Health, Sports & Rehabilitation Medicine
Vol. 26, no. 1, January-March 2025, 22–27

Optimizing VO2max by implementing a functional training program with innovative fitness equipment for students

Andreea-Maria Tacsa[1,2], Dana Badau[1]
[1] *Transilvania University of Brasov, Romania*
[2] *University of Medicine, Pharmacy, Sciences and Technology G.E.Palade of Targu-Mures, Romania*

Abstract

Background. Optimizing aerobic capacity is an essential aspect of students' physical development, directly impacting physical performance, overall health, and academic achievement.

Aims. The functional training program, utilizing innovative equipment, can optimize students' maximum oxygen volume (VO2max).

Methods. The experimental group, consisting of 40 students (20 male and 20 female) from the general medicine specialization, participated in functional training sessions that took place twice a week during physical education lessons. Cardiovascular exercises performed with innovative equipment were integrated into these functional training sessions. The study used the VO2max aerobic exercise test to evaluate parameters such as: volume of oxygen consumed per minute (VO2 L/min), volume of oxygen consumed per minute per kilogram of body mass (VO2/kg, ml/min/kg), respiratory exchange rate between O2 and CO 2 (RER), respiratory frequency (BF, cycles/minute), total amount of air breathed in one minute (VE /L/ min).

Results. Data analysis using SPSS software indicated a statistically significant improvement for all parameters. The greatest progress of the experimental group was in the VE parameter (total amount of air breathed in one minute). These results suggest that functional training using innovative equipment can effectively improve the maximum volume of oxygen.

Conclusion. The students' aerobic exercise capacity improved as a result of the functional training program, which was tailored to their individual characteristics and fitness levels.

Keywords: VO2max, aerobic capacity, functional training, fitness, cardiovascular exercises, Aqua Fit equipment.

Introduction

Aerobic capacity refers to the body's ability to perform physical exercise that utilizes oxygen to produce energy. It is based on two fundamental processes: oxygen supply, where oxygen is transported to the muscles, and oxygen utilization, where oxygen is used by muscle cells to produce energy (Cheng & Liao, 2016; Alpaslan et al., 2017). At the same time, aerobic capacity is influenced primarily by the efficiency of the cardiovascular system and the respiratory system, as well as by fitness level, muscle mass, and age. The cardiovascular and respiratory systems supply oxygen to the muscles and eliminate carbon dioxide from the body (Wassenaar et al., 2021; Eather et al., 2019).

Fitness level is a person's general physical condition and ability to perform various physical activities, including aerobic capacity, muscle strength, endurance, and flexibility. The more trained a person is, the greater their aerobic capacity will be. Aerobic capacity is an important component of general fitness and can be optimized through cardiovascular exercises, such as running, swimming or functional training that includes aerobic exercises (Baba et al., 2024; Rebryna et al., 2024; Badau, 2015). At the same time, it is a crucial factor in physical education, positively impacting overall physical development and academic performance. Aerobic activities are fundamental in creating a healthy lifestyle, contributing to good physical and mental balance, increasing heart rate and lung capacity, and, when practiced regularly, improving muscular endurance (Crossley, 2021; Sincki, 2021).

The most important parameter on which aerobic capacity depends is maximum oxygen consumption (VO2max), which represents the maximum amount of oxygen the body can transport and use per minute. The higher the VO2max, the more efficiently the body can utilize oxygen during exercise, allowing intense activities to be sustained for extended periods (Scurt et al., 2022; Usgu et al., 2020). Any effort carried out at an intensity that requires more energetic support through aerobic

Received: 2025, January18; *Accepted for publication:* 2025, January 27
Address for correspondence: Transilvania University of Brasov, Eroilor Av. 29, 500068 Brasov, Romania
E-mail: dana.badau@gmail.com
Corresponding author: Dana Badau; dana.badau@gmail.com
https://doi.org/10.26659/pm3.2025.26.1.22

Copyright © 2010 by "Iuliu Haţieganu" University of Medicine and Pharmacy Publishing

processes than VO2max triggers the intervention of anaerobic mechanisms. It is expressed in ml/kg body/min. The factors that influence VO2max are genotype (25-50%), age, muscle composition, and training status (Ionescu & Caramoci, 2017; Holmer, 2024). Aerobic activities improve VO2max through the adaptive changes they produce on the respiratory and cardiovascular systems.

