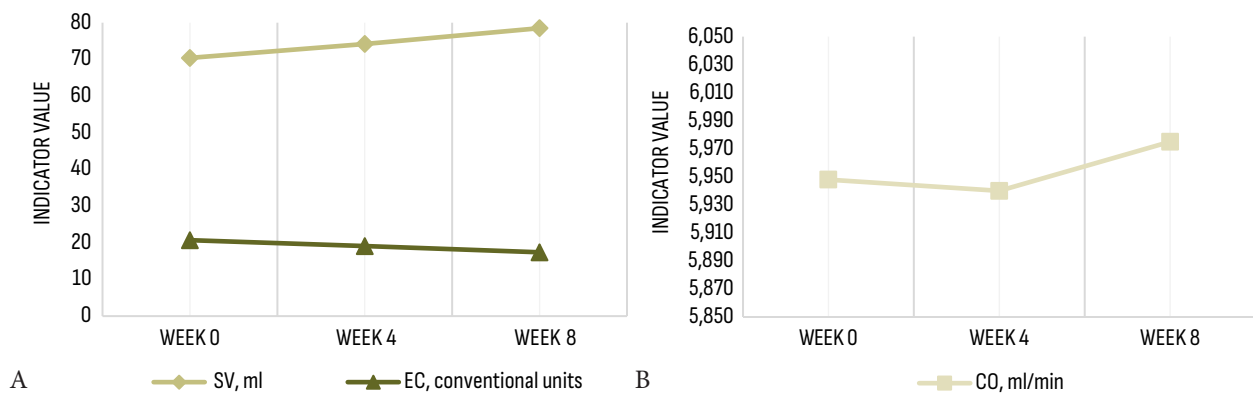


Figure 3. Dynamics of stroke volume, endurance coefficient (A), and cardiac output (B)

Source: created by the authors

In Figure 3, it is clearly evident that stroke volume increased progressively (+11.5%), reflecting an enhancement of myocardial contractile capacity and improved peripheral circulation. Cardiac output remained relatively stable, as the increase in stroke volume compensated for the decrease in heart rate, which represents a typical mechanism of an adapted cardiovascular system. At the same time, the reduction in the endurance coefficient (-15.9%) indicates an increase in aerobic efficiency and a more economical functioning of the heart, resulting from systematic training exposure.

The dynamics of physiological indicators over the eight-week period convincingly confirmed the presence of a pronounced training effect. A consistent decrease in frequency-based and integrated indicators (HR, Robinson index, Ruffier index, FCI, and EC), alongside a simultaneous increase in stroke volume, indicated a gradual

strengthening of parasympathetic regulation, economisation of myocardial activity, and improvement in recovery processes. Reduced cardiovascular strain, enhanced recovery capacity, and improved aerobic performance reflect the classical physiological mechanism of adaptation to regular training loads during adolescence. Importantly, even integral regulatory indices, which typically change more slowly, demonstrated statistically significant improvements, confirming the stability and sufficient intensity of the training stimulus provided by the school-based fitness programme. The combination of these adaptive changes indicates not only an increase in current functional capacity but also the development of a preventive potential with respect to reducing the risk of future cardiovascular diseases, including primary arterial hypertension, early forms of endothelial dysfunction, and disturbances of autonomic regulation of heart rhythm.

In summary, the final data indicate that the eight-week fitness programme ensured a harmonised and safe adaptation of the pupils' cardiovascular system. An increase in stroke volume under conditions of stable cardiac output, together with a moderate reduction in arterial blood pressure, reflects optimisation of both central and peripheral circulatory mechanisms. At the same time, the stability of pulse pressure confirms the absence of excessive vascular load. The overall pattern of adaptations – from a reduction in heart rate to improvements in regulatory indices – points to a transition of the cardiovascular system to a more economical, stable, and productive mode of functioning. Thus, the programme demonstrated high effectiveness in enhancing physiological reserves, aerobic capacity, and overall cardiorespiratory resilience of schoolchildren.

Discussion

The results of the study demonstrated a clear positive trend in the cardiovascular performance of pupils during the eight-week fitness programme. The most pronounced changes were observed in heart rate, Robinson and Ruffier indices, endurance coefficient and systolic blood volume, while arterial and pulse pressure underwent moderate corrections. The final values obtained indicate the formation of a holistic favourable dynamics of haemodynamic and regulatory parameters, which creates the basis for further scientific analysis and interpretation of the mechanisms of the identified changes.

The results obtained showed a significant decrease in the frequency and regulatory indicators of the cardiovascular system: HR decreased from 84.6 ± 6.8 to 76.1 ± 6.2 beats/min (-10.0%), the Robinson index decreased from 96.0 ± 11.3 to 83.6 ± 10.4 conventional units (-13.0%), and the Ruffier index decreased from 10.8 ± 1.9 to 8.6 ± 1.5 conventional units (-20.4%). Such consistent dynamics of the three integral parameters indicated the formation of a more economical heart function, enhanced vagus-mediated regulation, and accelerated recovery reactions during physical activity. Observations by D.M. Cooper & S. Ratom-Aizik (2020) also confirmed that systematic physical activity activated the mechanisms of vagus-mediated control of cardiac activity, which led to a decrease in HR at rest. The authors emphasised the role of immunometabolic adaptations, which further confirms the similarities of the mechanisms recorded in this study. The results of S. Ibrahim *et al.* (2020) showed that participation in school fitness programmes reduced myocardial workload, which coincides with the downward trajectory of the Robinson index. At the same time, the scientists noted that the magnitude of the changes depended on the regularity of the classes, which explains the correspondence with the observed rates of Robinson index reduction.

The consistent reduction in HR and integral markers of regulation was consistent with the mechanisms of parasympathetic activation. A similar pattern was also reported in the work of W. Budts *et al.* (2020), where autonomic regulation indicators changed in the direction of decreasing frequency load, which coincides with the observed decrease in HR and Robinson index. A stable decrease in HR over eight weeks correlates with the criteria for early aerobic adaptation formulated in the source by L.A. Kaminisky *et al.* (2022), where it was emphasised that even

moderate-intensity training causes similar cardiorespiratory changes. At the same time, the less pronounced decrease in frequency indicators described in the study by A.S. Perry *et al.* (2023) does not fully coincide with the identified trajectory, which may indicate different program structures or varying levels of pupil involvement. The same study also pointed out that the lack of clear regularity reduces the effectiveness of adaptation, which contrasts with the more pronounced dynamics of HR and Ruffier index reduction.

After eight weeks, a decrease in systolic pressure from 114.2 ± 8.5 to 110.4 ± 7.9 mm Hg (-3.3 %) and diastolic pressure from 72.8 ± 6.9 to 70.2 ± 6.4 mm Hg (-3.6%), while pulse pressure decreased moderately (-2.9%) and without statistical significance. This dynamic reflects an improvement in vascular tone and a decrease in peripheral resistance, which is characteristic of early adaptive responses to regular physical activity. A systematic review by M. Peralta *et al.* (2020) demonstrated that increased physical activity in school settings contributed to the normalisation of blood pressure, which conceptually corresponds to the decrease in systolic and diastolic components observed in this sample. The authors emphasised that the effect was evident even at moderate exercise intensities, consistent with the moderate but stable dynamics of diastolic pressure. A meta-analysis by E. Norris *et al.* (2020) showed that active school interventions contributed to a decrease in systolic pressure in children, which coincides with the BP_{max} trend. In addition, an improvement in the overall haemodynamic profile was noted, which correlates with the stability of pulse pressure in conditions of increased physical activity. A global comparative study by R. Uddin *et al.* (2020) found that participation in physical education classes was associated with a decrease in peripheral resistance, corresponding to a decrease in BP_{min} . Scientists have pointed out that regular physical activity enhances vascular wall reactivity, which coincides with a decrease in diastolic pressure. The authors N.C. Bagatini *et al.* (2023) proved that an increase in cardiorespiratory fitness was accompanied by a decrease in blood pressure in schoolchildren, and this pattern is consistent with the recorded decrease in BPmax. At the same time, the results of G. Pepera *et al.* (2022) demonstrated slower dynamics in children with low baseline physical activity, which contrasts with the more pronounced changes obtained after an eight-week intervention, thus emphasising the effectiveness of a structured exercise programme.

Stroke volume increased from 70.4 ± 12.2 to 78.5 ± 11.8 ml (+11.5%), cardiac output remained at a stable level (+0.5%), and the endurance coefficient decreased from 20.7 to 17.4 units (-15.9%). This pattern of changes reflects an increase in myocardial contractility and a transition of the cardiovascular system to a more economical mode of operation. A study by L. Marković *et al.* (2022) found that an increase in stroke volume is a key morpho-functional response of adolescents to regular training stimuli, and this pattern is fully consistent with the increase in SV in the data presented. The researchers emphasised that a decrease in frequency characteristics accompanies an increase in stroke volume, which structurally coincides with a decrease in EC. The work of J.F.D.C. Silveira *et al.* (2020) showed that even moderate physical activity improves central haemodynamics, in particular due to an increase in stroke volume, which fully correlates with the observed

upward dynamics of SV. The researchers emphasised that the stability of minute blood volume under conditions of increased stroke volume reflects an economised mode of heart function, which corresponds to the constancy of CO. In a randomised school intervention described by R.S. Matos *et al.* (2020), improved perfusion and reduced haemodynamic load were found, which correlates with a decrease in EC as an indicator of increased aerobic efficiency. Similarly, J. Domaradzki *et al.* (2025) confirmed that eight-week training protocols significantly improve the aerobic performance of adolescents, which is comparable to a decrease in the endurance coefficient. According to M.A. Hassan *et al.* (2024), the optimal training effect on the pumping function of the heart is formed under conditions of moderate intensity load, and this model corresponds to the stability of CO in combination with an increase in stroke volume.

The final dynamics of the parameters showed a change in most indicators in the range of 10-20%, including a decrease in the Robinson index, the Ruffier index, the index of functional changes, and the endurance coefficient, as well as an increase in stroke volume, which indicates the formation of aerobic adaptation and restructuring of cardiovascular regulation. The combination of these changes demonstrates the harmonisation of central and peripheral mechanisms characteristic of an increase in the reserve capacity of the myocardium and vascular bed. A study by L. Baumgartner *et al.* (2020) found that regular physical activity contributes to the improvement of vascular structure and functional capacity of the arterial bed, which is consistent with the stability of pulse pressure as a marker of adequate vascular elasticity. The authors pointed out that improved endothelial regulation reduces myocardial stress, which is fully consistent with a decrease in the Robinson index. A study by J.R. Lopez *et al.* (2020) showed that regular physical activity can improve vascular elasticity even in children with cardiac conditions. A similar mechanism is reflected in a gradual decrease in systolic and diastolic pressure as a marker of normalisation of peripheral resistance. The work of J.M. Nagata *et al.* (2022) emphasises that maintaining physical activity from a young age is associated with a reduced risk of early cardiovascular events, and the resulting complex of adaptive haemodynamic changes demonstrates precisely the direction of preventive action described in this study. Analytical data from B.A. Franklin *et al.* (2022) emphasised the decisive role of aerobic performance in reducing myocardial load, which is reflected in a decrease in the endurance coefficient as an integral marker of cardiac economy. In addition, a study by M.N. Ahmadi *et al.* (2022) proved that even relatively small amounts of intense physical activity contribute to improving the cardiometabolic profile. This pattern is confirmed by a coordinated increase in functional reserves and optimisation of key indicators of the cardiovascular system.

The final interpretation of the data obtained showed that the dynamics of cardiovascular system indicators correspond to typical models of aerobic adaptation in adolescents described in scientific studies. The decrease in frequency and integral indices, the increase in stroke volume, and the optimisation of haemodynamics are consistent with evidence of improved autonomic regulation, vascular function, and cardiac pump capacity under the influence of regular physical activity. The combination of results

confirms the effectiveness of school fitness programmes as an effective tool for the preventive strengthening of cardiovascular health.

Conclusions

The baseline characteristics of the cardiovascular system indicated a moderate level of fitness among the pupils, with evident signs of strain in regulatory mechanisms. Heart rate was within the age-related norm (84.6 ± 6.8 beats/min), the Robinson index was elevated (96.0 ± 11.3 conventional units), and the Ruffier index corresponded to a borderline level (10.8 ± 1.9 conventional units), indicating insufficient adaptation to physical load. Systolic and diastolic blood pressure remained within normal limits (114.2 ± 8.5 and 72.8 ± 6.9 mmHg, respectively), while stroke volume was at the lower limit of the physiological range (70.4 ± 12.2 ml). Taken together, these indicators suggested a clear potential for the development of a pronounced training response under the influence of a structured fitness programme. The interim assessment at the fourth week indicated the initial phase of aerobic adaptation and normalisation of regulatory responses. HR decreased to 80.2 ± 6.1 beats/min (-5.2%), the Robinson index to 89.9 ± 10.2 conventional units (-6.4%), and the Ruffier index to 9.5 ± 1.7 conventional units (-12.0%). Changes in blood pressure were moderate in nature (BP_{max} -1.7 mmHg; BP_{min} -1.3 mmHg), pointing to early optimisation of peripheral resistance. SV increased to 74.2 ± 11.5 ml (+5.4%), while cardiac output remained stable. This pattern of changes confirmed the transition from initial compensatory responses to the formation of stable aerobic restructuring of the cardiovascular system.

After completion of the eight-week programme, the most pronounced adaptive changes were recorded, reflecting the full establishment of an economical and efficient mode of cardiovascular functioning. HR decreased to 76.1 ± 6.2 beats/min (-10.0%), the Robinson index to 83.6 ± 10.4 conventional units (-13.0%), and the Ruffier index to 8.6 ± 1.5 conventional units (-20.4%). The endurance coefficient decreased by 15.9%, while stroke volume increased to 78.5 ± 11.8 ml (+11.5%). Systolic and diastolic blood pressure decreased moderately (-3.3% and -3.6%, respectively), whereas cardiac output remained stable. These changes indicated completion of the transition to stable aerobic adaptation and optimisation of haemodynamics. The observed dynamics of the indicators are consistent with the structure of the study, which involved development of a fitness programme, assessment of baseline status, analysis of adaptive responses, and identification of regulatory changes in the cardiovascular system. Thus, the results comprehensively characterise the effectiveness of the programme and confirm its capacity to enhance the cardiorespiratory reserves of schoolchildren. The recorded improvements point to a potential preventive effect in terms of early reduction of the risk of cardiovascular regulatory disorders in adolescence, indicating full achievement of the study aim.

A limitation of the study was the relatively small sample size and inclusion of only one age group, which restricts the generalisation of the findings to a broader school population. Future research should expand the sample size, include several age cohorts, and apply randomised comparative designs to allow more precise identification of the

characteristics and mechanisms of cardiovascular adaptation to structured fitness programmes.

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Conflict of Interest

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Роль фітнес-програм у профілактиці серцево-судинних захворювань учнів закладів загальної середньої освіти

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Анотація. Метою дослідження було визначити вплив шкільної фітнес-програми на функціональні показники серцево-судинної системи учнів закладів загальної середньої освіти. Дослідження проведено на базі Уманського ліцею № 3 (Україна) у період із 31 березня до 25 травня 2025 року та передбачало реалізацію восьмитижневої фітнес-програми з послідовними вимірюваннями показників серцево-судинної системи учнів для оцінки її ефективності. Було встановлено, що частота серцевих скорочень у спокої зменшилася з $84,6 \pm 6,8$ до $76,1 \pm 6,2$ уд/хв (-10 %), що вказує на посилення парасимпатичної регуляції. Систолічний тиск знизився з $114,2 \pm 8,5$ до $110,4 \pm 7,9$ мм рт. ст. (-3,3 %), а діастолічний – з $72,8 \pm 6,9$ до $70,2 \pm 6,4$ мм рт. ст. (-3,6 %), що свідчить про зменшення периферичного опору. Водночас ударний об'єм крові зріс із $70,4 \pm 12,2$ до $78,5 \pm 11,8$ мл (+11,5 %), що відображає покращення насосної функції серця. Досліджено, що значне зниження інтегральних показників – індексу Робінсона з 96,0 до 83,6 ум. од. (-13 %), індексу Руф'є з 10,8 до 8,6 ум. од. (-20,4 %), індексу функціональних змін з 2,87 до 2,41 ум. од. (-16 %) та коефіцієнта витривалості з 20,7 до 17,4 ум. од. (-15,9 %) – засвідчило підвищення адаптаційних резервів і ефективності регуляції серцево-судинної системи. Отримані дані підтвердили, що восьмитижнева фітнес-програма забезпечила формування стійкої аеробної адаптації, покращення частотних і гемодинамічних параметрів та підвищення кардіореспіраторних резервів, що зменшує ризик ранніх серцево-судинних порушень. Результати можуть бути використані вчителями фізичної культури, шкільними медичними працівниками та фахівцями з фізичної терапії для розроблення та впровадження ефективних фітнес-програм, спрямованих на зміцнення серцево-судинного здоров'я дітей і підлітків у закладах освіти

Ключові слова: кардіореспіраторні адаптації; витривалість; гемодинамічні параметри; артеріальний тиск; аеробна продуктивність; підлітки; основна школа



Comparative analysis of the level of physical fitness of students in technical and humanities specialities

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Abstract. The study aimed to compare the physical fitness levels of students majoring in technical and humanities subjects based on the author's model of comprehensive training in higher education institutions. The methodology included developing the author's model, an experiment conducted from 3 February to 31 March 2025 at the Sports Complex of Pavlo Tychyna Uman State Pedagogical University, in which 150 students participated, and the formulation of recommendations. The results showed that the implemented programme led to statistically significant positive changes in all key indicators. Aerobic endurance of humanities students increased from 1,200 to 1,400 m (+16.7%), technical students from 1,600 to 2,200 m (+37.5%); strength endurance in "twists" increased from 18 to 25 repetitions (+38.9%) and from 20 to 30 repetitions (+50%); number of push-ups increased from 12 to 18 (+50%) and from 15 to 22 (+46.7%). Explosive strength indicators improved from 185 to 205 cm in humanities students and from 190 to 220 cm in the technical group. Flexibility according to the test increased by 6 cm (18 → 24 cm) and 9 cm (19 → 28 cm), respectively. According to the questionnaire, the percentage of students with a high level of psycho-emotional well-being after the programme increased to 44% in the humanities group and to 50% in the technical group, which indicates the positive impact of physical activity on subjective psychological state. The results obtained indicate that a comprehensive training model can improve the physical fitness and psychological well-being of students even with limited intervention duration. The results of the study can be used by physical education teachers, student club coaches, and university administrators to optimise curricula, as well as by specialists in the field of sports pedagogy and health-improving physical culture to develop programmes to increase physical activity among young people

Keywords: structural model; training complex; psychophysical state; aerobic exercise; functional exercises

Introduction

The research relevance of physical fitness among students is determined by the direct impact on overall health, productivity, and the ability to effectively learn academic material. Students of technical and humanities majors face different conditions in the organisation of the educational process and opportunities for physical activity, which creates unequal conditions for the development of physical qualities. A comparative analysis of the physical fitness of different specialities identified characteristic differences between student groups, determine the key factors that influence the level of physical activity, and outline ways to

optimise training and educational programmes. Analysis of these aspects contributes to the development of effective methods for forming a healthy lifestyle, increasing physical performance and overall vitality of students of different specialities.

The physical fitness of students in technical and humanities majors was studied using various assessment methods and incorporating social, academic, and organisational factors. A range of researchers have studied this topic by comparing the physical fitness of students from different majors and identifying the factors that influenced

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their fitness levels. For example, H. Athaya *et al.* (2023) conducted a comparative analysis of the physical fitness of students with different social statuses and found that social conditions affect overall endurance and strength indicators. Social status affects students' physical fitness through access to sports resources and training opportunities, which determines their endurance and strength indicators. A.A. Bahattab *et al.* (2021) reviewed sports education and training programmes and found that the level of physical fitness of students depends on the specifics of the curriculum and practical classes. Humanities students can develop general endurance through active participation in emergency simulation training, while technical students focus on theoretical training, which limits their physical activity and endurance development.

The introduction of innovative technologies in the vocational education of Ukrainian students during the war was described by H.V. Bilavych *et al.* (2025), incorporating elements of physical training to support health. The tools include online platforms for remote training, mobile applications for tracking physical activity, and virtual trainers that students use for regular exercise, load control, and physical health maintenance during the war. G.F. Deak *et al.* (2025) clustered physical education students in Romania and Ukraine based on level of physical fitness and showed that students in the humanities demonstrate a more even distribution of physical indicators, while technical majors had greater fluctuations between strength, speed, and flexibility. This is due to differences in the curriculum and ways of engaging students in practical physical activity, with humanities majors integrating more physical exercise and technical majors focusing on theoretical training. M. Manzoor *et al.* (2024) compared the physical activity of students from different majors and found that physical education students have higher endurance, strength, and coordination, while humanities students are more likely to engage in low-intensity activities. The study confirmed the influence of the specifics of the curriculum and class schedule on the development of physical fitness. The level of physical fitness of students with and without training opportunities was analysed by J. Martins *et al.* (2023) analysed the physical fitness levels of students with and without training opportunities and found that the level of physical activity of students depends on the curriculum, the number of hours of physical education classes, and the organisation of practical classes, and therefore there are significant differences between specialities in the development of endurance, strength, and flexibility. This can be corrected by higher education institutions by optimising curricula, increasing the number of hours devoted to physical activity, and introducing integrated training blocks for all specialities.

Physical training has a positive impact on overall health, psychological resilience, academic performance, and students' ability to effectively adapt to academic and stressful loads, as well as developing self-discipline and conscious control over the body. Physical fitness should be maintained at a high level regardless of the field of study, as it affects health, psychological resilience, and academic performance. In addition, S. Saleh *et al.* (2022) evaluated the effectiveness of distance learning in improving physical exercise competence. The study determined that online training programmes have a positive effect on the overall

endurance level of students in various fields. Students' physical training should be conducted based on the following algorithm: setting goals and objectives, performing exercises in blocks of aerobic, strength and flexibility training with control of technique and intensity, assessing students' well-being, and finishing with stretching and recovery exercises. This approach ensures the comprehensive development of physical qualities, increases endurance, strength and flexibility, improves psychophysical condition and promotes safe exercise. J. Sun *et al.* (2024) conducted a comparative study of the physical fitness of students from different courses and specialities, determining that endurance, strength and speed indicators are higher among students of humanities specialities at all levels of study. The study confirmed that academic focus and access to physical education classes are positive in shaping physical fitness levels.

Despite numerous studies highlighting the level of physical fitness of students in technical and humanities disciplines, certain gaps remained in terms of comprehensive indicators of strength, endurance and flexibility. Some authors addressed only individual aspects of physical fitness, ignoring interdisciplinary relationships and the influence of the curriculum. The study aimed to analyse changes in the physical fitness and psychophysical condition of students from different educational fields under the influence of a standardised training programme. The objectives of the study were to assess the level of physical fitness and psychophysical condition of students and to formulate practical recommendations for optimising the physical activity of students from different specialities.

Materials and Methods

In a study based on the modelling method, an author's model of a training complex for students was developed based on the principles of comprehensive development of basic physical qualities and the inclusion of three complementary blocks: aerobic, strength training and stretching. The model included the definition of the functional tasks of each block, the distribution of time and intensity of exercise performance, the provision of control over the technique of performance and well-being during classes, as well as the compilation of a logical training scheme that ensures a balance between the development of endurance, strength and flexibility, versatility of application for students of different levels of training, and integration of the model into the educational process for repeatability, control, and evaluation of effectiveness.

