SCREENING YOUNG ADULTS' HEALTH USING NON-INVASIVE METHODS

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Abstract

Monitoring the health of young adults is essential for identifying potential risks and promoting long-term well-being. This study aimed to assess physiological and anthropometric parameters in 100 young adults (mean age 22.25 ± 0.46 years) using non-invasive methods, including ECG, blood pressure, BMI, and body composition analysis (muscle mass, body fat percentage, and visceral fat). A structured questionnaire collected demographic and lifestyle data, including physical activity and dietary habits. Participants were classified as athletes (42%) and non-athletes (58%) to examine the influence of regular physical activity on health indicators. Results showed that 74% of participants had a normal BMI, with 13% overweight and 13% obese. Elevated visceral fat was found in 12% of respondents, and total body fat was higher in non-athletes compared with athletes. Men had higher visceral and total body fat values, while athletes demonstrated greater muscle mass. ECG analysis revealed sinus bradycardia more frequently among athletes, as well as differences in PQ and QTc intervals, indicating the influence of regular exercise on cardiac electrophysiology. Following physical exertion, systolic blood pressure and heart rate significantly increased in both groups, confirming a normal cardiovascular response to exercise. Overall, regular physical activity was associated with healthier body composition and physiological cardiac adaptations, emphasizing its preventive role in reducing obesity and cardiovascular risk among young adults.

Keywords

young adults, screening, ECG, body composition

Introduction

Health represents a state of physical, mental, and social well-being, in which all systems of the human body function in harmony. Young adulthood—the transitional period between adolescence and full adulthood—is characterized by rapid physical, psychological, and social development. However, this phase is also critical for establishing lifelong habits that strongly influence future health outcomes. Unhealthy behaviors such as poor diet, low physical activity, stress, or substance use often originate in this period and may lead to obesity, cardiovascular disease, or mental health disorders in later life [1, 2].

Monitoring and supporting healthy lifestyles in young adults is therefore essential. Understanding which factors most affect their physiological and psychological health enables more effective prevention and early intervention strategies. Recent studies have demonstrated that non-invasive physiological measurements provide valuable insight into health status without posing risks to participants. Commonly used methods include 12-lead electrocardiography (ECG) for cardiac function assessment, oscillometric sphygmomanometry for blood pressure measurement, and bioimpedance analysis for body composition evaluation [3–6].

Several previous works have explored the influence of physical activity on cardiovascular parameters and body composition. Pentikäinen et al. [3] found minimal ECG and blood pressure differences between athletes and non-athletes, suggesting that sports participation may not strongly influence these variables in young adults. In contrast, Vecchiato et al. [4] identified a higher prevalence of early repolarization patterns among adolescent athletes, indicating specific cardiac adaptations to regular training. Other studies have linked

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physical activity with reduced cardiovascular risk and improved body composition [7–10], while lifestyle factors such as diet and stress management have been shown to play an additional role in young adults' well-being [11, 12].

Despite numerous studies on the relationship between exercise and health, there remains limited evidence combining cardiovascular parameters (ECG, blood pressure) and anthropometric indicators (BMI, body fat, visceral fat, muscle mass) in a single young adult population. Furthermore, little is known about how these markers differ between athletes and non-athletes or how sex modifies these associations.

Therefore, the aim of this study was to monitor and evaluate the health status of young adults using non-invasive physiological and anthropometric methods. Specifically, we assessed ECG, blood pressure, BMI, body composition, and lifestyle habits in a cohort of 100 participants aged 17–25 years. We hypothesized that (1) physically active individuals (athletes) would have lower BMI, lower body and visceral fat, and higher muscle mass compared with non-athletes, and (2) regular physical activity would be associated with more favorable ECG characteristics, reflecting better cardiovascular function.

Materials and Methods

A total of 100 volunteers (51 men and 49 women) aged 17–25 years (mean age 22.25 ± 0.46 years) participated in this study. Recruitment was conducted among university students through public announcements. All participants provided written informed consent prior to participation. The study protocol was approved by the Institutional Review Board of the Technical University of Košice (protocol code 62764/2024, approval date 8 November 2024) and complied with the Declaration of Helsinki.

