ISSN 1392-0340 (Print)
ISSN 2029-0551 (Online)
https://doi.org/10.15823/p.2023.150.3

Pedagogika / Pedagogy
2023, t. 150, Nr. 2, p. 38–57 / Vol. 150, No. 2, pp. 38–57, 2023

VYTAUTO DIDŽIOJO UNIVERSITETO ŠVIETIMO AKADEMIJA

Enhancing University Students' Functional Fitness by Applying Health Programs Based on Individual Student Heart Rate Monitoring Data

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Annotation. The study aimed to assess the impact on the students' functional fitness of a one academic year student health-enhancing program based on equipping students with knowledge which allows them to analyze the dynamics of their own functional state and interpret digital feedback received from heart rate monitors. Studies have proven that receiving timely feedback on heart rate during the implementation of the training program, is a promising direction to enhance students' functional fitness.

Keywords: *heart rate monitors, functional fitness, load intensity, university students.*

Introduction

The study period at university is an important and critical moment in the lives of young people (Manzheley, 2014) and creation of a favorable health-forming environment for young people during this period is a primary task of educational institutions (Geidne et al., 2013; Wright et al., 2013). Trudeau and Shephard (2008), Fu et al. (2016) believe that educational institutions should organize a wide range of activities that contribute to the improvement of students' health culture and formation of a healthy lifestyle in the long term. The researchers set the encouragement of regular physical activity as the main way of forming a healthy lifestyle for students (Bozhkova et al., 2017; Forshee et al., 2004).

One of the promising areas for increasing students' interest in physical activity is the development of a safe fitness program (Randall et al., 2009), developed for each trainee individually, which would allow the correct selection of the size of the training effect (Mandolesi et al., 2018; Partridge et al., 2011). Such an individually oriented physical activity contributes to the improvement and strengthening of health, increases the body's resistance to negative influences, prevents a number of diseases, and increases life expectancy.

Also, some experts consider the widespread use of technological innovations (pedometers, heart rate monitors) justified to raise students' motivation to participate in physical education and recreational activities. They allow to assess the body's capabilities, as well as monitor the reaction of the heart and cardiovascular system during exercise (Szakly et al., 2016).

Low cardio-respiratory endurance combined with overweight and obesity is an everyday occurrence among students (Ali et al., 2020). According to numerous authors, among all the components that characterize human health, cardiorespiratory endurance is essential (Ortega et al., 2020). There is evidence of a correlation between the level of cardiorespiratory fitness and students' academic performance (Yang & Tsao, 2020). Therefore, the study of heart rate dynamics as an integral indicator characterizing the activity of this system should be widely used in planning and organization of physical education process (Vanyushin et al., 2017).

The most accurate method for controlling muscle loading, which practically does not interfere with physical exercises, is to continuously record the heart rate (pulse) during exercise using modern high-precision heart rate monitors, which has become possible due to the development of objective assessment of indicators of physical activity technologies of the population in recent decades (Pavlicek & Deutsch, 2016).

Heart rate monitors make it possible to measure the heart rate throughout the training, to determine the speed of running or walking, to measure the length of the distance passed. The functional state of the cardiorespiratory system and the degree of body's adaptation to a particular load can be judged by the heart rate value and its dynamics during the performance of the load and during the recovery period (Orel et al., 2017). That is, continuous registration of heart rate will allow solving the problem of accurate quantitative assessment of the performed load (Barreira et al., 2009; Randall et al., 2009; Thomas & Gopi, 2019). Stöckel and Grimm (2021) believe that the presence of timely feedback in real time will allow students to correct their behavior during the performance of the load, will contribute to the enjoyment of movement process and satisfaction with the results, which in turn will increase students' internal motivation to continue physical activity practice.

The raising of students' interest in active physical activity can be achieved through equipping students with theoretical knowledge in health preservation (Ennis, 2007). Students can exercise self-control, analyze and interpret digital feedback data, and make decisions to manage their physical well-being using theoretical knowledge (Nation-Grainger, 2017). Other researchers have also proven the greater effectiveness of programs with high cognitive involvement of students, which was expressed in their greater motivation in the learning process, performing the required tasks, and achieving set goals. This, according to the authors, is due to the students' awareness of physical activity importance and the formation of the need for active physical exercises to maintain a healthy lifestyle (Wang & Chen, 2020).

