Pol. J. Sport Tourism **2024**, *31(3), 35-39*
DOI: 10.2478/pjst-2024-0020

Original research papers

THE IMPACT OF A TARGETED PHYSICAL ACTIVITY PROMOTION PROGRAM ON PHYSICAL FITNESS OF UNDERGRADUATE STUDENTS AT NAKHON PHANOM UNIVERSITY

SAKCHAI SRISUK

Nakhon Phanom University, Faculty of Management Science and Information Technology, Nakhon Phanom, Thailand

Mailing address: Faculty of Management Science and Information Technology, Nakhon Phanom University, Nakhon Phanom, Thailand, e-mail: sakchai0072@hotmail.com

Abstract
Introduction. Regular physical activity is crucial for enhancing health-related physical fitness and overall well-being, with research demonstrating superior cardiovascular fitness in active individuals compared to sedentary counterparts. This study aimed to investigate the effects of a physical activity promotion program on physical fitness changes among Nakhon Phanom University students ***Material and methods.*** Thirty Nakhon Phanom University students (16 females, 14 males) participated in the study. The mean age was 18.57 ± 0.50 years, height 163.88 ± 6.44 cm, weight 54.79 ± 4.24 kg, and body mass index (BMI) 20.49 ± 1.90 kg/m^2. The intervention consisted of a 90-minute daily physical activity promotion program implemented over 12 weeks. Comprehensive physical fitness assessments were conducted pre- and post-intervention, measuring body weight, BMI, resting heart rate, body fat percentage, upper and lower limb muscle strength, and maximal oxygen consumption (VO_2max). Descriptive statistics and paired sample t-tests were used for data analysis, with statistical significance set at $p < .05$. ***Results.*** Following the 12-week program, participants exhibited significant physiological changes, including decreased resting heart rate, increased arm muscle strength, and improved oxygen utilization efficiency. These findings suggest that participation in targeted physical activity promotion programs positively impacts students' health-related physical fitness. ***Conclusions.*** Encouraging students to participate in specific exercise programs can positively influence their health-related physical fitness. Universities should provide adequate facilities to enhance students' potential and promote a healthy lifestyle through regular physical activity and good health practices. To establish a culture of exercise and well-being on campus, institutions should encourage students and staff to walk or bike more frequently, engage in outdoor activities, and participate in organized sports or fitness classes. By implementing these initiatives, universities can foster an environment that prioritizes physical and mental health, ultimately leading to improved academic performance and overall quality of life for the campus community.

Key words: physical activity, physical fitness, well-being

Introduction

High blood pressure, a significant national health concern, is a major risk factor for cardiovascular diseases such as heart disease, coronary artery disease, atherosclerosis, and cerebrovascular stroke. One way to lower the risk of sickness and mortality from many chronic conditions, including heart disease and stroke, is to maintain optimal physical fitness [1]. Individuals with high blood pressure often do not experience any symptoms, which is why it is often referred to as the "silent killer." It is crucial to monitor blood pressure regularly and make lifestyle changes to reduce the risk of developing these serious health conditions. Furthermore, traditional foods high in fat, sugar, and sodium, coupled with a sedentary lifestyle, may exacerbate health issues. Years of research have shown that diet and physical activity greatly affect the risk of cardiovascular diseases (CVD), diabetes, and other health issues. Exercise can benefit individuals with normal blood pressure and those with high blood pressure by helping to lower it. Increasing physical activity is an important component of lifestyle modification in the prevention and treatment of high blood pressure. Therefore, a lower risk of cardiovascular disease is associated with greater participation in exercise training and physical activity programs [2, 3]. Regular physical activity shows a positive correlation with adolescent health and can be a factor promoting the adoption of an active lifestyle. However, the amount and intensity of physical activity should be moderate to intense (more vigorous than regular exercise). A person should engage in physical activity for a total of more than 30 minutes per day. Alves et al.'s study [4] revealed that moderate-to-intense physical activity is usually recommended for its health benefits. According to published research, engaging in regular physical activity can improve health. Research [5, 6] indicates that the incidence of heart disease and stroke (cardiovascular disorders) is significantly higher in obese and chronically inactive children than in active children. Everyone needs to participate in physical activity because it can effectively develop health-related physical fitness. Past studies have proven that those who engage in regular physical activity have better cardiovascular fitness than those who do not [7]. Maintaining a regular physical activity regimen that is appropriate in terms of both quantity and intensity can raise metabolism and alter blood hormone levels [8]. While physical education classes sometimes offer instructional time for physical activity, this is rarely enough to attain and sustain a reasonable level of physical fitness. Therefore, this study aimed to examine the effects of physical activity promotion on physical fitness changes and to provide recommendations to improve the lifestyle and health of Nakhon Phanom University students.