Inclusion criteria were age between 17 and 25 years, absence of known cardiovascular or metabolic disease, no medication affecting cardiovascular function, and no acute illness or pregnancy at the time of testing. Participants were classified as athletes if they engaged in structured physical activity ≥ 3 times per week for ≥ 60 min per session; others were classified as non-athletes.

Study design

This study combined questionnaire-based data with physiological and anthropometric measurements. Participants completed a 40-item questionnaire assessing demographic data, physical activity, personal and family health history, sleep, mood, and dietary habits. Subsequently, each participant underwent ECG, blood pressure, and body composition measurements under standardized conditions.

Anthropometric assessment methods

Body composition was assessed using a bioelectrical impedance analyzer (Omron BF511, Omron Healthcare, Japan). The device measured body weight, body fat percentage, skeletal muscle percentage, visceral fat level, and calculated BMI (kg/m²).

Reference ranges were defined as follows:

- BMI categories: underweight < 18.5 kg/m²; normal 18.5–24.9 kg/m²; overweight 25.0–29.9 kg/m²; obese ≥ 30 kg/m² (WHO 2020).
- Visceral fat: normal 1–9 units; high 10–14; very high ≥ 15 (manufacturer's index).
- Body fat (%): men 10–20%; women 18–28% [13].
- Muscle mass (%): men: low < 33.4%, normal 33.4–39.4%, high ≥ 39.5%; women: low < 24.4%, normal 24.4–30.2%, high ≥ 30.3%.

Cardiovascular parameter measurement methods

A 12-lead ECG (Model 1200 ECG, GE Healthcare, USA) was recorded with participants in the supine position after at least 5 min of rest. Standard electrode placement was used. The following parameters were analyzed: heart rate (derived from R-R interval), PR interval, QRS duration, QT interval, and corrected QT interval (QTc, calculated using Bazett's formula).

For each participant, the heart rhythm was categorized as bradycardia (< 60 bpm), normal (60–100 bpm), or tachycardia (> 100 bpm). Sex-specific QTc thresholds were applied: prolonged QTc > 450 ms in men and > 470 ms in women.

Blood pressure (BP) and heart rate (HR) were measured using an automatic oscillometric sphygmomanometer (Omron M3, Omron Healthcare, Japan). Measurements were taken on the left arm at heart level in a seated position, following at least 5 min of rest. The post-exercise measurement was conducted approximately 1 min after a standardized exercise bout consisting of 10 squats, 10 push-ups, and 10 sit-ups.

Results were expressed in millimeters of mercury (mmHg) for BP and beats per minute (bpm) for HR.

Statistical evaluation of data

The data were analyzed using standard descriptive and inferential statistical methods. For each continuous variable, the mean, median, standard deviation, minimum, and maximum were calculated. The equality of variances between independent groups was verified using the F-test.

Depending on its outcome, an independent samples t-test with equal or unequal variances was applied to test differences between groups (e.g., men vs. women, athlete vs. non-athlete). For repeated measurements (pre- vs. post-exercise blood pressure and heart rate), paired t-tests were used.

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The Shapiro–Wilk test and histogram inspection were used to assess data normality. Although some variables showed mild deviations from the normal distribution, none displayed extreme skewness or outliers. Given the sample size (n = 100), the data were considered approximately normal, allowing the use of parametric tests. To ensure robustness, results were verified using non-parametric tests (Mann–Whitney U test), which yielded consistent conclusions.

The significance level was set at α = 0.05. p-values below this threshold were considered statistically significant. Results are presented using boxplots and summary tables.

Results

According to questionnaire results, 90% of participants reported engaging in some form of physical activity during their free time. Based on activity frequency, individuals exercising ≥ 3 times per week for ≥ 60 minutes were classified as athletes (42%), while 58% were categorized as non-athletes.

Among athletes, the most common activities were fitness training (40%), running (20%), swimming (20%), cycling (15%), and dancing (5%), demonstrating a diverse range of physical engagement.

Exercise tolerance: Fainting during physical activity was rare (reported by 3%), while 37% experienced occasional shortness of breath during exertion.

Sleep and stress: Half of the respondents (50%) reported no sleep problems, whereas 15% had difficulty falling asleep and 17% reported frequent nocturnal awakenings. Stress was identified as a factor affecting sleep quality in 70% of participants.