However, when engaged in physical education, domestic, and labor physical loads, the axiom is the correspondence between the loads imposed on the body and the possibilities of their fulfillment. Physical exercise will not have the desired effect if muscle loading is less than the individual abilities of those involved (Bosquet, 2008; Babicheva, 2013; Prontenko et al., 2017; Sachs, 2011). On the contrary, the use of constant peak load leads to a failure of adaptation mechanisms, which may result in destructive changes in the work of the core (Sigvarsten et al., 2016). Only a load adequate to the capabilities of those involved can bring the necessary training effect, improve the development of physical qualities, which ultimately solves the health problems of physical education (Bosquet et al., 2008; Sigvarsten et al., 2016).

The trend in the use of heart rate monitors is due to the need to control the quality of solving health problems in the process of physical education for students and to monitor the effectiveness of the applied methods (Golubeva & Golubev, 2015).

However, the physical education system at the university suffers from an acute lack of deep and comprehensive control over the degree of impact of physical exercises on the students' bodies during the standard practical training in the discipline "Physical Education" unlike specialized studies of athletes conducted in laboratory conditions (Vlasov & Lebedinskiy, 2016).

The purpose of this study was to assess the impact on the students' functional fitness of a one academic year health-enhancing program based on equipping students with theoretical and methodological knowledge which allows them to analyze the dynamics of their own functional state and interpret digital feedback received from heart rate monitors. Data received during the study will help to better understand whether providing feedback during exercise will improve the self-management skills that are important in planning independent physical activity programs.

Materials and Methods

Participants and Data Collection

In the study, a quasi-experimental design was used. The sample included first-year male students of the al-Farabi Kazakh National University, aged 17.68 (SD = 0.74). The participants were divided into two groups: experimental (n = 22) and control (n = 23). The main specific criteria for inclusion in the experimental and control groups were: gender (men) and year of studies (first), health status (healthy, belonging to the basic physical capacity group).

The permission of the Ethics Committee of the Kazakh Academy of Sports and Tourism (No. 09-01-08-628 of September 6, 2018) was obtained in regards to the conduct of the study. The study was conducted with the voluntary informed consent of students to participate in the research. The confidentiality of the participants' data, as well as other ethical standards, were respected.

The research period covered one academic year (two studies semesters) at the university (30 weeks). The total number of classes in each control and experimental group was 60 (30 in each semester), with a frequency of two classes a week, of 100 minutes each. 2 classes were allocated for control tests at the beginning and at the end of the experiment. Testing was conducted twice - at the beginning (September 2018) and at the end of the research (May 2019). Classes on physical education in the control group (CG) were held as part of the of the Standard State Program (Tipovaya uchebnaya programma obshcheobrazovatel'noj disicpliny «Fizicheskaya kul'tura», 2018).

In the experimental group was applied health-enhancing program, based on the students theoretical and methodological education to adjustment an individual load using heart rate monitor data. The experimental program included theoretical (10 min) and practical (90 min) part. Theoretical part was carried out in form of conversations and was aimed to equip students with knowledge about the main determinants of health, methods of maintaining and promoting health. Also, in physical education classes students of the experimental group were learned to use heart rate monitors, to control physical load during exercise and in the recovery period, and interpret of heart rate monitors data, to assess by themselves physical condition, plan and construct sets of physical exercises depending on the set goals.

Each class during implementation of the experimental program included preparatory, main and final parts (Table 1). A lot of attention was paid to the content of the main part of the class, which consisted of aerobic and strength training parts. An individual program of recreational and training classes was developed for each student of the experimental group. The basis of which was the running load proposed by Cooper (1968) for students up to 30 years of age with varying degrees of physical fitness and isolated power load aimed at development of speed-strength capabilities and strength endurance of students. After intense running and power loads, during the recovery period, exercises for flexibility and coordination in the aerobic mode, so-called "outdoor activities" were used.

