CURRENT ASSESSMENT OF FUNCTIONAL WORK CAPACITY OF STUDENTS AT THE NATIONAL SPORTS ACADEMY "VASSIL LEVSKI", SOFIA

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ABSTRACT
Introduction: Physical performance and aerobic endurance are key factors for the healthy functioning of the human body, and their assessment and analysis require the combined approach of laboratory tests and functional diagnostics. Objective: The present study aims to assess the functional performance of students from the National Sports Academy "Vasil Levski" by analyzing fundamental physiological indicators related to aerobic endurance and cardiorespiratory efficiency. Methodology: The study subjects were 88 students (55 men and 33 women) who did not actively participate in sports activities. To assess their physical performance, a cardiopulmonary exercise test with increasing load on a bicycle ergometer (CPET) was used, through which the maximum oxygen capacity (VO_2 max), maximum heart rate (HRmax), maximum power (Wmax), and body mass index (BMI) were measured. Results show statistically significant differences between men and women regarding VO_2 max and Wmax. The average values of VO_2 max in women are 36 ml/min/kg, and in men, 42 ml/min/kg, which indicates better aerobic endurance in men. Similarly, Wmax is also higher in men, 270 W, compared to 210 W in women. Despite these differences, both groups demonstrate values corresponding to good general health. Conclusion: The study emphasizes the importance of regular physical performance assessment in young people, even without systematic sports activities. The data obtained can serve as a basis for developing individualized programs for physical activity and health prevention.

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INTRODUCTION

Physical health is a key element of overall well-being and includes various health-related qualities and skills. Together, they support a person's good functioning, enjoyment of leisure time, and ability to cope with life's challenges. Physical fitness is directly related to physical health and encompasses indicators such as muscle strength, endurance, agility, and others (Kyröläinen et al, 2010).

The term "physical performance" has different meanings depending on the sports discipline, and the methods for assessing it reflect the complexity of the metabolic pathways during muscular work. Sports performance refers to the athlete's ability to achieve a high result (Dushkov et al., 1986). The level of working capacity under the same loads is individual and depends on the individual's adaptive capabilities (Klechorov, 2024).

Some studies in recent years have focused on children and adolescents (Hölling et al., 2007; Kurth et al., 2007), while the age group 16-25 years has been studied less. These people's lives change rapidly, especially during the transition from school to working life, involving factors such as puberty and leaving the parental home. It is difficult to assess the extent to which negative changes in sports habits, nutrition, and health behaviors occur during this phase (Leyk et al, 2008).

Aerobic exercise requires energy through oxidative synthesis of adenosine triphosphate. Oxygen consumption and carbon dioxide production in muscles are related to VO_2 and VCO_2 in the lungs, regulated by the cardiovascular, respiratory, and other systems. Maximal oxygen uptake (VO_2 max) is an indicator of aerobic capacity. Endurance exercise is classified into intensity zones with different metabolic profiles and exercise tolerance (Sietsema & Rossiter, 2023). Gas exchange includes not only lung capacity and the ability of the cardiovascular system to transport oxygen to working muscles, but also the efficiency of its use in muscle tissue as an energy source during exercise (Heller, 2018).

VO_2max is determined by the capacity of the systems to transport oxygen to the working muscles

(hemoglobin level, blood pH, PR, stroke volume of the heart, the redistribution of peripheral blood flow, oxygen utilization in muscle cells, mitochondrial density and function, cellular diffusion) which is the product of the cardiac output (cardiac output) (Klechorov, 2023).

Laboratory studies, whether directly or indirectly determining maximal oxygen consumption, are among the most commonly applied. Maximal oxygen uptake is the main parameter of human fitness and performance, as it determines the upper tolerance limit to aerobic load (Marko, 2020). The purpose of functional research in laboratory practice is to study the dynamic changes in the parameters of the cardiorespiratory system and the neuromuscular apparatus, provoked by loads of different intensity and duration, performed using a bicycle ergometer, a treadmill, or specialized ergometers (Dushkov et al., 1986).