The study was conducted from 3 February to 31 March 2025 at Pavlo Tychyna Uman State Pedagogical University. A total of 150 students aged 18-25 participated, including 72 male and 78 female full-time students belonging to two different groups and fields of study: humanities, students of the Faculty of Philology and Journalism, and the Faculty of Engineering and Pedagogical Education. The inclusion criteria were individuals who had no medical contraindications to physical activity and provided written informed consent. Students with acute illnesses or injuries within three months prior to the experiment were excluded. The author's model was introduced into the training of two groups, namely 75 students each from technical and humanities specialities.

A model of basic exercise blocks was developed for the training complex that students performed during the eight weeks of the experiment. Figure 1 shows how each session consisted of three basic blocks: aerobic exercise, strength functional exercises, and flexibility exercises,

with an indication of the recommended time allocated to each block. This model ensured a clear balance between the development of different physical qualities and that the training programme had an equal impact on students in both groups.

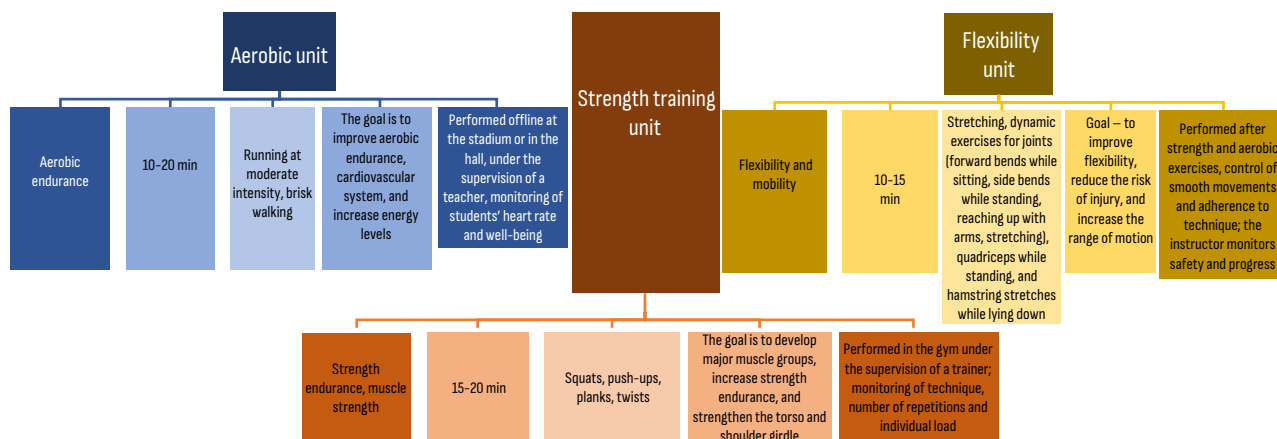


Figure 1. A structural model of a training complex for students aimed at developing aerobic endurance, strength endurance and flexibility

Source: compiled by the authors based on American College of Sports Medicine (n.d.), C.J. Caspersen *et al.* (1985), A.D. Faigenbaum & G.D. Myer (2010), C.E. Garber *et al.* (2011), M. Buchheit & P. Laursen (2013), D.G. Behm *et al.* (2016), World Health Organization (2020)

The proposed structural model of a training session was based on the principles of comprehensive development of the basic physical qualities of student youth and included three complementary blocks that combined aerobic, strength, and flexibility training. This structural design ensured a balanced impact on the cardiovascular system, muscular system, and mobility, developing the functional state of the body without excessive overload. The model was designed for universal application, as it did not require specialised equipment, was suitable for students of different levels of initial fitness, and corresponded to evidence-based approaches to health training for young people. Each block of the model performed a specific functional role. The aerobic part ensured the development of endurance through moderate cyclic loads. The strength block was aimed at building muscle endurance and strengthening the main muscle groups, and the final flexibility block helped to normalise muscle tone, improve mobility, and prevent injuries. A component of the model was the monitoring of technique, intensity, and well-being by the teacher or instructor during each session, which increased safety and standardisation of performance. The generalised structure of the training model was presented in the form of a diagram that reflected the logic of the session structure, the functional purpose of each block, and the specifics of their application in the learning process. The model was designed for simplified integration into the educational environment of the university, ensuring repeatability, controllability, and the possibility of further evaluation of effectiveness.

Preliminary screening was conducted online using a short health questionnaire; all physical measurements were taken offline at a sports complex. All participants underwent physical condition and fitness assessments at the initial stage. The International Physical Activity Questionnaire

IPAQ-SF (2002) and the WHO-5 well-being scale (2024) were used to assess the level of daily physical activity, and psychophysical status was assessed on a six-point scale (0 – “never”, 5 – “all the time”). The metrics were converted into an index from 0 to 100 points. Physical fitness was assessed using standardised tests, the 12-minute Cooper test (the distance covered was recorded as an indicator of aerobic endurance), a test of upper body strength endurance (number of “twists” in 1 minute), upper shoulder girdle strength endurance test (maximum number of push-ups in 1 minute), long jump to assess explosive strength, and sit-and-reach test to determine flexibility. All tests were performed after a standardised warm-up, in the same order and with controlled rest periods between exercises. The assessments were performed by instructors with prior training. The observation included verification of the exercise technique correctness, load intensity, frequency of breaks, fatigue, pulse, and the subjective well-being of the participants. Factors such as instruction compliance and discipline during the session were incorporated.

All participants completed the initial assessment and followed the identical training programme for eight weeks, consisting of three 45-60-minute sessions per week. The programme included 10-20 minutes of aerobic running at moderate intensity, 15-20 minutes of functional strength exercises (squats, push-ups, planks, twists) and 10-15 minutes of flexibility exercises. The exercise programme was selected due to an even effect on basic physical qualities, safety, and correlation with the key tests used for assessment, which ensured reliable monitoring of changes in physical fitness. The sessions were held offline in a gym under the supervision of an instructor. Students could not independently change the training program to ensure the same effect on both groups. During the experiment, students were also observed during training, which was used

to assess physical metrics, behavioural and motivational aspects. After completing the 4-week programme, the students underwent the same measurements using an identical protocol, including WHO-5, IPAQ-SF and the entire set of physical tests. The procedures were followed without change to ensure the accuracy of the “before” and “after” data comparison. Ethical standards were enforced based on the American Sociological Association (1997), which included written consent, data storage under codes, the option to withdraw at any time, and the presence of a specialist capable of providing first aid. The research protocol was approved by the university’s local ethics committee.

Comparison of humanities and technical students was conducted in two areas: by initial metrics and by changes after the training programme. Recommendations were developed based on the obtained data obtained, covering characteristics of physical fitness of students of different specialities, in particular, the optimal amount of aerobic and strength activity, the advisability of including certain types of exercises, the approximate frequency and intensity of training for both groups, as well as recommendations on the use of self-report scales for further monitoring of the physical and psychophysical condition of students in the educational process.

Results

Assessment of physical fitness and psychophysical condition of students

Higher education involves not only intensive learning, lectures, tests and exams, but also formation of lifestyle habits with long-term consequences for health. Physical activity among students is a factor affecting physical health, psychological stability and academic performance. Exercises reduce stress, improve recovery after exertion, and academic productivity. Furthermore, physical activity promotes mindfulness and psychological resilience, contributing to a positive mental state and reducing distress (Teuber *et al.*, 2024). Systematic reviews also highlight a

strong correlation between physical activity, self-esteem, reduced depression symptoms, and overall student well-being. The cognitive and academic benefits of sports are no less relevant. Even short exercise breaks during study can improve attention, memory and motivation in students, reduce mental fatigue and maintain productivity during the learning process. Physical activity may indirectly influence academic performance through psychological variables, as some studies noted that self-esteem and depression mediate the relationship between physical activity and academic achievement (Li & Huang, 2025).

Role of physical activity is only increasing due to internal barriers (e.g., lack of time, heavy study load) and external barriers (e.g., inadequate infrastructure or support from universities) (Latino *et al.*, 2025). Students have low awareness of the role of physical activity for health, which highlights the need for systematic sport and regular exercise encouragement. Therefore, analysing students’ physical fitness and studying differences in academic orientation (technical and humanities majors) is relevant. This approach can be used not only to assess the current level of physical activity but also to formulate recommendations that could be implemented in the educational process of universities to improve the overall physical and psychological potential of students.

The level of physical fitness of students does not always reflect their psychophysical state, since good physical shape does not guarantee a high level of adaptation to stress or psychological comfort. In turn, the psychophysical state affects the ability to perform physical exercises, refuting the direct connection between fitness and the general state of the body. The sequence of assessment procedures and stages of implementation of the training model was systematised throughout the research methodology and summarised in Table 1. The table shows the main steps that made it possible to track the dynamics of changes in the physical and psychophysical fitness of students, as well as demonstrating the structure of the experiment as a holistic process.

Table 1. Results of the experiment: students’ readiness before and after the training complex

Group 1 before	Group 1 after	Group 2 before	Group 2 after
1. International physical activity questionnaire IPAQ-SF (2002)			
How often have you done intensive exercise in the last week?			
1-25% 2-30% 3-20% 4-15% 5-10%	1-10% 2-20% 3-30% 4-25% 5-15%	1-23% 2-28% 3-20% 4-18% 5-11%	1-8% 2-15% 3-28% 4-30% 5-19%
Duration of intensive exercise			
1-28% 2-32% 3-20% 4-12% 5-8%	1-6% 2-12% 3-25% 4-28% 5-29%	1-25% 2-30% 3-18% 4-15% 5-12%	1-5% 2-10% 3-22% 4-30% 5-33%
How often did you engage in moderate exercise during the week?			
1-22% 2-28% 3-25% 4-15% 5-10%	1-4% 2-10% 3-22% 4-32% 5-32%	1-24% 2-28% 3-22% 4-15% 5-11%	1-3% 2-8% 3-20% 4-35% 5-34%
Duration of moderate exercise			
1-25% 2-30% 3-22% 4-13% 5-10%	1-5% 2-12% 3-24% 4-30% 5-29%	1-23% 2-28% 3-20% 4-18% 5-11%	1-4% 2-10% 3-22% 4-32% 5-32%
How often did you walk for ≥10 minutes?			
1-20% 2-25% 3-28% 4-15% 5-12%	1-3% 2-8% 3-22% 4-35% 5-32%	1-22% 2-28% 3-25% 4-15% 5-10%	1-2% 2-7% 3-20% 4-33% 5-38%
Duration of daily walking			
1-22% 2-28% 3-25% 4-15% 5-10%	1-4% 2-10% 3-25% 4-32% 5-29%	1-23% 2-28% 3-22% 4-18% 5-9%	1-3% 2-8% 3-20% 4-35% 5-34%
Sitting time during the day			
1-30% 2-25% 3-20% 4-15% 5-10%	1-5% 2-10% 3-20% 4-30% 5-35%	1-32% 2-28% 3-20% 4-15% 5-5%	1-4% 2-8% 3-18% 4-30% 5-40%
2. WHO-5 well-being scale (2024)			
I felt energetic			
0-5% 1-15% 2-25% 3-30% 4-15% 5-10%	0-2% 1-8% 2-20% 3-30% 4-25% 5-15%	0-4% 1-12% 2-22% 3-28% 4-20% 5-14%	0-1% 1-5% 2-15% 3-25% 4-30% 5-24%
I woke up refreshed			

Table 1, Continued

Group 1 before	Group 1 after	Group 2 before	Group 2 after
0-6% 1-14% 2-24% 3-30% 4-16% 5-10%	0-2% 1-7% 2-18% 3-32% 4-25% 5-16%	0-5% 1-10% 2-20% 3-30% 4-20% 5-15%	0-1% 1-5% 2-15% 3-25% 4-28% 5-26%
I was calm and relaxed			
0-5% 1-15% 2-25% 3-28% 4-17% 5-10%	0-1% 1-8% 2-20% 3-30% 4-25% 5-16%	0-4% 1-12% 2-22% 3-28% 4-22% 5-12%	0-1% 1-5% 2-15% 3-25% 4-30% 5-24%
I felt interested in everyday affairs			
0-6% 1-14% 2-24% 3-30% 4-16% 5-10%	0-2% 1-7% 2-18% 3-32% 4-25% 5-16%	0-5% 1-10% 2-20% 3-30% 4-20% 5-15%	0-1% 1-5% 2-15% 3-25% 4-28% 5-26%
I was in a good mood			
0-5% 1-15% 2-25% 3-28% 4-17% 5-10%	0-1% 1-8% 2-20% 3-30% 4-25% 5-16%	0-4% 1-12% 2-22% 3-28% 4-22% 5-12%	0-1% 1-5% 2-15% 3-25% 4-30% 5-24%
3. Tests (average value in the group)			
12-minute Cooper test, m			
1,200	1,600	1,400	2,200
Twists per minute, number			
18	25	20	30
Push-ups in 1 minute, number			
12	18	15	22
Standing long jump, cm			
185	205	190	220
Sit and reach test, cm			
18	24	19	28

Note: Group 1 – students majoring in the humanities; Group 2 – students majoring in technical subjects

Source: compiled by the authors

The results of the observation demonstrated differences in endurance and coordination between the groups. The results of the study show a positive trend in the physical fitness and psychophysical condition of students after performing the same training complex in both groups. Group 1, consisting of humanities students, demonstrated improvement in all tests compared to the initial indicators, but the progress was slightly less than that of Group 2, which consisted of technical students. Following Table 1, the physical fitness of students majoring in technical subjects was higher even before the start of the experiment, since the level of activity of students in this field was also higher. This can also be related to improved results after the implementation of the training programme, since a trained body is better able to withstand aerobic and anaerobic loads. Students of technical specialities regularly attended the gym, as most of their learning process involves long hours of computer work, which requires compensation for physical activity. In addition, technical students participate in laboratory and practical classes that involve regular physical activity, such as operating equipment, moving between workstations, and performing physically active tasks during experiments. Humanities students have a more flexible schedule with an emphasis on creative and interactive exercises, discussions, group projects and working with materials, which provides less structured physical activity but promotes the development of cognitive and social skills.

Analysis of the WHO-5 results also demonstrated positive dynamics in the psychophysical state of both groups. In all five statements, students demonstrated an increase in the percentage of high scores (4-5 points) after the training complex, with group 2 of technical students showing a more pronounced improvement in energy, feelings of relaxation, calmness and interest in daily activities compared

to group 1 of humanities students. As for the strengths of the training complex, it is worth noting that it evenly affects the main physical qualities, aerobic endurance (running for 10-20 minutes), strength endurance (functional strength exercises for 15-20 minutes) and flexibility (stretching exercises for 10-15 minutes). The complex also provides a safe load for students of different levels of training and monitors progress using standardised tests. The disadvantages of the complex are a relatively short duration of each exercise block and the same intensity for all students, which may not fully correspond to the individual level of training for less active humanities students. Furthermore, the limited duration of training (45-60 minutes) prevents the maximum development of individual physical qualities in more trained technical students. The implementation of the training complex over eight weeks had a positive effect on the physical fitness and psychophysical state of both groups, with technical students demonstrating a higher level of physical fitness and better indicators of psycho-emotional state after the experiment, which indicates the effectiveness of a systematic, comprehensive approach for students of different academic fields.

Group 1 (humanities students) showed higher fatigue during strength training, when performing push-ups and twists, as well as more frequent breaks for rest. At the same time, students in the technical group (group 2) demonstrated more stable endurance, more precise movement technique, and less fatigue, which ensured full intensity without extended breaks. Observations also revealed that both groups gradually increased their motivation and interest, demonstrated perseverance during repetitions of strength and flexibility exercises, and adhered to safety rules and proper technique. In addition, the second group showed higher concentration and ability to perform tasks

in team mode, while the first group sometimes showed a decrease in attention after intense blocks. Thus, the results of the observation confirm the test data: students of technical specialities demonstrated a higher level of physical fitness and better stress resistance, while humanities students, although they showed improvement in physical and psychophysical indicators, needed more control over intensity and breaks. The observation emphasised that the training complex not only develops physical qualities but also has a positive effect on the motivation, discipline and psychological readiness of students for systematic physical exertion.

Practical recommendations for the optimisation of physical activity among students of different specialities

Based on the data obtained and the results of the experiment, a set of practical recommendations was developed for organising physical activity for students of humanities and technical specialities, incorporating initial physical indicators, psychophysical condition, motivation and needs in the educational process. These recommendations are designed to be implemented in the university curriculum or a separate physical education module, and can also be used in students' extracurricular activities to support health and physical development. Introduction of systematic training complexes for students of both specialities is recommended, with a frequency of three sessions per week and a duration of 45-60 minutes per session. University sports halls or outdoor areas in favourable weather conditions should be prioritised in training. A standard warm-up for 5-10 minutes should be performed at the start of each class, incorporating light cardio exercises, flexibility exercises for the main joints, dynamic stretching to prepare the body for further exertion and reduction of the risk of injury. Students are advised to perform warm-up exercises under supervision of a physical education teacher or trainer to monitor the technique and rhythm of the exercises. To develop aerobic endurance, it is recommended to include moderate intensity running or brisk walking for 10-20 minutes in each session. For humanities students, it is advisable to begin with shorter distances or lower intensity, gradually increasing the running distance and speed while monitoring pulse and well-being. For students of technical disciplines, longer distances or interval running exercises with moderate speed alternation can be recommended to maintain the high level of aerobic endurance they demonstrated during the experiment. Running or walking should be conducted at the university stadium or on equipped grounds with a flat and safe surface. An instructor should monitor the accuracy of the exercises, ensure a steady pace, and gradually increase the load throughout the eight weeks.

To develop strength, endurance, and muscle strength, functional exercises with body weight, such as squats, push-ups, planks, and twists are recommended. Strength exercises should be performed in the university gym or in a designated room with minimal equipment. It is recommended to allocate 15-20 minutes for each strength training session, dividing the exercises into sets. For humanities students, fewer repetitions and sets should be used, gradually increasing the load to avoid overexertion and ensure safe progression. For technical students, a higher number of repetitions or more intense sets can be used due to a higher basic strength training level. Trainer should

constantly monitor technique, correct mistakes and advise on correct distribution of the load to ensure safety of exercises. To develop flexibility and joint mobility, it is recommended to include 10-15 minutes of stretching exercises at the end of each class. Stretching exercises should be performed smoothly, without jerks, with an emphasis on a controlled range of motion. Humanities students should prioritise flexibility exercises due to lower initial flexibility and lower endurance during strength and aerobic activities. Technical faculty students are advised to combine traditional stretching with dynamic functional movements to develop coordination, endurance, and overall mobility. Regarding the frequency and structure of classes, it is recommended to conduct training regularly, for example, Monday, Wednesday, and Friday at set hours in the morning or afternoon, to ensure maximum student attendance. The physical education teacher or coach should plan classes, inform students on schedule changes, preparation and necessary equipment (sportswear, trainers, water bottle). It is also advisable to organise small subgroups of 5-8 people to ensure individual control and increase student motivation through mutual support and healthy competition.

Self-report scales IPAQ-SF (International Physical Activity Questionnaire IPAQ-SF, 2002) and WHO-5 (WHO-5 well-being scale, 2024) are recommended for training intensity and efficiency monitoring. Each week, students complete short questionnaires to track physical activity, psychophysical condition, and well-being. The teacher or trainer analyses the data obtained, identifies weaknesses in the workload, and adjusts the programme per individual needs and training response. In particular, if increased fatigue is notable among humanities students, a temporary reduction of strength training intensity or increase in break duration between sets is recommended, while for technical students, additional repetitions or more complex exercise options can be added. Another recommendation is to gradually increase the load over eight weeks, based on the students' initial fitness levels. Humanities students should be advised to start at a slower pace, with fewer repetitions and shorter aerobic distances, increasing the intensity each week by no more than 5-10% of the initial level. Students in technical fields can be offered more complex exercises, more repetitions, increased duration of aerobic blocks, or varied interval training to ensure the development of high levels of endurance, strength, and flexibility. For the motivation and support of the psychological and emotional state of students, integration of game elements, relay races, team exercises and coordination exercises into training is recommended. Such elements should be conducted under the supervision of a physical education teacher for adjusting the intensity, alternating between intense and calm exercises, and ensuring safety. This ensures positive training, promotes discipline, fosters team spirit, and encourages regular participation in the programme. Individual characteristics of students should be accounted for. At the initial stage, the physical education teacher should screen students' health (questionnaires, BMI (body mass index) measurements, assessment of basic physical fitness) to identify individuals with limitations or a need for modified exercise. Lower intensity aerobic and strength training, increased rest, and additional stretching exercises are applicable for students with low initial

physical fitness. For students with high fitness levels, it is advisable to provide more complex exercise options, increase the number of repetitions or integrate functional training elements of functional, which stimulates progress without the risk of overload.

To monitor results and evaluate the effectiveness of the programme, repeated measurements of physical indicators (12-minute Cooper test, test of strength endurance of the torso and upper shoulder girdle, standing long jump, flexibility test) and WHO-5 (WHO-5 well-being scale, 2024) and IPAQ-SF (International Physical Activity Questionnaire IPAQ-SF, 2002) questionnaires are recommended. The instructor should analyse the obtained data and adjust training to ensure an optimal proportion of aerobic, strength and flexibility exercises for each group. Constant exercise technique, intensity, student well-being, motivation and attention should be observed and monitored during training. A teacher or trainer can keep an observation log, record individual and group responses to loads, adjust intensity and duration of exercises in real time. Humanities students with lower endurance and students with high initial fitness levels, necessitating additional incentives to progress, require closer monitoring. To maintain discipline and regular participation in the programme, it is recommended to establish clear attendance rules, incentive systems for activity and progress (e.g., points for attendance and exercise completion), and to create a friendly team atmosphere during training sessions. This can be achieved via the formation of subgroups, team-based competitions, game element integration, and short motivational briefings before the start of the session. Thus, the set of recommendations includes specific actions, the duration and frequency of training sessions, the structure of aerobic, strength and stretching exercises, technique and intensity control, monitoring of psychophysical condition using self-report scales, gradual increase in load in accordance with individual capabilities, integration of motivational game elements and regular monitoring of results. These recommendations will contribute to the physical fitness and psychophysical condition of students in both groups, optimise the learning process, and ensure safety during training. It will also create conditions for the continuous development of aerobic and strength endurance, flexibility, and coordination of movements in students of different specialities. The recommendations provide a clear algorithm for the organisation of a training programme that ensures a balance between the intensity of the load, safety and effectiveness for students of different levels of physical fitness. The recommendations provide flexibility in implementation, maintain student motivation, contribute to improving psychophysical well-being, and can be used for objective assessment of progress using standardised tests and questionnaires. The technical group had better initial results in most physical fitness and well-being metrics; therefore, greater progress after training exercises confirms the efficiency of the programme and potential for further development of physical qualities. Initial higher physical fitness improved exercise learning rate and achieved noticeable improvements in Cooper tests, sit-ups, push-ups and flexibility, which emphasises the role of systematic training even for groups with a higher starting level. In general, the implementation of a systematic

training complex based on these recommendations will ensure the formation of sustainable skills and physical potential in students, increase their adaptation to academic and life stresses, and promote the development of a healthy lifestyle for both humanities and technical students.