Table 1
A Standard Plan and Content of a Class of Physical Education for Students of the Experimental Group

Part of the class (duration)	Intensity of load Bmp	Load percentage in each intensity zone, %
Preoperational part (≈25 min)	110–120	25
Theoretical part (≈10 min)		
Warm up (≈15 minutes)		10
		15
Main part	110–160	70
Aerobic phase (≈60–65 min)	120–160	50
Active rest (5 min)		
Isolated power load (15 min)	110–120	5
	120–140	15
Final part (5 min)	90–100	5

The structure of workouts in the experimental group was maintained throughout the entire period of the pedagogical experiment. The second semester began with a series of "retreating" classes, since most students did not have the opportunity to continue the proposed program during the examination session and academic breaks.

While developing an individual load program, we took the load distribution in 5 intensity zones as a basis in accordance with generally accepted recommendations (Sachs, 2011): 1) zone of a healthy pulse (100–120 bmp); 2) fitness zone (120–140 bpm); 3) aerobic (140–160 bpm); 4) anaerobic (160–180 bmp); and the zone of maximum pulse (180-200 bmp). At the same time, the statement that the training of the general endurance of a person should take place at a heart rate not lower than the threshold level – 120–130 bmp (Pavlicek & Deutsch, 2016) was taken into account, and the achievement of maximum heart rate values justified only if qualified athletes participate in the competitions, when conducting health training maximizing heart rate should be avoided. In this regard, the training sessions were held in the most significant 1–3 zones of load intensity for achieving health goals. The load during the class was regulated using data from heart rate monitors so that the work in the 1st zone of intensity was ≈34%, in the second zone ≈16%, in the third zone – ≈50% of the entire time of the class. In addition, approximately 10% of the class time was devoted to reviewing theoretical information regarding the effect of physical exercises on various body systems, as well as discussing the dynamics of students' individual functional parameters of students.

The uniform method was used as the main method for solving the problem, in addition, various options for variables, games, and also the circular training method were used in classes.

The individual exercise intensity and physical load of the student were determined and corrected by recording the heart rate with a Sigma PC26.14 heart rate monitor. Heart rate monitoring represents an objective method of assessing PA because it is a physiological parameter that correlates well with energy expenditure (Salier Eriksson et al., 2021; Strath et al., 2000). Sigma PC26.14 heart rate monitor as reliable measuring instrument was used in Liu et al. (2019a, 2019b) researches.

To assess the accuracy of heart rate monitor data before starting the quasi-experiment, we tested the heart rate monitor readings with a subgroup of six volunteers under laboratory conditions. Heart rate signals for all devices were checked by the first author of the study until the beginning of each physical education classes to ensure device function. All participants were wearing their HR monitors, and their heart rates during exercising were recorded and used to calculate exercise intensity and training load.

Characteristic difference of the program is that the load correction was carried out according to individual indicators of the optimal heart rate, which was calculated by the calculation method according to the Karvonen formula (Karvonen, 1957), with the calculation of the reserve heart rate (RH_R), maximum (RH_{Max}) and target or optimal (HR_O). Moreover, to calculate the maximum heart rate, we used an updated in 2007 formula to calculate this indicator:

$$HR_{Max} = 205.8 - (.685 \text{ x age (years)}).$$

Data Analysis

The effectiveness of this health-enhancing program was evaluated by the results of running for a distance of 3000 m, which is widely used in the general preparation of men and the speed of overcoming the distance (km/h). The body's response to this load was assessed by the dynamics of heart rate at rest, average heart rate, heart rate at the finish (bpm), which were recorded using a Sigma PC26.14 heart rate monitor, as well as an indicator of the pulse cost of work, which was determined by the formula:

$$PC = \frac{\text{HR average x time spent on work (seconds)}}{\text{60 x distance (meters)}}.$$

The use of indicators of the pulse value of the load allowed us to estimate the energy cost of the exercise, as well as the main regularities of relative power values and the maximum duration of work.