Functional training improves the body's natural movements by performing exercises that mimic current activities (Rebryna et al., 2024; Lu et al., 2021). A key aspect of this type of training is to enhance aerobic capacity and muscle strength, which are crucial for overall health and optimal daily performance. Aerobic exercises in functional training also facilitate faster recovery between sets, increasing performance capacity in functional movements. Functional exercises that target aerobic movements prevent injuries, improve flexibility, and are fundamental to sports performance by activating the cardiovascular system and muscle groups (Kohli, 2024). Functional training and aerobic capacity are interconnected because they involve exercises simultaneously stimulating multiple muscle groups, thereby improving the body's long-term efficiency in transporting and utilizing energy. It is carried out at a sustained pace or with high-intensity intervals, directly influencing VO2max, positively impacting aerobic capacity.

The elements of novelty and originality are the Aqua Fit equipment, consisting of a bag, ball, dumbbells, and inflatable kettlebells. They represent a reinterpretation of classic fitness materials. What makes them different is that the Aqua Fit equipment can be filled with water, depending on the physical condition of each student (Wezenbeek et al., 2022). At the same time, it adds instability to functional movements and activates additional muscle groups to maintain balance and correct posture, thereby increasing the intensity of the exercises. The cardiovascular system is more stressed at a higher intensity, resulting in improved aerobic capacity. We believe this study will provide evidence on improving the maximum oxygen volume of students through a functional training program using innovative equipment. The study aimed to optimize the VO2max of students from non-profile faculties by implementing an experimental program using innovative equipment.

Hypothesis

The study hypothesis was based on the assumption that implementing a functional training program using inflatable equipment would significantly improve the aerobic capacity of students from non-profile faculties.

Materials and methods

Research protocol

a) Period and place of the study

The study was conducted over 16 weeks, including an initial test (IF) and a final test (FT), as well as the implementation of an experimental functional training exercise program using innovative Aqua Fit equipment. The experimental program was practiced for 14 weeks, consisting of two 60-minute lessons per week. The program was structured to integrate moderate-intensity exercises, which help optimize aerobic capacity. Each lesson was structured into a general warm-up section, a specific exercise section featuring Aquafit, and a final recovery section following the exercise. I want to mention that, for the conduct of the cardiopulmonary aerobic exercise test to determine VO2max at the Center for Advanced Medical and Pharmaceutical Research, I received approval no. 3169/ 27.05.2024 from the Ethics and Scientific Research Committee of UMFST G.E. Palade, Târgu Mureș.

b) Subjects and groups

The study included 40 subjects (20 males, 20 females) aged 20.3±0.966 years, weight: 71.518±5.428 kg, average height: 1.73±0.053 m, average BMI: 21.475±1.515. Study inclusion criteria: active students in good health without contraindications to physical exertion, aged 19-25 years, who have completed the experimental program in full, including both initial and final tests. Participants are students at the G.E. Palade University of Medicine, Pharmacy, Sciences and Technology in Târgu Mureș, specializing in general medicine.

c) Evaluation tools and test protocol

For this study, we selected the standardized cardiopulmonary exercise test, specifically the VO2max. The testing equipment consisted of the Cortex Metalyzer 3B spiroergometry system, the Cosmed VO2max mask, the X Trend treadmill, and the Polar heart rate monitoring belt. The Cortex Metalyzer 3 B spiroergometry equipment is an advanced system used to measure a person's maximum oxygen consumption (VO2max) during physical exercise (Fig. 1). The face mask collects the air exhaled by the subject during the test. The gas analyzer measures the oxygen and carbon dioxide concentration in the exhaled air. The flow sensor measures the volume of air inhaled and exhaled by the subject, and the heart rate monitor measures the subject's heart rate to correlate oxygen consumption with cardiovascular effort, providing insight into exercise capacity. All these components are connected to the control unit and software, providing information about cardiopulmonary capacity and VO2max.

