



Analysis of cardiovascular fitness among Slovakian university students

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Abstract: *Introduction:* University studies often reduce physical activity (PA), which can harm students' fitness and cardiovascular health, a trend worsened by the COVID-19 pandemic. *Materials and Methods:* We examined resting heart rate (RHR), aerobic capacity, and VO₂ max in students from two universities in Košice, Slovakia. The study included 586 students (227 males, 359 females; mean age = 19.75 ± 1.55 years) from UPJŠ and TUKE, selected during physical education classes in 2021/2022 and 2022/2023. We recorded the total number of shuttles and aerobic and anaerobic threshold times in a 20-m shuttle run test (SRT). *Results:* Male students at TUKE showed superior aerobic performance and fitness compared to their counterparts at UPJŠ, with lower RHR (MED = 60.0 bpm vs. 65.0 bpm), superior aerobic capacity (MED = 152.0 sec. vs. 110.0 sec.), and increased VO₂ max (MED = 46.4 vs. 43.1 ml/kg/min). UPJŠ female students outperformed TUKE females in VO₂ max (MED = 33.2 vs. 29.9 ml/kg/min), despite their superior aerobic capacity. There were significant correlations between RHR, aerobic capacity, and VO₂ max, particularly in TUKE females ($r_s = -0.4359$, $p < 0.05$), indicating gender and university-specific patterns. Results show significant cardiovascular fitness differences between universities. *Conclusion:* TUKE male students had higher VO₂ max, aerobic capacity, and lower RHR compared to UPJŠ peers, while UPJŠ female students had slightly higher aerobic capacity. Female groups showed less differences, which may be related to their motivation and effort. Future research should use controlled RHR measurements and systematic tracking to understand how diet, sleep, and stress affect students' fitness.

Keywords: 20-meter shuttle run test; VO₂ max; aerobic threshold; anaerobic threshold

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INTRODUCTION

Regular physical activity (PA) confers numerous benefits, most notably the enhancement of aerobic capacity, which constitutes an indispensable element in the prevention of coronary heart disease [1]. Aerobic capacity serves as an indicator of physical fitness, reflecting the capacity to maintain full-body physical activity at a rapid and sustained pace [2]. An increase in the duration spent in Zone 2, which is situated between the aerobic and anaerobic thresholds, has been observed to correlate with an enhanced anaerobic threshold and superior overall performance outcomes [3, 4]. In addition to the training itself, age has a significant impact on aerobic capacity. Research [2] indicates that this begins to decline between the ages of 20 and 29. Nevertheless, this does not imply that it is not possible to preserve or even increase aerobic capacity in later life through consistent physical activity. The age at which the greatest improvements in aerobic capacity have been observed is during the college or university phase. The completion of secondary education in Slovakia signifies the conclusion of mandatory school attendance, which typically lasts for 10 years. During this period, students are obliged to participate in physical activity as part of the school curriculum. The transition to a selective study model, coupled with universities' prioritisation of intellectual pursuits, results in a reduction of the physical fitness of undergraduates—an essential factor in aerobic capacity—to a lower priority [5]. Cardiovascular fitness is defined as the capacity of the cardiopulmonary system to supply oxygen to skeletal muscles during physical activity or the capability of active skeletal muscles to utilise oxygen during aerobic exercise [6]. Cardiovascular fitness is extensively recognised as an essential indicator of overall health and physical fitness, as demonstrated by a numerous of studies [7–11]. Reduced levels of physical fitness are correlated with diminished academic performance [12–14]. Heart rate (HR) functions as a crucial metric for assessing physical fitness and aerobic capacity. Endurance athletes may demonstrate a resting heart rate (RHR) that falls below 40 beats per minute (BPM), with elite athletes attaining values as low as 30 BPM. Conversely, individuals who are not athletes, as well as the general population, generally exhibit RHR values ranging from 50 to 90 BPM [15]. Morning evaluations of HR and HR variability are regarded as the most accurate and dependable indicators of cardiovascular fitness [16–18]. A comprehensive study encompassing more than 92,000 participants (mean age: 45.8 ± 14.4 years) indicated a mean RHR of 65 BPM, with males exhibiting a lower average HR (64 BPM) in comparison to females (68 BPM) [19]. In a comparable investigation [20] encompassing 28,175 participants (22,750 men and 5,425 women; mean age: 37 ± 12 years), a mean RHR of 57 ± 8 BPM was observed, with male participants averaging 56 ± 7 BPM and female participants averaging 61 ± 8 BPM. Intersex variations in HR are apparent from birth, as supported by a multitude of historical and current research [21–23]. RHR is influenced by several factors, including body mass index (BMI), age, gender, arterial stiffness, and blood pressure [18, 23–25]. A lower RHR generally indicates a higher fitness level [17, 18], as endurance training has been shown to reduce HR over time [26]. Individuals engaged in endurance training also demonstrate reduced sympathetic activity during submaximal exercise compared to sedentary individuals [27]. Studies investigating the cardiovascular fitness of college students, particularly through maximal oxygen uptake (VO_2 max), have produced inconsistent findings. This variability may stem from differences in sample size and methodological approaches. Most studies have utilised the 20-meter shuttle run test (SRT) as a field test to estimate VO_2 max, applying formula-based calculations to samples ranging from 60 to 244 participants. The practicality and efficacy of the 20-m SRT for estimating aerobic capacity across diverse populations have been supported by numerous studies [28, 29]. Larger-scale studies, including one with over 30,000 participants [30], further corroborate its utility. In addition to formula-based VO_2 max calculations [28, 29, 31], noteworthy findings emerged from a Polish study [32], where the 20-m SRT was conducted using a portable K4b2 gas analyser, providing highly objective measurements. For clarity, the findings from