Functional diagnostics is an objective tool for assessing functional fitness and sports performance by examining the physiological response and adaptation of the body to physical exertion (Bartůňková et al, 2013). The maximal cardiopulmonary step test (CPET) assesses the integrated function of the cardiac, pulmonary, vascular, and musculoskeletal systems during exercise. It is used both for optimizing training programs and for the clinical evaluation of athletes with cardiovascular disease (Petek et al., 2021). CPET measures $\dot{V}O_2$, $\dot{V}CO_2$, heart rate, and other variables that reflect cardiac and pulmonary responses to exercise (Sietsema & Rossiter, 2023).

Aim and Objectives

To assess the functional capacity of students at the Vasil Levski National University of Physical Education by analyzing key physiological indicators related to aerobic capacity, work capacity, and cardiorespiratory efficiency. Measurements include VO_2 max, maximum power, heart rate (HRmax), and body mass index (BMI). The results are analyzed to identify gender differences and compare them with reference values for functional fitness. The inclusion of BMI provides information about the relationship between body composition and physical work capacity.

METHODOLOGY

The participants in the study were students from all faculties of the National Sports Academy, without active sports activities, randomly selected. The subjects were 55 men (mean age 21.1 ± 1.3 years, height 183 ± 7.2 cm, weight 80.3 ± 12.3 kg, BMI 24 ± 3.1) and 33 women (mean age 21.1 ± 1.4 years, height 168 ± 7.2 cm, weight 60.8 ± 6.1 kg, BMI 21.6 ± 2.4). The tests were conducted in the functional diagnostics laboratory of the National Sports Academy "Vasil Levski", Sofia.

All participants signed an informed consent form confirming their voluntary participation in the study. The form outlined the objectives, methods, and nature of the test — a maximal incremental exercise test to exhaustion performed on a cycle ergometer, with monitoring of cardiovascular and respiratory parameters. Participants were informed that they could withdraw from the study at any time without any negative consequences. The anonymity of the provided data was ensured, and all ethical standards related to personal data protection and participant health were strictly adhered to. Prior to the test, participants completed a health status questionnaire as part of the initial screening process.

Participants underwent a maximal cardiopulmonary exercise test (CPET) on an ERGOLINE cycle ergometer, starting at 60W for men and 30W for women. The load was increased by 30W every minute and a half (Iliev, 1974), and the test was terminated when it was impossible to maintain the set power and speed. Anthropometric measurements of height (SECA, 225 UK) and weight (Tanita RD-545) were performed before the load. Gas exchange parameters were recorded in real time with a portable gas analysis system (MetaMax 3B-R2, Leipzig, Germany), and heart rate was recorded with a Polar H7.

Statistical processing was performed with Microsoft Excel, with data presented as maximum, minimum, and mean values (±) and standard deviation (SD), with correlation analysis performed.

RESULTS

Anthropometric characteristics

Table 1 presents the leading anthropometric indicators for the women studied (n = 33). The group is young, with a mean age of 21 years and a slight standard deviation of 1.5 years. Height varies over a wide range, from 156 to 183 cm, indicating some heterogeneity in the population. Body weight also shows moderate variation, with the mean value being within the normal range. The calculated body mass index (BMI) is mainly within the healthy range, although borderline or slightly elevated values were reported in individual participants, indicating a tendency towards being overweight.

Table 1. *Anthropometric data (n = 33)*

Female	Age	Height (cm)	Weight (kg)	BMI
M	21	168	60,5	21
SD	1,4	7,2	6,1	2,4
Min	19	156	52	18
Max	25	183	74	28

Table 2 summarizes the anthropometric data of the men studied (n = 55). The mean age of the group was similar to that of the women, at 21.1 years, with a relatively small standard deviation (SD = 1.3). However, the heights of the men varied more significantly – from 170 to 202 cm - and their body weights ranged from 62 to 117 kg. The BMI values had an average value of approximately 24, which falls within the normal range; however, participants with a BMI above 25 were observed, indicating mild overweight.