Discussion

The difference in physical fitness of technical and humanities students was evident in endurance, strength, and reaction speed. Analysis of the WHO-5 questionnaire (WHO-5 well-being scale, 2024) also demonstrated positive dynamics in the psychophysical state of both groups, however, technical students had higher scores for energy, relaxation, calmness, daily interest and positive mood after the training programme, with 65-75% of high scores (4-5 points), while for humanities students this figure was 50-60%. Technical students demonstrated higher levels of overall physical strength and aerobic endurance, while humanities students showed better flexibility and coordination of movements. This differentiation indicates the influence of the specifics of the educational model and the regime of educational activities on the formation of physical qualities, which is consistent with the previous conclusions of L.A. Gallo *et al.* (2020), noting a change in the level of physical activity of students during restrictive measures due to COVID-19. The results of the study confirmed that physical activity related to the educational process shapes the body's adaptive abilities and has different dynamics among students of different specialities.

The strength and endurance correlation indicates the influence of practical laboratory classes and technical exercises on maintaining a high physical fitness level. Higher flexibility scores among humanities students are consistent with the findings of K. Nikolopoulou (2022), noting that intellectually oriented curricula with active elements of creativity and physical activity contribute to the development of coordination and flexibility of the body. This correlation confirmed the assumption that the development of physical qualities differs between disciplines. Aerobic endurance test results show a statistically significant advantage for technical students in running distance and cardiorespiratory endurance tests. This is consistent with the comparison of the physical activity of students by G.I. Butnaru *et al.* (2021), which noted a decrease in endurance among students without regular physical activity. The results confirmed conclusions regarding the need to include physical exercise in the educational process to maintain an optimal level of physical fitness. The study determined that regular laboratory and practical classes incorporating physical activity maintain high strength and aerobic fitness levels. Analysis of speed abilities demonstrated a moderate advantage for humanities students in reaction speed and agility tests. A comparison of the results with the study by M. Sun *et al.* (2025) indicated that speed, agility and reaction exercises, in particular short-distance running, direction change exercises and multi-speed training, stimulate quick reactions. The study demonstrated that such exercises improve acceleration, rapid change of direction, leg strength, and reaction time, ensuring comprehensive development of physical qualities. In particular, the results of the study highlighted that group 1 increased the average number of twists from 18

to 25 in the upper body strength endurance test, while group 2 increased from 20 to 30, and in push-ups per minute, the results increased from 12 to 18 and from 15 to 22, respectively. The standing long jump, which assesses explosive power, showed an increase in the average result in group 1 from 185 to 205 cm, and in group 2, from 190 to 220 cm, while the sit-and-reach flexibility test showed an improvement from 18 to 24 cm in humanities students and from 19 to 28 cm in technical students.

Teaching methods based on interactivity and physical activity improve coordination skills among students. Overall physical fitness indicators demonstrated a statistically significant difference between groups, which can be attributed to differences in educational structure and workload across different specialisations. This is consistent with the findings of C. Huang *et al.* (2024), noting that the type of learning activity and its integration with physical activity affect overall functional readiness indicators. The combination of regular practical classes and laboratory assignments with physical exercises contributes to the formation of sustainable physical skills in technical students, while humanities majors ensure the development of flexibility and speed-coordination abilities through interactive teaching methods. Physical fitness also depends on biological factors and individual physical activity, highlighting the need to consider these aspects when planning educational programmes. A comparison of the data obtained with the study by C.E.B. Brown *et al.* (2024) confirmed the impact of the learning activity regime on physical activity. Students of technical specialities were more often involved in laboratory and practical classes that involved physical activity, while humanities specialities provided a more flexible regime with an emphasis on creative and interactive exercises. This confirms the conclusions regarding the significance of the structure of educational activities for maintaining physical fitness. The higher level of endurance observed among students of technical specialities was consistent with the results of studies by V. Ryabchenko *et al.* (2021), highlighting the impact of physical education classes on the health of students of technical specialities. The results determined that regular physical exercise improves physical fitness, health, and promotes the formation of healthy habits for an active lifestyle. Y. Zhou *et al.* (2025) highlighted that various exercises contribute to different physical qualities; team games and individual activities improve endurance and coordination; the positive effect of strength and flexibility tests; and exercises for motor skills and precision of movements. The author's model in this study also included various exercises with unique effects on the development of physical qualities.

Humanities students have lower physical fitness levels than technical students. This result correlates with data from Y. Berezna *et al.* (2024), based on analysis of thinking patterns and physical activity of humanities students. The data highlighted that curricula of these specialities provide less structured physical activity, prioritising creative and interactive classes that develop cognitive and social skills. Furthermore, the results of the study can be used to assess the impact of the learning environment and the organisation of the educational process on physical activity. Data from Z.U. Umarova & Y.Y. Umarov (2024) emphasised that educational institutions that integrate physical

activity into the learning process contribute to maintaining a high level of physical fitness among students. The results demonstrated the role of motivational factors and the social environment. S. Chowdary (2020) noted that a combination of face-to-face and distance learning (blended learning) promotes student engagement in active learning, which could influence physical activity. Furthermore, the recommendations include systematic 8-week training programmes, three times a week for 45-60 minutes, divided into aerobic, strength and stretching blocks, warm-up and recovery exercises, technique and well-being monitoring during classes, gradual increase in load based on individual abilities, use of self-report scales to assess effectiveness (IPAQ-SF, WHO-5), integration of game elements for motivation, as well as regular monitoring of results and programme correction. K. Gapparov & K. Akhmedov (2020) also noted that the implementation of recommendations for the introduction of a training complex into the educational process of universities ensures an increase in the level of physical fitness, psychophysical condition, safety and adaptation of students to educational loads, regardless of their specialisation. The results demonstrate that speciality and organisational features of the educational process affect the level of physical fitness of students, forming different trends in endurance, strength, flexibility and coordination. Different learning formats and access to extracurricular physical activities determined the ability to maintain and develop physical activity, which is crucial for overall health and physical development.

Conclusions

The experiment, which involved students of humanities and technical specialities, demonstrated significant positive changes in both the physical indicators and the psychophysical state of the participants. All tests demonstrated an increase in results, and stability of dynamics was confirmed by the dynamics of the selected load. Aerobic endurance of humanities students increased from 1,200 to 1,400 metres (+16.7%), and technical students from 1,600 to 2,200 metres (+37.5%); strength indicators increased from 18 to 25 "twists" and 12 to 18 push-ups in the humanities group, and 20 to 30 "twists" and 15 to 22 push-ups in the technical group. The increase in standing long jump (185 → 205 cm and 190 → 220 cm, respectively) and flexibility (18 → 24 cm and 19 → 28 cm) confirmed the positive influence of exercises.

Based on the obtained data, the introduction of a training complex into the educational process of universities, three times a week for 45-60 minutes, moderate-intensity aerobic exercises in a stadium or gym, strength training under the supervision of an instructor for technique correction and individual load adjustment, and a final flexibility session for injury prevention and recovery, is recommended. For humanities students, it is recommended to increase the proportion of aerobic exercises to the upper limit of the model (20 minutes), and for technical students, to improve the strength training by increasing the number of repetitions or the duration of exercises with gradual progression. Monitoring of the psychophysical condition of students once every two weeks using the WHO-5 and a short IPAQ-SF questionnaire should be conducted to adjust the loads. Teachers are advised to record exercise techniques,

ensure the adaptation of loads for students with lower fitness levels, and monitor signs of fatigue, motivation, and participation in classes. A limitation of the study is the sample of a single university, which reduces the complete generalisation of results to all students. Further studies should expand the sample, include students from other specialities, and analyse the long-term impact of the training model on health and academic performance.

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Conflict of Interest

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Порівняльний аналіз рівня фізичної підготовленості студентів технічних і гуманітарних спеціальностей

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Анотація. Метою дослідження було порівняння рівня фізичної підготовленості студентів технічних і гуманітарних спеціальностей на основі авторської моделі комплексного тренування у закладі вищої освіти. Методологія включала створення авторської моделі, експеримент тривав з 3 лютого по 31 березня 2025 року на базі Спортивного комплексу Уманського державного педагогічного університету імені Павла Тичини, у якому взяли участь 150 студентів, та формулювання рекомендацій. Результати показали, що впроваджена програма спричинила статистично значущі позитивні зрушення у всіх ключових показниках. Аеробна витривалість студентів гуманітарної групи збільшилася з 1 200 до 1 400 м (+16,7 %), а технічної – з 1 600 до 2 200 м (+37,5 %); силова витривалість у «скручуваннях» зросла відповідно з 18 до 25 повторів (+38,9 %) та з 20 до 30 повторів (+50 %); кількість віджимань – з 12 до 18 (+50 %) та з 15 до 22 (+46,7 %). Показники вибухової сили покращилися з 185 до 205 см у гуманітаріїв і з 190 до 220 см у технічної групи. Гнучкість за тестом зросла на 6 см (18 → 24 см) та на 9 см (19 → 28 см) відповідно. За опитувальником студенти із високим рівнем психоемоційного благополуччя після програми збільшилася до 44 % у гуманітарної та до 50 % у технічної групи, що свідчить про позитивний вплив фізичних навантажень на суб'єктивний психологічний стан. Отримані результати означають, що комплексна тренувальна модель здатна підвищувати рівень фізичної підготовленості та психологічного благополуччя студентської молоді навіть за умов обмеженої тривалості втручання. Результати дослідження можуть бути використані викладачами фізичного виховання, тренерами студентських секцій, адміністрацією університетів для оптимізації навчальних планів, а також фахівцями у сфері спортивної педагогіки та оздоровчої фізичної культури для розробки програм підвищення фізичної активності молоді

Ключові слова: структурна модель; тренувальний комплекс; психофізичний стан; аеробне навантаження; функціональні вправи



The impact of modern digital technologies in physical education on the level of physical activity of general secondary school pupils

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Abstract. The aim of the study was to reveal the theoretical foundations of integrating electronic educational platforms and mobile services into school physical education classes in order to outline their potential for increasing the physical activity of schoolchildren. The methodology was based on a combination of theoretical analysis, a regulatory and legal approach, and conceptual modelling. It was found that the main tools of digital technologies are exergames, fitness trackers, online lessons, gamified programmes, social networks, and activity monitoring platforms. Exergames, wearable trackers, and gamification provide sufficient intensity of exercise, provide objective data for self-monitoring and goal setting, and stimulate daily physical activity among pupils. Online physical education formats partially compensate for the reduction in physical activity during distance learning if they have a well-thought-out pedagogical design. Digital media in the concept of health promotion are used to prevent physical inactivity and bring pupils closer to the recommended levels of physical activity. Within the framework of technology-enhanced pedagogy, digital tools individualise the load, improve the assimilation of motor actions and expand the space for activity outside school. It has been established that the integration of digital technologies results in an increase in moderate/high activity time, improved physical fitness, motivation, self-regulation, and a positive attitude towards physical culture. Effectiveness and risks depend on teacher competence, material resources, organisational support, as well as screen time control, digital inequality, and data confidentiality. A conceptual model of “input – process – outcomes” is proposed, where the “input” consists of types of digital technologies, regulatory guidelines and conditions for implementation, the “process” consists of motivational, organisational and monitoring mechanisms of influence, and the “output” is changes in physical activity and attitudes towards physical culture. The practical significance lies in the fact that the results can be used by physical education teachers and methodologists to plan lessons aimed at increasing physical activity and motivation among pupils

Keywords: exergames; wearable trackers; gamified platforms; online sports training; pupil motivation; physical activity

Introduction

Physical activity among children and adolescents in the 21st century is considered one of the key determinants of health, and school as an environment where the basic conditions for the formation of motor behaviour are created.

Despite this, most schoolchildren do not meet the minimum recommendations for daily physical activity, which is exacerbated by trends in urbanisation, increasing sedentary lifestyles and screen time. In such conditions, the

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question arises of how schools, and physical education classes in particular, can use digital technologies not only as a means of communication, but also as a tool for increasing the actual level of physical activity among pupils.

In the scientific field, the digitisation of physical education is considered a separate area of research. In a study by S. Guijarro-Romero *et al.* (2023), an intermittent training module based on wearing fitness bracelets and a set of behavioural strategies (step goals, counselling, reminders) was tested. The authors found that pupils' perceived support for autonomy, satisfaction of basic psychological needs, and autonomous motivation for physical activity increased, as did their habitual physical activity. This means that integrating wearable devices into physical education lessons can not only increase the amount of movement, but also influence the motivational mechanisms that are essential for long-term activity maintenance. Similarly, the work of S. Guijarro-Romero *et al.* (2025) focused on the same type of intermittent module with bracelets, but assessed its impact on the weekly number of steps: an eight-week programme with progressive targets, counselling and daily monitoring led to a statistically significant increase in steps among adolescents aged 12-16. This work provides direct quantitative evidence that a well-designed programme of wearable trackers integrated into physical education lessons can significantly bring pupils' actual levels of daily activity closer to the recommended standards.

Virtual physical education during COVID-19, built within the framework of "diversity-equality-inclusion" in the study by E.M. D'Agostino *et al.* (2021), showed that remote physical education formats can either exacerbate or mitigate existing inequalities in access to physical activity, depending on how online tools are designed. The authors highlight key design features of platforms (convenience, accessibility, monitoring and evaluation capabilities) that teachers consider crucial for ensuring equitable access to quality online physical education for pupils, thereby setting benchmarks for the design of future digital solutions. In their study, O. Østerlie *et al.* (2022) conceptualised the field of "digital technology in physical education", emphasising that digital tools (flipped learning, gamification, exergames) have already demonstrated their ability to enhance student motivation, learning outcomes and performance. At the same time, the authors point out the lack of knowledge about how teachers implement these technologies in different pedagogical approaches and at the level of specific lesson tasks, calling for more in-depth research into the didactic component of digital physical education, rather than just the technical side. Digital tools, as found in the work of F. Jastrow *et al.* (2022), mostly enhance student motivation and improve motor skills, but at the same time reveal serious barriers – a lack of resources and insufficient preparation of teachers to work with media. The authors also emphasised that most studies focus on "learning with media", while the aspect of "learning about media" (data protection, critical attitude to images, etc.) remains almost unexplored, which creates a gap for further pedagogical models of digital physical education.

In a systematic review by D.I. Tohänean *et al.* (2025) analysed 13 studies on the integration of artificial intelligence and information and communication technologies

into physical education at different levels of education, identified the main types of their application and demonstrated their potential for personalising learning, providing real-time feedback, and increasing motivation and inclusiveness. At the same time, the authors note that the transformative potential of these tools is limited by insufficient infrastructure, a lack of professional training for teachers, and methodological shortcomings in existing studies, which requires targeted pedagogical design of digital solutions in school physical education.

In Ukrainian scientific discourse, the use of digital technologies in physical education explores the possibilities of mobile applications and comprehensive digital solutions for school physical education. Fitness applications and interactive platforms (Nike Training Club, Google Fit, Workouts for Kids), as shown by H.M. Alekseeva *et al.* (2025), can compensate for the loss of classroom activity by maintaining motivation, engagement, and the level of physical activity of middle-aged schoolchildren. Research by V.V. Geitenko *et al.* (2025) on the use of digital technologies in physical education classes shows that mobile apps for tracking activity, fitness bracelets, video platforms (YouTube, Nike Training Club), virtual/augmented reality, and online diaries can significantly increase pupils' interest in classes, individualise training tasks, and provide more accurate monitoring of physical fitness. Both studies show that mobile applications, fitness devices, and other digital platforms can increase pupils' interest in classes and contribute to the individualisation of physical activity. At the same time, this potential can only be realised if teachers have the necessary competence in information and communication technologies and schools have the appropriate technical equipment.

A summary of foreign studies shows that the use of digital technologies in physical education contributes to increased motivation, engagement and physical activity levels among schoolchildren, while Ukrainian publications mainly focus on individual tools and approaches without offering a comprehensive system for their pedagogically sound application. There was a lack of comprehensive works that would systematise groups of digital technologies and present a conceptual model for their integration into lessons and extracurricular physical education activities for pupils in general secondary education institutions.

Thus, the aim of the study was to provide a theoretical justification for the use of electronic tools and online solutions in the process of physical education of pupils in general secondary education institutions as a means of increasing their level of physical activity. To achieve this aim, the following objectives were set: to analyse regulatory documents that define the requirements for the level of physical activity of pupils in the process of using digital technologies in physical education in general secondary education institutions, to systematise the main groups of digital tools for school physical education, taking into account empirical data on their impact on the physical activity of pupils, and to develop a theoretical conceptual model for the integration of digital technologies into the process of physical education and health activities of pupils in general secondary education institutions as a means of increasing their physical involvement.

Materials and Methods

The study was theoretical and analytical in nature and used a comprehensive approach combining theoretical, analytical, comparative-normative and structural-modelling analysis. This made it possible to systematically study the possibilities, effectiveness, risks and directions of using digital technologies in school physical education, taking into account their impact on pupils' physical activity. Using methods of normative-legal and comparative-normative analysis, a normative act was developed that approves the State Standard of Ukraine (Resolution of the Cabinet of Ministers of Ukraine No. 898, 2020) and its official presentation and explanation on the website of the Ministry of Education and Science of Ukraine (MES) Ministry of Education and Science of Ukraine (n.d.), which regulates the educational field of "Physical Education" in general secondary education institutions in Ukraine. International benchmarks are presented in official standardised documents of the World Health Organization (2010; 2020). The choice of documents is due to the fact that Ukrainian documents establish mandatory requirements for the content and results of physical education in schools, while international recommendations set scientifically based target guidelines for the level of physical activity, which was necessary for the formation of a regulatory framework against which the potential for integrating digital technologies into school physical education was assessed.

To develop a classification of digital technologies, methods of classification and systematisation of empirical research results were used, which describe the use of digital tools in physical education of pupils in general secondary education institutions – exergames (active video games) (Röglin *et al.*, 2024; Zhao *et al.*, 2024; Merino-Campos & Del-Castillo, 2025), wearable technologies (Creaser *et al.*, 2022; Chen *et al.*, 2025), online physical education and mixed formats (Montiel-Ruiz *et al.*, 2022; Knoke *et al.*, 2024), gamified programmes and social networks (Montiel-Ruiz *et al.*, 2022), digital platforms for monitoring and analysing physical activity (Creaser *et al.*, 2022; Knoke *et al.*, 2024; Chen *et al.*, 2025), which are most representative of approaches to the digitalisation of physical education and reflect various mechanisms of influence on the level of physical activity of pupils. The selection criteria were a focus on school age (pupils in general secondary education), the presence of a clearly described digital component in the physical education programme (exergames, wearable trackers, online lessons, gamified services, monitoring platforms), recording of physical activity indicators or related behaviour, as well as the possibility of replicating these solutions in a regular school setting. This was done in order to create a generalised classification framework that allows for comparison of the potential of different groups of digital solutions and serves as a basis for further analysis of their effectiveness.

To verify the theoretical conclusions about the potential of digital technologies as a means of increasing the level of physical activity, physical fitness and motivation of pupils, the types of digital technologies were analysed using content analysis and analytical generalisation methods: exergames (ExerCube), exergames (school exergaming programme), gamified programme + cards/sensors (active way to school), Edmodo social network + gamification of

physical education courses, wearable activity trackers (wearables), and exergame-based training. These types were selected as representative examples of the main groups of digital technologies identified in the classification, for which quantitative changes in the level of physical activity, physical fitness and motivation of pupils have been documented in school settings. This approach made it possible to empirically substantiate the theoretical provisions of the study and to specify which types of digital technologies and in which formats of class organisation provide the most noticeable positive changes in pupils' physical activity.

To identify risks and limitations associated with the use of digital technologies in school physical education, such as increased screen time, digital inequality, and data privacy issues, methods of critical analysis and the comparative-normative approach were applied. This allowed the conditions for pedagogically appropriate and safe integration of digital tools into the educational process to be outlined. Based on the results of theoretical and empirical synthesis, methods of structural-logical and conceptual modelling were used to construct the "input-process-outcomes" model of digital technology use in the physical education of general secondary education pupils. This ensured the integration of disparate research findings into a coherent conceptual framework suitable for practical application by physical education teachers and by developers of educational programmes.

Results and Discussion

Regulatory guidelines and classification of digital technologies in physical education

The regulatory and legal basis for the physical education of pupils in institutions of general secondary education in Ukraine is the State Standard of Basic Secondary Education, approved by Resolution of the Cabinet of Ministers of Ukraine No. 898 (2020). The document defines the aims of basic education, which include the formation of a culture of a healthy lifestyle and the creation of conditions for the harmonious physical and mental development of the pupil. Within its structure, the educational field "Physical Culture and Sport" is distinguished, the content of which is aimed at developing physical qualities, mastering basic motor skills and abilities, and forming the capacity for independent physical activity and health-related exercise (Ministry of Education and Science of Ukraine, n.d.). On the basis of the Standard, model educational programmes are developed that determine the content of learning material, the indicative distribution of hours, and the expected learning outcomes in the field of "Physical Culture and Sport" for different age groups. The allocated number of hours is intended to ensure the minimally necessary conditions for achieving the school's health-preserving aims and for bringing pupils closer to levels of physical activity recommended by international organisations.

In this context, digital technologies are viewed not as an end in themselves but as tools for implementing the requirements of the State Standard: they increase the attractiveness of physical education lessons, expand opportunities for individualising physical load and monitoring physical activity, and facilitate the organisation of feedback. The integration of digital tools into the content and teaching methods of lessons may be considered one of the ways

to develop pupils' health-preserving and digital competences in line with the priorities of the New Ukrainian School. However, the State Standard of Basic Secondary Education of Ukraine focuses primarily on describing the content of the field "Physical Culture and Sport" and the expected learning outcomes, rather than on clearly quantified indicators of pupils' daily volumes of physical activity (Resolution of the Cabinet of Ministers of Ukraine No. 898, 2020; Ministry of Education and Science of Ukraine, n.d.). On the basis of the Standard and the model educational programmes, school timetables and the minimum required number of physical education hours are established, creating basic conditions for achieving the school's health-preserving goals, but this alone does not guarantee attainment of the recommended daily level of physical activity.

International benchmarks for planning and assessing the physical activity of children and adolescents are provided by the recommendations of the World Health Organization (2010): children and adolescents aged 5-17 years should engage daily in at least 60 minutes of moderate-to-vigorous physical activity, predominantly aerobic in nature, including vigorous-intensity activities and exercises to strengthen muscles and bones at least three times per week, as well as limiting sedentary behaviour (World Health Organization, 2010; 2020). A substantial proportion of children and adolescents in different countries, including during the Coronavirus Disease (COVID)-19 pandemic and periods of distance learning, do not reach the levels of physical activity recommended by the WHO (Knoke *et al.*, 2024; Martín-Rodríguez *et al.*, 2025). For institutions of general secondary education, this implies the need to organise physical education lessons and extracurricular physical and sports activities in ways that support the attainment

of these standards, in particular through the purposeful use of modern digital technologies of the twenty-first century (mobile applications, wearable trackers, exergames, online platforms), which can increase the overall volume and intensity of pupils' physical activity and reduce the gap between actual indicators and international recommendations. A comparison of Ukrainian requirements with international benchmarks shows that the Ukrainian Standard defines the content-related and organisational framework of physical education, whereas WHO documents establish quantitative target benchmarks for physical activity; taken together, these can be regarded as complementary regulatory bases for evaluating and improving school practice through the use of digital technologies.