these studies [30, 33–37] are summarised in Table 4. The aim of this study is to assess the relationships between RHR and performance in the 20-m SRT. This assessment is based on the collected RHR data, the time frame required to attain both aerobic and anaerobic thresholds, as well as a total count of completed shuttle runs. These factors collectively facilitate the estimation of VO₂ max in undergraduate students from the University of Pavol Jozef Šafárik in Košice (UPJŠ) and the Technical University of Košice (TUKE). In order to fulfil the main objective of this study, we have developed two main research questions designed to explore potential relationships among significant physiological variables within various student populations. Initially, we investigated the potential differences in RHR among students from two universities that possess distinct academic orientations. Furthermore, in light of the expected associations among the variables of interest, we investigated the existence of relationships: (a) between RHR and aerobic capacity, segmented by gender and university; (b) between RHR and aerobic performance, segmented by gender and university; and (c) between aerobic capacity and aerobic performance, segmented by gender and university.

MATERIAL AND METHODS

Participants

The research sample consisted of 586 students, including 227 males and 359 females, with a mean age of 19.75 years \pm 1.55 years. Participants were randomly selected from students in their first to third years who were enrolled in physical education (PE) classes called "Sports activities" or "Sports" at the University of Pavol Jozef Šafárik (UPJŠ) and the Technical University of Košice (TUKE). UPJŠ predominantly emphasises the fields of natural sciences, social sciences, humanities, and medical sciences, providing academic programs in disciplines such as medicine, law, public administration, psychology, as well as natural sciences including biology, chemistry, and physics. Comparatively, TUKE places a significant emphasis on engineering and technology, offering programs in various disciplines including engineering, information technology, architecture, aviation, and applied sciences such as materials science. Participation in the research was limited to those students who demonstrated an interest in the study and subsequently provided written informed consent.

The data collection process was executed utilising the 20-meter SRT [29]. Evaluations were conducted on all participating students during their designated PE classes. The documented parameters encompassed the amount of time necessary for reaching the calculated aerobic threshold from the commencement of the test, the duration required to reach the anaerobic threshold from the initiation of the test, and the aggregate number of shuttles completed. The HR was monitored throughout the testing process utilising Polar H10 wireless chest straps, with data being recorded through the Polar Team software on an iPad. One week before the administration of the 20-m SRT, participants completed anonymised Physical Activity Readiness Questionnaires (PAR-Q) and International Physical Activity Questionnaires (IPAQ). The questionnaires were distributed in the native languages of the participants, specifically Slovak or Ukrainian. An additional inquiry pertaining to RHR was integrated into the PAR-Q. Participants recorded their RHR over three consecutive mornings immediately upon spontaneous awakening, employing the palpation method. The mean of these measurements was recorded and submitted as a response to the questionnaire. Theoretical HR values for the aerobic and anaerobic thresholds were derived from the average morning RHR measurements using Karvonen's formula [38].

