

ADAPTATION OF AEROBIC CAPACITY (VO₂MAX) AMONG SPORTS COACHING EDUCATION STUDENTS IN THE DIGITALIZATION ERA THROUGH 1600 METER RUNNING TRAINING

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Abstract

VO₂max is the most valid parameter to measure the functional capacity of the circulatory and respiratory systems in supplying oxygen to working muscles. The digitalization era has changed the physical activity patterns of students to be more sedentary, which has the potential to reduce aerobic capacity (VO₂max). Objective: This study aims to analyze the adaptation of VO₂max of students of the Sports Coaching Education Study Program through 1600-meter running training carried out in a structured manner for nine weeks. Method: The study used a longitudinal quasi-experimental design without control. A total of 39 students took the 1600-meter running test once per week (9 sessions). Data analysis used a Paired t-test to see differences between measurement times. Results: The results showed a consistent increase in VO₂max in the majority of subjects (92%), which was marked by a decrease in the average 1600-meter running time between 25–60 seconds from the first week to the ninth week. The average VO₂max increased from 38.50 mL/kg/min (Poor category) to 42.25 mL/kg/min (Sufficient category). Statistical tests showed a significant increase ($p < 0.05$). Conclusion: Although students live in a digital era with a tendency for low physical activity, structured and regular 1600-meter running training can provide significant aerobic adaptations. This program can be recommended as a practical and effective fitness intervention in the college environment.

Keywords: VO₂max, 1600-meter run, aerobic adaptation, students, digitization

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INTRODUCTION

The development of information and communication technology in the digital era has brought about significant changes in almost every aspect of life, including the physical activity patterns of university students (Annisa et al., 2024). Advancements in digital devices such as smartphones, laptops, and various social media platforms have made it easier to access information and complete academic tasks, however, they have also led to a decline in daily physical activity. Research

indicates that today's university students spend a significant amount of time in sedentary positions sitting for hours while working on assignments, attending online classes, consuming digital entertainment, or playing games (Pristianto et al., 2021). Research conducted by Yuniarti et al., (2024) in Surakarta, Central Java, revealed that university students spent an average of 595 minutes per day on sedentary activities on weekdays and 615 minutes on weekends, with the majority (92%) sitting for more than 5 hours daily. These findings align with a cross-country study across five ASEAN nations involving 3,223 university students, in which only 11.7% met all three daily movement guidelines (physical activity, sedentary time, and sleep duration), while 13.1% met none of the guidelines (Pengpid & Peltzer, 2025). This condition leads to an increase in sedentary behavior, resulting in a decline in overall physical fitness.

One of the physical fitness components most affected by a sedentary lifestyle is aerobic capacity, which can be measured by maximal oxygen uptake, or $\text{VO}_{2\text{max}}$. $\text{VO}_{2\text{max}}$ is a key indicator reflecting the body's ability to optimally consume and utilize oxygen during intense physical activity. This parameter is crucial because it is closely linked to cardiovascular health, aerobic endurance, muscle work efficiency, and the risk of metabolic diseases (Sutriawan, 2025). Individuals with a good $\text{VO}_{2\text{max}}$ value possess greater physical endurance, faster recovery, and a lower risk of chronic diseases.

In the context of college students, $\text{VO}_{2\text{max}}$ plays a strategic role not only in maintaining physical fitness but also in improving quality of life and productivity. Research (Hidayah et al., 2025) confirming that self-efficacy is positively correlated with $\text{VO}_{2\text{max}}$ and quality of life among physical education students, indicating that increased aerobic capacity contributes directly to physical and psychological well-being. Physical activity has been shown to correlate positively with mental health, academic focus, sleep quality, and cognitive ability. However, various studies reveal that physical activity levels among university students in the digital era tend to be low. In addition to increased device usage, factors exacerbating this situation include heavy academic workloads, a lack of sports facilities, and limited understanding of the importance of physical fitness (Kholifaqurrozi et al., 2025).