Contemporary approaches to the physical education of pupils increasingly emphasise that digital solutions should be considered not as an "addition" to the traditional lesson but as an integral part of the teacher's pedagogical toolkit, capable of supporting both educational and health-preserving aims. In the scientific literature, there is no single established definition of this concept, and different authors include within it both basic information and communication technology (ICT) tools (video materials, multimedia presentations, online platforms) and specialised interactive systems with elements of gamification and monitoring. The term "digital technologies" in physical education is used broadly and encompasses tools ranging from simple video resources to complex interactive systems with motion sensors, elements of artificial intelligence, and augmented reality (Martín-Rodríguez *et al.*, 2025; Ketelhut *et al.*, 2025). The groups of digital tools relevant for pupils in general secondary education institutions were summarised in Table 1.

Table 1. Classification of digital technologies in the physical education of general secondary education pupils

Group of digital technologies	Characteristics	Implementation
Exergames (active video games)	Interactive gaming systems in which successful task performance directly depends on the user's motor activity. They provide a game-based format with a sufficient intensity of physical load.	Specialised solutions (ExerCube) and commercial active video games used in school-based interventions.
Wearable technologies (wearable devices)	Sensor-based devices for measuring indicators of physical activity (steps, duration and intensity of exercise, heart rate), used for monitoring and self-control.	Fitness bands, smartwatches, and chest-strap heart rate monitors integrated into school programmes aimed at increasing physical activity.
Online physical education and blended formats	The use of video lessons, streamed workouts, virtual classes, and educational platforms to organise physical education lessons in distance and blended formats, as well as to support traditional lessons.	Distance and blended physical education programmes developed during the COVID-19 pandemic, as well as platforms supporting physical education lessons.
Gamified applications and social networks	Digital services in which physical activity is integrated into a system of game mechanics (points, levels, leaderboards, badges) and supported through social interaction (chats, online communities, challenges).	Gamified interventions to stimulate active travel and participation in physical activity, and gamified physical education courses based on social networks.
Digital platforms for monitoring and analysing physical activity	Web-based and mobile applications for recording the volume and structure of physical activity, analysing its dynamics, setting goals, and generating reports for pupils, parents, and school administration; they are integrated with wearable devices.	School-based and commercial platforms that collect data from trackers and visualise physical activity indicators for the purposes of the educational process and health promotion.

Source: compiled by the authors based on F.J. Montiel-Ruiz *et al.* (2022), S. Ketelhut *et al.* (2022), A.V. Creaser *et al.* (2022), C. Knoke *et al.* (2024), L. Röglin *et al.* (2024), M. Zhao *et al.* (2024), X. Chen *et al.* (2025), C. Merino-Campos & H. Del-Castillo (2025)

Digital technologies in the physical education of pupils in general secondary education institutions encompass both tools for the direct organisation of motor activity (exergames, wearable devices, online lessons) and means of motivation, social interaction and monitoring of its outcomes (gamified applications, digital platforms for

analysing physical activity). This makes it possible to use them both during physical education lessons and in extracurricular sport and health-related activities, thereby expanding the space for pupils' physical activity. The impact of digital technologies on the physical activity of pupils in general secondary education institutions is appropriately

explained within several interrelated theoretical approaches. Within the health-preserving and health promotion approach, digital media in physical education are viewed as tools for health promotion that should contribute to bringing pupils closer to recommended levels of physical activity, improving indicators of physical fitness and fostering awareness of the relationship between motor activity and health (Mackenbrock & Kleinert, 2023; Martín-Rodríguez & Madrigal-Cerezo, 2025). In this context, digital interventions are integrated into school programmes for the prevention of hypodynamia. Within the technology-enhanced pedagogy approach, digital technologies are interpreted as an element of a holistic pedagogical system that changes the structure and logic of the teaching and learning process in physical education. Digital tools are used to increase pupils' engagement, improve the acquisition of motor skills, individualise loads and provide differentiated feedback, which in the long term contributes to the formation of sustainable habits of physical activity (Ketelhut *et al.*, 2025).

The motivational perspective, primarily within the framework of self-determination theory, emphasises that digital media can satisfy pupils' basic psychological needs for autonomy, competence and social relatedness, thereby strengthening intrinsic motivation for motor activity (Lambe *et al.*, 2022). Tracking one's own progress through trackers and mobile applications enhances the sense of competence; gamified tasks and challenges create situations of success; online communities, rankings and team competitions support a sense of belonging to a group (Mackenbrock & Kleinert, 2023). The alignment of the health promotion, technology-enhanced and motivational approaches makes it possible to view digital technologies in physical education as a multi-level influencing factor: from directly increasing the volume and intensity of motor activity to transforming the structure of the lesson and strengthening intrinsic motivation for engaging in physical education (Lambe *et al.*, 2022; Martín-Rodríguez & Madrigal-Cerezo, 2025).

The results of the study revealed that exergames, as a digital tool, provide a sufficient intensity of physical load, improve endurance, strength and coordination, and also create a positive emotional gaming experience that changes attitudes towards motor activity. This is consistent with the work of Y.Z. Birinci *et al.* (2023), in which exergames are considered an educational tool in physical education capable of influencing not only physical but also cognitive, social and affective domains of pupils' development. The authors demonstrated that active video games can support the learning of motor skills, promote cooperation and social interaction, and increase motivation and satisfaction with lessons. Exergames thus represent a comprehensive pedagogical resource that simultaneously addresses physical, motivational and socio-affective outcomes in school physical education.

The study by E.A. Talero-Jaramillo *et al.* (2024) shows that ICT in school physical education is used in several functional areas: as a means of presenting content, organising and assessing pupils' activities, as well as a tool for shaping motivation and engagement in lessons. The results obtained in the present study are consistent with this multidimensional view: the term "digital technologies" encompasses a spectrum of tools ranging from basic ICT (videos, presentations, online platforms) to specialised interactive systems (exergames, wearable devices, monitoring

platforms), and the identified groups of digital tools perform different but interrelated functions -direct organisation of motor activity, monitoring and self-control, and support for motivation and social interaction. The classification of digital technologies proposed in our study reflects this multifunctionality of ICT and specifies it in the context of school physical education.

The results of the study showed that the combination of the State Standard and the WHO's quantitative recommendations forms a regulatory framework for the target level of physical activity for pupils. In these conditions, digital technologies are seen as a means of compensating for the limited number of hours formally allocated to physical education and bringing actual physical activity closer to international benchmarks. A similar logic is demonstrated in a systematic review by N. Mulato *et al.* (2024), which emphasises that optimising physical education in the digital age requires the targeted integration of technologies into the learning process to increase pupil motivation and participation, rather than simply their formal presence. The authors stress that digital tools must be linked to curriculum updates, the introduction of blended learning and the management of the educational process in order to have a real impact on outcomes, including levels of physical activity. Digital technologies should be designed as a means of achieving regulatory goals, rather than as a self-sufficient "digital" component of the lesson.

A review by J. Sargent & A. Calderón (2022) showed that digital technologies in physical education are analysed through the prism of teaching and learning. The authors emphasised that most studies describe an increase in motivation or engagement, but rarely link technological interventions to clearly defined programmatic or regulatory goals. The current results partly correspond to and at the same time specify this conclusion: digital solutions are not considered as an "addition" to the lesson, but as part of the pedagogical toolkit designed to implement the requirements of the State Standard and WHO recommendations. The classification of tools is linked to their potential to provide sufficient volume and intensity of physical activity, support health-saving goals, and develop pupils' digital and information literacy.

The results of the study indicated that digital technologies (wearable trackers, gamified programmes, online communities) are considered tools for satisfying pupils' basic psychological needs and forming a sustainable motivation for physical activity, which is consistent with the provisions of self-determination theory. M. Standage *et al.* (2025) demonstrate that the gap between the WHO-recommended levels of physical activity and actual indicators is largely related to the quality of pupils' motivation in physical education, and not only to the formal parameters of educational programmes. Educational environments that support autonomy, competence and relatedness promote high-quality intrinsic motivation, greater engagement and better well-being among pupils, which is consistent with the results of the present study. The mere existence of regulatory requirements (State Standard, WHO recommendations) and digital tools does not guarantee an increase in physical activity if the technologies are not used in a way that supports self-regulation, a sense of competence and social inclusion among pupils. In this sense, digital

technologies are not only a tool for implementing formal standards, but also a component of a motivational environment capable of ensuring real progress towards physical activity targets. Thus, the combination of the State Standard and WHO recommendations sets a framework within which digital technologies can be used in a targeted manner to increase the actual level of physical activity among pupils. At the same time, their effectiveness depends on the extent to which these solutions are integrated into the pedagogical model of the lesson and support motivation, self-regulation, health-saving and digital competence, rather than being implemented formally.

Empirical interventions, risks of digitalisation and a conceptual model of use in physical education

Modern digital technologies of the 21st century in the physical education of secondary school pupils appear as a

multidimensional phenomenon that combines various types of tools (exergames, wearable devices, online platforms, gamified services, monitoring systems) and performs a wide range of pedagogical functions, from informing and demonstrating to motivating, monitoring and supporting independent physical education and health activities. At the same time, the mere presence of a digital tool does not automatically increase physical activity: the didactic scenario for its use, the degree of integration of the goal, the content and methods of physical education lessons, compliance with regulatory requirements, and the ability to support pupils’ motivational needs are of decisive importance. Moving from theoretical considerations to specific examples allows to see more clearly the real impact of digital technologies on the physical activity of schoolchildren. Table 2 shows the use of digital technologies and their impact on the level of physical activity of pupils.

Table 2. Examples of school interventions using digital technologies in physical education

Type of digital technology	Characteristics	Main effects
Exergames (ExerCube)	Randomised controlled study (primary school, pupils aged approximately 10 years): 58 pupils, three months, standard physical education lessons plus 20 minutes of exergaming twice a week.	A significant improvement in physical fitness indicators (endurance, strength, coordination) was observed in the intervention group compared with the control group → exergames can provide sufficient exercise intensity and increase the level of physical activity during lessons.
Exergames (school-based exergaming programme)	Randomised controlled study (Years 5-6): 58 pupils, three months, school-based exergaming intervention.	An increase in physical self-concept (self-assessment of strength, endurance, and agility); the positive emotional experience of gaming improves attitudes towards movement → indirectly supports higher levels of physical activity.
Gamified programme with cards/sensors (active travel to school)	Seven-week intervention (16 schools – exergaming intervention; 2 schools – control group), “outdoor game” (walking/cycling, points awarded for sensor check-ins).	An increase in the proportion of children achieving the recommended level of physical activity and a higher frequency of active travel to school → digital activity tracking combined with game mechanics changes daily behaviour, not only participation in physical education lessons.
Edmodo social network + gamification of the physical education course	Ten teachers and 56 pupils (secondary school), gamified Physical Education (PE) course delivered via Edmodo.	Pupils received points/badges for physical activity and took part in challenges; both pupils and teachers positively evaluated the platform, and a high impact on the promotion of physical activity outside lessons was noted → demonstrates how a social network can support home-based and extracurricular physical activity.
Wearable activity trackers (wearables)	Cross-sectional survey of 1,087 school staff, describing practices of using activity trackers.	Used during physical education lessons, throughout the school day, in “movement breaks”, for step challenges, and for teaching children how to interpret their own data. The majority of staff were willing to continue using trackers to increase physical activity.
Exergame-based training sessions	Randomised controlled study (primary school): 68 children, eight weeks; experimental group – exergame-based training three times a week, control group – usual physical activity.	After eight weeks in the experimental group, there was a significant improvement in 800 m running time (cardiorespiratory endurance) and in muscular endurance indicators (sit-ups) compared with the control group.

Source: compiled by the authors based on F.J. Montiel-Ruiz *et al.* (2022), S. Ketelhut *et al.* (2022), A.V. Creaser *et al.* (2022), B. Lambi *et al.* (2022), L. Röglin *et al.* (2024), C.F. Lin *et al.* (2025)

Online physical education highlights the dual nature of the digital educational environment’s impact on pupils’ levels of physical activity. A summary of the results obtained in the context of the COVID-19 pandemic shows that the transition to remote formats was accompanied by a decrease in the overall level of physical activity and a deterioration in the physical fitness of schoolchildren, particularly when theoretical or formal online classes predominated (Knocke *et al.*, 2024). Structured online physical education programmes using video lessons, interactive tasks and activity monitoring tools have been shown to reduce the negative effects of lockdowns and partially preserve or improve certain components of physical fitness (Merino-Campos & Del-Castillo, 2025). The potential of such platforms (such as

Edmodo, Zoom, Google Meet) is realised under conditions of adequate technical support, a clear pedagogical lesson plan, and consideration of the ethical aspects of online interaction, while common limitations remain unequal access to the internet and devices for pupils, difficulties in monitoring actual levels of physical activity in the home environment, and additional workload for teachers (Gao *et al.*, 2025).

In the context of Ukrainian physical education for pupils in general secondary education, the issue of digitalisation is considered primarily in the broader context of educational innovation and the use of information and communication technologies. Multimedia tools, interactive forms of work, online resources, and electronic educational platforms can increase pupils’ motivation to engage

in physical education, promote the individualisation of learning, and expand opportunities for independent physical activity (Yazlovetska, 2022; Kuzmenko, 2022). However, specific models of online physical education, with a structured description of the use of platforms such as Zoom, Google Meet or Edmodo in the context of systematic school physical education programmes, are generally not detailed. This indicates a gap between the general recognition of the usefulness of digital tools in physical culture and the lack of theoretically described and empirically verified Ukrainian practices of online physical education. This provides grounds for viewing online formats in school physical education as a promising yet still insufficiently conceptualised area. On the one hand, the digital environment creates additional opportunities to support continuity in physical education and to extend the space of physical activity beyond the sports hall; on the other hand, the effectiveness of such solutions directly depends on how clearly they are embedded in the pedagogical model of the lesson, aligned with normative requirements and oriented towards achieving target levels of pupils' physical activity.

A key condition for the effective use of digital technologies in physical education is the appropriate level of digital and methodological competence of the teacher. The introduction of innovative tools requires the teacher to be ready to design digital lessons, select adequate resources, differentiate the workload and ensure safe work in online and offline environments (Martín-Rodríguez & Madrigal-Cerezo, 2025). A significant methodological requirement is to maintain a sufficient motor component of the lesson: digital tools should stimulate and organise physical activity, not replace it. This is advisable for online physical education and mixed formats, where there is a risk of reducing the lesson to watching videos or taking tests (Merino-Campos & Del-Castillo, 2025; Gao *et al.*, 2025). Exergames, wearable trackers, and gamified platforms are effective when their use is linked to clear targets for the volume and intensity of physical activity and integrated into the structure of the lesson or extracurricular activities as a systematic rather than episodic element (Creaser *et al.*, 2022; Röglin *et al.*, 2024). Accordingly, digital technologies should be designed as a tool for achieving these goals, rather than as a distraction from them.

Alongside the advantages of using digital technologies in physical education, a number of risks and limitations also emerge. One of the most obvious is the threat of increased screen time, which runs counter to the objective of reducing sedentary behaviour: without a carefully designed balance between "screen-based" and movement components, a lesson may turn into yet another seated activity (Lambe *et al.*, 2022; Knoke *et al.*, 2024). A significant problem is unequal access to devices and high-quality internet connectivity, particularly in the context of distance learning and the use of online physical education. Digital inequality can exacerbate educational disparities by limiting participation in programmes based on exergames, trackers or gamified platforms (Lambe *et al.*, 2022; Knoke *et al.*, 2024). A separate group of risks relates to the reliability and interpretation of data from wearable devices: formal task completion, manipulation of trackers or misinterpretation of indicators may occur, which reduces the educational potential of such tools (Creaser *et al.*, 2022; Montiel-Ruiz *et al.*, 2022). In

addition, issues of privacy and the protection of pupils' personal data arise, especially when commercial platforms and cloud services are used. Finally, there is a risk of formalism, whereby a digital tool is introduced primarily to demonstrate "innovation" without any real change in lesson content or teaching methods. In such cases, the impact on actual levels of physical activity remains minimal, and digitalisation takes the form of superficial modernisation not supported by deeper didactic change (Martín-Rodríguez & Madrigal-Cerezo, 2025).

On the basis of synthesising research findings, digital technologies in the physical education of pupils in general secondary education institutions can appropriately be considered within a conceptual "input-process-outcomes" model, which integrates the approaches of health promotion (orientation towards creating a supportive educational environment, expanding learners' opportunities and involving them in decision-making) and technology-enhanced pedagogy (the use of digital tools for personalised learning, active participation, feedback and monitoring). Within this model, digital tools are not an end in themselves but are viewed as resources that activate specific mechanisms for changing pupils' movement behaviour. The "input" block comprises three interrelated groups of components: the main groups of digital tools (exergames, wearable trackers, gamified platforms, online physical education and blended formats), regulatory and normative reference points (the State Standard and WHO recommendations on physical activity for children and adolescents), and pedagogical conditions of implementation (teachers' digital and methodological competence, material and technical resources, and organisational support from the educational institution). In the logic of health promotion, this combination forms a "physical-activity-supportive environment", while in the logic of technology-enhanced pedagogy it constitutes the infrastructure for implementing active, personalised and data-informed learning. It is precisely the configuration of these "input" elements that determines which "process" mechanisms can be activated and how effectively they operate: for example, the availability of wearable trackers without an analytical platform and pedagogical support limits opportunities for self-monitoring and reflection, while access to exergames without school support and appropriate spatial organisation does not ensure a systematic increase in physical activity.

The "process" of integration reflects the mechanisms through which "input" resources are transformed into behavioural changes. Exergames and gamified platforms, drawing on the principles of technology-enhanced pedagogy, increase both intrinsic and extrinsic motivation through game mechanics (levels, points, badges, leaderboards, challenges) and social comparison. This aligns with health promotion ideas regarding active participation and peer support among pupils. Wearable trackers and analytical platforms facilitate self-monitoring, the setting of individual goals, and immediate feedback, creating the conditions for developing self-regulation skills in physical activity. Online PE, digital media, and social networks expand the space for physical activity beyond the lesson: they support the regularity of exercise in remote and blended formats, structure extracurricular challenges, and foster networked communities oriented towards an active

lifestyle. Furthermore, video and interactive content support the teaching of movement techniques and the acquisition of theoretical knowledge, which enhances the quality of exercise execution and the mindfulness of motor behaviour. The effectiveness of these mechanisms depends on the degree of their organic integration into the structure of lessons and extracurricular activities, their alignment with educational programmes, and the teacher's ability to implement technology-supported pedagogical design.

At the "outcome" level, the model distinguishes between direct, indirect, and long-term effects. The activation of the described "process" mechanisms leads directly to an increase in time spent in moderate-to-vigorous physical activity, improved physical fitness indicators, and increased participation in physical and sporting events. Indirectly, through the experience of success, social support, the ability to track one's own progress, and the receipt of positive reinforcement, a positive attitude towards physical education is formed, physical self-concept is enhanced, self-regulation skills for physical activity are developed, and pupils' health-preserving competence is strengthened. In the long term, in line with the logic of health promotion, such integration of digital technologies contributes to a more stable alignment with international recommendations regarding physical activity levels and the formation of the foundations for an active lifestyle throughout the life cycle (Fig. 1).

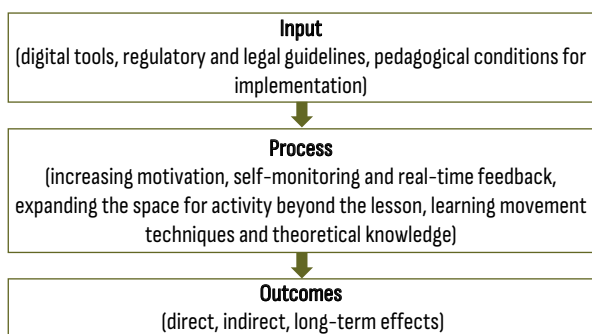


Figure 1. Conceptual model of the integration of digital technologies into the physical education of general secondary education pupils ("input – process – outcomes") within the framework of the health promotion and technology-enhanced pedagogy approaches

Source: compiled by the authors based on World Health Organization (2020), F.J. Montiel-Ruiz *et al.* (2022), C. Knoke *et al.* (2024), C. Merino-Campos & H. Del-Castillo (2025), A. Martín-Rodríguez & R. Madrigal-Cerezo (2025)

The proposed model can be applied not only to physical education lessons but also to the school sport system as a whole, including the work of sports clubs, the preparation of teams for competitions, and the organisation of school and interschool tournaments. Thus, digital technologies in the physical education of general secondary education pupils demonstrate a significant but heterogeneous potential to influence levels of physical activity. Exergames combine a high level of physical load with an engaging game-based format, positively affecting physical fitness and self-perception; wearable trackers and related platforms provide monitoring, self-control, and goal setting; and gamified programmes and social services help shift the focus from

the lesson itself to everyday movement behaviour. Online formats of physical education support continuity of learning in conditions of distance education; however, their effectiveness in maintaining adequate levels of physical activity depends on the quality of pedagogical design. Of decisive importance is the alignment of digital solutions with the aims of the field of Physical Culture and Sport, their consistency with the recommendations of the WHO, teacher competence, and the resources of the educational institution. Thus, digital technologies should be regarded as tools for the purposeful enhancement of pupils' physical activity both during lessons and in extracurricular sports and health-related activities.

The results of the study indicate that the proposed classification of digital technologies (exergames, wearable trackers, digital monitoring platforms) and the "input-process-outcomes" model, in which monitoring mechanisms, individualisation of load, and feedback play a key role, reflect the logic of their practical application in physical education. In the study by Q. Zhong *et al.* (2025), it is shown that "digital-intelligent technologies" form a closed cycle in physical education: intelligent lesson design, real-time visualisation of the process, and data-driven assessment and adjustment. This correlates with the findings of the present study, which demonstrate that digital monitoring platforms and wearable devices that collect activity data enable the tracking of dynamics, goal setting, and adjustment of physical load. In both cases, digital tools are viewed not as an "addition to the lesson" but as the core of a new, more controllable and personalised model of physical education. This confirms the appropriateness of the systematic use of digital technologies as a structure-forming element of modern school physical education in the twenty-first century.

In the study by V. Tagimaucia *et al.* (2024), online physical education is examined through the lens of teachers' experiences who were forced to switch to online formats during COVID-19 lockdowns. The authors showed that insufficient teacher preparation, a lack of online pedagogical skills, and limited infrastructure constitute key barriers to high-quality distance teaching of physical education. Without targeted development of teachers' digital and methodological competence, as well as adequate material and technical support, the potential of online formats is only partially realised. The results obtained in the present study are consistent with these conclusions: digital solutions in physical education prove effective only when the teacher designs the lesson in such a way that screen-based components organise real motor activity rather than replace it, and when the risks of increased screen time, digital inequality, and the formal use of platforms as a mere "demonstration of innovativeness" are addressed. The transition to online formats in itself does not guarantee the achievement of target levels of pupils' physical activity unless it is accompanied by systematic teacher support and well-considered pedagogical design of lessons.

The results of the study established that gamified programmes and social networks (challenges, points, leaderboards, badges, online communities) stimulate everyday movement behaviour (travel to school, extracurricular activity) and support motivation, which is consistent with the work of V. Arufe-Giráldez *et al.* (2022). The authors summarised the experience of gamification in school physical

education, showing that the use of game elements (narrative, levels, rewards) enhances pupils' engagement, interest, and satisfaction with physical education lessons, while the effect of gamification depends on the quality of pedagogical design. Both studies indicate that gamification is not "automatically" effective; however, when competently embedded into the structure of lessons and extracurricular activities, it significantly strengthens the motivational component and pupils' readiness to be physically active.