Material and methods

Study design

This was a controlled trial in human experimental research conducted at the Faculty of Management Science and Information Technology, Nakhon Phanom University, Thailand. Participants were selected based on pre-established inclusion and exclusion criteria. They engaged in a 12-week physical activity program, with fitness assessments conducted at the beginning (baseline) and end (post-test) of the semester by the same evaluators.

Participants

The study conducted was a controlled trial within human experimental research. It included thirty healthy students (14 males and 16 females; age 18.57 ± 0.50 years, height 163.88 ± 6.44 cm, mean body weight 54.79 ± 4.24 kg, and mean body mass index 20.49 ± 1.90 kg/m²). All participants, with no specific sports specialization, were recruited from the student body at Nakhon Phanom University, Thailand. The students were selected using the following criteria: being physically normal and able to perform normal activities of daily living. Students were excluded if they had injuries to their upper and lower limbs or a musculoskeletal problem that affected their upper and lower extremities. The study was approved by the Nakhon Phanom University Research Ethics Committee (approval number: HE12367). Before participating in the study, participants read the study's description and potential risks, and signed an informed consent.

Treatment procedures

Physical activity promotion plan for students at Nakhon Phanom University. This program is available to all students who are studying sport and recreation for health at the university. It comprises 12 weeks of progressive training divided into four blocks. Each block spans 3 weeks, with participants receiving training three days per week (Mondays, Wednesdays, and Fridays). Training sessions for the physical activity promotion program occur between 4:00 p.m. to 5:00 p.m. It can be inferred that each session consisted of two parts: one dedicated to building strength and the other to improving endurance. Strength training consisted of six exercises including: half-squat, bench press, leg extension, arm curl, shoulder press, and wrist curl. The intensity was calculated from one repetitive maximum (1RM) value. During the first week, the load was settled at 50% of 1RM, and then it was increased by 5% each week. Endurance training was performed running on a treadmill. Every session included a 30-minute treadmill run. Each session began with a brief warm-up, 10 min. Intensity was maintained at 50–85% heart rate reserve. Target heart rates were determined using the Karvonen formula: targeted heart rate = (220 – age – resting heart rate) x 60-85% + resting heart rate. A smartwatch monitored the participant's heart rate during the workout. Table 1 outlines the specifics of the physical activity promotion plan for students at Nakhon Phanom University.

Equipment for measuring anthropometry parameters

This means using equipment to measure the physical dimensions and proportions of the human body, such as height, weight, and body mass index. The direct anthropometric measurements of the body were taken with subjects wearing only sportswear and without shoes. All the measurements were performed by a well-trained technician. Body weight was measured with a digital scale. Body height was measured with a manual stadiometer, with 0.1 cm precision, and while measuring height, subjects were asked to look straight. The subjects stood straight with their heels, buttocks, and backs touching the vertical limb of the wall. The body mass index was calculated to grade chronic energy deficiencies. The body mass index was calculated following the measurement of each participant's height and weight using the following formula: Body mass index (BMI) = weight in kg/height in meter².