Test protocol: participants performed the test in sports equipment, which lasted approximately 45 minutes. General anthropometry involved measuring body weight and height using a Tanita scale and a thalimeter. Heart rate measurement involves measuring the arterial pulse by attaching the Polar belt, which features a textile surface and a rubber portion. Positioning was done at chest level using a fixed clamping system. Blood pressure was also measured by attaching a pneumatic cuff at 2-3 cm from the elbow. After the measurements were taken, the participants were fitted with the face mask, and the data was transmitted via a wireless system, ANT+. The test began with a warm-up, consisting of easy running for 5 minutes. For this study, we selected the standardized cardiopulmonary exercise test, specifically the VO2max. The testing equipment included the Cortex Metalyzer 3B spiroergometry system, the Cosmed VO2max mask, the X-Trend treadmill, and the Polar heart rate monitoring belt. The Cortex Metalyzer 3 B spiroergometry system is an advanced tool used to measure a person's maximum oxygen consumption (VO 2 max) during physical exercise. The face mask collects the air exhaled by the subject during the test. The gas analyzer measures the concentration of oxygen and carbon dioxide in the exhaled air. The flow sensor assesses the volume of air inhaled and exhaled by the subject. At the same time, the heart rate monitor tracks the subject's heart rate to correlate oxygen consumption with cardiovascular effort, providing insight into exercise capacity. All these components connect to the control unit and software, providing information about cardiopulmonary capacity and VO2 max.

Test protocol: participants performed the test using sports equipment, and the test lasted approximately 45 minutes. General anthropometry included measuring body weight and height with a Tanita scale and a thalimeter. Heart rate measurement involved assessing the arterial pulse by attaching the Polar belt, which has a textile surface and a rubber portion. Positioning was done at chest level with a fixed clamping system. Blood pressure was also measured by attaching a pneumatic cuff 2-3 cm from the elbow. After taking the measurements, participants were fitted with the face mask, and the data was transmitted via a wireless system, ANT+. The test began with a warm-up (easy running for 5 minutes at a speed of 5 km/h, without incline). Following the warm-up, the running speed gradually increased by 1 km/h at one-minute intervals. The test continued until the students could no longer maintain the effort due to fatigue, indicating that their maximum oxygen uptake (VO2 max) had been reached. Throughout the test, heart rate, blood pressure, and breathing values were continuously monitored. After completion, participants underwent a post-exercise recovery period of approximately 10 minutes to reduce heart rate and prevent dizziness. Testing was conducted under standardized conditions, using the same equipment and at the same time. The parameters evaluated included the volume of oxygen consumed per minute (VO 2 L/min), the volume of oxygen consumed per minute per kilogram of body mass (VO 2/kg, ml/min/kg), the respiratory exchange rate between O 2 and CO2 (RER), the respiratory frequency (BF - cycles/minute), and the total amount of air breathed in one minute (VE /L/min). a speed of 5 km/h, without inclination). After the warm-up phase, the running speed was gradually increased by 1 km/h, at one-minute intervals. The test continued until the students could no longer maintain the effort due to fatigue, where VO2max was reached. During the test, heart rate, blood pressure and breathing values were constantly monitored. After the test was completed, the participants performed a post-exercise recovery of approximately 10 minutes to reduce the heart rate and prevent dizziness. The testing was performed under standardized conditions, at the same time and with the same testing equipment. The parameters evaluated were: the volume of oxygen consumed per minute (VO2 L/min), the volume of oxygen consumed per minute per kilogram of body mass (VO2/kg, ml/min/kg), the respiratory exchange rate between O2 and CO2 (RER), the respiratory frequency (BF - cycles/minute), the total amount of air breathed in one minute (VE /L/min).

Fig. 1 – Image of the VO2max Cardiopulmonary Exercise Test.

d) Statistical processing

The SPSS24 software was used for the statistical processing of the results of this study, calculating the following parameters: mean, standard deviation (SD), minimum, maximum, variation, and coefficient of variation (CV). To identify the differences between the means of the two tests, we calculated the paired t-test and the Cohen's d parameter, highlighting the effect size. Interpretation of the effect size: <0.3, small effect; 0.3 < 0.5, medium effect; 0.5 < 0.8, large effect; >0.8, very large effect. The significance threshold value was set at $p < 0.05$.