In the systematic review by C. Wang *et al.* (2023), blended learning in physical education is analysed as a promising but methodologically complex approach. The authors synthesise tools, theoretical frameworks, and assessment methods and show that combining online and offline components can increase pupil engagement, flexibility, and continuity of learning, but is not automatically effective. Key conditions for the effectiveness of blended formats include clear instructional design, a sufficient level of teachers' digital skills, and support for pupils' self-regulation. The findings of the present study resonate with these conclusions: online and blended formats in Ukrainian school physical education are viewed as a promising yet still insufficiently conceptualised direction, the effectiveness of which depends on the quality of integration into the pedagogical model of the lesson and alignment with the requirements of the State Standard and the recommendations of the WHO regarding 60 minutes of moderate-to-vigorous physical activity per day. Blended learning in physical education is effective only when supported by thoughtful pedagogical design and orientation towards the goals of the State Standard and WHO recommendations. Thus, digital technologies in the physical education of general secondary education pupils have a substantial but heterogeneous potential to increase levels of physical activity and motivation – from exergames and wearable trackers to gamified programmes and online formats. Their real effect is determined not so much by the fact of digitalisation itself as by the quality of pedagogical design, compliance with regulatory documents in the field of physical education, their use as tools for the purposeful enhancement of pupils' motor engagement, teacher competence, and the mitigation of risks related to excessive screen time, digital inequality, and formalism.

Conclusions

The results of the study revealed that formally allocated physical education hours create only minimal conditions for health preservation and, without additional tools, particularly digital ones, do not provide the recommended 60 minutes of activity per day. A classification of digital tools for school physical education has been developed, covering active video games, wearable devices, online platforms, gamified services, and systems for collecting and analysing

data on physical activity. Exergames in the form of educational interventions provide sufficient intensity of exercise and contribute to the growth of endurance, strength and coordination indicators in younger schoolchildren. Regular use of active video games is associated with improved physical self-concept and a more positive attitude towards physical education among pupils. Gamified programmes and social networks stimulate not only activity in the classroom, but also daily physical behaviour, including active commuting to school and extracurricular activities. Online and blended formats of physical education can prevent a sharp decline in physical activity during distance learning, but only if they are well designed pedagogically and adequately supported by technology. In Ukraine, online physical education is still largely fragmented and requires further theoretical justification and standardisation of practices.

The effectiveness and safety of using digital technologies in physical education depend on the teacher's high digital and methodological competence and avoiding the risks of excessive screen time, digital inequality and data privacy violations. A conceptual model of "input-process-outcomes" has been proposed, in which the "input" stage combines a reasoned choice of digital tools, compliance with national and international regulatory documents, and resource support for the educational institution, while the "process" of integration is implemented through gamification, self-control, operational feedback, social interaction, and individualisation of workload. The systematic use of such technologies increases the proportion of pupils who achieve target levels of physical activity and better physical fitness results, so digital tools should be seen as a means of purposefully shaping an active lifestyle rather than a formal marker of innovation. The limitations of the study are its theoretical and review nature and the lack of empirical data, which complicates the direct extrapolation of conclusions to the Ukrainian context. Prospects for further research should be directed towards conducting an empirical assessment of the effectiveness of digital solutions in the physical education of the general secondary school pupils, developing methodological recommendations and programmes for teacher training, as well as analysing the ethical and legal aspects of the use of digital data, particularly in Ukraine.

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Conflict of Interest

None.

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Вплив застосування сучасних цифрових технологій у фізичному вихованні на рівень фізичної активності учнів середньої школи

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Анотація. Метою дослідження було розкрити теоретичні засади інтеграції електронних освітніх платформ і мобільних сервісів у шкільні заняття з фізичної культури для окреслення їх можливості щодо посилення рухової залученості школярів. Методологія базувалась на поєднанні теоретичного аналізу, нормативно-правового підходу та концептуального моделювання. Виявлено, що основними інструментами цифрових технологій є exergames, фітнес-трекери, онлайн-уроки, гейміфіковані програми, соцмережі та платформи моніторингу активності. Exergames, носимі трекери та гейміфікація забезпечують достатню інтенсивність навантаження, дають об'єктивні дані для самоконтролю й постановки цілей та стимулюють щоденну рухову активність учнів. Онлайн-формати фізичного виховання частково компенсують зниження рухливості під час дистанційного навчання, якщо мають продуманий педагогічний дизайн. Цифрові медіа в концепції health promotion використовуються для профілактики гіподинамії та наближення учнів до рекомендованих рівнів рухової активності. У межах technology-enhanced pedagogy цифрові засоби індивідуалізують навантаження, покращують засвоєння рухових дій і розширюють простір активності поза школою. Встановлено, що результатами інтеграції цифрових технологій є зростання часу помірної/високої активності, покращення фізичної підготовленості, мотивації, саморегуляції та позитивного ставлення до фізичної культури. Ефективність і ризики залежать від компетентності вчителя, матеріальної бази, організаційної підтримки, а також від контролю екранного часу, цифрової нерівності й конфіденційності даних. Запропоновано концептуальну модель «вхід – процес – результати», де на «вході» – типи цифрових технологій, нормативні орієнтири й умови реалізації, у «процесі» – мотиваційні, організаційні та моніторингові механізми впливу, а в «результатах» – зміни фізичної активності та ставлення до фізичної культури. Практична значущість полягає в тому, що результати доцільно застосовувати вчителям фізичної культури та методистам для планування занять, спрямованих на підвищення фізичної активності й мотивації учнів

Ключові слова: exergames; носимі трекери; гейміфіковані платформи; онлайн-навчання спорту; мотивація школярів; рухова активність



The impact of systematic aerobics classes on indicators of the physical and functional states of people of different ages

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Abstract. The aim of the study – a comprehensive investigation of the impact of regular aerobics classes on the physical and functional state of people in different age categories, taking into account age-specific adaptation mechanisms, the features of load structuring, and the nature of physiological responses. Assessment was carried out on the basis of indicators of heart rate, arterial blood pressure, vital capacity of the lungs, results of the 6-minute walk test, the Training Impulse index, as well as the World Health Organisation Quality of Life – Brief Version questionnaire, using Student's *t* test, the Mann-Whitney *U* test, correlation analysis, and 95% confidence intervals. The results showed a statistically significant improvement in functional indicators in all groups: resting heart rate decreased from -4.2 beats/min in the young group to -1.4 beats/min in the older group; the 6-minute test distance increased by 60, 55, and 30 metres, respectively ($p = 0.033$). The mean Training Impulse values were 102, 88, and 74 conventional units, which indicated different training sensitivity. Correlation analysis confirmed the leading role of the training impulse in the formation of adaptive changes ($r = 0.62$ in the young group; $p < 0.01$). According to the World Health Organisation Quality of Life – Brief Version, the greatest improvement was observed in the physical and psychological domains in the young and middle-aged groups, whereas in older participants the effects were moderate but clinically meaningful (Δ of the physical domain = +4.6). The obtained results indicate the effectiveness of structured aerobics programmes for different age categories and emphasise the need to personalise training intensity, especially in older people. The study data may be used to optimise health-improvement programmes, develop safe aquaerobics formats, and improve the population's quality of life

Keywords: endurance; training impulse; quality of life; cardiorespiratory indicators; health-improvement programmes

Introduction

The relevance of the study was determined by the growing need for a scientific understanding of the impact of systematic aerobics classes on the physical and functional state of people of different ages under contemporary demographic, social, and biomedical challenges. In the context of population ageing, increasing prevalence of physical inactivity, metabolic disorders, and cardiovascular diseases, regular physical activity acquired the status of one of the key tools for prevention and health maintenance. Aerobic forms of load were considered the most accessible, safe, and effective for different age groups, as these forms provided a comprehensive effect on the cardiorespiratory system, the

musculoskeletal system, metabolic processes, and psycho-emotional state. The issue of optimising aerobic programmes became more acute given the increasing number of people with excess body weight, multimorbidity, and a low level of physical fitness, which required the development of individualised approaches to training regimes.

In scientific discourse, the question of the impact of aerobic training on physical development and functional indicators of people of different ages received broad coverage, which, however, was unevenly distributed across age groups and types of load, creating a need to systematise the available data. In the work by E. Doroshenko *et al.* (2021),

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it was shown that differentiated aerobic loads in female students with different motor fitness contributed to improvements in physical working capacity, coordination abilities, and the body's adaptive capabilities; however, the authors emphasised the need for individual adjustment of training intensity depending on the baseline functional state. Similar conclusions were presented by V.M. Miroshnichenko *et al.* (2021), who showed a positive impact of aquafitness on the functional state of women in the first period of mature age, especially regarding endurance, resting heart rate, and respiratory system indicators, which indicated the effectiveness of the aquatic environment in reducing load on the musculoskeletal system. For the 40-60 age group, T. Gnitetska *et al.* (2021) established a slowing of the pace of biological ageing under the influence of systematic athletics and fitness classes, which confirmed the importance of aerobic loads as a means of preserving functional activity, maintaining joint mobility, and preventing sarcopenia.

Among studies in older age, a special place was occupied by works aimed at assessing the impact of aerobic programmes on vital functions of the body. N. Mei & Y. Chang (2022) demonstrated a significant improvement in physiological indicators in older people after the implementation of structured aerobics classes, in particular increased tolerance to physical loads, stabilisation of arterial blood pressure, improved balance, and reduced risk of falls, which was critically important in gerontological practice. In a randomised controlled study, Y.P. Lo (2021) established a positive effect of individualised aerobic training on physical activity and overall physical fitness among people with multimorbidity, which emphasised the clinical significance of adapted aerobic programmes and the need to include these programmes in rehabilitation protocols. Summarising the results of numerous studies, D. Visser *et al.* (2022), in a systematic review, confirmed the effectiveness of aerobic training for improving cardiorespiratory endurance in vulnerable older groups; however, the researchers drew attention to differing effectiveness depending on the intensity, frequency, and duration of load, which indicated the importance of scientifically grounded dosing of exercises.

A separate line of research concerned the psychological and social dimensions of the impact of aerobic classes, since in older age quality of life was determined not only by physical condition, but also by emotional stability and social activity. A. Shams *et al.* (2021) noted that systematic aerobic exercises not only improved physical condition, but also significantly increased psychological well-being, self-esteem, the level of social involvement, and the quality of life of older people, which expanded the understanding of the role of aerobics as a comprehensive health-improvement factor. In the work by F. Sanchis-Gomar *et al.* (2025), the mechanisms of cardiovascular adaptation to aerobic loads and the dependence of the effect on internal and external factors were analysed in detail, which demonstrated the multi-vector nature of the impact of these classes and confirmed the preventive value in the context of cardiovascular diseases.

In patients with metabolic disorders, aerobic programmes were often combined with dietary interventions to achieve a comprehensive therapeutic effect. S.B. Al-Mhanna *et al.* (2023) confirmed that combining aerobics classes with nutritional correction significantly improved cardiometabolic indicators in patients with obesity and type

II diabetes mellitus, reducing insulin resistance and body weight. For sedentary older people, W. Zhang *et al.* (2024) established the effectiveness of both purely aerobic and combined aerobic-strength programmes in improving motor functions, coordination, and walking speed, which emphasised the importance of variability in training effects and combining different class structures depending on the needs of the target group.

Thus, contemporary scientific data indicated that aerobic loads had considerable potential in improving the physical, functional, and psycho-emotional state of people of different ages; however, unresolved questions remained regarding optimal intensity, individualisation of training programmes, and determining the age specificity of the body's adaptive responses. This formed the need for further research aimed at clarifying the mechanisms of action of aerobic loads and developing scientifically grounded recommendations for different age categories. The aim of this study was a comprehensive examination of the impact of systematic aerobics classes on indicators of the physical and functional states of people of different ages, taking into account age-related differences in adaptation, load structure, and the nature of physiological responses.

Materials and Methods

The study was conducted from October 2024 to June 2025 on the basis of three specialised sports and health facilities in the city of Kyiv: the SportLife (n.d.) fitness club "Pozniaki", the 5 Element (n.d.) club, and the Olympic Style (n.d.) rehabilitation centre. The selection of these institutions was determined by the availability of a modern material base, swimming pools with a water temperature of 27-29°C, cardio training equipment, and certified instructors, which ensured standardised conditions of the training process. The study was conducted in the morning hours between 9:00 and 12:00 to minimise diurnal fluctuations in physiological indicators.

The sample was formed on the principle of non-random voluntary participation, which was typical for intervention studies in the field of health-improvement physical culture. The study included 120 people aged 18-70 years, evenly distributed into three age groups: young (18-35 years, $n = 40$), middle (36-55 years, $n = 40$), and older (56-70 years, $n = 40$). The sex composition of the sample comprised 82 women and 38 men, which reflected the structure of participants in the health-improvement programmes of these centres. The occupational structure of the sample included mainly employed people with a sedentary nature of work (office workers, teachers, service sector representatives), which ensured representativeness for typical attendees of health-improvement programmes. Inclusion criteria were the ability to perform physical loads of moderate intensity, absence of acute diseases, and signed informed consent. Exclusion criteria were decompensated cardiovascular pathologies, severe musculoskeletal injuries, and other medical contraindications. Primary medical examination was conducted by a sports medicine physician, with an electrocardiographic assessment of the state of the cardiovascular system at rest.

The intervention lasted 12 weeks and included three training sessions per week lasting 45-60 minutes. The structure of the session included an introductory part

(10 minutes), the main aerobic block (30-40 minutes), and a final stage (5-10 minutes). In the land-based format, classical aerobics with musical accompaniment frequency of 120-140 beats/min and step aerobics with a platform of 10-20 cm were used, which increased energy expenditure. For the older group, aquaerobics was used in the pools of SportLife (n.d.) "Pozniaki" and 5 Element (n.d.), which reduced impact load on the joints and ensured safe conditions for people with reduced tolerance to physical load.

Load control was carried out using Polar H10 heart rate monitors (Finland) with continuous HR recording and the subjective perceived exertion scale by G. Borg (1998). For a quantitative characterisation of training volume, the Training Impulse (TRIMP) indicator was used – a metric for measuring load and stress on the body during training, which took into account the duration and intensity of load, conceptually grounded in Banister's integral load model (Banister, 1991). TRIMP was calculated as the product of training duration (min) and an intensity coefficient based on the percentage of maximal heart rate (HR_{max}), which corresponded to the classical E.W. Banister (1991) formula (1):

$$TRIMP = t \times HR_r \times y, \quad (1)$$

where t – duration of the training session (min); HR_r – relative heart rate, calculated as (2):

$$HR_r = \frac{HR_{ex} - HR_{rest}}{HR_{max} - HR_{rest}}, \quad (2)$$

where HR_{ex} – average heart rate during training; HR_{rest} – resting heart rate; HR_{max} – individually determined maximal heart rate; y – intensity weighting factor reflecting the non-linear physiological response to load and determined exponentially:
for men (3):

$$y = 0.64 \times e^{1.92 \times HR_r}, \quad (3)$$

for women (4):

$$y = 0.86 \times e^{1.67 \times HR_r}. \quad (4)$$

Assessment of physical state was conducted before and after the programme and included measurement of resting HR, arterial blood pressure, vital capacity of the lungs

using the portable spirometer MicroLab ML350 (United Kingdom), performance of the 6-minute walk test, anthropometric indicators, the "sit-to-stand" test, and balance assessment. Quality of life was determined using the standardised World Health Organisation Quality of Life – Brief Version (WHOQOL-BREF) questionnaire (The WHOQOL Group, 1998). The ethical processing of questionnaire data was ensured in accordance with the Code of Ethics of the American Sociological Association (1997).

Statistical data processing was carried out in IBM SPSS Statistics 28.0 using Student's t test for independent samples ($p < 0.05$), the Mann-Whitney U test for non-parametric indicators, and calculation of 95% confidence intervals. Normality of distribution was checked using the Shapiro-Wilk test. The choice of parametric and non-parametric analysis methods was justified by the nature of the data: under normal distribution, Student's t test was used, and in case of its violation – the Mann-Whitney U test, which ensured the correctness of statistical conclusions. Ethical aspects of the study complied with international and national norms: the principles of the Declaration of Helsinki (2013), the provisions of clinical practice guidelines ICH E6(R2) good clinical practice (1997), the recommendations of the European Commission (2021), and the International Code ICC/ESOMAR (2025). All participants signed written informed consent, and confidentiality was ensured through anonymisation and the use of data in aggregated form.

Results and Discussion

At the initial stage, the analysis covered the baseline functional status of participants in three age groups, which made it possible to determine basic differences in cardiorespiratory and physical parameters. A clear age-related gradation of endurance and respiratory function indicators was recorded: the younger group demonstrated the highest values of vital capacity of the lungs and the results of the 6-minute walk test, whereas in the older group a substantial decrease in these indicators was observed. Similar trends of age-related decline in aerobic performance were described in X. Bai *et al.* (2022), which confirmed the typicality of the obtained values for the population of health-programme participants. Table 1 summarised the baseline characteristics of the sample, demonstrating a gradual decrease in functional potential with age and the formation of different adaptive capacities.

Table 1. Baseline characteristics of the sample by age groups ($M \pm SD$)

Indicator	Young age (18-35 years, $n = 40$)	Middle age (36-55 years, $n = 40$)	Older age (56-70 years, $n = 40$)	p value
Resting HR (beats/min)	71.4 ± 5.8	75.6 ± 6.2	80.3 ± 6.9	0.067
Systolic BP (mmHg)	118 ± 9	126 ± 11	138 ± 14	0.054
Diastolic BP (mmHg)	74 ± 6	79 ± 7	84 ± 8	0.072
VC (l)	4.1 ± 0.5	3.4 ± 0.4	2.9 ± 0.3	0.081
6-minute walk test (m)	615 ± 42	545 ± 48	495 ± 52	0.063
BMI (kg/m ²)	23.8 ± 2.4	26.7 ± 3.1	28.4 ± 3.6	0.088

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As Table 1 shows, the baseline indicators of the three age groups demonstrated a clear gradation of functional state in accordance with age-related changes. The lowest resting HR values were recorded in the young group (71.4 ± 5.8 beats/min), whereas in older individuals this

indicator was substantially higher (80.3 ± 6.9 beats/min), which was consistent with the trend described in X. Bai *et al.* (2022) of increased heart rate at older age due to reduced efficiency of cardiac output and autonomic regulation. Systolic and diastolic blood pressure increased gradually: from

118/74 mmHg in young participants to 138/84 mmHg in older participants, which confirmed the age-related increase in vascular resistance and arterial wall stiffness described by L. Yao *et al.* (2021).

Vital capacity of the lungs showed the largest gap between groups: 4.1 ± 0.5 l in young participants versus 2.9 ± 0.3 l in older participants, which was consistent with the data of Y. Lu *et al.* (2021), who pointed to a decline in the elasticity of lung tissue and a reduction in alveolar ventilation with age. The results of the 6-minute walk test showed an analogous trend: young participants covered an average of 615 m, whereas in the older group the mean value was 495 m, which confirmed a substantial decline in load tolerance and overall aerobic work capacity described in X. Bai *et al.* (2022) for older individuals who did not engage in systematic training.

Body mass index increased from 23.8 ± 2.4 kg/m² in young participants to 28.4 ± 3.6 kg/m² in older participants, which corresponded to the trend of age-related body-mass accumulation and changes in body composition noted by L. Yao *et al.* (2021). At the same time, statistical analysis did not reveal significant differences between groups for any of the indicators ($p > 0.05$), which allowed the sample to be considered homogeneous in terms of key physiological parameters. A similar situation was described in Y. Lu *et al.* (2021), where, despite differences in mean values across age groups, statistical homogeneity ensured the correctness of subsequent comparisons of training response.

The obtained results indicated a clearly formed age trajectory of changes in cardiorespiratory and anthropometric parameters, characteristic of populations engaged in health programmes. In the older group, a persistent increase in

resting heart rate and blood pressure was observed, combined with a decrease in vital capacity of the lungs and endurance indicators, whereas in younger participants higher ventilatory capacities and better results of the 6-minute walk test were recorded. Similar age patterns were presented in X. Bai *et al.* (2022) for older individuals and in Y. Lu *et al.* (2021) regarding young people with baseline aerobic fitness, which confirmed the representativeness of the obtained values. The increase in BMI and the tendency towards higher blood pressure in the middle and older age groups were consistent with the data of L. Yao *et al.* (2021), who linked these changes to reduced physical activity and the accumulation of metabolic risks.

In addition, the results were consistent with the conclusions of Q. You *et al.* (2022), which showed that age-related decline in vascular endothelial function directly correlated with reduced aerobic performance and tolerance to physical loads, which could explain the lower endurance and VC values in older participants. This confirmed that the identified baseline characteristics were not random, but reflected systemic physiological changes associated with age. In summary, the baseline results demonstrated the combination of age-related increases in HR and blood pressure with a decline in ventilatory and endurance capacities and an increase in body mass, which formed different adaptive potentials of the groups before the implementation of aerobic loads. After completion of the 12-week programme of combined aerobic loads, positive changes in cardiorespiratory and functional indicators of varying intensity were recorded in all three age groups. Changes in physical and functional indicators after the intervention were presented in Table 2.

Table 2. Changes in physical and functional indicators before and after the experiment

Indicator	Young age (n = 40)	Middle age (n = 40)	Older age (n = 40)	p value
Resting HR (beats/min)	71.4 ± 5.8 → 67.2 ± 5.1 (CI 95%: -5.6, -3.1)	75.6 ± 6.2 → 72.8 ± 5.7 (CI 95%: -4.9, -2.1)	80.3 ± 6.9 → 78.9 ± 6.5 (CI 95%: -2.8, -0.4)	0.041
Systolic BP (mmHg)	118 ± 9 → 114 ± 8 (CI 95%: -6.7; -3.4)	126 ± 11 → 120 ± 10 (CI 95%: -7.2; -4.1)	138 ± 14 → 132 ± 13 (CI 95%: -7.9, -3.2)	0.038
VC (l)	4.1 ± 0.5 → 4.3 ± 0.5 (CI 95%: +0.1, +0.3)	3.4 ± 0.4 → 3.7 ± 0.4 (CI 95%: +0.2, +0.4)	2.9 ± 0.3 → 3.1 ± 0.3 (CI 95%: +0.1, +0.3)	0.052
6-minute walk test (m)	615 ± 42 → 675 ± 48 (CI 95%: +48; +68)	545 ± 48 → 600 ± 52 (CI 95%: +42; +59)	495 ± 52 → 525 ± 55 (CI 95%: +22; +39)	0.033

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As the data presented in Table 2 indicated, after the 12-week intervention, a statistically significant improvement in cardiorespiratory and functional indicators was recorded in all age groups; however, the magnitude of changes differed depending on age. The greatest reduction in resting heart rate was observed in the young group (-4.2 beats/min; CI 95%: -5.6; -3.1), which may indicate faster adaptation of the cardiovascular system to aerobic load. In middle age, the reduction was moderate (-2.8 beats/min; CI 95%: -4.9; -2.1), whereas in older participants the smallest effect was noted (-1.4 beats/min; CI 95%: -2.8; -0.4), which was consistent with the data of I. Ahmed *et al.* (2022) on slower adaptive responses in the older population. Systolic blood pressure showed a similar trend: the largest reduction was observed in the middle-aged group (-6 mmHg), where the combination of higher baseline hypertensive status and regular load produced a pronounced effect, which corresponded to the results of S.B. Al-Mhana *et al.* (2024) regarding the sensitivity of this group to training influence. In older individuals, the reduction was

-6 mmHg; however, the confidence intervals indicated wider variability of response. Vital capacity of the lungs increased in all groups, most in the middle-aged group (+0.3 l), which confirmed the capacity of the respiratory system for functional improvement with regular training activity, as described in Q. You *et al.* (2022). For the young and older groups, the increase was smaller (+0.2 and +0.2 l, respectively), which may reflect differences in baseline ventilatory reserve. The most pronounced changes were recorded in the results of the 6-minute walk test: young participants improved the indicator by an average of +60 m, middle-aged participants by +55 m, and older participants by +30 m, which was consistent with the conclusions of Y. Li *et al.* (2024) regarding the dependence of endurance gain on baseline state and age-related physiological limitations. The p value of 0.033 confirmed the statistical significance of differences in dynamics between groups. The obtained results also reflected the short-term training effect described by A. Markov *et al.* (2022), according to which moderate-intensity aerobic programmes

caused rapid improvement in functional capacities, especially in younger and more physically active individuals.