Table 1. Physical activity promotion plan for students at Nakhon Phanom University

Block	Parameter	Strength Part	Endurance Part
1	Volume Intensity Rest	3x12 reps 50-55%1-RM 3 min	30 min 50-55%THR
2	Volume Intensity Rest	3x10 reps 60-65%1-RM 3 min	30 min 60-65%THR
3	Volume Intensity Rest	3x8 reps 70-75%1-RM 3 min	30 min 70-75%THR
4	Volume Intensity Rest	3x6 reps 80-85%1-RM 3 min	30 min 80-85%THR

Body composition measurement

Body fat (%) was calculated from skinfold thicknesses (ST). The measurement was carried out with a Lange caliper to the nearest 0.1 mm at the following four sites on all subjects: at the biceps, triceps, subscapular, and suprailiac areas along the right body side, and measurement was repeated two consecutive times and presented in Table 2. The sum in millimeters of the 4 skinfold thickness measurements [9].

Table 2. Skinfold thickness sites for measurements

Skinfold Thickness (ST)	Sites for measurements
Biceps skinfold	On the front of the upper right arm, directly above the center of the cubital fossa, at the same level as the triceps skinfold
Triceps skinfold	Midpoint of the back of the upper right arm, halfway between the acromion process and the olecranon process
Subscapular skinfold	About 20 mm below the tip of the scapula, at an angle of 45 degrees to the lateral side of the body
Suprailiac skinfold	In the midaxillary line, about 20 mm above the iliac crest

Muscular strength test

Hand grip strength test: Using a typical adjustable handle mechanism, the force of the dominant hand's grip strength was determined. Takei's grip strength dynamometer (produced in Japan) was used. For standardization, it was set at the second handle position for all participants. The standing position with the shoulder adducted, neutrally rotated, and elbow in full extension. The findings were expressed in kilograms per body weight. Strength in test 1 and 2 is calculated as the mean of the top scores obtained in these two tests [10]. Regardless of hand dominance, the participants' hand grip strength data was displayed as left or right.

Leg strength test: The leg strength is an isometric evaluation of maximal leg strength using a dynamometer. Participants' leg strength was measured with the Takei T.K.K. 5402 (Japan) Back strength dynamometer, which is a simple and popular device to test back, legs and chest strength with a sensitivity up to 300 kg. Procedure: Ensure the meter is reset to zero before beginning. Stand upright on the dynamometer base with your feet shoulder-width apart. Extend your arms straight down to grip the center of the bar with both hands. Adjust the chain to ensure that the knees are bent at around 110 degrees. In this position, you should have a slight forward bend at the hips, keep your head upright, and look straight ahead. Without bending your back, pull as hard as you can on the chain and try to straighten your legs while keeping your arms straight. Pull steadily against the weight without any sudden movements, and keep your feet flat on the base of the dynamometer. The results are given in kilograms for each body weight. The mean of the highest scores received in tests 1 and 2 is used to calculate strength in those tests [11, 12].

Cardiorespiratory fitness

Cooper 12-minute walk/run test: The purpose is to test aerobic fitness, which is the body's ability to use oxygen to power itself while running. Before the test, explain the procedures to the subject. The participants warm up with some light jogging and dynamic movements of 10 to 15 minutes. Place markers are set along the route to help keep track of the distance covered. Participants ran for 12 minutes and noted the total distance they ran. They were allowed to walk during the run, but competitors are encouraged to push themselves to run as far as they can within the time limit. The formula to estimate VO2max (ml/kg/min) based on the distance covered in kilometers is as follows: [13].

$$VO_2max = (35.971 \times \text{distance in kilometers}) - 11.288$$

Data analysis

The data collected from the pre-test and post-test was organized and prepared for analysis using IBM SPSS Statistics version 27.0. The pre- and post-test results were reported as mean ± SD. The coded and organized data were analyzed using a paired t-test to evaluate changes in physical fitness performance from baseline (pre-test) to post-test. The level of statistical significance was set at $p < 0.05$.