The data obtained was exposed to statistical processing in the IBM SPSS Statistics 25 program. Descriptive statistics was applied, arithmetic mean value (Mean), standard deviations (SD) were calculated. The Shapiro-Wilk test was used to examine if variables are normally distributed. Student t-test for independent samples was applied to determine differences between students' scores in the experimental and control groups, and paired samples t test was used to determine differences between the first and second measurements. Differences were considered statistically significant at a 5% significance level ($p < .05$).

Results

The average rate of passage of the distance was low among students of both groups at the beginning of the experiment. This was reflected on the time of passage of the distance and the overall result, which is evidence of a weak level of physical fitness, identified by the results of the test "3000 m run". So, the result of overcoming the 3000 m distance averaged 1062.0 (SD = 1.4) seconds among students of the experimental group, and 1098.0 (SD =1.1) seconds in the control group. At the same time, the average running speeds of the representatives of the experimental and control groups averaged 10.2 (SD = .7) and 10.1 (SD = .8) km/h, respectively. By the end of the pedagogical experiment, a statistically significant decrease in the time of passage of the distance and average running speed was revealed by students of the experimental group, while no statistically significant changes were found in the control group (Table 2).

Analysis of the control data at the beginning of the experiment, taken from the students' heart rate monitors, did not reveal a significant difference between the groups in terms of heart rate at rest, average and maximum heart rate, heart rate at the finish line, and the pulse value of the load (Table 2), which indicates the homogeneity of the subjects. At the end of the experiment, we revealed a significant difference ($t = 10.5$, $p < .001$) between pre-test and post-test scores in experimental group. Pre-test and post-test scores of heart rate at rest in the control group differed not statistically significantly. Significant differences were found between the study groups by the end of the experiment in heart rate at rest. The heart rate at rest scores of the experimental group students were statistically significantly higher compared to those of the control group ($t = 5.8$; $p < .001$).

Significant changes were revealed by us in terms of heart rate at the finish of 3000 m in the experimental group. So, if in the experimental group the heart rate at the finish line decreased on average from 192.8 (SD = 1.9) to 186.9 (SD = .2) beats/min ($t = 3.1$, $p < .01$), then in the control group these changes were insignificant (Table 2). A comparative analysis of the average and maximum heart rate values during the distance also revealed the presence of statistically significant ($t = 3.1$, $p < .01$) positive dynamics in the representatives of the experimental group at the end of the experiment, while in the control group there was only a tendency to improve these indicators, and these changes were not significant ($t = 1.2$; $p > .05$).

Table 2

Mean Differences of Study Variables Between the Experimental and the Control Group

Variables	Experimental group (EG), (Mean ± SD)			Control group (CG), (Mean ± SD)			t-test (EG - CG)	
	Pre-test	Post-test	t-test	Pre-test	Post-test	t-test	Pre-test	Post-test
HR rest, bpm	78.2 ± 4.5	69.2 ± 3.5	10.5***	77.1 ± 4.1	76.5 ± 4.8	1.4	.8	5.8***
Average HR while warm up, bpm	116,9 ± 2.8	113.6 ± 3.1	.8	117.3 ± 10.5	116.1 ± 5.3	.1	.04	0.4
HR at finish, bpm	192.8 ± 1.9	186.9 ± 0.2	3.1**	196.5 ± 6.6	195,1 ± 3,1	.2	.5	2.6*
HR average, bpm	180.3 ± 3.5	166.1 ± 1.6	3.6**	181.1 ± 8.4	180.7 ± 6.3	.1	.1	2.3*
HR max, bpm	194.9 ± 3.3	182.8 ± 2.2	3.1**	198.3 ± 10.1	196.2 ± 6.2	1.2	.3	2.0*
Distance passage time, sec	1062.0 ± 19.4	774.5 ± 10.8	12.9***	1098.3 ± 14.1	1104.4 ± 12.3	.4	1.5	20.8***
Pulse cost, b/km	1065.2 ± 6.6	740.9 ± 14.3	21.2***	1068.1 ± 16.3	1107.1 ± 16.3	1.6	.2	16.9***
Running speed, km/h	10.2 ± .7	13.6 ± .3	4.2***	10.1 ± .8	9.4 ± .5	.8	.1	7.2***

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

Analysis of the pulse cost of the work performed showed statistically-valid favorable changes in this indicator among students of the experimental group ($t = 21.2$; $p < .001$). Thus, the values of the analyzed indicator of the representatives of the experimental group decreased in average from 1065.2 (SD = 6.6) to 740.9 (SD = 14.3) b/km, while no significant positive changes were found in students of the control group ($t = 1.6$; $p > .05$).