Sports Coaching Education is one of the study programs offered by the Faculty of Sports Science. This choice is based on the characteristics of coaching students, who possess higher levels of foundational competence and fitness literacy compared to the general student body, given that their curriculum demands a deep understanding of physical training principles and proper physical activity. Learning activities involving regular physical training serve as an effective means to mitigate the negative impacts of digitalization. One form of exercise widely used to both measure and improve $\text{VO}_{2\text{max}}$ is the middle-distance running test specifically, the 1,600meter run (Herlan1, 2020). This test enables the measurement of aerobic capacity in a simple, efficient manner that is easily implemented in student practical activities.

Through repeated measurements over several weeks, the 1600meter run test can provide insight into the physiological adaptation patterns occurring in the body (Saputro, 2021). These adaptations may include increased lung capacity, improved cardiac pumping efficiency, a higher number of muscle capillaries, and enhanced mitochondrial energy production. Furthermore, the 1,600meter run test has proven to be a reliable instrument for assessing the VO₂max of sports coaching students, with over 70% of them falling into the superior to moderate VO₂max categories (Kusuma, 2022). Conducting longitudinal research of this nature on university students in the digital era is highly relevant, as it can reveal the extent to which their bodily systems adapt to structured physical activity amidst high levels of exposure to technology.

This study aims to analyze changes in students' VO₂max over a nine week period based on their performance in a 1,600meter run. It is expected to provide deeper insight into the aerobic fitness of students in the digital era and offer a scientific basis for lecturers, educational institutions, and the students themselves to design effective and sustainable training programs.

METHODS

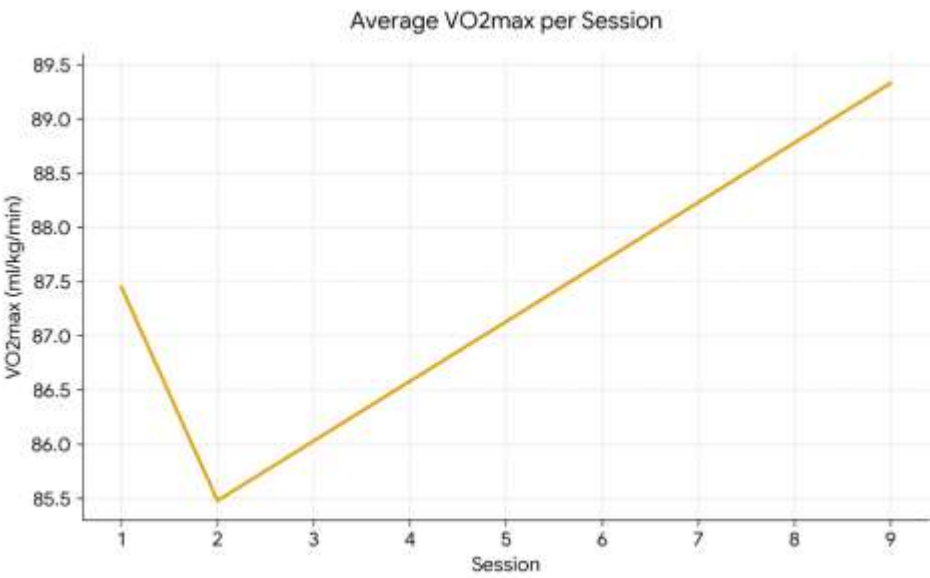
The research design employed was a quasi-experiment without a control group, utilizing a longitudinal observational method involving periodic repeated measurements over a total of nine weeks (Zhu et al., 2022). The study subjects consisted of 39 first year students from the sports coaching study program, all participants were confirmed to be in good health and capable of completing the 1,600meter run test series. These subjects exhibited more homogeneous physical characteristics compared to the general student population. Furthermore, at this age, the cardiorespiratory system is highly responsive to physical stimulation. Utilizing the 1,600meter run as both a measurement tool and a training method yields significant and reliable data regarding physiological adaptation.

Research procedure:

1. Students performed a 1,600-meter run test on a standard track
2. The test was conducted once a week for nine weeks
3. Completion times were recorded in minutes and seconds
4. The 1-Mile Run Test was used, applying the formula: $VO_{2max} = (1,600/time_in_seconds) \times 35.97 - 3.10$
5. Statistical analysis involved the Paired T-Test. Data were analyzed by examining trends in completion times and VO₂max changes from 1-9 session ($p < 0.05$)

RESULTS AND DISCUSSION

RESULTS



Graph 1. VO₂max Progression

The following table presents the research data on a weekly basis, showing the average VO₂max, minimum and maximum values, and the corresponding Rockport norm categories.