Results

Anthropometric characteristics of the participants

Table 3 outlines the participants' baseline characteristics. Thirty individuals (14 males, 16 females) participated in the study, with a mean age of 18.57 ± 0.50 years and an average height of 163.88 ± 6.44 cm. The physical activity promotion program significantly reduced participants' body weight and BMI ($p < 0.05$).

The effects on physical fitness

There was a significant increase in arm strength (0.50 ± 0.11 vs. 0.57 ± 0.12 repetitions, p = 0.00), leg strength (1.43 ± 0.53 vs. 1.94 ± 0.60 repetitions, p = 0.00), and oxygen consumption (24.51 ± 2.36 vs. 26.19 ± 2.71, p=0.00) from pre- to post-intervention, as shown in Table 4. The promotion of physical activity resulted in a significant decrease in resting heart rate (83.478.87 vs. 79.176.49, p = 0.01) and body fat (26.734.49 vs. 24.644.31, p = 0.00).

Discussion

Thirty participants were students at Nakhon Phanom University. The study aimed to investigate how promoting physical activity affects physical fitness. The anthropometric characteristics of the participants revealed an average age of 18.57 ± 0.68 years, a standing height of 161.80 ± 7.43 cm, body weight of 50.70 ± 7.31 kg, and body mass index of 19.63 ± 2.45 kg/m^2. The physical activity promotion program effectively augmented increases in muscular strength and oxygen consumption. Additionally, the average resting heart rate and body fat decreased after participating in the physical activity encouragement program.

Table 3. Average values of the anthropometric parameters of the participants

Variables	N	Before training		After training		t	p-value
		Mean	SD	Mean	SD		
Age (years)	30	18.57	0.50	18.57	0.50		
Height (cm)		163.88	6.44	163.88	6.44		
Body weight (Kg)		54.79	4.24	54.15	4.49	2.12	0.04*
BMI (kg/m^2)		20.49	1.90	20.08	1.87	5.42	0.00*

p < 0.05.

Table 4. Results of paired sample t-test on selected physical fitness variables

Variables	Pre-Training		Post-Training		Std. Error mean	t	df	p-value
	Mean	SD	Mean	SD				
Resting heart rate (beats/min)	83.47	8.87	79.17	6.49	1.30	3.30	29	0.01*
%Body fat (millimeter)	26.73	4.49	24.64	4.31	0.40	5.25	29	0.00*
Arm strength (kg/body weight)	0.50	0.11	0.57	0.12	0.01	9.19	29	0.00*
Leg strength (kg/body weight)	1.43	0.53	1.94	0.60	0.08	6.13	29	0.00*
Oxygen consumption (ml/min/kg)	24.51	2.36	26.19	2.71	0.20	8.56	29	0.00*

p < 0.05.

Overall, there was an observed improvement in general physical fitness. Encouraging physical activity in young people is crucial for reducing the risk of high blood pressure, diabetes, and coronary heart disease. Regular physical activities are vital for overall development, good health, and physical fitness throughout life. The findings suggest that as moderate and vigorous physical activity levels increase, the quality of life of both male and female adolescents also improves.

The effects of a physical activity promotion program on resting heart rate and body fat percentage

After completing the 8-week physical activity promotion program, a significant decrease in resting heart rate and body fat percentage was observed among participants. Engaging in regular, moderate-intensity physical activity over an extended period leads to cellular adaptations that enhance the body's ability to generate energy through a process called oxidative phosphorylation. This metabolic improvement also helps the body utilize fat more efficiently as a source of fuel. High-intensity continuous training can permanently alter resting metabolic rate and heart rate. Trained individuals demonstrated a higher resting metabolic rate compared to untrained individuals only when there was significant energy expenditure, indicating that exercise intensity and energy consumption can impact resting metabolic rate. The resting metabolic rate and heart rate can be permanently altered by high-intensity continuous training. However, trained individuals only exhibited a higher resting metabolic rate compared to untrained individuals when there was a substantial energy expenditure. This finding indicates that both exercise intensity and energy consumption can significantly impact the resting metabolic rate [14]. Furthermore, moderate and vigorous exercise was found to be negatively associated with BMI and subcutaneous fat in college students. This suggests that reducing sedentary behavior among this population and increasing both the intensity and duration of vigorous physical activity can effectively lower their BMI and subcutaneous fat levels. Consequently, these improvements can help reduce various risk factors associated with cardiovascular disease.