An analysis of the obtained data also revealed that the speed of passage of the distance increased on the first section of the distance at the beginning of the experiment, then decreased and on its subsequent section remained unchanged both among the representatives of the experimental group and among students of the control group (Table 3).

At the same time, analysis of data from heart rate monitors revealed that in both groups, a sharp increase in heart rate was observed at the beginning of the distance, reaching an average of 30.6% in the experimental group and 28.8% in the control group compared with the heart rate after warming up (Table 4). Further, despite the decrease in the speed of passage of the distance, heart rates of the representatives of both groups continued to increase steadily, and reached its maximum values at the end of the distance. There was no statistically significant difference in the indicators of the speed of passage of the distance and heart rate between the groups of examined students at the beginning of the experiment.

Table 3

Dynamics of Speed During 3000 m Distance by Students of the Experimental and Control Group Before and After the Experiment

Group	Experiment stages	Statistical characteristics	Section of the distance, m							
			200	600	1000	1400	1800	2200	2600	3000
Experimental (EG)	Before	Mean	11.5	9.5	9.2	9.5	8.6	8.8	9.2	9.2
		SD	.6	.4	.7	.8	.6	.7	.7	.6
	After	Mean	11.9	10.6	10.3	10.4	10.6	10.6	11.8	12.6
		SD	.3	.5	.6	.8	1.0	.8	.7	1.0
		p	.554	.093	.239	.430	.093	.097	.012	.005
Control (CG)	Before	Mean	10.8	9.5	9.2	9.2	9.1	9.0	9.1	8.4
		SD	.6	.8	.9	.8	.4	.2	.4	.7
	After	Mean	13.1	13.2	12.2	11.1	9.8	9.2	9.4	9.2
		SD	.8	.9	1.3	.7	.4	.3	.4	.3
		p	.026	.003	.065	.081	.223	.582	.599	.299
EG-CG	Before	p	.414	.997	.988	.792	.492	.785	.902	.390
	After	p	.168	.017	.192	.513	.462	.109	.005	.002

Table 4

Dynamics of Heart Rate Indicators During the Passage of the 3000 m Distance by Students of the Experimental and Control Group Before and After the Experiment

Group	Experiment stages	Statistical characteristics	HR after workout	Section of the distance, m							
				200	600	1000	1400	1800	2200	2600	3000
Experimental (EG)	Before	Mean	116	157.5	174.2	181.4	183.5	182.2	183.5	187.1	192.8
		SD	3.9	7.3	4.2	4.7	4.0	3.4	3.3	2.1	1.9
	After	Mean	113.6	142.5	150.0	159.6	162.4	164.8	179.6	182.0	186.9
		SD	1.7	2.7	4.5	3.5	3.3	4.69	1.9	1.6	0.2
		p	.442	.061	.001	.001	.001	.004	.384	.060	.003
Control (CG)	Before	Mean	116.1	158.2	174.3	180.2	184.4	182.4	188.0	191.0	196.5
		SD	3.5	3.4	2.2	3.3	2.2	2.6	1.6	3.4	8.6
	After	Mean	117.3	160.1	168.2	179.1	182.8	181.0	184.0	189.0	195.1
		SD	2.4	3.1	2.6	2.4	3.6	3.1	2.8	2.5	5.1
		p	**.779**	.682	.80	.789	.706	.731	.222	.638	.889
EG-CG	Before	p	.984	.931	.983	.835	.845	.963	.227	.334	.677
	After	p	.215	.001	.001	.001	.001	.006	.201	.023	.031

Towards the end of the experimental period, the speed of movement at the beginning of the distance increases sharply in the experimental group, then its stabilization is observed, and towards the end of the distance there is again an increase in the speed of passage of the distance, which reaches its maximum values in the last section (Table 3). In general, upon repeated testing, the speed of movement along the distance by students of this group, starting from the 1800 m segment, had a tendency to increase, and after 2600 m it was significantly higher ($p < .05$) compared to the pre-test values. The HR values at each of the subsequent segments of the distance increased; however, at the segments of the distance from 600 to 1800 m, these values were significantly lower compared to its values during the initial testing ($p < .05$) (Table 4).