Results

Table I presents the descriptive results of the aerobic VO2max test. Analyzing the results, we found that the mean values increased compared to the initial testing for all test parameters, which signifies the evolution of the subjects. The coefficient of variability falls between 10% and 20% and decreases in the final testing, indicating that the subjects' results are close, with the group being relatively homogeneous.

Paired Student T-test interpretation highlights that for all parameters of the aerobic test, VO2max between the initial and final testing was statistically significant, for $p<0.05$ (Table II). Analyzing the results in Table 2, we find that the most significant progress between the initial and final testing was in the total amount of air breathed in one minute (VE), at 3.819 L/min, followed by the number of cycles per minute (BF), at 2.303. The value of the VO2 parameter (ml/min/kg) was 1.930 ml/min/kg; for VO2 (L/min), it was 1.288 L /min. The smallest progress was recorded for the RER parameter with a value of 0.304. Cohen's d values were greater than 0.8 for all parameters, indicating a very large effect size and demonstrating the efficiency of the experimental program using innovative equipment.

Discussion

In the present study, we aimed to optimize VO2max in students by implementing a functional training program using innovative equipment. The study's results highlighted that, by practicing a functional training program using innovative equipment, the progress achieved by the group of students in the final testing was superior to that in the

Table I
Descriptive statistics for the VO2max aerobic test.

Parameters		Mean	SD	Min.	Max.	Variance	CV (%)
VO2 (L/min)	IT	1.506	0.447	0.780	1.970	0.200	28.68
	FT	2.795	0.333	2.20	3.42	0.111	11.914
VO2 (ml/min/kg)	IT	12.404	0.732	10.89	13.60	0.537	5.90
	FT	14.334	0.613	12.78	15.24	0.377	4.276
VE (L/min)	IT	27.778	0.838	25.20	29.10	0.704	3.016
	FT	31.598	0.905	28.45	34.10	2.557	2.864
BF (cycles/min)	IT	22.754	0.934	21.00	24.20	0.873	4.104
	FT	25.058	0.678	23.67	26.45	0.460	2.705
RER	IT	0.809	0.077	0.660	0.950	0.006	9.517
	FT	1.114	0.092	0.90	1.32	0.009	8.258

IT – initial test, FT – final test, Mean - Media, SD - standard deviation, Min - minimum, Max - maximum, CV% - coefficient of variability, VO2 (L/min) - volume of oxygen consumed per minute, VO2/kg (ml/min/kg) - volume of oxygen consumed per minute per kilogram of body mass, RER - respiratory exchange rate between O2 and CO2, BF(cycles/minute) - respiratory frequency, (VE/L/min) - total amount of air breathed in one minute.

Table II
Paired samples T and Cohen's size for the aerobic VO2max test.

Parameters	Dif (XFT-XIT)	SD	95% CI		t	p	Cohen's d
			Lower	upper			
VO2 (L/min)	1.288	0.623	1.188	1.089	13.067	0.00	3.270
VO2 (ml/min/kg)	1.930	0.577	2.114	1.745	21.147	0.00	2.858
VE (L/min)	3.819	1.422	4.274	3.364	16.987	0.00	2.983
BF	2.303	0.504	2.465	2.142	28.876	0.00	2.823
RER	0.304	0.073	0.328	0.280	26.097	0.00	3.595

Dif (XFT-XIT) - difference of the mean, SD – standard deviation, SEM - Standard Error of the Mean, CI – confidence coefficient, t – Student T value, p – level of statistical significance.

initial testing. The present study significantly contributes to deepening knowledge in the fitness field, consistent with previous research on the same topics.

A study conducted by Usgu et al. (2020) analyzed the effects of functional training on the performance of basketball players. 28 athletes participated in two weekly training sessions for 20 weeks. The results demonstrated significant improvements in muscular endurance, strength, relaxation, and flexibility. The study conducted by Sang et al. (2023) analyzed the effects of functional training on the athletic quality of aerobic practitioners. At the end of the 12-week experimental period, the results showed significant improvement for the experimental group compared to the control group. A series of studies have focused on highlighting the impact of functional training on the components of physical fitness in students differentiated by gender (Liao et al., 2022; Wassenaar et al., 2021; Badau et al., 2021; Ganciu et al., 2015). Rankovic et al. (2010) analyzed the importance of aerobic capacity in various sports. A group of 66 soccer and volleyball players achieved significant results in terms of VO2max, with the best results obtained by the soccer players.