The effects of a physical activity promotion program on muscular strength

A notable characteristic of skeletal muscle is its capacity to adapt to changes in contractile activity patterns, a trait commonly known as phenotypic plasticity [15]. For beginners, participating in resistance training three times a week can significantly improve muscle strength. Research shows that regular exercise can help build stronger muscles and enhance overall muscular function. Regular exercise helps increase the number of mitochondria in muscle cells, which improves the cells' ability to produce energy through oxidative processes [16]. This adaptation enhances muscular endurance and performance. Mitochondria are responsible for producing energy in the form of adenosine triphosphate (ATP) through a process called oxidative phosphorylation. Therefore, having more mitochondria means that muscle cells have a greater capacity to produce energy, leading to improved function and performance. ATP is the primary energy currency of cells, powering various cellular processes, including muscle contraction. Therefore, having more mitochondria means that muscle cells have a greater capacity to produce energy, leading to improved function and performance in activities requiring muscular effort, such as endurance exercise and strength training.

The effects of a physical activity promotion program on oxygen consumption

Participation in a specific physical activity program resulted in improved oxygen consumption for individuals compared to their pre-program levels. Previous research indicates that engaging in high-intensity physical activity for more than two weeks can enhance aerobic capacity [17]. Furthermore, participating in moderate-intensity physical activity for 20-30 minutes, three to four times a week, can significantly boost the immune system and reduce the risk of viral infections [18]. Regular exercise strengthens the body's defenses, making it more resistant to illnesses. The physiological adaptation following aerobic exercise is an increase in cardiorespiratory fitness (CRF), typically measured using the VO_2max test. Studies have shown that high-intensity interval training (HIIT) and/or sprint interval training (SIT) can improve CRF in diverse populations, including adults, children [19, 20], elderly individuals [21, 22], healthy individuals [23, 24, 25], overweight or obese individuals [26], and those with type 2 diabetes (T2D) [27, 28]. Maximal aerobic capacity is a key determinant of endurance performance, as improving VO_2max enhances cardiovascular health by strengthening the heart and improving blood circulation. Additionally, individuals with higher VO_2max recover faster after intense exercise due to better oxygen supply and waste removal. This is because regular endurance training increases VO_2max by improving oxygen delivery to muscles and enhancing their ability to utilize oxygen efficiently.

Conclusions

The results of this study demonstrate that a targeted physical activity promotion program can significantly improve the physical fitness of Nakhon Phanom University students. Engaging in continuous physical activities with brief rest periods effectively stimulates cardiovascular development. Regular participation in moderate-to-vigorous physical activity is associated with enhanced overall fitness. Lifestyle modifications, particularly increased physical activity levels, can substantially improve quality of life. Therefore, it is crucial for educational institutions to promote physical activity among young people to maintain good health, reduce the risk of substance abuse, and foster long-term well-being.