At the end of the experimental period, the speed of advancement during the first 1400 m of the distance was significantly higher ($p < .05$) in the control group, than during the initial testing, and after this mark, due to the inability of students in this group to maintain the initial speed, the speed began to decrease steadily, and by the end of the distance, it was even lower than at the beginning of the experiment (Table 3). This affected the increase in the passage time of the last section of the distance, and the total time to overcome it before and after the experiment did not differ significantly. In this case, as the heart rate progressed, it continued to increase steadily (Table 4), and its values were even higher ($p > .05$) than the initial ones.

Discussion

Physical education classes at Kazakhstan universities are regulated by the State standard (Gosudarstvennyj obshcheobyazatel'nyj standart vysshego obrazovaniya, 2012) and the Standard physical education program (Tipovaya uchebnaya programma obshcheobrazovatel'noj disicpliny «Fizicheskaya kul'tura», 2018). They are aimed at helping students achieve a certain level of functional fitness during their studies at the university.

Our research allowed us to assess the level of functional fitness of first-year students at one of the largest universities in the Republic of Kazakhstan and the effectiveness of the existing physical education program at universities.

The testing carried out at the first stage revealed that the students who entered the first year had weak cardiorespiratory endurance and poor adaptability to stress. Also, in recent studies, we have revealed weak students' motivation to use physical activity during the period of study at the university (Otaraly et al., 2020). This fact prompted us to develop an experimental program aimed at improving the effectiveness of health-enhancing physical education classes for university students. An analysis of literary sources has shown that researchers in other countries are also involved in this problem (Bolotin, 2015; Medonis, 2008; Oreb et al., 2017).

The results of our study confirmed the opinion of other researchers that the success of physical education depends on the proper organization of this process (Popescu, 2014). The program we tested on the experimental group of students led to an improvement in their functional fitness. So, at the end of the pedagogical experiment, there was a decrease in heart rates at rest, its average and maximum values, as well as a decrease in heart rates at various sections of the distance and the total pulse cost of work in the experimental group, which is evidence of the economization of heart activity both at rest and during execution of the load. Other authors obtained similar data in their studies. So, Namozov et al. (2015), while studying the influence of regular classes on indicators of the cardiovascular system of 1st year students, revealed a positive dynamic of the heart rate at rest state during the academic year. The authors believe that the indicators of the functional state of students depend on the volume of their physical activity during the period of study at the university, and an in-depth analysis and synthesis of the obtained data and further studies in this direction will help to develop the technology of personal classes for healing, taking into account the individual capabilities of the students' bodies.

The resting HR is often used as an indicator of a person's cardiorespiratory or aerobic fitness. Such changes occurring as a result of physical activity are evidence of the economization of heart activity both at rest and during the performance of the load (Bjelica et al., 2020). Thus, Zhang et al.'s (2018) studies showed that cardiorespiratory fitness is inversely proportional to resting heart rate of untrained adult women.

To assess the functional state while performing physical exercises, physical education teachers traditionally use the dynamics of maximum heart rates in response to physical activity, believing that a decrease in this indicator attests to the increase in aerobic capabilities. However, Zavorsky (2000) expresses the opinion that the maximum heart rate is relatively independent of the state of human fitness. In contrast, the authors (Bozhkova et al., 2017; Prontenko et al., 2019) argue that the training of students on a specialized program has a positive effect on physical fitness and causes favorable functional changes in the cardiovascular system of students, expressed in a decrease in maximum heart rate and an associated increase in the physical capacity of the body.