Mood and mental health: 37% of respondents indicated mood disturbances or reduced psychological well-being.

Family health history: 13% reported hereditary or chronic conditions in family members, including allergies, psoriasis, rheumatism, or cancer predisposition.

Cardiovascular history: 63% had previously undergone preventive ECG examination, and 20% reported a history of cardiovascular problems in the past. At the time of data collection, none of the participants were under chronic cardiac medication or reported active cardiac disease.

Dietary factors: Most participants (83%) reported no food allergies, while 17% indicated some form of food intolerance.

Evaluation of the results of measured data using a medical scale - Omron BF511

The mean BMI across all participants was 23.9 ± 4.1 kg/m², ranging from 19.3 to 35.3 kg/m².

According to WHO classification, 74% of respondents had a normal weight (BMI 18.5–24.9 kg/m²), 13% were overweight (BMI 25.0–29.9 kg/m²), and 13% were obese (BMI ≥ 30 kg/m²). None of the participants were classified as underweight.

When comparing groups by sex, men showed significantly higher BMI values than women (25.1 ± 4.6 vs. 22.8 ± 3.2 kg/m²; p = 0.004).

When comparing based on physical activity, athletes had significantly lower BMI compared with non-athletes (22.2 ± 1.7 vs. 25.2 ± 4.9 kg/m²; p < 0.001).

Table 1: Basic statistical characteristics for BMI (kg/m²) values according to sex and physical activity.

Statistical Characteristics	Sex groups		Sport status groups	
	female	male	athletes	non-athletes
n (%)	49	51	42	58
Mean	22.77	25.08	22.17	25.23
Median	22.30	22.90	22.00	23.40
Standard Deviation	3.21	4.60	1.65	4.87
Standard Error	0.46	0.64	0.25	0.64
Min	19.30	20.10	19.30	20.10
Max	31.00	35.30	24.50	35.30
p-value	0.004		< 0.001	

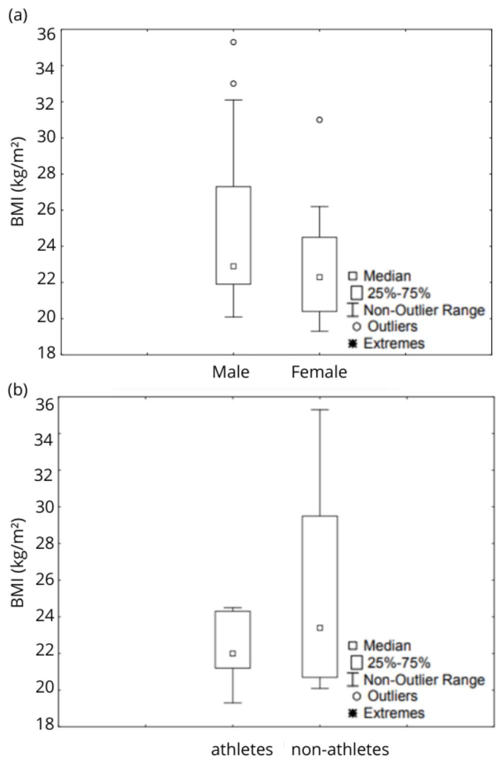

Fig. 1: Box-plot graph of BMI by: (a) Sex; (b) Physical activity groups.

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Among men, the difference between athletes and non-athletes was particularly evident—non-athletes had substantially higher BMI values (27.9 vs. 22.4 kg/m²; p < 0.001).

Among women, the difference between athletes and non-athletes was smaller and not statistically significant (23.2 vs. 21.8 kg/m²; p = 0.086).

These findings indicate that regular physical activity is strongly associated with maintaining a normal body mass, especially among men. Detailed statistical characteristics are presented in Table 1, and the distribution of BMI values is illustrated in Figure 1.

Evaluation of measured data – Visceral fat

The mean visceral fat index among all participants was 5.3 ± 2.9 units, with recorded values ranging from 2 to 15. According to the manufacturer's reference scale (Omron Healthcare, Japan), 88% of respondents were within the normal range (1–9 units), 9% had high levels (10–14 units), and 3% had very high levels (≥ 15 units).