Acknowledgements

This research project was fully funded by a 2024 grant from the Faculty of Management Science and Information Technology, Nakhon Phanom University, Thailand

References

1. Biddle S.J., Gorely T., Stensel D.J. (2004). Health-enhancing physical activity and sedentary behaviour in children and adolescents. *Journal of Sports Sciences* 22(8), 679-701. DOI: 10.1080/02640410410001712412
2. Blair S.N., Kohl H.W., Barlow C.E., Paffenbarger R.S., Gibbons L.W., Macera C.A. (1995). Changes in physical fitness and all-cause mortality: a prospective study of healthy and unhealthy men. *Jama* 273(14), 1093-1098.
3. Whelton S.P., Chin A., Xin X., He J. (2002). Effect of aerobic exercise on blood pressure: A meta-analysis of randomized, controlled trials. *Annals of Internal Medicine* 136(7), 493-503. DOI: 10.7326/0003-4819-136-7-200204020-00006

4. Alves A.R., Dias R., Neiva H.P., Loureiro N., Loureiro V., Marinho D.A. et al. (2022). Physical Activity, Physical Fitness and Cognitive Function in Adolescents. *Trends in Sport Sciences* 29(3), 91-97. DOI: 10.23829/TSS.2022.29.3-2
5. Strong W.B., Malina R.M., Blimkie C.J., Daniels S.R., Dishman R.K., Gutin B. et al. (2005). Evidence based physical activity for school-age youth. *The Journal of Pediatrics* 146(6), 732-737. DOI: 10.1016/j.jpeds.2005.01.055
6. Andersen L.B., Riddoch C., Kriemler S., Hills A.P. (2011). Physical activity and cardiovascular risk factors in children. *British Journal of Sports Medicine* 45(11), 871-876. DOI: 10.1136/bjsports-2011-090333
7. Boddy M.L., Fairclough J.S., Atkinson G., Stratton, G. (2012). Changes in cardiorespiratory fitness in 9- to 10.9-year-old children: SportsLinx 1998-2010. *Medicine & Science in Sports & Exercise* 44(3), 481-486. DOI: 10.1249/Mss.0b013e3182300267
8. Galbo H. (2001). Influence of aging and exercise on endocrine function. *International Journal of Sport Nutrition and Exercise Metabolism* 11, 49-57. DOI: 10.1123/ijsnem.11.s1.s49
9. Durnin J.V., Womersley J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *The British Journal of Nutrition* 32(1), 77-97. DOI: 10.1079/bjn19740060
10. Incel N.A., Ceceli E., Durukan P.B., Erdem H.R., Yorgancioglu Z.R. (2002). Grip strength: Effect of hand dominance. *Singapore Medical Journal* 43(5), 234-237.
11. Eyuboğlu E., Aslan C.S., Karakulak I., Sahin F.N. (2019). Is there any effect of non-suitable pull technique in back & leg dynamometers on the leg strength test results? *Acta Medica Mediterranea* 35(3), 1373-1377. DOI: 10.19193/0393-6384_2019_3_211
12. Ten Hoor Gill A., Kirsty M., Kenneth M., Guy P. (2016). Test-retest reproducibility and validity of the back-leg-chest strength measurements. *Isokinetics and Exercise Science* 24(3), 209-216.
13. Cooper K.H. (1968). A means of assessing maximal oxygen uptake. *Journal of the American Medical Association* 15(3), 201-204.
14. Bullough R.C., Gillette C.A., Harris M.A., Melby C.L. (1995). Interaction of acute changes in exercise energy expenditure and energy intake on resting metabolic rate. *American Journal of Clinical Nutrition* 61(3), 473-481. DOI: 10.1093/ajcn/61.3.473
15. Pette D., Sketelj J., Skorjanc D., Leisner E., Traub I., Bajrović F. (2002). Partial fast-to-slow conversion of regenerating rat fast-twitch muscle by chronic low-frequency stimulation. *Journal of Muscle Research and Cell Motility* 23(3), 215-221. DOI: 10.1023/a:1020974710389
16. Joyner M.J., Coyle E.F. (2008). Endurance exercise performance: The physiology of champions. *The Journal of Physiology* 586(1), 35-44. DOI: 10.1113/jphys iol.2007.143834