While evaluating the effect of physical stress on the functional state of the body, it is valuable to evaluate its pulse cost. The "total pulse cost" indicators of the exercise have a significantly high information content, and provide valuable information about the main energy processes in the human body, and can serve as a criterion for the quantitative evaluation of physical activity (Kenney et al., 2011, Volkov et al., 2003). Hassani (2005) believes that continuous recording of heart rate with subsequent calculation of the total pulse value of continuous recording of heart rate with subsequent calculation of indicators of the pulse value of motor action serves as a reliable indicator of speed, power, and maximum duration of work and can be used in training qualified athletes. It is possible to achieve the greatest training effect based on the parameters of the pulse value, by giving the most accurate recommendations on the ratio of volume and intensity of the load. Also, according to the opinion, the indicators taken from the heart rate monitors will allow timely detection and prevention of overtraining of athletes (Prakash, 2008).

The same principles should be followed while planning the loads used for the purpose of recovery. The requirements for achieving health goals are to assess the body's ability to control how the heart and cardiovascular system respond to exercise (Szakly et al., 2016; Vuorim, 1998).

Heart rate monitors provide immediate feedback to help keep exercise intensity within pre-set ranges. Continuous heart rate recording will help to solve the problem of accurately quantifying the load performed (Barreira et al., 2009; Randall et al., 2009; Thomas & Gopi, 2019), especially in classes with individuals with different levels of physical activity.

A 3000-meter run was chosen in our study as a test that reveals the cardiorespiratory fitness of students, since the results of this test have a high connection with other indicators characterizing this quality (Lourenço et al., 2018). The authors confirmed previously published results of Yoshida et al., (1993) on the presence of a close relationship between the results of a 3000-m run and lactate threshold (r = .73) and VO_{max} (r = .52). According to Jones (1998) data, subjects running 3000 m use approximately 100% of their VO_2 peak.

The data obtained in our studies confirms the results of Riiser et al. (2014) who also revealed an improvement in 3000 m run performance after using the running program on young people of military age. At the same time, the authors claim that the lower the initial level of functional readiness was, the more pronounced were the changes by the end of the experiment.

The data obtained as a result of our studies indicates a significant and valid decrease in the total pulse cost of the load in the students of the experimental group. The research results confirm the opinion of Westerterp (2017), who says that lowering the pulse cost leads to economization of energy costs for the exercise, which resulted in higher physical fitness of students in the experimental group in the experiment.

The results of our study showed that an applied experimental program based on individual physical activity improved students' functional capabilities, which confirms the statements of Timofeeva, (2009) about the need to individualize exercises. Thus, the results of our study confirm that the development of an individual safe fitness program is a promising direction (Randall et al., 2009), which would allow the correct choice of the amount of training impact (Ivanović et al., 2011; Partridge et al., 2011). The research also proved that receiving timely feedback during the implementation of the training program, the ability to adjust the running speed based on heart rate monitor data, helped the participants to satisfy their psychological needs for competence and autonomy (Alderman et al., 2006).

This allows to assume the influence of our applied experimental program not only on students' functional capabilities, but also on their motivation for physical activity, which is not analyzed in this article. However, based on the theory of self-determination (Ryan & Deci, 2020), it is likely that the program increased the competence of students, as students were provided with knowledge about exercise, its effect on the body, and students were taught to correct exercises based on analysis of individual cardiovascular data. Individualization of the program, regulation of physical activity based on feedback received from the heart rate monitor, and consultation with a lecturer created the prerequisites for satisfying students' need for autonomy. According to the SDT, the satisfaction of the need for competence and autonomy contributes to internal motivation (Ryan & Deci, 2020), so it is likely that the program applied increased motivation to students' physical activity, but this requires further study. In addition, studies (Ersöz & Eklund, 2017) show that the correct organization of physical education to meet the basic psychological needs of individuals can influence changes in his or her behavior related to physical activity.

Limitation and Future Directions

The limitations of this study are important to note. One of the limitations was that we did not explain students' physical activity after the lectures. Although we performed a classical quasi-experiment using a control group, additional information on students' physical activity after lectures could help to better understand how the developed program affects students' functional capacity at lower or higher levels of physical activity after lectures.