Men had significantly higher visceral fat values than women (6.71 ± 3.98 vs. 3.88 ± 1.17 units; p < 0.001). Elevated values (≥ 10 units) occurred exclusively among men.

Athletes had significantly lower visceral fat compared with non-athletes (4.05 ± 1.31 vs. 6.24 ± 3.90 units; p < 0.001).

These findings indicate that regular physical activity is associated with reduced visceral adiposity, while sedentary men represent the group most at risk for excessive visceral fat accumulation. Detailed statistical characteristics are presented in Table 2.

Table 2: Basic statistical characteristics for values of the proportion of visceral fat (units) in the body according to sex and physical activity.

Statistical Characteristics	Sex groups		Physical activity groups	
	female	male	athletes	non-athletes
n (%)	49	51	42	58
Mean	3.88	6.71	4.05	6.24
Median	4.00	6.00	4.00	4.5
Standard Deviation	1.17	3.98	1.31	3.90
Standard Error	0.17	0.56	0.20	0.51
Min	3.00	2.00	2.00	3.00
Max	7.00	15.00	6.00	15.00
p-value	< 0.001		< 0.001	

Evaluation of measured data – Body fat (%)

The mean body fat percentage in the total sample was 26.8 ± 8.4%, ranging from 8% to 44%. According to reference ranges proposed for young adults by Hung et al. (2017), normal body fat was defined as 10–20% in men and 18–28% in women, with values above these thresholds considered elevated.

Based on these criteria, 49% of participants had normal body fat values, while 48% exceeded the normal range.

When analyzed by sex, women exhibited significantly higher body fat percentages than men (31.7 ± 6.9% vs. 21.9 ± 9.2%; p < 0.001). When analyzed by physical activity, athletes demonstrated significantly lower body fat than non-athletes (23.2 ± 8.3% vs. 30.1 ± 8.6%; p < 0.001). Among men, this difference was pronounced (16.1% vs. 28.0%; p < 0.001), while among women it was smaller but still statistically significant (29.0% vs. 33.0%; p = 0.009).

These findings are consistent with the literature, confirming that regular physical activity contributes to maintaining lower body fat levels in young adults of both sexes, particularly among men. Detailed statistical characteristics are presented in Table 3.

Table 3: Basic statistical characteristics for the values of the percentage of body fat (%) according to sex and physical activity.

Statistical Characteristics	Sex groups		Physical activity groups	
	female	male	athletes	non-athletes
n (%)	49	51	42	58
Mean	31.71	21.91	20.98	30.87
Median	29.50	18.10	19.50	30.65
Standard Deviation	6.88	9.20	7.21	8.77
Standard Error	0.98	1.29	1.11	1.15
Min	25.40	7.60	7.60	14.20
Max	50.10	38.60	32.40	50.10

Evaluation of measured data – Muscle mass (%)

The mean skeletal muscle mass percentage among all participants was 33.7 ± 6.8%, with values ranging from 22% to 49%.

According to manufacturer reference data for bioelectrical impedance analysis (Omron Healthcare, Japan), values of ≥ 33% in men and ≥ 24% in women are considered normal for healthy adults.

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Table 4: Basic statistical characteristics for the values of the percentage of muscle mass (%) according to sex and physical activity.

Statistical Characteristics	Sex groups		Physical activity groups	
	female	male	athletes	non-athletes
n (%)	49	51	42	58
Mean	28.50	38.88	37.79	30.91
Median	29.30	40.80	40.80	29.6
Standard Deviation	3.07	5.55	6.49	5.63
Standard Error	0.44	0.78	1.00	0.74
Min	21.00	29.20	28.40	21.00
Max	32.50	48.40	48.40	43.00