Table 2. *Anthropometric data (n=55)*

Male	Age	Height (cm)	Weight (kg)	BMI
M	21,1	183	80,3	24
SD	1,3	7,2	12,3	3,1
Min	19	170	62	19
Max	25	202	117	34,9

Physiological indicators during exercise

Physiological indicators during exercise

The following two tables summarize the results of physiological measurements during exercise, differentiated by gender.

Table 3. *Physiological performance indicators in female participants (VO_2max test) (n=33)*

Statistic	VO_2 (ml/min/kg)	VO_2max (%predicted)	HRmax (bpm)	HRmax (%predicted)	Max Power Output (W)
M	36	96	181	91	195
SD	7,5	12,5	11,6	6	43
Min	29	74	156	79	150
Max	56	124	203	102	330

Table 3 presents the main physiological parameters in women measured during maximal step exercise to the point of failure. Relative oxygen consumption (VO_2) varied considerably, from 29 to 56 ml/min/kg, with a mean value of 36 ml/min/kg, which is considered a normal level for women of active age. In some participants, values above 40 mL/min/kg were observed, indicating high aerobic fitness. VO_2max, expressed as a percentage of the predicted value, also showed promising results – an average of 96%, with maximum values up to 124%. The maximum heart rate (HRmax) in women averaged 181 bpm, with maximum values reaching up to 203 bpm. As a percentage of the predicted HRmax, the average was 91%. Maximum power output ranged from 150 to 330 W, with a mean value of 195 W, indicating good physical performance.

Table 4. *Physiological performance indicators in male participants (VO_2max test) (n=55)*

Statistic	VO_2 (ml/min/kg)	VO_2max (%predicted)	HRmax (bpm)	Hrmax (%predicted)	Max Power Output (W)
M	42	93	181	91	266
SD	6,9	19,1	12	6,1	55,8
Min	25,4	52	148	74	180
Max	60	141	206	104	390

Table 4 presents similar physiological parameters in men. The mean VO_2 value is higher – 42 ml/min/kg, with a variation from 25.4 to 60 ml/min/kg. VO_2max (% predicted) is on average 93%, with

some participants reaching 141%, indicating very high functional fitness. HRmax is identical in both men and women, averaging 181 bpm, with maximum values reaching up to 206 bpm. As a percentage of predicted HRmax, men also show an average value of 91%. In terms of maximum power, the differences between the sexes are most significant – men reach an average of 266 W, with maximum values up to 390 W.

Comparative analysis

Figure 1 complements the tabular data by visualizing the minimum, maximum, and average values of the key indicators. The graphical representation helps to more easily interpret trends and variation in the data and facilitates direct comparison between genders.