Functional training significantly impacts exercise capacity through essential physiological and motor adaptations. In students, this type of training stimulates the cardiovascular system and muscle strength and coordination, improving physical condition. Exercises involving integrated movements and multi-joint type demands contribute to the development of efficiency in effort and resistance to fatigue (Liao et al., 2022; Wassenaar et al., 2021). Studies have shown that HIIT or functional circuit training significantly increases VO_2max and aerobic capacity in college students, comparable to or even superior to traditional methods such as running (Rebryna et al., 2024; Lu et al., 2021). In addition, this type of training is feasible and well tolerated among the young population, bringing benefits both physically, cognitively, and emotionally (Wassenaar et al., 2021; Eather et al., 2019). Another important aspect is the improvement of movement quality and injury prevention through functional training, which has also been demonstrated in adolescents within functional strength interventions (Liao et al., 2022; Leahy et al., 2019). In the medium term, these trainings support better adaptation to variable-intensity efforts and facilitate the maintenance of a good overall state of health. Functional training has proven to be an effective method for improving exercise capacity in students, having a positive impact not only on physical performance but also on functional capacity.

Limitations of the study

Our study was conducted only on 40 subjects (20 female and 20 male) aged between 19 and 25 years; we did not include a control group in the study to compare the results: the limited implementation period of the 14-week program and other VO2max parameters were not quantified through other standardized tests; we did not include other age categories in the study.

Practical implications of the study

Based on our results, training progress can be optimized by introducing innovative Aqua Fit equipment, which, when combined with specific functional training exercises, helps improve VO2 max. Any innovative equipment contributes to optimizing aerobic capacity, and specialists in the field of physical education and sports must stay up-to-date with it to enhance the efficiency and attractiveness of physical education classes.

Conclusions

1. The study's results on the VO2max aerobic exercise test highlight that the experimental program was effective, and the use of Aqua Fit equipment contributes to improving students' VO2max.
2. The most significant progress was made on the VE parameter. We believe that improving all parameters of the VO2max aerobic test through specialized exercises enhances aerobic capacity, a crucial factor in functional training.
3. The experimental program implemented in the study, which targeted functional training, was adapted to the age and fitness level of the study subjects, which in turn determined the improvement in aerobic capacity.

Conflict of interest

No conflict to declare.

Acknowledgements

The study results are part of the doctoral research conducted by Ph.D. student Tacsa Andreea Maria at the Intersdisciplinary Doctoral School of Transilvania University of Brasov.

References

Alpaslan G, Bekır T, Adela B. The effects of three different types of exercises on aerobic and anaerobic power. Phys Educ Stud. 2017;21(4):152–7. doi:10.15561/20755279.2017.0401.

Baba D, Mijaica R, Nechita F, Balint L. Evaluating the Effectiveness of the Annual Physical Training Plan for Masters +45 Women Half Marathon Athletes: A Guideline Model for Good Practices for Programming Effort Volume and Intensity. Sports. 2024; 12(9):256. doi: 10.3390/sports12090256.

Badau A. The level evaluation of motric qualities at medicine students. The Annals of "Dunarea De Jos" University of Galati, Fascicle XV, 2015;1:20-25.

Badau D, Badau A, Trambitas C, Trambitas-Miron D, Moraru R, Stan AA, Oancea BM, Turcu I, Grosu EF, Grosu VT, et al. Differences between Active and Semi-Active Students Regarding the Parameters of Body Composition Using Bioimpedance and Magnetic Bioresonance Technologies. Int J Environ Res Public Health. 2021;18(15):7906. Available from: https://doi.org/10.3390/ijerph18157906.

Badau D, Camarda A, Serbanoiu S, Virgil T, Bondoc D. Modern methods of performance management implementation in sports for all. Recent Adv Manag Mark Financ. 2007;2(4):83-90.

Basset DR, Howley ET. Maximal oxygen uptake: "Classical" versus "contemporary" viewpoints. Med Sci Sports Exerc. 2000;32(1):70-83. doi:10.1097/00005768-200001000-00011.