Statistical analysis

The Real Statistics software was employed to assess both statistical and substantive significance. The non-parametric Mann-Whitney test for two independent samples was utilised to compare RHR, aerobic capacity, and aerobic performance between

female and male students, as well as between the two universities. The Spearman rank correlation coefficient was utilised to evaluate the relationships among the datasets. The assessment of the normality of the data distribution was conducted utilising the Shapiro-Wilk test.

Ethics committee

The project was approved by the Pavol Jozef Šafárik University Ethics Committee in Košice under approval number 3/2023.

RESULTS

The findings related to the RHR are presented in Table 1. Male students from TUKE demonstrated a median RHR that was over 7% lower (MED = 60.0 bpm), suggesting a higher level of physical fitness in comparison to their peers at UPJŠ (MED = 65.0 bpm). The interquartile range (IQR) for male students at TUKE was noted to be lower (IQR = 56.3–65.8 bpm) when compared to that of the male students at UPJŠ (IQR = 60.0–72.0 bpm). Conversely, the median RHR for female students was found to be more than 5% higher among students from TUKE (MED = 72.0 bpm) when compared to their counterparts from UPJŠ (MED = 68.0 bpm). The IQR of HR among female students at UPJŠ (IQR = 63.0–76.0 bpm) was found to be lower in comparison to their counterparts at TUKE (IQR = 68.0–75.0 bpm). Female students exhibited an opposite trend in comparison to their male counterparts during the execution of a comparative analysis of the universities.

Aerobic capacity

The aerobic capacity of male students was assessed by measuring the duration of time spent within the aerobic zone, specifically between the aerobic and anaerobic thresholds, quantified in seconds (Table 1). The median aerobic capacity of male students from TUKE was documented at 152.0 seconds, which is substantially higher than the median of 110.0 seconds noted among male students from UPJŠ. The observed elevated IQR for TUKE males (IQR = 99.5–214.5 seconds) provides additional evidence for this heightened level of physical fitness. The aerobic capacity of female students from TUKE was shown to be superior to that of their counterparts from UPJŠ. In contrast to the female participants from UPJŠ, who exhibited a median time of 63.0 seconds with an IQR of 36.8–107.0 seconds, the female participants from TUKE presented a broader IQR of 45.0–123.0 seconds and a higher median aerobic capacity of 83.0 seconds.

Aerobic performance (VO_2 max)

The median VO_2 max for male students from UPJŠ (MED = 43.1 ml/kg/min) is presented in Table 1, indicating a difference of approximately 7% in comparison to the median value for male students from TUKE (MED = 46.4 ml/kg/min). Male students from TUKE exhibit enhanced aerobic performance, as indicated by the interquartile range analysis for both groups, which spans from 43.1 to 49.7 ml/kg/min. The median VO_2 max for female students from UPJŠ was recorded at 33.2 ml/kg/min, representing a 10% increase compared to the median value observed in female students from TUKE, which was 29.9 ml/kg/min. The IQR for females at UPJŠ (IQR = 29.9–36.5 ml/kg/min) was found to be significantly greater than that of females at TUKE. Although the maximum VO_2 max for TUKE females was 53.0 ml/kg/min, the median value of 29.9 ml/kg/min suggests that the majority of female participants exhibited below-average performance (Table 4).

Table 1. Descriptive statistics of variables by gender and university

Variables	Groups	Gender	Q1	MED	Q3	Min	Max	MOD
Resting heart rate (beat per minute)	UPJŠ	M	60.0	65.0	72.0	41.0	96.0	60.0
		F	63.0	68.0	76.0	40.0	95.0	68.0
	TUKE	M	56.3	60.0	65.8	43.0	92.0	60.0
		F	68.0	72.0	75.0	51.0	90.0	70.0
Aerobic Capacity (seconds)	UPJŠ	M	74.0	110.0	165.0	15.0	334.0	95.0
		F	36.8	63.0	107.0	2.0	327.0	39.0
	TUKE	M	99.5	152.0	214.5	4.0	396.0	152.0
		F	45.0	83.0	123.0	2.0	321.0	45.0
Aerobic Performance VO ₂ max (ml/kg/min)	UPJŠ	M	36.5	43.1	46.4	29.9	62.9	43.1
		F	29.9	33.2	36.5	23.4	49.7	33.2
	TUKE	M	43.1	46.4	49.7	29.9	62.9	46.4
		F	29.9	29.9	33.2	26.7	53.0	29.9