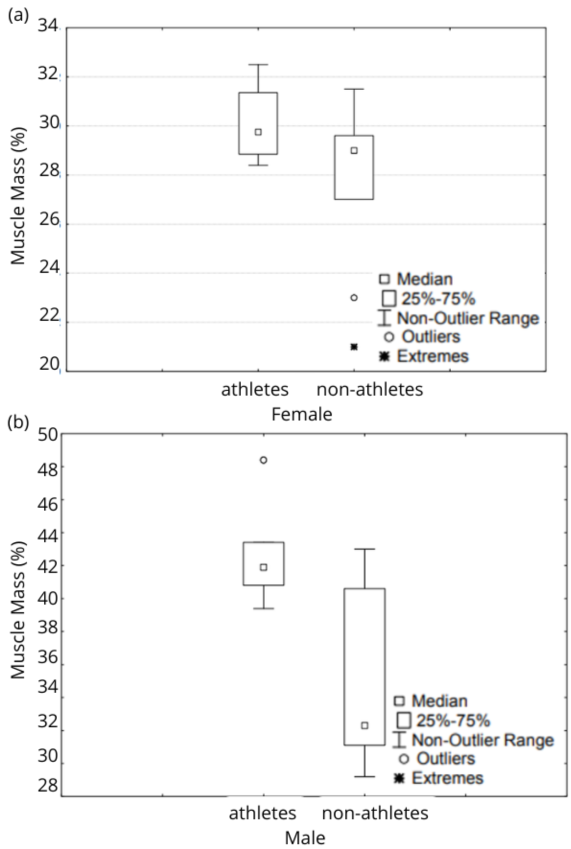

Fig. 2: Box plots of skeletal muscle mass (%) according to physical activity: (a) Women; (b) Men.

When analyzed by sex, men exhibited significantly higher skeletal muscle percentages than women (38.9 ± 5.6% vs. 28.5 ± 3.1%; $p < 0.001$). When analyzed by physical activity, athletes demonstrated markedly higher skeletal muscle mass compared with non-athletes (37.8 ± 6.5% vs. 30.9 ± 5.6%; $p < 0.001$).

This difference remained significant in both sexes (men: athletes vs. non-athletes: $p < 0.001$; woman: athletes vs. non-athletes: $p = 0.002$).

These results indicate that regular physical activity, particularly resistance and endurance training, is strongly associated with greater skeletal muscle development. This effect is more pronounced in men, reflecting physiological differences in muscle composition and hormonal regulation. Detailed statistical characteristics of skeletal muscle mass are presented in Table 4, and its distribution according to physical activity is illustrated in Figure 2.

Evaluation of the results of the measured data using a 1200ECG device

Electrocardiographic (ECG) evaluation revealed that 91% of participants showed normal sinus rhythm (60–100 bpm).

Sinus bradycardia (< 60 bpm) was observed in 9% of participants, more frequently among athletes (14%) than non-athletes (5%). No cases of sinus tachycardia (> 100 bpm) were detected.

The PQ (PR) interval was within the normal range (120–200 ms) in 84% of all participants. A short PQ interval (< 120 ms) was observed in 16%, occurring significantly more often in athletes ($p = 0.04$). This pattern may reflect enhanced atrioventricular conduction associated with regular endurance training rather than pathology.

The QTc interval, corrected according to Bazett's formula [14], showed a mean of 404 ± 41 ms in men (median 397 ms; range 360–550 ms) and 392 ± 31 ms in women (median 399.5 ms; range 348–444 ms).

Pathological QTc prolongation (≥ 450 ms in men, ≥ 460 ms in women) was observed in two men participants only.

The difference in QTc distribution between sexes, analyzed using the Mann–Whitney U test, was not statistically significant ($U = 1363$, $p = 0.55$).

This result indicates comparable QTc values in both sexes despite the presence of extreme values in the men group.

All participants had normal QRS duration (< 120 ms), and no conduction blocks or repolarization abnormalities were identified. A summary of ECG findings is presented in Table 5.

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Table 5: Summary of ECG findings by sex and physical activity.

Parameter	Reference range	All participants	Male	Female	p-value
Heart rate (bpm)	60–90	73.6 ± 8.9	74.9 ± 9.2	72.1± 8.7	0.21 (t-test)
Sinus bradycardia (< 60 bpm)	-	9%	11%	7%	-
PQ (PR) interval (ms)	120–200	142.5 ± 16.2	140.8 ± 15.1	144.3 ± 17.0	0.04
Short PQ (ms)	< 120	16%	19%	13%	-
QTc (ms)	< 450 (men), < 460 (women)	-	404 ± 41 (360–550)	392 ± 31 (348–444)	0.55 (U-test)
Prolonged QTc (ms)	≥ 450/460	2%	2 (men)	0 (women)	-
QRS duration (ms)	< 120	93.5 ± 9.8	94.1 ± 10.2	92.9 ± 9.3	n.s.