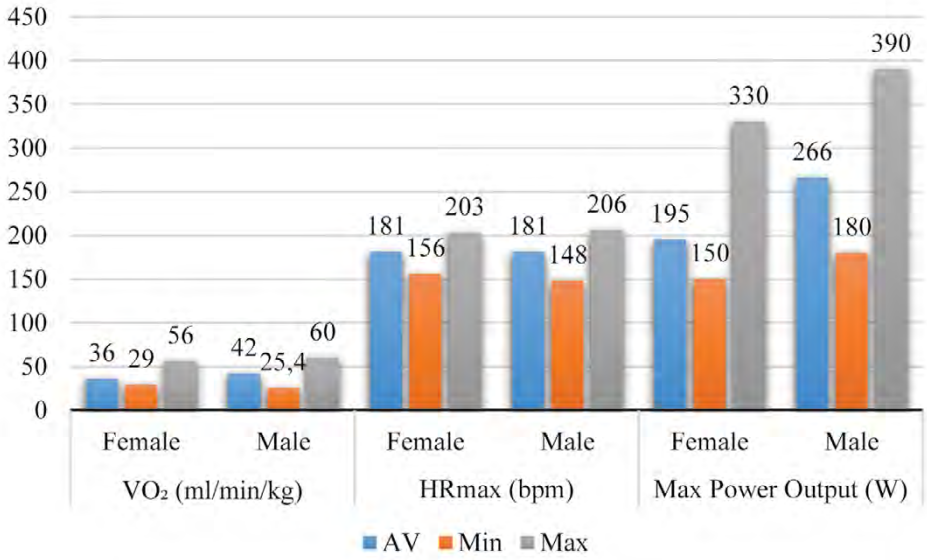

Figure 1. *Comparison of functional fitness indicators in men and women (VO_2, HRmax, and maximum power – minimum, maximum, and average values)*

Apparent gender differences are observed in some physiological indicators related to functional fitness. Men show higher average values in both relative oxygen consumption (VO_2) and maximum power output, which is consistent with known physiological differences between the sexes.

Maximum heart rate (HRmax), both in absolute values and as a percentage of predicted, is almost identical in both sexes, which may limit its usefulness as a sensitive indicator for distinguishing fitness level.

DISCUSSION

Men show higher VO_2 max values and power, and greater performance variability, than women. These differences are due to physiological factors, such as greater muscle mass, higher hemoglobin, and greater cardiac output in men, which result in better oxygen transport. Mean VO_2 max values are 36 ± 6.9 ml/min/kg in women and 42 ± 6.9 ml/min/kg in men, confirming men's higher aerobic capacity. Women typically have VO_2 max values 15%–30% lower than men, which is explained by higher body fat percentage and lower hemoglobin levels (Santisteban et al, 2022).

Despite these differences, the functional fitness of both sexes falls into the "average" category according to Heyward's (2006) classification, indicating that both sexes are in a similar range of aerobic fitness relative to reference values. Men have significantly higher maximum power output (266 ± 55.8 W) compared to women (195 ± 43 W), highlighting the better capacity of men to generate mechanical power.

Maximum heart rate (HRmax) did not show significant differences between genders, with both genders failing to reach the theoretically calculated value, which may be due to the test's early termination. The higher variability of results in men can be explained by differences in physical fitness level and sports experience, while in women, the values were more homogeneous.

Body mass and composition influence maximal oxygen uptake (VO_2 max) and physical endurance (Bassett & Howley, 2000; Venkata et al., 2004). Analysis of BMI and VO_2 data shows that higher VO_2 (better aerobic endurance) is generally associated with lower BMI, especially in women, as better

aerobic endurance leads to lower body fat percentage.

For women:

- Average VO_2: 36 ml/min/kg
- Average BMI: 21
- Minimum values: VO_2 = 29 ml/ min / kg , BMI = 18
- Maximum values: VO_2 = 56 ml/ min / kg , BMI = 28

For men:

- Average VO_2: 42 ml/min/kg
- Average BMI: 24
- Minimum values: VO_2 = 25.4 ml/ min / kg, BMI = 19
- Maximum values: VO_2 = 60 ml/ min / kg, BMI = 34.9

Despite a higher BMI, men typically have greater muscle mass, which may reduce VO_2 max efficiency at higher BMI (Maciejczyk et al., 2014).

CONCLUSION

The study's results confirm the expected physiological differences between the sexes regarding aerobic endurance, heart rate, and physical power. Men demonstrated higher VO_2 max values and maximum power, while women reached a higher percentage of their predicted oxygen capacity. Despite the same average maximum heart rate, the variation in values was greater in men.

Analysis of the data showed a relationship between VO_2 max and BMI, with higher aerobic endurance generally associated with lower BMI in women, likely due to lower body fat percentage. This relationship was not as direct in men, as higher BMI may be due to greater muscle mass and not necessarily excess body fat. This highlights the importance of individual body composition in interpreting aerobic endurance results.

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