M: males; F: females; MIN: minimum; MAX: maximum; MOD: modus; Q1: first quartile; MED: median; Q3: third quartile

The findings of the statistical analysis indicated variations concerning gender and university affiliation, in addition to the interrelationships among the examined variables. Male and female students from the two universities demonstrated significant differences in aerobic capacity and performance. In contrast to their counterparts at UPJŠ, male students at TUKE demonstrated improvement in aerobic parameters, with effect sizes varying from small to medium. In contrast, female students at UPJŠ exhibited marginally superior aerobic performance values, as indicated by VO₂ max measurements, compared to their counterparts at TUKE (Table 2). The examination of the interrelationships among the studied components revealed a notable correlation between RHR and aerobic capacity (Table 3), specifically within the cohort of female students at TUKE. A statistically significant moderate negative correlation between RHR and aerobic capacity was identified exclusively among female students at TUKE. No substantial correlations were observed for the remaining cohorts. The most notable disparities in the relationship between RHR and maximal oxygen uptake (VO₂ max) were identified among the female participants from TUKE, while the correlations were found to be somewhat less robust in the female cohort from UPJŠ (Table 3). Subsequent comparisons did not indicate any notable relationships with others. The most pronounced correlation was identified among TUKE students, suggesting that an increased aerobic capacity serves as a significant predictor of enhanced aerobic performance. A significant correlation was observed between aerobic capacity and aerobic performance among male students at TUKE. Statistically significant moderate correlations were identified for both male and female students at UPJŠ. Conversely, the correlation among female students at TUKE exhibited a less strong relationship and failed to reach statistical significance. A statistically significant negative correlation was observed between RHR and aerobic performance among male students at UPJŠ. Conversely, no significant relationships were identified for female students within either university cohort. Within the cohort of female students at TUKE, a positive yet statistically non-significant correlation was identified between aerobic capacity and aerobic performance, as demonstrated in Table 3. A total of 30 participants from TUKE and 9 participants from UPJŠ failed to reach the anaerobic threshold during the assessment of aerobic performance. Despite this, the VO₂ max values recorded for these participants, specifically one male student from UPJŠ (46.43 ml/kg/min) and female participants from UPJŠ (35.07 ml/kg/min), exceeded the average for their respective cohorts.

Table 2. Comparison of variables between universities by gender

Variables	Groups	Gender	N	p-value	ES
RHR	UPJŠ	M	133	<0.001	0.27 ^r
	TUKE	M	92		
	UPJŠ	F	303	0.098	0.09 ^r
	TUKE	F	55		
Aerobic Capacity	UPJŠ	M	132	0.001	0.22 ^r
	TUKE	M	92		
	UPJŠ	F	294	<0.001	0.27 ^r
	TUKE	F	25		
Aerobic Performance (VO ₂ max)	UPJŠ	M	133	<0.001	0.29 ^r
	TUKE	M	92		
	UPJŠ	F	303	0.008	0.14 ^r
	TUKE	F	55		

N: number of participants; M: males; F: females; Mean: arithmetic mean; ES: effect size „Cohen’s r“

Table 3. Relationship between variables by gender and university

Variables	University	Gender	rs	p-value
RHR & Aerobic capacity	UPJŠ	M	-0.091	0.297
		F	-0.066	0.254
	TUKE	M	-0.094	0.368
		F	-0.435	0.029*
RHR & Aerobic performance	UPJŠ	M	-0.174	0.045*
		F	-0.067	0.247
	TUKE	M	-0.102	0.331
		F	-0.412	0.040*
Aerobic capacity & Aerobic performance	UPJŠ	M	0.308	<0.001**
		F	0.274	<0.001**
	TUKE	M	0.455	<0.001**
		F	0.371	0.067

M: males; F: females; rs: Spearman’s rho; p-value: statistical significance: * (p < 0.05); ** (p < 0.001).

Table 4. Overview of VO₂ max of university students

Author	Year	Country	VO ₂ max (ml/kg/min) in Males	VO ₂ max (ml/kg/min) in Females	N (M/F)
Razak et al.	2020	Malaysia	44.5	34.34	180 / 150
Rafati & Melhem	2023	Saudi Arabia	46.38	-	244 / -
Wilson & Swanson	2022	USA	49.8	41.2	79 / 82
Buttar et al.	2022	India	45.3	35.71	200 / 219
Eriksson et al.	2021	Sweden	37.9	37.9	173130 / 142986
Pacholek	2022	Saudi Arabia	34.2	-	237 PAS
Pacholek	2022	Saudi Arabia	31.8	-	160 NAS

N: number of participants; M: males; F: females; PAS: Physically active students; NAS: Non-active students.