Evaluation of the results of measured data using Omron M3 sphygmomanometer

At rest, the mean systolic blood pressure (SBP) in the total sample was 122.8 ± 9.9 mmHg, and the mean diastolic blood pressure (DBP) was 73.3 ± 8.2 mmHg. Resting HR averaged 73.6 ± 8.9 bpm. No participant had resting hypertension according to ESC guidelines (SBP ≥ 140 mmHg or DBP ≥ 90 mmHg).

After exercise, both SBP and HR increased significantly (paired t-test, $p < 0.001$), indicating a normal cardiovascular response to physical exertion.

The mean post-exercise SBP rose to 134.6 ± 11.0 mmHg, while DBP remained nearly unchanged (74.5 ± 8.4 mmHg; paired t-test, $p = 0.19$).

HR increased to 88.9 ± 9.9 bpm (paired t-test, $p < 0.001$).

Athletes had slightly lower resting SBP and HR compared with non-athletes (SBP: 121.9 ± 9.8 vs. 123.7 ± 10.1 mmHg; HR: 71.8 ± 8.5 vs. 75.2 ± 9.0 bpm), but these differences were not statistically significant ($p > 0.05$).

After exercise, both groups showed a significant rise in SBP and HR, yet the magnitude of increase was smaller in athletes (ΔSBP = +10.1 mmHg; ΔHR = +15.3 bpm) compared to non-athletes (ΔSBP = +11.8 mmHg; ΔHR = +16.6 bpm).

No significant differences were observed between sexes for either SBP or HR changes ($p > 0.05$). The distribution of systolic and diastolic blood pressure according to physical activity is illustrated in Figure 3.

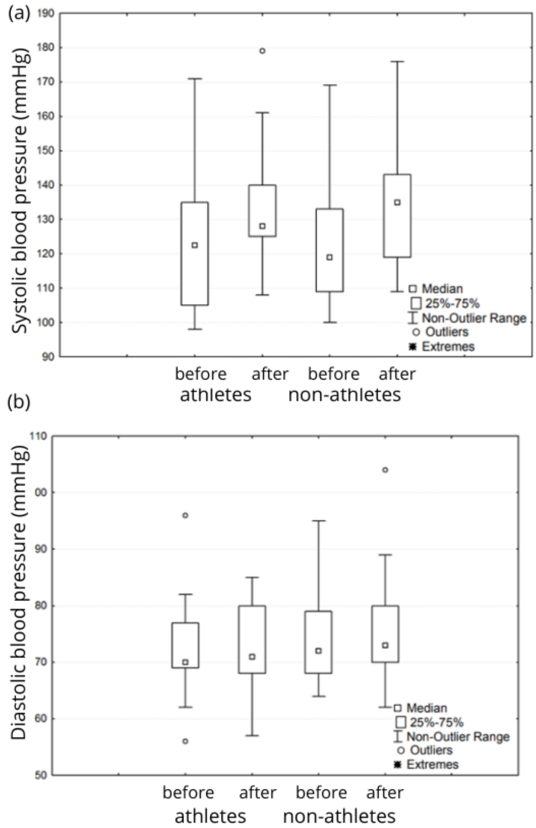

Fig. 3: Box plots of systolic and diastolic blood pressure according to physical activity: (a) Systolic; (b) Diastolic.

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Discussion

This study aimed to assess body composition and cardiovascular characteristics in young adults and to determine how regular physical activity influences these parameters.

Our results confirmed both working hypotheses: (1) physically active individuals (athletes) demonstrated lower BMI, lower body and visceral fat, and higher skeletal muscle mass compared with non-athletes; and (2) regular physical activity was associated with more favorable ECG characteristics and indicators of cardiovascular regulation.

The BMI distribution in this study showed that most participants (74%) had normal weight, while 13% were overweight and 13% obese. This distribution aligns with trends observed in young adult populations, where normal BMI values predominate but overweight prevalence is rising [15, 16]. The absence of underweight individuals may reflect the demographic homogeneity of the sample. Physical activity was a major determinant of BMI, consistent with evidence that regular exercise reduces obesity risk and improves weight control [17, 18].