Table 1. Research data

Week	Mean VO ₂ max	Minimum Value	Maximum Value	Average Rockport Norm Category
Week 1	38.50	31.00	45.20	Poor
Week 2	36.85	29.50	43.50	Very Poor
Week 3	37.50	30.20	44.10	Very Poor
Week 4	38.20	31.50	45.50	Poor
Week 5	39.10	32.80	46.80	Poor
Week 6	39.95	33.50	47.90	Poor
Week 7	40.80	34.20	49.20	Poor
Week 8	41.65	35.00	50.40	Fair
W-9 (Post)	42.25	35.80	51.50	Fair

Almost all participants demonstrated a trend of improving performance from week to week, evidenced by a reduction in completion times. Some students experienced a dip in performance during the initial sessions but subsequently showed positive adaptation in the following weeks. Pattern of progress:

1. Sessions 1–2: Initial fluctuations; some participants slowed down due to the adaptation process.
2. Sessions 3–5: Steady improvement; the majority of participants began showing time reductions of 5–15 seconds per week.
3. Sessions 6–9: Significant improvement; most achieved their best times by session 9.

VO₂max Description

1. The VO₂max of participants with good performance (running time of 7–9 minutes) fell within the 47–60 ml/kg/min range, an increase of 3–7 points from the first week
2. Participants with moderate performance (10–12 minutes) fell within the 35–45 ml/kg/min range, an increase of 2–5 points.
3. Participants with low performance (12–15 minutes) showed a moderate increase in VO₂max of 1–4 points.

Table 2. Descriptive Statistics

Descriptive Statistics	Value
Number of Data Points (N)	9
Minimum value (Min)	36.85
Maksimum value (Max)	42.25
Range	5.40
Mean / Average	39.42
Median	39.10
Standar Deviasi (SD)	1.84
Varians	3.38

Overall, this study found significant positive aerobic adaptations among the group of students, with 36 out of 39 subjects (92%) experiencing an increase in VO₂max. This performance improvement was marked by a reduction in the average 1,600meter run time of 25 to 60 seconds between the first and ninth weeks. However, a small minority three students showed negligible or stagnant VO₂max improvements, likely due to factors such as suboptimal training intensity or fatigue affecting their

performance.

DISCUSSION

The study results showed an improvement in 1,600meter running performance and an increase in students' estimated VO_2max over nine weeks of measurements. This improvement indicates physiological adaptation to structured aerobic training. According to (Rahmawati & Prastowo, n.d.), Increased aerobic capacity occurs through increased stroke volume, increased cardiac output, increased ventilation efficiency, and increased muscle capillary density. Furthermore, (Rodrigues Barbosa et al., 2024) A systematic review of 120 adult runners found that aerobic training volume is significantly associated with improvements in VO_2max and race performance, with longer training programs yielding greater gains. These cardiovascular adaptations including increased stroke volume and blood pressure regulation occur through structural, functional, and molecular changes that enhance cardiac efficiency (Sanchis-Gomar et al., 2025). This is evident from the reduction in running times among the majority of students, indicating an improvement in their bodies' ability to utilize oxygen during intense activity.

VO_2max adaptation is a combination of central and peripheral adaptations. Central adaptation relates to the heart's increased ability to pump blood, whereas peripheral adaptation relates to the muscles' enhanced capacity to extract oxygen through an increase in mitochondrial content and oxidative enzyme activity (Pettarani et al., 2025). A study conducted by (Kesuma, 2025), also confirmed that consistent aerobic exercise can increase VO_2max by 5-25% over a period of 6-12 weeks, depending on the frequency, duration, and intensity of the exercise. This statement is supported by a comprehensive meta-analysis of the effectiveness of HIIT among university students conducted by (Yin et al., 2025). The study found that high-intensity interval training significantly reduced body fat percentage and increased VO_2max among university students, with greater effects observed in longer-duration training programs. Notably, improvements occurred even with a training frequency of just once per week, indicating a positive adaptive response among the students. These findings are supported by recent research showing that low-frequency training even as infrequent as twice weekly can still yield significant VO_2max improvements in healthy adults, with increases reaching 12.7% after a four-month intervention. (Shimada et al., 2026).