DISCUSSION

Building on the foundational assumptions outlined in the introduction, this discussion focuses on RHR, maximal oxygen consumption (VO₂ max), and aerobic capacity as primary indicators of cardiovascular fitness within our study cohort. Accordingly, we seek to examine the research questions presented, assessing these physiological metrics in connection with our findings. This study utilised medians to characterise the data, given the application of non-parametric tests. Comparisons with other studies that reference

means are included to offer context and to align with the existing literature, as there is a limited availability of literature that references medians. The variations in statistical measures are recognised as a possible limitation; however, the comparisons continue to provide valuable insights for comprehending relative trends.

RHR

Students from TUKE demonstrated a median RHR of 60.0 BPM, which may indicate improved cardiorespiratory fitness, as supported by prior research [18,39,40]. In comparison to their male counterparts from TUKE, the male participants from UPJŠ exhibited a higher median RHR (65.0 BPM), which may suggest a comparatively lower level of physical fitness. For instance, a study conducted on university students indicated a mean RHR of 74.1 ± 7.09 BPM, which is significantly greater than the values recorded in our cohort [41]. Additionally, the study in question revealed a comparable RHR (63 ± 6.88 BPM) in individuals who engage in regular physical activity, thereby highlighting the possible correlation between a lower RHR and higher levels of physical activity. Although our study did not explicitly evaluate the participants' levels of physical activity, the comparatively lower RHR observed among male students from TUKE may imply a greater involvement in physical activities. This is consistent with the current body of evidence that associates increased levels of physical activity with a decrease in RHR [42,43]. Nevertheless, additional research is necessary to ascertain a direct correlation between levels of physical activity and RHR within our population. In the comparison of genders, it was observed that female students demonstrated higher median RHR values than their male counterparts, a result that aligns with existing literature. The observed difference is frequently ascribed to biological factors, including increased resting metabolic rates and reduced heart sizes in females [44,45]. The notable gender disparity identified in our research provides additional evidence for the hypothesis that male students generally demonstrate higher levels of physical fitness in comparison to their female counterparts. Furthermore, a substantial number of participants in our research exhibited a RHR below 75 BPM, a metric that is regarded as suggestive of a comparatively healthy demographic [18]. Nevertheless, it is essential to consider additional health-related factors that may impact RHR. For the limited subset of individuals exhibiting RHR values surpassing 80 BPM, scientific study advocates for the monitoring of potential contributing factors and the adoption of preventive strategies aimed at improving cardiovascular health [18,42]. In the extensive body of literature, a higher RHR has been significantly correlated with diminished cardiorespiratory fitness. For example, a particular study indicated that a 1 BPM increase in RHR was associated with a decrease of 0.23 ml/kg/min in VO_2 max [18]. Although our data do not permit a direct calculation of such relationships, it is conceivable that a comparable trend may be present among our participants.

Aerobic capacity

Aerobic capacity, defined as the duration of time engaged within the aerobic zone (ranging from the aerobic threshold to the anaerobic threshold), serves as a significant measure of physical fitness [46,47]. In the present study, the median aerobic capacity for students from TUKE was determined to be 152.0 seconds. The median aerobic capacity of students from TUKE was 42 seconds greater than that of students from UPJŠ, thereby indicating a superior level of aerobic capacity among the former group. Female students in both groups spent less time in the aerobic zone compared to their male counterparts, a finding that aligns with existing research. For instance, some of the studies [46,48] revealed that men possess a greater aerobic capacity than women, which aligns with our results. This approach to estimating aerobic capacity, however, appears to be deficient in precision. The diverse outcomes concerning RHR and maximal oxygen uptake may have been influenced by the premature reaching of the aerobic threshold HR in specific participants, which can be ascribed to pre-start stress. Research indicates that students

who engage in physical activity, especially males, exhibit elevated VO_2 max levels [43] and a reduced risk of cardiovascular disease [43,49].