Our findings also confirmed that athletes had significantly lower BMI and body fat levels, emphasizing the protective role of physical activity in maintaining healthy weight and metabolic balance.

Regarding visceral fat, higher levels were observed in non-athletic men, which mirrors prior studies identifying sex-specific risks associated with central fat accumulation [19, 20].

Visceral fat is a recognized predictor of metabolic and cardiovascular disease, and our data highlight physical inactivity—particularly among men—as a modifiable risk factor. These results are consistent with Hung et al. [17], who reported that combining BMI and body fat percentage improves obesity screening accuracy in young adults.

Athletes exhibited significantly higher skeletal muscle mass compared with non-athletes, reflecting adaptive changes to regular physical training. This finding supports previous evidence that habitual exercise enhances muscle hypertrophy and lean mass, contributing to improved metabolic health and reduced visceral adiposity [11, 19, 20].

The observed sex differences, with men showing higher relative muscle mass, correspond to physiological hormonal differences influencing muscle development.

Resting blood pressure values in both groups were within the normal range, consistent with epidemiological findings in young populations [8, 9]. Exercise caused a normal physiological increase in systolic blood pressure and heart rate, with diastolic pressure remaining relatively stable, confirming an expected hemodynamic response [21, 22].

Although these acute responses did not differ significantly between groups, athletes exhibited slightly lower resting HR and smaller post-exercise increases, reflecting better cardiovascular conditioning and higher vagal tone.

These findings support prior work linking habitual activity with lower baseline heart rate and improved autonomic regulation in youth [11, 21].

The second hypothesis, concerning ECG differences between active and inactive participants, was also supported.

While all subjects demonstrated normal ECGs, athletes exhibited mild sinus bradycardia and shorter PQ intervals—findings consistent with physiological adaptations to endurance and mixed-type training.

Contrary to Pentikäinen et al. [3], who found no ECG differences between athletes and non-athletes, our study revealed variation in QTc intervals, particularly in men, although these differences were not statistically significant ($U = 1363$, $p = 0.55$).

This pattern is consistent with previous observations of training-related ECG modifications in adolescents and young adults [3, 4, 7].

Moreover, no pathological QT prolongation was recorded in women, and only two isolated cases among men, indicating that all deviations were within physiological ranges.

These findings support the concept that regular physical activity in youth promotes beneficial cardiac adaptations [4, 5, 7].

This study represents one of the few analyses of body composition and cardiovascular parameters among young adults from Slovakia. Data from this region and age group (17–25 years) remain limited, particularly in studies combining anthropometric and ECG assessment. The findings therefore extend current knowledge by providing regionally relevant evidence on the effects of physical activity in Central European youth. These results may help inform local prevention and health promotion strategies targeting young adults.

Several limitations should be noted. The sample size was moderate and relatively homogeneous, which may limit the generalizability of the findings. Future studies should validate these findings using multi-method body composition assessment and stratify participants by training intensity or sport type [5]. Lifestyle data were self-reported, and future phases should employ validated instruments such as the International Physical Activity Questionnaire (IPAQ) and the Pittsburgh Sleep Quality Index (PSQI) to improve accuracy [7]. Longitudinal research is recommended to monitor how long-term physical activity affects cardiovascular and metabolic outcomes.

Despite these limitations, our results provide valuable insights into the interplay between physical activity, body composition, and cardiac health in young adults. They underscore the importance of promoting active lifestyles during late adolescence and early adulthood to

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support favorable anthropometric and cardiovascular development, consistent with current public health recommendations.

Conclusion

This study confirmed that regular physical activity is associated with improved body composition and healthier cardiovascular profiles in young adults. Physically active individuals had lower BMI, body and visceral fat, and higher muscle mass compared with non-athletes, while ECG findings reflected physiological rather than pathological cardiac adaptations. These results support both working hypotheses and demonstrate that regular exercise contributes to better autonomic and metabolic regulation.

The study also provides one of the first datasets describing these relationships in a Slovak young adult population, extending current knowledge to a Central European context. Promoting regular physical activity among youth remains a key strategy for obesity prevention and long-term cardiovascular health.

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