The differences in improvement between participants also suggest that aerobic adaptation is individual. According to (Sukartidana & Anam, 2025), Variability in training response is influenced by genetic factors, initial fitness level, nutrition, academic workload, sleep quality, and stress. (Zhang & Xu, 2023) A data-mining study of university students indicates that chronic sedentary behavior characterized by low physical activity is directly correlated with reduced physical fitness and increased psychological distress; furthermore, the level of participation in recreational physical activity is a critical factor distinguishing physically healthy students from those who are not. Students with

sedentary habits may experience smaller improvements, consistent with research findings. (Hamdani & Hasye, 2019), which found that an inactive lifestyle can diminish the adaptive response of muscle cells to exercise. Nevertheless, the majority of students still recorded improvements in performance, indicating that structured exercise can counteract the negative effects of sedentary behavior often associated with the digital age. Paparan digital yang tinggi pada masyarakat modern telah dikaitkan dengan meningkatnya perilaku sedentari, yang selanjutnya menurunkan kapasitas aerobik (R. Yuniarti et al., 2024). In the digital era, university students spend more time sitting due to technology-driven academic activities, ranging from online learning to completing assignments on laptops. Recent evidence also indicates that students who meet the WHO's physical activity recommendations engaging in at least 150 minutes of moderate-intensity aerobic activity per week exhibit lower cardiovascular risk and better indicators of metabolic health (Lv et al., 2024). However, the results of this study demonstrate that even though students live in a highly digital environment, the body's ability to adapt to exercise remains optimal when a consistent exercise stimulus is provided. This supports the statement (Nurliani, 2025), that regular physical activity of at least moderate intensity can provide significant benefits for cardiovascular health and aerobic fitness, even in individuals with high levels of sedentary behavior.

The findings of this study have significant implications for educational institutions. The WHO (2020) emphasizes the importance of regular physical activity in reducing the risk of non-communicable diseases such as obesity, hypertension, and diabetes. Campus environments should provide structured fitness interventions to address the negative impact of digitalization on student health. Study by Herbert, (2022) confirms that integrated physical activity programs within university settings significantly contribute to improving students' mental health, well-being, and active lifestyles. Imran et al., (2025) It was found that students with low VO₂max (below 41.7 mL/kg/min) accounted for more than 50% of the general student population a finding that underscores the urgent need to implement systematic and sustainable aerobic fitness intervention programs in higher education institutions. Simple programs, such as a progressive 1,600meter run, have been shown to improve fitness without requiring complex facilities. Consequently, this study can serve as a basis for designing effective, low-cost, and easily implementable physical activity curricula within the higher education context.

Although the study results show a positive trend, there are several limitations. Estimating VO₂max using the Cooper formula only provides an estimate of aerobic capacity. Furthermore, there is no control for external factors such as diet, hydration, additional physical activity, weather conditions, or individual motivation during the test, which could influence the results. Nevertheless, the field estimation approach using a middle-distance running test has been recognized as having sufficient validity for use in educational settings and community sports research. as shown by Muhyi et al., (2024) which compares various aerobic capacity test instruments and finds that each instrument has specific advantages depending on the context of its use.

Overall, this study confirms that structured exercise even when simple and of moderate intensity can improve students' VO₂max. This demonstrates that physiological adaptations remain achievable for students in the digital age, a time often characterized by sedentary behavior. In other words, even a minimal exercise program can serve as an effective intervention for maintaining students' physical fitness, provided it is carried out consistently and systematically.

CONCLUSION

Observations revealed an increase in participants' VO₂max from the initial to the final test. These findings indicate that regular participation in the 1600meter run which serves as a distinct physical stimulus correlates with improved aerobic fitness. Amidst a digital-era lifestyle that tends to reduce physical activity, the positive aerobic adaptation observed among the students highlights the potential of repeated running as a stimulus for maintaining or enhancing aerobic conditioning. Consequently, periodic 1600-meter running can be considered a practical alternative activity to support students' aerobic fitness.

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