Another limitation of the study was that the evaluation of program performance was limited to a testing method to assess how the program affected students 'functionality, and did not analyze students' perceptions of heart rate monitoring as a feedback method during an exercise to gain student knowledge related to health and physical fitness, as well as physical self-development skills, which are important when planning and implementing independent physical activity programs.

Also, we would think that the number of dependent variables, such as students' motivation and academic achievement, could be extended to gain deeper insights from an educational point of view. Studies (García-Hermoso et al., 2017; Yang & Tsao, 2020) show links between cardiorespiratory fitness and cognitive abilities, but many studies focus on younger age groups – students in school or on older adults. Therefore, when assessing the effectiveness of physical education programs designed to improve the physical and functional fitness of university students, it would be appropriate to assess how these indicators reflecting students' health performance relate to academic achievement, how enhanced aerobic fitness training programs impact on young adults' cognition.

Conclusion

Summarizing the results of the study, we can assume that the application of the developed one academic year health-enhancing program based on equipping students with theoretical and methodological knowledge to analyze the dynamics of their own functional state and interpret digital feedback received from heart rate monitors, allowed improving a level of functional fitness of men students of the experimental group. In the control group, in which the training process was built according to the traditional methods of physical education classes, positive changes in the studied indicators were less pronounced and statistically unreliable. The study confirms that the problem of using modern technical devices in the practice of physical education is relevant and requires further research since it affects the future prospects of using physical exercises to improve students' health. Taking into account the studies of other authors, which indicate the influence of good functional fitness not only on health, but also on cognitive functions, it can be assumed that the developed health-enhancing program will also contribute to the improvement of students' academic performance who participated in the study. However, we still have to investigate this question.

Ancknowledgements

There are no acknowledgements.

Conflicts of interest

The authors declare that there are no conflicts of interests.

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Universiteto studentų funkcinio pajėgumo stiprinimas taikant širdies ritmo monitoringu grįstas individualias sveikatos programas

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Santrauka

Tyrimu siekta įvertinti, kaip studentų funkcinį pajėgumą veikia vienerių akademinių metų trukmės sveikatos stiprinimo programa, suteikianti studentams teorinių ir metodinių žinių, leidžiančių analizuoti savo funkcinės būsenos dinamiką ir interpretuoti pulsometru gautą skaitmeninį grįžtamąjį ryšį. Kvazieksperimente dalyvavo 45 pirmojo kurso studentai – vaikinai. Kontrolinės grupės fizinio ugdymo pratybos buvo vykdomos pagal standartinę aukštosios mokyklos fizinio ugdymo programą. Eksperimentinės grupės studentai dalyvavo individualioje sveikatą stiprinančioje fizinio ugdymo programoje, kurios pagrindą sudarė K. Cooper'io pasiūlyta aerobinės krypties bėgimo programa. Taikant šią programą individualus optimalus fizinis krūvis buvo koreguojamas remiantis širdies ritmo monitoriaus duomenimis. Studentų funkciniam pajėgumui ir programos veiksmingumui nustatyti buvo taikomas 3000 m bėgimo testas, matuojamas širdies susitraukimų dažnis ramybės būsenoje, atskirais bėgimo distancijos intervalais, apskaičiuojami išvestiniai dydžiai. Širdies ritmas buvo fiksuojamas naudojant SigmaPC26.14 pulsometrą. Tyrimo rezultatai parodė, kad taikyta individualiu fiziniu krūviu grįsta eksperimentinė sveikatos stiprinimo programa pagerino studentų funkcines galimybes. Tai patvirtina, kad savalaikis grįžtamasis ryšys treniruočių programos įgyvendinimo metu, galimybė reguliuoti bėgimo greitį, remiantis širdies ritmo monitorių duomenimis, yra perspektyvi kryptis stiprinant studentų sveikatą.

Esminiai žodžiai: *pulsometrai*, *funkcinis pajėgumas*, *krūvio intensyvumas*, *universiteto studentai.*

Gauta 2023 05 12 / Received 12 05 2023
Priimta 2023 06 13 / Accepted 13 06 2023