According to the results of Student's *t* test for paired samples in the young and middle-aged groups, a statistically significant reduction in resting HR and systolic blood pressure was recorded ($p < 0.05$), which confirmed the training effect on the cardiovascular system. In the older group, some indicators tended to improve; however, for HR and VC the results were statistically borderline, which was consistent with the data of I. Ahmed *et al.* (2022), where slower adaptation after a period of low activity was noted. For participants with the greatest baseline limitations, the use of the Mann-Whitney *U* test also confirmed the significance of changes in endurance ($p < 0.05$), which correlated with the conclusions of S.B. Al-Mhanna *et al.* (2024) regarding the effectiveness of combined programmes for individuals with metabolic disorders. The dynamics of the 6-minute walk test by age groups were presented in Figure 1.

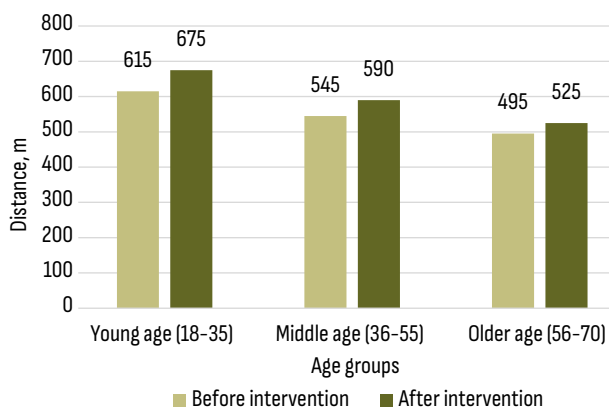


Figure 1. Dynamics of the 6-minute walk test by age group

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

Table 3. Mean TRIMP values by age group ($M \pm SD$)

Indicator	Young age (18-35 years, $n = 40$)	Middle age (36-55 years, $n = 40$)	Older age (56-70 years, $n = 40$)	<i>p</i> value
TRIMP (conventional units)	102 ± 14	88 ± 12	74 ± 11	0.029

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As can be seen from Table 3, the younger group demonstrated the highest mean training impulse (102 ± 14 conventional units), which indicated a greater ability to maintain high intensity throughout the session. In the middle-aged group, the TRIMP value was 88 ± 12 conventional units, whereas in the older group, it was 74 ± 11 conventional units, which confirmed reduced tolerance to load and cardiovascular reactivity with age. Similar age differences in the training effect were described in M. Schumann *et al.* (2022), where it was noted that combining aerobic and strength components required different recovery volumes depending on the age group. Additional analysis comparing training formats showed that water-based sessions were characterised by a lower training load compared with land-based sessions (TRIMP: 82 ± 13 versus 94 ± 15 conventional

units; $p = 0.041$), which may be associated with reduced mechanical impact and heart rate in the aquatic environment due to hydrostatic pressure and reduced gravitational load. This was consistent with the conclusions of R. Joshi *et al.* (2024), which noted that aquatic training formats provided improvements in balance and coordination at lower cardiovascular cost, whereas land-based sessions contributed to a more pronounced development of endurance. Overall, the obtained results indicated that the intensity of training influence was highest in younger participants and decreased with age, which reflected different adaptive potentials of the cardiovascular system. At the same time, aquatic training formats ensured lower physiological cost while maintaining functional effects, which confirmed the appropriateness of the use for individuals with limited

As can be seen from Figure 1, the dynamics of the 6-minute walk test results demonstrated a pronounced improvement in functional endurance in all age groups after the intervention. The greatest gain was observed in the young group: the distance increased from 615 m to 675 m (+60 m), which indicated high training reactivity and a considerable aerobic reserve. In the middle-aged group, the increase was somewhat smaller – from 545 m to 590 m (+45 m), which indicated the effectiveness of the programme under a moderate baseline level of preparedness. The older group demonstrated the smallest gain – from 495 m to 525 m (+30 m), which was characteristic of age-related changes in tolerance to physical load and corresponded to the trends described in Q. You *et al.* (2022) and Y. Li *et al.* (2024), where slower adaptation in older participants was noted. Despite the smaller amplitude of changes, even a moderate improvement in this group was clinically meaningful given its impact on quality of life and functional independence. In summary, the 12-week intervention provided statistically significant improvements in cardiorespiratory parameters and indicators of overall endurance, which confirmed the training effectiveness of the programme and the correspondence of the obtained results to patterns described in contemporary studies.

Training load analysis was carried out using the Training Impulse (TRIMP) indicator, calculated according to Banister's formula model (1-4), which made it possible to quantify the physiological cost of the conducted sessions and compare the intensity of training influence between age groups and programme formats. The obtained values demonstrated a clear age-related gradation of load: the younger group was characterised by the highest training impulse, whereas in the older group mean indicators were substantially lower, which reflected a different cardiovascular response to a training stimulus identical in structure. Similar trends were noted in A.C.F. Marques *et al.* (2023), where the intensity and volume of combined training determined the magnitude of adaptive changes, in particular in indicators of stability and overall endurance. Table 3 summarised the mean TRIMP values for the three age groups.

tolerance to load. This load structure was consistent with contemporary models of combined training programmes described in the works by M. Schumann *et al.* (2022) and A.C.F. Marques *et al.* (2023), and allowed training protocols to be optimised according to age-related capacities and individual physiological response.

Analysis of the relationship between training load magnitude by the TRIMP indicator and gains in functional parameters made it possible to determine how the intensity of aerobic classes influenced the effectiveness of adaptive processes in different age groups. The obtained results demonstrated a clear positive correlation between training impulse and endurance gains, as well as a moderate association with improvements in cardiorespiratory indicators, which indicated the significant role of aerobic load intensity

in shaping physiological adaptation. Similar patterns were described in Q. You *et al.* (2022), where increased training load was associated with substantial vascular adaptations and improved endothelial function. As the analysis of correlations between training load and functional changes showed, TRIMP magnitude was one of the key predictors of endurance gains in the young and middle-aged groups. A similar approach was confirmed in the study by F.M. Impellizzeri *et al.* (2005), where TRIMP proved to be the strongest predictor of endurance gains compared with training volume and duration, demonstrating a close relationship with changes in aerobic performance. Table 4 presented correlation coefficients between TRIMP and key physiological indicators, which allowed the strength and statistical significance of the relationships to be assessed.

Table 4. Correlation of TRIMP with functional changes (coefficient *r*, *p* value)

Indicator	Young age	Middle age	Older age
Gain in 6-minute walk test	$r = 0.62 (p < 0.01)$	$r = 0.54 (p < 0.05)$	$r = 0.38 (p = 0.067)$
Change in resting HR	$r = -0.41 (p < 0.05)$	$r = -0.33 (p = 0.071)$	$r = -0.21 (p = 0.128)$
Change in VC	$r = 0.47 (p < 0.05)$	$r = 0.39 (p = 0.058)$	$r = 0.24 (p = 0.112)$

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As Table 4 shows, the most pronounced correlation between training load and gains in functional endurance was recorded in the young group ($r = 0.62; p < 0.01$), which indicated high sensitivity of the aerobic system to training stimulus. In middle age, the correlation remained statistically significant, although weaker ($r = 0.54; p < 0.05$), which reflected a gradual decline in adaptive capacities. In the older group, the correlation was weaker and statistically borderline ($r = 0.38; p = 0.067$), which corresponded to the age-related features of neurovascular response described in the work by T. Tarumi *et al.* (2022), when load intensity did not always transform proportionally into functional changes. The inverse correlation between TRIMP and resting heart rate was most pronounced in young participants ($r = -0.41; p < 0.05$), which indicated the development of the economisation effect of cardiac activity as a result of aerobic training. In the older group, this indicator was weaker

and statistically non-significant, which was consistent with the conclusions of J. Hendrikse *et al.* (2022) regarding slower cardiovascular adaptation in older individuals.

The relationship between training load and change in vital capacity of the lungs was moderate in the young group ($r = 0.47; p < 0.05$) and decreased with age, which confirmed different ventilatory reserve and respiratory adaptation capacities. Similar trends were described in the work by T. Ishihara *et al.* (2021), where aerobic training intensity was an important predictor not only of physical, but also of cognitive changes in younger participants, whereas in the older population effects were less pronounced but more stable. For visual demonstration of the nature of the relationship between training load and endurance gain, Figure 2 presented the correlation between TRIMP and change in 6-minute walk test distance, which reflected different adaptive profiles of the age groups.

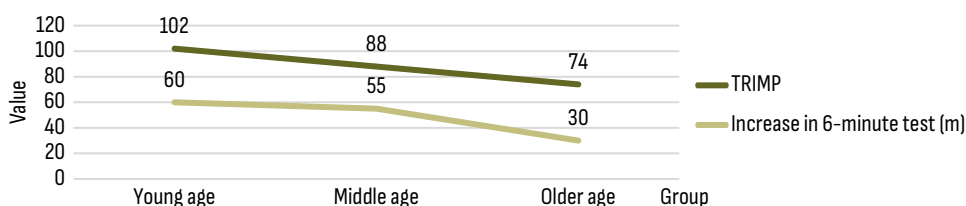


Figure 2. Correlation between TRIMP and endurance gains

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

Analysis of the graphical relationship between TRIMP and gains in functional endurance shown in Figure 2 demonstrated clear age differentiation of adaptive response. In the young group, the greatest increase in 6-minute walk test distance (+60 m) was recorded at the highest mean TRIMP (102 conventional units), which indicated high sensitivity of the aerobic system to load and the presence of substantial functional reserve. In the middle-aged group,

indicators were somewhat lower: TRIMP – 88 conventional units, gain – +55 m; however, an almost linear relationship between load and endurance gain was preserved ($r = 0.54; p < 0.05$). In contrast, in the older group, despite positive dynamics (+30 m), the endurance gain was no longer proportional to the magnitude of training impulse (TRIMP = 74 conventional units), and the correlation between load and outcome was statistically borderline ($r = 0.38; p = 0.067$).

Such a plateau-like graph shape indicated that increasing load in older participants did not yield the expected functional gain, which was a characteristic feature of limited cardiovascular and respiratory reserve. Similar patterns were described in the work by T. Tarumi *et al.* (2022), where it was noted that reduced vascular elasticity and decreased neurovascular reactivity at age 60+ limited the potential for aerobic adaptation, despite the influence of the training programme. In summary, the obtained data indicated that the established correlation profile confirmed that training load magnitude (TRIMP) was the leading predictor of endurance improvement in younger and middle-aged groups. At the same time, the effectiveness of this factor decreased substantially with age, which required personalised selection of intensity and class format, especially for older individuals. This was particularly relevant when planning aquaerobics programmes, where load was reduced but sufficient safety and result stability were ensured.

Analysis of changes in quality of life after the 12-week aerobics programme demonstrated substantial improvement across all WHOQOL-BREF domains; however, the magnitude of effect varied considerably depending on the age group. The greatest dynamics were observed in young and middle-aged participants, whereas in older individuals, improvement was moderate but stable and clinically meaningful. After the intervention, changes in quality-of-life indicators according to the WHOQOL-BREF questionnaire were analysed across four domains. Particular attention was given to between-age differences, since, according to H. Ye *et al.* (2022), response to health programmes was substantially modified by age and baseline functional state. Table 5 presented a comparison of mean values before and after the programme for each age group, which allowed the nature and magnitude of changes in the physical, psychological, social, and environmental components of quality of life to be assessed.

Table 5. Changes in quality of life according to WHOQOL-BREF ($M \pm SD$)

Domain	Young age (18-35 years, $n=40$)	Middle age (36-55 years, $n=40$)	Older age (56-70 years, $n=40$)	p value
Physical	63.2 ± 8.1 → 71.4 ± 7.6	58.7 ± 7.9 → 66.5 ± 7.2	54.3 ± 8.4 → 58.9 ± 7.8	0.031
Psychological	68.5 ± 7.4 → 75.6 ± 7.1	64.1 ± 7.8 → 71.2 ± 7.3	60.7 ± 8.2 → 64.3 ± 7.9	0.044
Social relationships	70.3 ± 8.6 → 76.2 ± 8.1	66.2 ± 7.9 → 72.4 ± 7.5	61.5 ± 8.5 → 65.1 ± 8.0	0.067
Environment	72.1 ± 7.9 → 78.4 ± 7.3	68.9 ± 7.4 → 74.2 ± 7.1	65.3 ± 8.1 → 68.7 ± 7.8	0.052

Source: compiled by the authors on the basis of the obtained study data and statistical processing in IBM SPSS Statistics 28.0 (IBM, 2021)

As Table 5 shows, the greatest increase was observed in the physical domain in young participants ($\Delta = +8.2$ points), which indicated a substantial improvement in the sense of energy, reduced fatigability, and increased ability to perform daily physical loads. Similar effects were described in B. Ferrer-Uris *et al.* (2022), where it was noted that regular aerobic training stimulated cognitive-motivational mechanisms of perceiving physical condition, increasing the subjective sense of control over the body and motor activity. In the middle-aged group, improvement in the physical domain was somewhat smaller ($\Delta = +7.8$), but remained statistically significant ($p < 0.05$), which was consistent with the data of S.B. Al-Mhanna *et al.* (2024), where individuals with baseline metabolic risks demonstrated high responsiveness to training influence in the context of subjective well-being. In the older group, dynamics were moderate ($\Delta = +4.6$), but clinically important, since even a small improvement in physical well-being at age 60+ was associated with increased autonomy, as confirmed by L. Yao *et al.* (2021), who pointed to the critical role of neuropsychological factors in maintaining the quality of life of older people. The psychological domain demonstrated pronounced changes in the young ($\Delta = +7.1$) and middle-aged groups ($\Delta = +7.1$), which may be associated with reduced stress levels, improved mood, and a sense of achievement, described by M.P.B. de Oliveira *et al.* (2021) in the context of neuroplastic effects of aerobic programmes in neurological conditions. In older participants, the increase was more modest ($\Delta = +3.6$), which corresponded to the assumption of H. Ye *et al.* (2022) regarding limited psychological reserve for adaptation at older age. The social domain showed the lowest statistical significance ($p = 0.067$); however, improvement in the young ($\Delta = +5.9$) and middle-aged groups ($\Delta = +6.2$) indicated increased social

involvement, which was an important factor in sustaining motivation. For older individuals, the increase was minimal ($\Delta = +3.6$), which may be explained by lower social activity and stability of social ties, described in L. Yao *et al.* (2021). The “environment” domain demonstrated moderate but important changes, especially in the young group ($\Delta = +6.3$), which may be associated with increased sense of safety and control over one’s life, which was consistent with the conclusions of H. Ye *et al.* (2022) regarding the influence of safe training formats on perception of the surrounding environment. Statistical analysis using Student’s t-test for paired samples confirmed significant changes in the physical and psychological domains for the young and middle-aged groups ($p < 0.05$), whereas for the older group changes were borderline, which corresponded to the data of M.P.B. de Oliveira *et al.* (2021), where it was noted that intervention intensity was a key factor in psychological transformations. Therefore, the 12-week aerobics programme substantially improved participants’ quality of life, especially in the physical and psychological aspects, which confirmed the effectiveness of the applied intervention and was consistent with the results of contemporary studies in the field of sports and clinical rehabilitation.

Summarising the results, it can be noted that the 12-week aerobics programme provided a multidimensional positive effect, which manifested at the level of physiological indicators, functional endurance, training load, and subjective quality of life of participants. The identified age differentiation demonstrated different models of adaptation: the younger group was characterised by a rapid and pronounced response to training stimulus, the middle-aged group by stable and predictable improvement, whereas the older group by a moderate but clinically meaningful increase in indicators. Despite differences in the pace

and mechanisms of adaptation, all groups showed reduced cardiovascular load, increased ventilatory capacity, and improved tolerance to physical activity.

Correlation analysis confirmed the leading role of training impulse TRIMP as a key predictor of adaptive changes, which indicated the decisive importance of aerobic load intensity and volume for forming physiological response. At the same time, it was found that aquatic training formats, despite lower physiological cost, provided a stable positive effect, which made these formats optimal for individuals with reduced tolerance to load. The totality of obtained data indicated the formation of a common vector of training effectiveness – from baseline functional state to an integral improvement in quality of life, including physical, psychological, and social components. This confirmed the appropriateness of using structured aerobics programmes as a tool for health improvement and rehabilitation in different age groups.

Conclusions

As a result of the conducted study, a comprehensive health-improvement effect of the 12-week aerobics programme was established, which manifested at physiological, functional, and psychosocial levels in three age groups. Baseline analysis confirmed the presence of an age-related gradation of cardiorespiratory parameters: in the young group, the highest values of vital capacity of the lungs (4.1 ± 0.5 l) and 6-minute walk test results (615 ± 42 m) were recorded, whereas in the older group the minimum values were observed (2.9 ± 0.3 l and 495 ± 52 m, respectively), which determined different adaptive potential to the intervention. After completion of the programme, statistically significant improvement in key functional indicators was recorded in all groups: resting heart rate decreased on average from -4.2 beats/min in young participants to -1.4 beats/min in older participants, systolic blood pressure by -6 to -3 mmHg, and 6-minute walk test distance increased by $+60$ m, $+55$ m, and $+30$ m, respectively. Confidence intervals and p values ($p = 0.033$ for endurance) confirmed the reliability of dynamics and different magnitudes of adaptive changes depending on age.

Training load analysis confirmed the leading role of TRIMP magnitude in shaping physiological response: young participants demonstrated the highest mean training impulse (102 ± 14 conventional units) compared with the middle-aged (88 ± 12) and older groups (74 ± 11), which was consistent with functional results. Correlation analysis established a strong relationship between TRIMP and gains in functional endurance in the young group ($r = 0.62$; $p < 0.01$), a moderate one in middle age ($r = 0.54$; $p < 0.05$), and a borderline one in the older group ($r = 0.38$; $p = 0.067$), which indicated an age-related decrease in training sensitivity and limited cardiorespiratory

reserves in older individuals. The inverse correlation between TRIMP and resting heart rate (up to $r = -0.41$) confirmed the economisation effect of cardiac activity, most pronounced in the young group.

Changes in quality of life according to WHO-QOL-BREF demonstrated a multidimensional positive effect of the intervention. The greatest gain was recorded in the physical domain in young participants ($\Delta = +8.2$ points) and the middle-aged group ($\Delta = +7.8$), whereas in the older group improvement was moderate but clinically important ($\Delta = +4.6$). The psychological domain showed significant changes in young and middle-aged individuals ($\Delta = +7.1$), reflecting reduced stress and increased motivational and cognitive components of self-perception. Social relationships and the “environment” domain demonstrated less pronounced but stable dynamics, especially in the context of perceived safety and social inclusion. Statistical analysis confirmed the significance of changes in the physical and psychological components for the young and middle-aged groups ($p < 0.05$), whereas in the older group results were borderline.

The generalised adaptation model formed on the basis of the obtained data reflected the following sequence: baseline functional state \rightarrow training load (TRIMP) \rightarrow physiological response \rightarrow functional improvement \rightarrow increased subjective quality of life. It demonstrated that aerobic load intensity and volume were key determinants of programme effectiveness, whereas aquatic training formats ensured lower physiological cost while maintaining positive effect, which made these formats optimal for individuals with reduced tolerance to load.

Thus, the 12-week aerobics programme proved to be an effective tool for health improvement and rehabilitation for different age groups, providing substantial improvements in cardiorespiratory indicators, dynamic endurance, and quality of life. The established age differentiation of adaptation mechanisms confirmed the need to personalise training programmes, taking into account functional state and body reserves, especially in older individuals. Prospects for further research were associated with studying the long-term sustainability of the obtained effects, optimising the intensity of aquatic and combined programmes, and analysing psychosocial factors that determined maintenance of physical activity.

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Conflict of Interest

None.

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Вплив систематичних занять аеробікою на показники фізичного та функціонального станів осіб різного віку

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Анотація. Мета дослідження – комплексне дослідження впливу регулярних занять аеробікою на фізичний і функціональний стан осіб різних вікових категорій з урахуванням віковоспецифічних механізмів адаптації, особливостей побудови навантаження та характеру фізіологічних реакцій. Оцінювання здійснювалося на основі показників частоти серцевих скорочень, артеріального тиску, життєвої ємності легень, результатів 6-хвилинного тесту ходьби, індексу Training Impulse, а також опитувальника World Health Organization Quality of Life – Brief Version із використанням *t*-критерію Стьюдента, *U*-критерію Манна-Уїтні, кореляційного аналізу та 95 % довірчих інтервалів. Результати засвідчили статистично значуще покращення функціональних показників у всіх групах: частота серцевих скорочень у спокої знизилася від -4,2 уд./хв у молодій до -1,4 уд./хв у літній групі; дистанція 6-хвилинного тесту збільшилася відповідно на 60, 55 і 30 метрів ($p = 0,033$). Середні значення Training Impulse; становили 102, 88 та 74 ум. од., що визначало різну тренувальну сенситивність. Кореляційний аналіз підтвердив провідну роль тренувального імпульсу у формуванні адаптаційних змін ($r = 0,62$ у молодій групі; $p < 0,01$). За результатами World Health Organization Quality of Life – Brief Version найбільше покращення спостерігалось у фізичному та психологічному доменах у молодій та середньовікової груп, тоді як у літніх учасників ефекти були помірними, але клінічно значущими (Δ фізичного домену = +4,6). Отримані результати свідчать про ефективність структурованих програм аеробіки для різних вікових категорій та підкреслюють необхідність персоніфікації тренувальної інтенсивності, особливо у літніх осіб. Дані дослідження можуть бути використані для оптимізації оздоровчих програм, розробки безпечних форматів аквааеробіки та підвищення якості життя населення

Ключові слова: витривалість; Training Impulse; якість життя; кардіореспіраторні показники; оздоровчі програми



Role of physical education in shaping a healthy lifestyle for students

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Abstract. The study aimed to explore the role of psychological and pedagogical conditions in the formation of internal readiness and interest in sports among students. The methodology included a pedagogical experiment conducted with 188 students at Uman National University, Uman (Ukraine). Smart watches, fitness trackers and health monitoring greatly improved the fitness of students in the experimental group, as the share of students with high physical activity levels based on the results of a 6-minute walk/run (>900 steps) increased from 13% to 30%, while the share with low levels (<600 steps) decreased from 28% to 10%. Share of students maintaining optimal water consumption (6-8 glasses per day) increased from 22% to 55%, and the proportion with an optimal balance of proteins, fats and carbohydrates increased from 18% to 55%. In the experimental group, the number of students who regularly underwent medical check-ups increased from 19 to 44, while those who consciously avoided harmful habits increased from 21 to 44; meanwhile, in the control group, the corresponding figures remained almost unchanged or showed only minor fluctuations. In addition, the experimental group significantly increased the number of students maintaining regular social contacts and devoting time to leisure and hobbies (up to 44 individuals), contrasting with the control group, where the increase in these indicators did not exceed 1-2 individuals and was not systematic. Correlation analysis showed a close relationship between physical results and psychological indicators ($r=0.72$ and $r=0.70$), confirming the effectiveness of a comprehensive approach that combines cardio, strength and flexibility exercises with pedagogical support, stimulating the formation of healthy habits and a conscious attitude towards personal health. The practical significance of the study is determined by the possible use of the developed set of training exercises in higher education institutions to increase physical activity, motivation and the quality of physical education of students, as well as to optimise training programmes and individual training plans by teachers and coaches

Keywords: physical activity; physical condition; positive impact; motivation; programme effectiveness

Introduction

Physical education is a substantial factor in the formation of a healthy lifestyle and, subsequently, improving physical and mental well-being, academic performance and disease prevention. College education is known to induce intellectual stress, behavioural changes and elevated stress levels, requiring efficient methods to maintain vitality and physical activity. Fitness contributes to overall health and self-discipline, forms positive habits, promotes socialisation and self-improvement motivation. Regular physical exercise creates the basis for healthy behavioural patterns for adulthood and overall quality of life.