Behm DG, Muehlbauer T, Kibele A, Granacher U. Effects of strength training using unstable surfaces on strength, power and balance performance across the lifespan: a systematic review and metaanalysis. Sports Med. 2015;45(12):1645-1669. doi:10.1007/s40279-015-0384-x.

Cheng HL, Liao TY. Aerobic and anaerobic training effects on physical fitness: a meta-analysis. J Strength Cond Res. 2016;30(5):1422-1432. doi:10.1519/JSC.0000000000001184.

Crossley J. Functional Exercise and Rehabilitation: The Neuroscience of Movement, Pain and Performance. Boca Raton: CRC Press; 2021.

Eather N, Riley N, Miller A, et al. Efficacy and feasibility of HIIT training for university students: The Uni-HIIT RCT. J Sci Med Sport. 2019;22(5):596-601. doi:10.1016/j.jsams.2018.11.016.

Ganciu M, Aducovschi D, Mihaiu C, Ganciu OM, Litoi F. Sport activities-healthy life style major components. In International Multidisciplinary Scientific Conference On Social Sciences And Arts SGEM 2015:887-894.

Holmer B. VO2max Essentials. Kindle Edition, 2024.

Ionescu A, Caramoci A. Medicină sportivă. Fiziologia și fiziopatologia efortului fizic. Ed Univ Carol Davila București. 2017,35-48.

Kohli BM. Functional Fitness – A Personal Perspective. Kindle Edition, 2024.

Leahy AA, Eather N, Smith JJ, et al. Feasibility and Preliminary Efficacy of a Teacher-Facilitated High-Intensity Interval Training Intervention for Older Adolescents. Pediatr Exerc Sci. 2019;31(1):107-117. doi:10.1123/pes.2018-0039.

Liao T, Duhig SJ, Du G, Luo B, Wang YT. The Effect of a Functional Strength Training Intervention on Movement Quality and Physical Fitness in Adolescents. Percept Mot Skills. 2022;129(1):176-194. doi:10.1177/00315125211056865.

Lu Y, Wiltshire HD, Baker JS, Wang Q. The Effects of Running Compared with Functional High-Intensity Interval Training on Body Composition and Aerobic Fitness in Female University Students. Int J Environ Res Public Health. 2021;18(21):11312. doi:10.3390/ijerph182111312.

Ranković G, Mutavdžić V, Marković S, Ilić I, Vidaković HM. Aerobic capacity as an indicator in different kinds of sports. Biomol Biomed. 2010;1(1):16-20. doi:10.17305/bjbms.2010.2734.

Rebryna AA, Rebryna AA, Kolomoiets HA, et al. Dynamics of indicators of functional state and physical development of students in the process of high-intensity interval training. Wiad Lek. 2024;77(3):387-392. doi:10.36740/WLek202403103.

Sang X. Effects of functional training on the athletic quality of aerobics practitioners. Rev Bras Med Esporte. 2023;29(2). DOI:10.1590/1517-8692202329012022_0626.

Scurt MD, Scurt C, Balint L, Mijaica R. Relationship between Body Mass Index and Muscle Strength, Potential Health Risk Factor at Puberty. Revista Romaneasca pentru Educatie Multidimensionala, 2022;14(4): 93-111. Available from: https://doi.org/10.18662/rrem/14.4Sup1/661.

Sincki A. Functional Training and Beyond. Mango Media, Miami. 2021,32-40.

Usgu S, Yakut Y, Kudaş S. Effects of functional training on performance in professional basketball players. Turk J Sports Med. 2020;55(2):59–64. doi:10.21653/tjsm.2020.553.

Wassenaar TM, Wheatley CM, Beale N, et al. The effect of a one-year vigorous physical activity intervention on fitness, cognitive performance and mental health in young adolescents: the Fit to Study cluster randomised controlled trial. Int J Behav Nutr Phys Act. 2021;18(1):47. doi:10.1186/s12966-021-01113-y.

Wezenbeek E, Verhaeghe L, Laveyne K, Ravelingien L, Witvrouw E, Schuermans J. The effect of Aquabag use on muscle activation in functional strength training. J Sport Rehabil. 2022;31(4):420-427. doi:10.1123/jsr.2021-0245.