Aerobic performance (VO_2 max)

In the assessment of aerobic performance, it was noted that male students from TUKE exhibited VO_2 max values that are in close alignment with the peak levels reported in the current literature [34]. The male students from UPJŠ exhibited VO_2 max values that were inferior to the average documented in the majority of studies, as presented in Table 4. Notably, the trend observed among female students exhibited an opposite pattern. Female students from UPJŠ demonstrated a slightly higher VO_2 max in comparison to their counterparts at TUKE. Nevertheless, both cohorts did not meet the benchmarks set forth in previous research [36], as outlined in Table 4. The VO_2 max of UPJŠ female students was found to be in close alignment with the findings documented by Razak and colleagues in 2020 [33], whereas TUKE female students exhibited lower levels of aerobic performance. The observed disparities among universities may be ascribed to variations in training programs or lifestyle factors affecting both male and female students [50,51].

Intervariable relationship

The most significant correlation between RHR and aerobic capacity was observed among female students at TUKE, characterised by a moderate relationship (Table 3). This finding indicates that a lower RHR within that group serves as a significant predictor of enhanced aerobic capacity, aligning with prior research [42,52]. In contrast, neither male nor female students at UPJŠ exhibited a comparable correlation, as the connections between RHR and aerobic capacity were found to be very weak and statistically insignificant. The observed differences suggest that the relationship between RHR and aerobic capacity may vary not only across genders but also among different universities, potentially attributable to the diverse fitness levels of the participants [18,46,53]. A comparable pattern emerged concerning the correlation between RHR and maximal oxygen uptake measured in VO_2 max. A moderate relationship was identified between these variables among female participants from TUKE, suggesting that a lower RHR may serve as an indicator of a higher VO_2 max and, consequently, enhanced aerobic performance, as being established by findings in other studies [43,54]. A weak yet statistically significant relationship was identified among male UPJŠ students, indicating that a lower RHR may be correlated with enhanced aerobic performance within this demographic, although to a diminished degree (Table 3). The most significant correlation between aerobic capacity and VO_2 max was observed among male TUKE students, thereby confirming earlier research [53,55,56] which indicates that greater aerobic capacity is associated with improved aerobic performance. A statistically significant yet weaker relationship was identified between male and female UPJŠ, which supports the assumption that an increase in aerobic capacity correlates with elevated VO_2 max levels.

Limits of the study

This research presents several limitations that must be considered when analysing the results. The primary limitation pertains to the methodology employed for the collection of RHR data, which was conducted independently by participants without the direct oversight of an expert. This methodology may have led to inaccuracies in the measurements; therefore, it is advisable that subsequent research employs controlled measurement conditions. Another limitation pertains to the motivation and psychological comfort of the participants, which may have influenced their performance in aerobic performance assessments, particularly the 20-minute SRT. The absence of tracking differences in motivation and psychological readiness may have led to biased disparities between the groups. The research sample included only students from two universities in one city, limiting the results' applicability to a larger population. Consequently, it is

advisable that future study endeavours incorporate a more extensive sample, that includes students from diverse geographical regions and a variety of university types.

CONCLUSION

The findings of this study indicate that significant differences exist in cardiovascular fitness among students, particularly among males, at the two universities examined. Male students from TUKE exhibited superior aerobic capacity, VO_2 max, and RHR compared to their male counterparts from UPJŠ. Female students from UPJŠ demonstrated marginally superior aerobic capacity, whereas their counterparts from TUKE exhibited greater variability in their results, suggesting a disparity in fitness levels within this cohort. A moderate negative correlation between RHR and aerobic capacity was identified exclusively among female students at TUKE, suggesting that a lower RHR may serve as an indicator of enhanced aerobic capacity within this demographic. The male students from TUKE and UPJŠ exhibited weak correlations that did not reach statistical significance. The findings suggest that the relationship between RHR and aerobic capacity may vary not only between genders but also between universities, most likely due to differences in physical fitness and training programs. The male student population at TUKE exhibits a higher mean VO_2 max in comparison to their counterparts at UPJŠ. Nevertheless, there exists considerable variability within this cohort, which may suggest different levels of physical fitness. The elevated dropout rate observed among female students at TUKE may be attributed to variations in preparation or motivation levels. Following that, studies ought to incorporate controlled measurements of RHR, alongside systematic monitoring of variables that may impact physical fitness, including dietary habits, sleep patterns, and stress levels. The comprehensive results indicate that students at TUKE, especially male participants, exhibit higher levels of aerobic fitness.

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