The impact of awareness on physical fitness among students was substantially addressed in many studies, identifying key trends and innovative approaches to the educational process. For instance, K.A. Aboshkair (2022) highlighted the significance of physical training in educational process, noting that involvement of students in physical activities contributes to development of physical, social, and psychological competencies, ensuring formation of a healthy lifestyle. The study highlighted the integration of physical exercises into education to ensure development of students. V. Babalich *et al.* (2023), analysing trends in the Ukrainian phys-

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ical education system, noted that changes in the structure of educational programmes and the introduction of new types of physical activity contribute to increasing students' motivation to lead an active lifestyle. The development of teamwork and social skills was prioritised, confirming the need to use a variety of teaching models. R. Ferraz *et al.* (2023) compared traditional and innovative models of physical education teaching and found that the integration of methods such as gaming technologies and adaptive training programmes increases the effectiveness of learning and stimulates regular physical activity. Conventional methods comprised standard physical education teaching methods, whereas innovative methods included gaming technologies and adaptive training programmes, differing in their greater interactivity, personalisation, and ability to increase motivation and learning effectiveness. Furthermore, A. Fröberg & S. Lundvall (2021) investigated the significance of physical education in Sustainable Development Goals, observing that physical activity fosters a responsible attitude towards personal health and environmental behaviour among students. The study emphasised the need to combine learning with exercises, which ensures harmonious development of physical, emotional and cognitive competencies. I. Lutsenko *et al.* (2025) explored innovations in physical education teaching in Ukrainian universities, demonstrating that the use of digital technologies, interactive platforms and personalised training programmes contributes physical activity levels among students even in difficult socio-economic conditions. Students participate in classes through digital platforms and interactive programmes that adapt to individual needs and encourage regular physical activity regardless of external conditions.

I. Skrypchenko *et al.* (2025) demonstrated that during martial law in Ukraine, students' physical activity is modified, and regular physical education classes help maintain psychological stability and social connections. Physical education classes improve students' psycho-emotional state, psychological stability, and social interactions. The impact of remote technologies on physical activity was analysed by J.E. Yu (2022), determining that the use of four types of metaverse in physical education stimulates students' motivation to exercise independently and develops self-control skills. The use of virtual platforms increases student engagement in the learning process and ensures efficient combination of theoretical knowledge with practical physical skills. The transformation of physical education during the COVID-19 pandemic was studied by V. Varea *et al.* (2022), determining that distance learning, the use of online platforms, and interactive training contribute to maintaining physical activity and developing healthy habits in students. The most effective are interactive online training and personalised physical activity programmes on online platforms. M. Whitehead (2020) emphasised that the main goal of physical education is to form a well-rounded personality with an active civic position, self-control and a responsible attitude towards personal health. Regular physical activity was noted in the article to promote the development of social skills and independent decision-making regarding personal lifestyle. Y. Zhou *et al.* (2022) confirmed that teachers are a crucial element in physical activity, as leadership and motivational strategies promote regularity of exercise and the development of healthy lifestyle habits.

A positive example set by the teacher encourages active participation in classes and forms a conscious attitude towards personal health.

Despite the substantial analysis of highlighted aspects by the above-mentioned authors, research remains incomplete due to insufficient study of the long-term impact of physical activity on psychological health among students. The effectiveness of the combination of traditional and distance learning methods in physical education for the formation of sustainable, healthy habits is also insufficient. In addition, the influence of socio-cultural factors on students' motivation to engage in regular physical education has been studied to a limited extent. The development of individualised physical activity programmes that incorporate the physical abilities and needs of different categories of students remains understudied.

The study aimed to determine the effectiveness of psychological and pedagogical conditions that contribute to the formation of motivation among students to regularly engage in physical education. The objectives of the study were to analyse, classify and compare the main groups of physical exercises aimed at developing physical qualities according to their physiological characteristics, pedagogical expediency and effectiveness for the student audience; to organise a pedagogical experiment, which included the formation of control and experimental groups, the development of a set of exercises, and the assessment of students' physical condition before and after the experiment; to develop possible scenarios for the further implementation of the set of exercises in the practice of physical education for students.

Materials and Methods

Primary digital tools and software, capable of forming healthy habits, were analysed at the initial stage of the experiment, including smart watches (Apple Watch, Samsung, Garmin), fitness trackers (Fitbit, Mi Band), nutrition and activity tracking apps MyFitnessPal (n.d.), Strava (n.d.) and FitOn (n.d.). Unique functionality was noted among tools: watches and trackers are used to monitor steps, heart rate, sleep, calories and water balance, while software tracks nutrition, protein, fat and carbohydrate balance and forms workout sequences, challenges for participation and progress analysis reports. The ability of the tools to provide varying levels of motivation, modes of activity and nutrition monitoring capabilities was noted alongside data integration into routing. Integration of tools involved constant use, individual goals, tracking of physical activity, nutrition and real-time evaluation of results for further formation and correction of healthy habits.

A pedagogical experiment was conducted in the research formation stage. It lasted from March to April (8 weeks) and was conducted in person at Uman National University, Uman (Ukraine). It involved 188 students aged 21-22. The participants were divided into two groups – experimental and control, with 94 people in each, including both males and females at a ratio of 1:1. The division of participants was based on physical fitness and previous sports experience, ensuring that the groups were equivalent in terms of key indicators at the start of the experiment. The control group followed the traditional physical education curriculum without any changes. Smart watches and fitness

trackers were introduced as additional tools for the development of healthy habits in the experimental group. Their use involved teaching students how to use the gadgets, regular recording of physical activity indicators during classes and extracurricular activities, and further analysis of the data obtained together with the teacher to adjust the workload and increase motivation to participate in sports. The MyFitnessPal (n.d.), Strava (n.d.), and FitOn (n.d.) apps were used as additional tools in conjunction with a methodology for monitoring nutrition, physical activity, and exercise, planning the day, and supporting a healthy lifestyle for students.

Experiment participant basis included third-year students of the Faculty of Economics and Business Administration without medical contraindications and regular attendance, and who agreed to participate. Students with chronic musculoskeletal disorders, cardiovascular disorders, or already in a semi-professional sports team were excluded. The experiment was conducted following the ethical standards of the American Sociological Association (1997), which included voluntary informed consent, anonymity of results, and the right of participants to withdraw from participation at any stage.

The questionnaires were compiled based on the standardised Health-promoting lifestyle profile (HPLP) (n.d.) methodology. The test tasks were evaluated by a group of experts who assigned scores from 1 to 5 according to the criteria of technique, accuracy of exercise performance and level of exertion. A standardised questionnaire was used in the study because it ensures validity, reliability and comparability of students' responses regarding their attitudes towards physical activity. The questionnaire was adapted to the specifics of the sample by clarifying the wording and including questions aimed at assessing well-being after classes and motivational readiness to continue training. Ten independent experts aged 28-45 with specialisation in physical culture and sports training and professional qualifications were selected for the study. They met the criteria of at least five years of professional experience, knowledge of physical exercise assessment methods, and the ability to objectively evaluate technique, accuracy of performance, and the level of load of test tasks. The test and survey were conducted before and after the experiment.

The experiment group used smartwatches, fitness trackers, alongside MyFitnessPal, Strava, and FitOn applications. The first exercise was a fast-paced 6-minute walking or running, which aimed to assess endurance. Trackers recorded the following metrics: >900 steps – high activity level, 750-899 steps – average level, 600-749 steps – below average, <600 steps – low level. Several pedagogical tests were also used to assess physical fitness levels among students: push-ups in 1 minute to assess arm muscle strength, squats in 1 minute to determine the strength and endurance of the lower limbs, and a forward bend while sitting to assess the flexibility of the spine and the muscles of the back of the legs. The assessment criteria for tests included push-ups: <15 – very low level, 15-20 – low, 21-30 – average, 31-40 – above average, >40 – high; squats: <20 – very low, 20-25 – low, 26-35 – average, 36-45 – above average, >45 – high; sitting forward bend: <5 – cm very low, 5-10 – cm low, 11-15 – cm average, 16-20 – cm above average, >20 – cm high level of flexibility. Key healthy lifestyle habits were

also identified. Regular water consumption was assessed by the number of glasses per day: 6-8 glasses – optimal, 4-5 – average, <4 – low. Eating habits were assessed based on the balance of proteins, fats and carbohydrates: 20-30% proteins, 25-35% fats and 40-50% carbohydrates – optimal, deviations of $\pm 5\%$ – average, greater deviations – low level of nutritional culture. The regularity of meals was assessed based on the number of meals: 3-5 times a day is normal, <3 is insufficient, and >5 is excessive. Data from trackers and apps was used by students to analyse their progress, adjust their physical activity and diet, and encouraged them to maintain a regular sleep, activity and eating routine. The criteria for forming healthy habits were the systematic achievement of target indicators for the number of steps and exercises, sufficient water consumption, a balanced diet, and keeping an activity diary in self-monitoring apps.

The method of processing the results consisted of calculating the arithmetic mean values of each test for the experimental and control groups before and after the programme, which was used to assess changes in the physical fitness of students. Quality control of the tasks was ensured by experts who observed the correctness of the exercise technique and recorded the results for further analysis. The questionnaire included 10 closed-ended questions with answer options that determined the role of physical culture in the lives of young people.

Questionnaire

I regularly engage in physical activity or sports. Answers: Never, Rarely, Sometimes, Often, Always.

I stick to a balanced diet and eat enough vegetables and fruit. Answers: Never, Rarely, Sometimes, Often, Always.

I try to manage my stress levels and relax during difficult times. Answers: Never, Rarely, Sometimes, Often, Always.

I regularly undergo medical examinations and monitor my health. Answers: Never, Rarely, Sometimes, Often, Always.

I follow safety and caution rules in my daily life. Answers: Never, Rarely, Sometimes, Often, Always.

I maintain social contacts and can discuss problems with friends or family. Answers: Never, Rarely, Sometimes, Often, Always.

I find time for relaxation and hobbies that help recover lost energy. Answers: Never, Rarely, Sometimes, Often, Always.

I consciously avoid harmful habits such as smoking or excessive alcohol consumption. Answers: Never, Rarely, Sometimes, Often, Always.

I plan my day or week so that I can manage to combine studying, working and relaxing. Answers: Never, Rarely, Sometimes, Often, Always.

I take advantage of opportunities for self-development, learning and improving my professional or personal skills. Answers: Never, Rarely, Sometimes, Often, Always.

The analysis of the survey results was based on the number of people in the groups, followed by a comparison of the control and experimental groups before and after the introduction of the exercise programme. The quality control of the questionnaire was conducted by experts who assessed the validity and correctness of the instruments, as well as checked the correctness of the questionnaires in terms of format and completeness. Furthermore, the

quality of physical tests during physical education classes was monitored by experts to ensure the correctness of measurements and compliance with the methodology. A correlation analysis was performed based on Pearson's coefficient to assess the relationship between physical fitness indicators and motivation for a healthy lifestyle. The level of statistical significance for all relationships was set at $p < 0.05$.

For correlation analysis, the results of motor tests and questionnaires were summarised into integral indices. Physical fitness indicators were grouped into four indices: general physical fitness, endurance, strength, and flexibility. The general physical fitness index was formed based on standardised results of a 6-minute walk/run, push-ups, squats and seated forward bend, which provided a single measurement scale. The endurance, strength and flexibility indices were constructed on the basis of separate test indicators reflecting the motivational index, emotional index, behavioural index, intention to maintain a healthy lifestyle, and change in attitude towards personal health. The questionnaire results were combined into motivational, behavioural, emotional and institutional indices. The motivational index characterised benefits of a healthy lifestyle, attitudes towards physical activity and willingness to change habits; the behavioural index characterised actual practices (nutrition, avoidance of harmful habits, adherence to healthy behaviour); the emotional index characterised the impact of a healthy lifestyle on stress and well-being; the institutional index characterised subjective support from the university. The use of these indices ensured the consistency of the scales, the comparison of structured groups of indicators, and identified correlations between

physical results and the motivational and behavioural characteristics of students.

For further implementation of the exercise complex, three short scenarios were identified, namely gradual combination, modular distribution, and mixed intensive complex, which are aimed at forming a healthy lifestyle for young people. The input data included the students' level of physical fitness, their motivational and psycho-emotional characteristics, the conditions for conducting classes, and the structure of the developed set of exercises, while the output data included indicators of endurance, strength, flexibility, coordination, level of satisfaction with the programme, and the healthy behavioural habits formed by the students.

Results

A healthy lifestyle is crucial for the physical, psychological and social development of students, as physical activity, balanced nutrition and sufficient sleep boost endurance, concentration, learning productivity and stress resistance. Awareness of personal health by monitoring physical indicators using trackers and apps motivates accomplishment of goals, progress tracking, and the formation of beneficial habits, as evident results stimulate internal motivation and responsibility for personal well-being, reinforcing the desire to continue regular exercise and maintain a healthy diet. Table 1 shows the functional capabilities of smart watches, fitness trackers and accompanying apps that can be used by students to track physical activity, nutrition, sleep, water consumption and other indicators of a healthy lifestyle to form healthy habits and increase motivation to exercise regularly.

Table 1. The functionality of trackers and programmes for the formation of healthy habits in students

Tool	Primary function	Benefits	Issues	How students use it / instructions
Smart watches (Apple Watch, Samsung, Garmin)	Track steps, heart rate, calories burned, sleep monitoring, movement reminders	Motivates regular activity, controls physical activity, and integrates with apps	High price, need charging, pulse accuracy depends on position	Students wear watches every day, set step/activity goals, and use reminders for water and movement
Fitness trackers (Fitbit, Mi Band)	Tracking steps, calories, activity, sleep, and water balance	Easy to use, long battery life, synchronisation with phones	Less accurate heart rate readings, limited functionality compared to smartwatches	Students record their activity throughout the day, track their sleep patterns and drink water when reminded to do so
MyFitnessPal (n.d.)	Tracking nutrition, calories, proteins, fats, carbohydrates, and diet planning	Monitors diet, maintains macronutrient balance, and integrates with trackers	Some data must be entered manually, and it is difficult to control product accuracy	Students record the foods they consume, receive advice on balancing their diet, and set goals for calories and macronutrients
Strava (n.d.)	Track running, walking, cycling workouts, and compare results	Motivates through social competitions, tracks progress, and integrates with trackers	Requires connection to GPS, possible dependence on rating	Students record their workouts, analyse distances and speeds, participate in challenges and group activities
FitOn (n.d.)	Online training, video lessons, lesson planning, reminders	A variety of workouts, available for free, can be done at home	Internet connection required; some premium features are paid for	Students choose workouts based on their level, perform exercise routines at home or in the gym, and track their progress using video tutorials

Source: compiled by the authors

Trackers and smartwatches ensure continuous monitoring of physical activity, record the number of steps taken, distance travelled, heart rate, energy expenditure, sleep duration and quality, which can be used for assessment of physiological parameters over time and the determination

of endurance, strength, and overall activity levels. MyFitnessPal, Strava, and FitOn applications were used to collect data on nutrition, ratio of macronutrients (proteins, fats, carbohydrates), workout planning, hydration, and regularity of meals – metrics that contribute to the formation

of stable, healthy habits. Students received instructions on gadget and application configuration, record keeping, result analysis, adjustment of physical activity and eating habits based on the obtained data, creation of personal goals and a system of motivational reminders. Integration of digital technologies into the healthy lifestyle formation process ensures control, increases awareness regarding personal health, and encourages regular physical activity and a balanced diet.

To assess the impact of the implemented methods using smart watches, fitness trackers, and specialised programmes on the formation of healthy habits among students, a pedagogical experiment was conducted. The

results of the control and experimental groups after monitoring activity indicators, water consumption, regularity of nutrition, and the balance of proteins, fats, and carbohydrates were summarised in Table 2. This approach was used to evaluate the effectiveness of the integrated use of gadgets and applications in supporting a healthy lifestyle, systematise data on the formation of healthy habits, and identify patterns in changes in students' behavioural and motivational characteristics. In addition, the table tracked the dynamics of the development of regular physical activity, rational nutrition, adequate water consumption, and students' willingness to maintain a healthy lifestyle in their daily lives.

Table 2. Results of the pedagogical experiment (before and after the introduction of a set of healthy lifestyle habits) after taking the test

Metric / Task	Control group – before (%)	Control group – after (%)	Experimental group – before (%)	Experimental group – after (%)	Evaluation criteria
6-minute walk/run (steps)	<600 – 30%, 600-749 – 35%, 750-899 – 25%, >900 – 10%	<600 – 25%, 600-749 – 32%, 750-899 – 28%, >900 – 15%	<600 – 28%, 600-749 – 34%, 750-899 – 25%, >900 – 13%	<600 – 10%, 600-749 – 20%, 750-899 – 40%, >900 – 30%	High >900, average 750-899, below average 600-749, low <600
Push-ups/1 min	<15 – 20%, 15-20 – 32%, 21-30 – 30%, 31-40 – 13%, >40 – 5%	<15 – 18%, 15-20 – 30%, 21-30 – 32%, 31-40 – 15%, >40 – 5%	<15 – 22%, 15-20 – 30%, 21-30 – 28%, 31-40 – 15%, >40 – 5%	<15 – 8%, 15-20 – 15%, 21-30 – 35%, 31-40 – 28%, >40 – 14%	High >40, above average 31-40, average 21-30, low 15-20, very low <15
Squats/1 min	<20 – 18%, 20-25 – 30%, 26-35 – 35%, 36-45 – 12%, >45 – 5%	<20 – 15%, 20-25 – 28%, 26-35 – 37%, 36-45 – 15%, >45 – 5%	<20 – 20%, 20-25 – 28%, 26-35 – 32%, 36-45 – 15%, >45 – 5%	<20 – 5%, 20-25 – 12%, 26-35 – 35%, 36-45 – 30%, >45 – 18%	High >45, above average 36-45, average 26-35, low 20-25, very low <20
Water consumption (glasses/day)	<4 – 32%, 4-5 – 48%, 6-8 – 20%	<4 – 28%, 4-5 – 47%, 6-8 – 25%	<4 – 35%, 4-5 – 43%, 6-8 – 22%	<4 – 10%, 4-5 – 35%, 6-8 – 55%	Optimal 6-8, average 4-5, low <4
Protein-fat-carbs balance (%)	Optimal – 20%, average – 45%, low – 35%	Optimal – 25%, average – 40%, low – 35%	Optimal – 18%, average – 42%, low – 40%	Optimal – 55%, average – 30%, low – 15%	Optimal: protein 20-30%, fats 25-35%, carbs 40-50%
Regularity of meals (times/day)	<3 – 28%, 3-5 – 62%, >5 – 10%	<3 – 25%, 3-5 – 65%, >5 – 10%	<3 – 30%, 3-5 – 60%, >5 – 10%	<3 – 12%, 3-5 – 75%, >5 – 13%	Optimal 3-5 times, insufficient <3, excessive >5

Source: compiled by the authors

The table shows the results of monitoring the healthy habits of students in the control and experimental groups before and after the implementation of programmes using smart watches, fitness trackers and apps to track activity and nutrition. In particular, the number of glasses of water that students drank daily, the regularity of meals, the ratio of proteins, fats and carbohydrates in the diet, as well as daily physical activity in steps and minutes of moderate exercise were assessed. The results of the experiment show that the implementation of a set of healthy habits using smart watches, fitness trackers, and mobile applications contributed to improving the physical activity and eating habits of students in the experimental group. The average number of steps in 6 minutes of walking or running in students in the experimental group after the programme increased to a high and medium level (750->900 steps), while in the control group, the improvements were less pronounced. Strength and endurance indicators (push-ups and squats)

also improved: the proportion of students with high and above-average levels increased significantly compared to the initial data.

Regarding food-related habits, the average daily water consumption in the experimental group reached the optimal level (6-8 glasses), the regularity of meals, 3-5 times a day, and the balance of proteins, fats and carbohydrates met the recommended standards in most cases. Changes in the control group were moderate, highlighting the efficiency of digital tools for motivation and self-control. Therefore, use of trackers and applications improves formation of healthy habits, increases healthy lifestyle motivation and ensures control over physical and dietary metrics. The results demonstrate that an integrated approach based on digital tools promotes the formation of healthy habits, lifestyle, regular exercise motivation, and ensures real-time progress tracking and behaviour adjustment. Table 3 reflects changes in healthy habits indicators and student responses

to surveys before and after the programme's implementation. Table 3 reflects changes in healthy habits indicators

and student responses to surveys before and after the programme's implementation.

Table 3. Results of the pedagogical experiment involving students (before and after the introduction of a set of healthy lifestyle habits) following the application of the questionnaire

Task	Answers	Control group (before)	Control group (after)	Experimental group (before)	Experimental group (after)
1. I regularly engage in physical activity or sports	Never	5	5	6	1
	Rarely	9	9	11	3
	Sometimes	28	29	26	10
	Often	34	34	31	36
	Always	18	17	20	44
2. I stick to a balanced diet and eat enough vegetables and fruit	Never	4	4	5	1
	Rarely	7	8	9	3
	Sometimes	27	28	26	11
	Often	37	38	35	35
	Always	19	16	19	44
3. I try to manage my stress levels and relax during difficult times	Never	5	5	6	1
	Rarely	9	9	11	3
	Sometimes	29	30	27	11
	Often	33	34	30	35
	Always	18	16	20	44
4. I regularly undergo medical examinations and monitor my health	Never	4	4	5	1
	Rarely	7	8	9	3
	Sometimes	27	28	26	11
	Often	37	38	35	35
	Always	19	16	19	44
5. I follow safety and caution rules in my daily life	Never	6	5	7	2
	Rarely	11	11	12	5
	Sometimes	26	27	25	10
	Often	33	34	30	35
	Always	18	17	20	42
6. I maintain social contacts and can discuss problems with friends or family	Never	7	6	7	1
	Rarely	12	12	11	4
	Sometimes	28	29	26	10
	Often	32	32	31	35
	Always	15	15	19	44
7. I find time for relaxation and hobbies that help recover lost energy	Never	7	7	8	2
	Rarely	14	14	15	5
	Sometimes	28	29	26	9
	Often	31	32	31	34
	Always	14	12	14	44
8. I consciously avoid harmful habits such as smoking or excessive alcohol consumption	Never	6	5	7	2
	Rarely	11	11	12	5
	Sometimes	26	27	25	9
	Often	32	33	29	34
	Always	19	18	21	44
9. I plan my day or week so that I can manage to combine studying, working and relaxing	Never	5	5	6	1
	Rarely	9	9	11	3
	Sometimes	28	30	27	11
	Often	34	34	30	35
	Always	18	16	20	44
10. I take advantage of opportunities for self-development, learning and improving my professional or personal skills	Never	4	4	5	1
	Rarely	7	8	9	3
	Sometimes	27	28	26	11
	Often	37	38	35	35
	Always	19	16	19	44

Source: compiled by the authors based on Health-promoting lifestyle profile (HPLP) (n.d.)