17. Astorino T.A., Allen R.P., Roberson D.W., Jurancich M. (2012). Effect of high-intensity interval training on cardiovascular function, VO2max, and muscular force. *The Journal of Strength and Conditioning Research* 26(1), 138-145. DOI: 10.1519/JSC.0b013e318218dd77
18. Nieman D.C., Nehlsen-Cannarella S.L., Markoff P.A., Balk-Lamberton A.J., Yang H., Chritton D.B. et al. (1990). The effects of moderate exercise training on natural killer cells and acute upper respiratory tract infections. *International Journal of Sports Medicine* 11(6), 467-473. DOI: 10.1055/s-2007-1024839
19. Bacon A.P., Carter R.E., Ogle E.A., Joyner M.J. (2013). VO-2max trainability and high intensity interval training in humans: a meta-analysis. *PLoS ONE* 8(9), e73182. DOI: 10.1371/journal.pone.0073182.30
20. Gist N.H., Fedewa M.V., Dishman R.K., Cureton K.J. (2014). Sprint interval training effects on aerobic capacity: a systematic review and meta-analysis. *Sports Medicine* 44(2), 269-279. DOI: 10.1007/s40279-013-0115-0
21. Bouaziz W., Malgoyre A., Schmitt E., Lang P.O., Vogel T., Kanagaratnam L. (2020). Effect of high-intensity interval training and continuous endurance training on peak oxygen uptake among seniors aged 65 or older: a meta-analysis of randomized controlled trials. *International Journal of Clinical Practice* 74(6), e13490. DOI: 10.1111/ijcp.13490
22. Sant'Ana L.O., Machado S., Ribeiro A.A.S., Dos Reis N.R., Campos Y.A.C, da Silva J.G.V. et al. (2020). Effects of cardiovascular interval training in healthy elderly subjects: a systematic review. *Frontiers in Physiology* 11, 739. DOI: 10.3389/fphys.2020.00739
23. Milanovic Z., Sporiš G., Weston M. (2015). Effectiveness of High-Intensity Interval Training (HIT) and continuous endurance training for VO2max improvements: a systematic review and meta-analysis of controlled trials. *Sports Medicine* 45(10), 1469-1481. DOI: 10.1007/s40279-015-0365-0.33
24. Sloth M., Sloth D., Overgaard K., Dalgas U. (2013). Effects of sprint interval training on VO2max and aerobic exercise performance: a systematic review and meta-analysis. *Scandinavian Journal of Medicine & Science in Sports* 23(6), e341-52. DOI: 10.1111/sms.12092.34
25. Vollaard N.B.J., Metcalfe R.S., Williams S. (2017). Effect of number of sprints in an SIT session on change in VO2max: a meta-analysis. *Medicine and Science in Sports and Exercise* 49(6), 1147-1156. DOI: 10.1249/MSS.0000000000001204
26. Sultana R.N., Sabag A., Keating S.E., Johnson N.A. (2019). The effect of low-volume high-intensity interval training on body composition and cardiorespiratory fitness: a systematic review and meta-analysis. *Sports Medicine* 49(11), 1687-1721. DOI: 10.1007/s40279-019-01167-w
27. Liu J.X., Zhu L., Li P.J., Li N., Xu Y.B. (2019). Effectiveness of high-intensity interval training on glycemic control and cardiorespiratory fitness in patients with type 2 diabetes: a systematic review and meta-analysis. *Aging Clinical and Experimental Research* 31(5), 575-593. DOI: 10.1007/s40520-018-1012-z
28. Lora-Pozo I., Lucena-Anton D., Salazar A., Galan-Mercant A., Moral-Munoz J.A. (2019). Anthropometric, cardiopulmonary and metabolic benefits of the high-intensity interval training versus moderate, low-intensity or control for type 2 diabetes: systematic review and meta-analysis. *Internation Journal of Environmental Research and Public Health* 16(22), 4524. DOI: 10.3390/ijerph16224524

Submitted: July 27, 2024
Accepted: October 29, 2024