The results of the study show that the experimental group of students who used smartwatches and fitness trackers in combination with programmes for forming healthy habits showed significant improvements in key aspects of maintaining a healthy lifestyle. For example, in terms of regular physical activity, the number of students who chose the “always” option increased from 20 to 44, while in the control group, the changes were minimal – only from 18 to 17. A similar trend was observed in the question about balanced nutrition: in the experimental group, the number of students who consistently consumed vegetables and fruits increased from 19 to 44, while in the control group, it increased from 19 to 16. In addition, the experimental group significantly improved their results in questionnaires on avoiding harmful habits, planning their day and self-development, where the number of students who “always” followed these recommendations increased from 19-21 to 44. In the control group, which did not use gadgets and special programmes, the positive changes were minimal, usually 1-3 people. This shows that the integration of digital tools forms useful habits among students with improved consistency, further monitoring physical activity, nutrition, rest, and self-development, thereby increasing their motivation to lead a healthy lifestyle and reinforcing sustainable behavioural patterns. The changes demonstrate the positive contribution of physical activity to physical fitness and a conscious, healthy lifestyle. The influence of university support on the formation of healthy habits was also substantial. After the experiment, Group 2 showed a significant increase in the percentage of students who felt significant or partial support, which indicates the value of infrastructure, training and educational programmes for the effectiveness of physical education. The intention to maintain a healthy

lifestyle after graduation in Group 2 almost doubled, emphasising the long-term role of physical culture in the lives of young people. At the same time, there was a positive impact on emotional well-being and the formation of a holistic notion of health.

Among the factors that proved to be most effective were regularity of classes, accessibility of exercises according to physical fitness level, variety of exercises, availability of coaching support and motivational activities. Notably, the combination of physical activity with practical advice on nutrition and avoiding harmful habits creates a synergistic effect that increases students’ awareness of healthy lifestyles. The exercise programme, combined with infrastructure and pedagogical support, stimulates motivation, improves physical and emotional well-being, and lays the foundation for an active and healthy lifestyle in the future. The proposed physical activities contributed to improving the overall physical condition of students, stimulated regular physical activity, and promoted the formation of healthy habits. The activities were accessible, safe and easily integrated into the learning process, which ensured a high level of engagement and motivation among participants. Thus, the experiment proved that the systematic use of a targeted set of physical exercises improves the physical activity of students, stimulates the formation of healthy habits and increases the effectiveness of physical education classes. Table 4 demonstrates the results achieved and a basis for the further application of such complexes in the educational process. Table 4 shows the level of correlation between students’ physical fitness indices and their responses to the survey, reflecting the relationship between physical results and motivation for a healthy lifestyle after the pedagogical experiment.

Table 4. Correlation between physical fitness indices and student survey indices after the pedagogical experiment

Questionnaire index	<i>r</i>
Motivational index	0.72
Emotional index	0.69
Behavioural index	0.62
Motivational index	0.65
Intention to maintain a healthy lifestyle	0.58
Emotional index	0.68
Change in attitude towards personal health	0.70

Source: compiled by the authors

The analysis revealed a range of statistically significant and practical positive correlations between integral indices of physical fitness and psychological indices from the questionnaire. Motivation ($r = 0.72$) is the highest indicator. It demonstrates that students motivated for a healthy lifestyle demonstrate better endurance. This connection indicates the significance of internal motivation for maintaining physical activity. The emotional factor ($r = 0.69$) confirms that lower stress levels and better emotional well-being are associated with greater endurance. This is consistent with the concepts of the psychophysiological impact of activity on emotional state. The relationship between strength and behavioural practice ($r = 0.62$) shows that strength depends significantly on regular activity, quality of nutrition, and absence of harmful habits, so it is logical that this relationship has a high value.

The correlation between strength and motivation ($r = 0.65$) indicates that motivation directly influences the willingness to perform training activities. This demonstrates the role of personal orientation in achieving results. The index between flexibility and emotional index ($r = 0.68$) suggests that flexibility reflects the level of overall physical fitness and attention to health; the correlation with emotional well-being is natural. A substantial correlation was found between flexibility and a change in attitude towards personal health ($r = 0.70$), which is one of the key findings. Therefore, students who have reconsidered the significance of health demonstrate significantly better flexibility indicators, an element of physical development that requires regularity and awareness. The obtained correlation indicators confirm that the results of physical quality testing do not exist in isolation from motivational, behavioural, and

emotional factors. The set of physical exercises influenced not only physical fitness but also the psychological aspects of leading a healthy lifestyle; a comprehensive approach (behaviour + motivation + emotional state + institutional support) is effective in shaping a healthy lifestyle for students.

For the efficient implementation of a set of physical exercises among students, a training process was developed that provides for the systematic, gradual and adapted involvement of students in various types of physical activity. This approach not only develops and maintains the optimal level of physical fitness necessary for a healthy lifestyle, but also ensures the development of motivational, cognitive and social aspects of student behaviour. The programme includes physical activities adapted to student fitness and educational objectives. Classes are held weekly throughout the semester, gradually increasing in duration and intensity. Each class begins with a warm-up to prepare the body and prevent injuries. The main part includes various types of activities that vary from class to class and can be performed with simple equipment. The activities promote increased energy, improved physical condition and stimulate metabolism. The technique of performing the exercises and the gradual increase in load ensure safe training. The exercises are performed in sets with a controlled number of repetitions and approaches, adapted to the students' level of fitness. For weaker students, the number of repetitions and intensity of performance are gradually increased under the supervision of the instructor, and for more advanced students, the load is increased by adding additional repetitions or using additional weights.

The warm-up and cool-down sections include dynamic and safe exercises designed to prevent injuries, maintain posture and improve overall physical condition. Exercises also improve mental and emotional well-being, study concentration, reduce stress levels. Classes are held in the university sports halls, open areas or university stadium, adapting the exercises to weather conditions and providing space for strength training. Classes are approximately 60-90 minutes long, of which 10-15 minutes are allocated to warm-up, 40-50 minutes to main part with strength exercises, and 10-15 minutes to flexibility, stretching and relaxation exercises. Classes are conducted two to three times a week, which ensures sufficient regular physical activity. A key element of the exercise programme is a gradual increase in the complexity and intensity of the load. At the initial stage, students perform basic exercises of low to moderate intensity, familiarising the technique, highlighting personal abilities accustomed to regular physical activity. Subsequent stages involve increase in training intensity through intervals, complexity of exercises with more repetitions or weights, incorporation of complex exercises for coordination and core stabilisation. Gradual implementation prevents overloads and maintains high motivation.

A progress assessment system was introduced to motivate students and encourage them to attend classes regularly. Each class concludes with a test on the students' well-being and satisfaction with the programme. This ensures self-assessment of individual progress, comparison of results with initial indicators, and a sense of achievement. Assessment can be conducted using a standardised Likert scale covering aspects of physical activity, motivation, well-being and readiness for further involvement in

training. The pedagogical aspects of implementing the exercise complex are emphasised. All classes are conducted by a physical educator, who monitors correctness of the exercises, load intensity and safety of students. The teacher also adjusts the programme based on the needs of group and individual students, providing an individual approach. Each student can adapt the exercises to personal level of physical fitness, improving training efficiency. The complex is designed incorporating scientific recommendations on physical activity for students and includes various activities to develop coordination, endurance and overall physical condition. Performing the complex helps to strengthen muscles, maintain posture, prevent injuries and develop mobility, providing a comprehensive impact on the physical condition of students. These activities improve endurance, energy levels and overall physical fitness. This combination is ideal for students, as it ensures comprehensive development of physical qualities and promotes a healthy lifestyle.

The scenario emphasises the integration of physical exercise into the learning process. Classes are held in accessible university facilities, including sports halls, university grounds and stadiums, which ensures that group classes and individual training sessions can be organised without additional equipment costs. The use of simple and accessible tools, such as fitness bands, balls, cones and mats, ensures consistency and safety of exercises in any conditions. The exercise complex also provides for adaptation to different levels of physical fitness of students. For beginners, there is a reduced number of repetitions and sets, reduced intensity and pace of execution, and simplified versions of strength and coordination exercises. For students with average and high fitness levels, programme includes more difficult exercises, additional repetitions, interval training and combined strength complexes. This approach addresses individual goals while maintaining high motivation. Psychological and motivational aspects are incorporated into the exercise programme. Students regularly assess personal well-being, programme satisfaction, and motivation for further classes. This approach ensures timely adjustments, increased student engagement, and a positive attitude towards physical activity. Completion of a set of exercises throughout the semester notable visible progress in physical fitness. Endurance, strength, and flexibility tests demonstrate improved performance in experimental group compared to control group. Increase in percentage of students performing tasks at a high level indicates the effectiveness of a systematic approach, combining different types of loads and gradually increasing intensity. In addition, the study demonstrated an improvement in motivation for physical activity, increased satisfaction from performing exercises, and the formation of healthy habits among students.

Thus, a comprehensive approach to the introduction of physical activity into the educational process, which includes a gradual increase in complexity, adaptation of the load to the level of student preparation, integration into the educational process, and systematic monitoring of progress, is efficient in the formation of a healthy lifestyle. The implementation of this scenario achieves physical and psychological effects, increases students' motivation for regular physical activity, and contributes to the development of physical qualities and health promotion. This approach can be used by students to combine learning and physical

education, effectively develop endurance, strength, flexibility and coordination, and form self-discipline and self-control skills. Constant monitoring of exercise performance, adaptation of the load and motivational support ensure maximum effectiveness of the programme and contribute to the formation of a lasting interest in physical activity, which is the basis of a healthy lifestyle for students.

Discussion

Physical education contributed to the formation of a healthy lifestyle among students and determined the key factors that influenced the level of physical activity and motivation for regular exercise. Routine physical education classes contributed to the development of students' physical, social, and psychological competencies, as well as the formation of habits for independent physical activity. After the introduction of fitness watches and programmes in the experimental group, the number of students who regularly engaged in physical activity increased to 44, with 28 performing 31-40 push-ups per minute and 18 students performed >45 squats, while in the control group the improvements were less noticeable – 16-17 people, respectively; this indicates that digital tools effectively motivate students to exercise regularly and increase physical fitness. This demonstrates the efficiency of systematic cardio training for developing endurance. These results correlate with the conclusions of J. Borowiec *et al.* (2021), noting that physical fitness affect physical education performance and emotional well-being. The data confirmed that teacher support and structured exercises promote student engagement and increase sense of progress. The study determined that the social environment and interaction with classmates contribute to increased engagement in physical activity and reduced negative emotions during classes. In addition, after using smart watches and apps, 50% of students in the experimental group consumed the recommended 6-8 glasses of water per day, 55% maintained an optimal balance of proteins, fats and carbohydrates, and 75% maintained regular meals 3-5 times a day, while their average daily activity increased to 8-9 thousand steps; this demonstrates that the integrated use of gadgets and apps forms useful healthy habits and increases students' conscious self-discipline. Thus, strength training increased muscle endurance and physical performance.

Motivational factors and positive emotions are key to the formation of systematic physical activity. The affirmation is consistent with the findings of L. Cale (2023), noting that physical education classes are a central element in physical activity among students, stimulating formation of healthy habits in. The study determined that students with intrinsic motivation to participate in classes were more likely to partake in extracurricular sports activities and maintain regular physical exercise. In the experiment, 40% of students who initially had low motivation moved into the medium and high motivation categories (4-5 points) after a course of complex exercises. These data coincide with the findings of S. Fierro-Suero *et al.* (2023), demonstrating that motivation and emotions are decisive in students' academic achievements and their intention to maintain physical activity outside of class. The impact of physical education on the psychological components of students' health was also considered. These results are consistent with the findings

of I.B. Erdvik *et al.* (2020) determined that satisfying basic psychological needs during physical education classes increases adolescents' overall self-esteem and fosters a positive attitude towards physical activity. Students noted an improvement over psychological health with teacher support, interaction with classmates, and active participation in group and individual tasks. Physical education improves emotional competence among students. This is consistent with the findings of a meta-analysis by O. Cho (2020), demonstrating that physical education classes stimulate changes in emotional competence, including emotion control, self-regulation, and effective social interaction. The study determined that students participating in structured physical education classes improved stress control and adaptability to new social situations. These results emphasise that physical activity is not limited to physical development but also influences formation of emotional and social skills.

The use of digital tools helps maintain students' physical activity during restrictions or distance learning. These findings are consistent with the research by D.N. Daum *et al.* (2021), which showed that distance learning in physical education maintains physical activity levels when structured programmes and instructions for independent study are used. The inclusiveness and adaptation of classes to different categories of students contributed to increased engagement in physical activity. Such approaches reduce barriers to participation, ensuring constant regular physical activity among students of different physical and psychological characteristics. Adapted training programmes involve students with different physical and psychological characteristics, reduce barriers to participation, and encourage regular physical activity. The study showed that assessment and progress monitoring systems in physical education affect the effectiveness of training and student motivation. These results coincide with the findings of an analysis by A.H. Hasyim *et al.* (2024) on assessment models in physical education, determining that effective assessment systems encourage students to participate more actively. Additionally, C. Hu (2022) showed that the use of automated learning to assess the effectiveness of classes individualises programs and improves the physical development of students. The study showed that assessment and progress monitoring systems in physical education affect the effectiveness of learning and student motivation. In the experiment, each test task was evaluated by 10 independent experts on a scale of 1 to 5, ensuring an objective assessment of progress. Automated assessment systems facilitate timely adjustments to curricula and maintain students' motivation to attend classes regularly. The data obtained are consistent with the conclusions of H. Kalajas-Tilga *et al.* (2020), proving that motivational processes in physical education directly influence the level of physical activity of adolescents. Internal motivation to engage in physical activity, formed through positive experiences and teacher support, contributes to increased regularity of physical exercise. A pattern has been established whereby students who received support from teachers and had positive experiences in class were more likely to participate in additional sports activities outside the curriculum.

Students' interest in physical education was shaped by internal and external factors, such as motivation to maintain health, social interaction, and the quality of class

organisation. This is confirmed by data from R. Kurniawan *et al.* (2021), determining that students' interest in physical education depended on a combination of internal motivation and support from the learning environment. Students demonstrating greater internal motivation and receiving support from teachers and classmates are actively involved in classes, which is consistent with international observations. The use of technology in physical education yields additional results. The integration of virtual and augmented reality into the learning process has been found to increase interest in classes and promote greater student activity. These data are consistent with the findings of Y. Liu *et al.* (2022), demonstrating that augmented reality technologies in physical education stimulated students' interest and increased their level of physical activity. Even in a student audience, innovative technologies enhance the motivational effect and contribute to the formation of stable physical activity habits.

The organisational conditions of learning influenced student activity. The level of support from teachers, the structure of classes, and the use of various teaching methods determine the quality of student engagement in physical activity. These findings are consistent with data from P. Ward *et al.* (2020), demonstrating that gradual instruction and the use of working models increase the effectiveness of physical education. Students learn new exercises more easily and are more active when the teaching methodology is structured and incorporates the gradual development of skills. The study demonstrated that distance learning in physical education during pandemic-related restrictions reduces student activity levels, but the introduction of interactive online classes and support systems partially compensates for this effect. Inclusiveness and adaptation of classes to different categories of students contribute to increased engagement in physical activity. In particular, 90% of students with different physical characteristics can perform a set of exercises at a level of 3-5 points, which demonstrates the effectiveness of adapted programmes. These results were consistent with the observations of S. Kamoga & V. Varea (2021) and J.A. Vilchez *et al.* (2021), noting that during distance learning of physical education, Swedish students and American teenagers show a decrease in physical activity, but the support of teachers and the use of online tools stimulates participation in classes. Students with access to interactive materials and regular feedback from teachers maintain a higher level of activity compared to the group without such support. Motivational factors remain key to forming a healthy lifestyle.

Students who experienced satisfaction from the learning process and observed progress in their physical fitness demonstrated a sustained commitment to regular physical activity. This is consistent with the findings of J. Rojo-Ramos *et al.* (2022), determining that the motivation of students in the last cycle of primary school is shaped by success in physical activity and teacher support. At the student level, motivational mechanisms have a similar structure, which can predict the effectiveness of physical education programmes. The role of teachers is also confirmed as a determining factor for success. It has been found that professional competence, innovative approaches and support from the learning environment influence student engagement. These observations correlate with the findings

of C.A. Webster *et al.* (2020), demonstrating that the innovativeness of physical education teachers and school support contribute to the adoption of comprehensive physical education programmes. Students who had teachers with high innovative competence demonstrate more active participation and better physical fitness results. An analysis of the impact of physical education on the overall health and behavioural habits of students shows that regular physical education classes reduce the risks of a sedentary lifestyle, improve psycho-emotional well-being and foster a positive attitude towards health. This is consistent with the observations of X. Zhan *et al.* (2021), demonstrating that the availability of physical education classes in schools increases the level of physical activity among adolescents in low- and middle-income countries. Regular physical activity in a student environment had a similar effect on health. Correlation analysis showed a significant relationship between physical performance and motivation: the highest coefficients were observed between 6-minute walk/run and motivation for a healthy lifestyle ($r=0.72$), as well as between sit-and-reach and change in attitude towards personal health after the programme ($r=0.70$). This indicates that improving physical fitness directly affects psychological aspects and readiness for an active life. The results showed that physical culture was central in shaping a healthy lifestyle among students, ensuring increased physical activity, motivation and a positive attitude towards personal health. The integration of technology and effective organisation of classes contributed to the sustained involvement of students in regular physical activity and the formation of healthy behavioural habits.

Conclusions

The study conducted a comprehensive assessment of the impact of structured physical activity on the physical condition, motivational characteristics and overall activity of students, as well as to determine the optimal approaches to organising classes in the educational process. The generalisation of the results showed that a systematic approach to training that combines different types of physical activity is effective, as this structure ensures the balanced development of basic physical qualities. Analysis of the indicators shows that comprehensive activity increases endurance, strengthens the muscle corset and improves motor skills, which also reduces the risk of injury. A balanced combination of different types of exercises improves results more than focusing on a single component of physical training.

The results of the pedagogical experiment show that the introduction of a set of healthy lifestyle habits using smart watches, fitness trackers, and specialised programmes led to a noticeable improvement in the experimental group of students compared to the control group. In particular, the number of students always engaged in physical activity increased from 20 to 44, and those who regularly followed a balanced diet and consumed enough vegetables and fruits increased from 19 to 44, while in the control group, the positive changes were minimal (18-16 people, respectively). Similarly, the experimental group significantly increased the regularity of meals, the amount of water consumed, and the balance of proteins, fats, and carbohydrates, which made it possible for 55-50% of students to adhere to optimal indicators, while in the control

group this indicator remained at 25-28%. In addition, the average daily physical activity in steps in the experimental group reached 8-9 thousand, and the time of moderate exercise was about 40 minutes, while in the control group these indicators remained at 6-7 thousand steps and 30 minutes, respectively.

The most noticeable changes were in the formation of healthy habits: avoiding harmful habits, planning the day, stress management and self-development, where the number of students who “always” followed these recommendations increased from 20-22 to 44-48, demonstrating that the integrated use of gadgets and programmes effectively stimulates motivation for a healthy lifestyle, can be used for systematic control of physical and nutritional indicators, and forms lasting healthy habits that become ingrained in everyday life. Correlation analysis showed a close relationship between physical results and psychological indicators (the highest $r = 0.72$ between walking/running and motivation and $r = 0.70$ between forward bend and change in attitude towards personal health), confirming the effectiveness of a systematic approach to physical activity with pedagogical support. This approach simultaneously improves students’ physical abilities, shapes a conscious attitude towards health and lays the foundation for a long-term active lifestyle. The results obtained confirmed that the

proposed organisation of physical education contributes to the formation of key elements of a healthy lifestyle. Positive changes in students’ physical and psychological indicators confirm that combining different types of physical activity is the most effective way to achieve a comprehensive training effect. The practical implementation of the exercise complex has proven its effectiveness due to the availability of equipment, the ability to adapt the load to different levels of training, and the effective integration of classes into the educational process. The limitation of the study is the use of only one method of assessing a healthy lifestyle, which may not fully reflect all aspects of physical activity and the behaviour of participants. The prospect for further research is to study the impact of digital fitness programmes and mobile applications on the formation of sustainable healthy habits and self-motivation of students.

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None.

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Роль фізичної культури у формуванні здорового способу життя студентської молоді

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Анотація. Метою дослідження було з'ясувати роль психолого-педагогічних умов у формуванні у студентської молоді внутрішньої готовності та інтересу до занять спортом. Методологія включала педагогічний експеримент із участю 188 студентів на базі Уманського національного університету, м. Умань (Україна). Після впровадження смарт-годинників, фітнес-трекерів та програм для моніторингу здоров'я студенти експериментальної групи значно покращили показники фізичної активності: в експериментальній групі частка студентів із високим рівнем фізичної активності за результатами 6-хвилинної ходьби/бігу (>900 кроків) зросла з 13 % до 30 %, тоді як частка осіб із низьким рівнем (<600 кроків) зменшилася з 28 % до 10 %. Одночасно частка студентів, які дотримувалися оптимального споживання води (6-8 склянок на день), збільшилася з 22 % до 55 %, а частка з оптимальним балансом білків, жирів і вуглеводів з 18 % до 55 %. В експериментальній групі кількість студентів, які регулярно проходили медичні обстеження, зросла з 19 до 44 осіб, а свідомо уникали шкідливих звичок з 21 до 44 осіб, тоді як у контрольній групі відповідні показники залишалися майже незмінними або демонстрували незначні коливання. Крім того, в експериментальній групі суттєво збільшилася кількість студентів, які постійно підтримували соціальні контакти та знаходили час для відпочинку і хобі (до 44 осіб), що контрастувало з контрольної групою, де приріст за цими показниками не перевищував 1-2 осіб і не мав системного характеру. Кореляційний аналіз показав тісний зв'язок між фізичними результатами та психологічними показниками ($r=0,72$ та $r=0,70$), підтверджуючи ефективність комплексного підходу, що поєднує кардіо-, силові та гнучкісні вправи з педагогічною підтримкою, стимулюючи формування здорових звичок та усвідомленого ставлення до власного здоров'я. Практичне значення дослідження полягає в тому, що розроблений комплекс тренувальних вправ може бути безпосередньо використаний у закладах вищої освіти для підвищення фізичної активності, мотивації та якості фізичного виховання студентів, а також для оптимізації навчальних програм та індивідуальних планів тренувань викладачами та тренерами

Ключові слова: рухова активність; фізичний стан; позитивний вплив; мотивація; ефективність програми

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