







**Research Article**

## Screen time, physical activity, and VO<sub>2</sub>max in Indonesian vocational school adolescents (aged 15–17): A cross-sectional study

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### ABSTRACT

Background: Excessive screen time has been linked to decreased physical activity and reduced cardiorespiratory fitness in adolescents. Objective: This study aimed to examine the relationship between screen time and physical activity on VO<sub>2</sub>max estimation in vocational high school adolescents in Indonesia. Methods: This study employed a cross-sectional design with 70 students aged 15–17 years at SMK Negeri 2 Salatiga. Screen time was measured using QueST, physical activity was measured using GPAQ v2.0, and VO<sub>2</sub> max was estimated using the 20-meter MFT. Data analysis was performed using Pearson correlation and multiple linear regression. Result: The results showed that the average VO<sub>2</sub>max of male students was  $41.85 \pm 8.79$  mL kg<sup>-1</sup> min<sup>-1</sup>, and that of female students was  $31.10 \pm 4.96$  mL kg<sup>-1</sup> min<sup>-1</sup>. Physical activity was positively correlated with VO<sub>2</sub>max ( $r = 0.45$ ,  $p < 0.05$ ), while screen time showed no significant correlation ( $r = 0.082$ ,  $p = 0.498$ ). In multiple linear regression, screen time and physical activity together explained 21% of the variance in VO<sub>2</sub>max ( $R^2 = 0.210$ ,  $F = 8.894$ ,  $p < 0.001$ ). Physical activity remained a significant predictor of VO<sub>2</sub>max ( $B = 0.276$ ,  $\beta = 0.412$ , 95% CI [0.108–0.444],  $p = 0.002$ ), while screen time did not ( $B = -0.154$ ,  $\beta = -0.286$ , 95% CI [-0.296–0.012],  $p = 0.34$ ). Conclusion: Higher physical activity was associated with higher VO<sub>2</sub> max in this sample; screen time alone was not associated after adjustment for other factors. Longitudinal and objective measurements are recommended.

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adolescent; physical activity; screen time; students; VO<sub>2</sub>max.

### Introduction

The increasing use of digital technology has a significant influence on adolescent behavior, particularly regarding excessive screen time (Thomas et al., 2020). This is associated with low physical activity and a decreased VO<sub>2</sub>max, indicating decreased cardiorespiratory fitness. High screen time often leads to sedentary behavior, reducing opportunities for physical activity that supports cardiovascular health. Research indicates that adolescents with lower screen time exhibit better physical activity levels, which supports optimal cardiorespiratory capacity (Vella et al., 2020). Academic demands, social pressures, and technological advances often influence challenges in maintaining physical activity (Anjelina et al., 2022; Baldonado et al., 2022). Factors such as diet, genetics, and environment influence cardio-respiratory health (Hardy et al., 2018).

Irregular physical activity can increase the risk of non-communicable diseases, such as obesity, high blood pressure, diabetes, and osteoporosis (Anderson & Durstine, 2019). Good physical fitness in adolescents supports their ability to perform daily activities and physical tasks effectively (Malm et al., 2019). Physical fitness encompasses cardiorespiratory endurance (VO<sub>2</sub>max), strength, agility, flexibility, and balance, with VO<sub>2</sub>max serving as the primary indicator of physical fitness levels. However, a decrease in VO<sub>2</sub>max is increasingly common in adolescents. One of the primary causes is the increase

in screen time, particularly among information technology students who often use digital devices for 4-6 hours per day for learning or leisure activities (Garcia-Continente et al., 2013).

Based on preliminary research, it was found that most adolescent students, especially those majoring in information technology and computer networks, use computers extensively. They use computers at school for approximately 5-6 hours, plus additional activities carried out during school hours. Researchers also found that adolescents needed to be more active during physical education lessons to stay engaged in the lesson. They also tire when taking physical education lessons, especially during athletics and big ball games. Various research studies have shown that excessive screen time can lead to a reduction in physical activity time, resulting in poor cardiovascular health (Bergmann et al., 2018; De Oliveira & Guedes, 2016; Mineshita et al., 2021; Stiglic & Viner, 2019). However, findings regarding the magnitude and nature of this relationship remain inconsistent. Previous studies have found a moderate inverse correlation between screen time and aerobic capacity (Bai et al., 2016; da Costa et al., 2021). Similarly, studies have shown that screen time influences physical activity levels but not directly physical fitness (Prakoso et al., 2024). These inconsistencies highlight the need for further investigation using diverse adolescent populations and more comprehensive models that consider screen time and physical activity simultaneously.

Recent systematic reviews have also noted that most existing research has been conducted in Western contexts, with limited evidence from Southeast Asia, particularly Indonesia (Bennàsser Torrandell & Vidal Conti, 2021; Nagata et al., 2023). Furthermore, few studies have examined the combined effect of screen time and physical activity on VO<sub>2</sub>max among vocational high school students, a population typically exhibiting higher exposure to digital technology and lower participation in physical activity. Therefore, this study aims to fill this empirical gap by analyzing the relationship between screen time, physical activity, and VO<sub>2</sub>max among adolescents in an information and networking technology program in Indonesia.

This study is urgently needed to understand the impact of screen time and physical activity on cardiovascular health. Maintaining an optimal VO<sub>2</sub> max is essential for heart and lung health, as well as many aspects of overall health. Based on the description, the formulation of the problem in this study is whether screen time and physical activity are related to the cardiovascular endurance of adolescent students. This study aims to determine the relationship between screen time and physical activity on the cardiovascular endurance of adolescent students. This study contributes to understanding the relationship between screen time, physical activity, and VO<sub>2</sub> max, which is crucial for developing policies and interventions that support adolescent health and well-being.

## Method

### Research Design

This is an analytical observational research study with a cross-sectional design, which involves a single observation and the completion of a subject data sheet to determine the relationship between screen time and physical activity on the VO<sub>2</sub> max of adolescent students. This research was conducted at State Vocational High School 2, Salatiga. It consisted of the variables screen time, physical activity, and VO<sub>2</sub> max.

### Participants

This study used a convenience sampling approach. The participants were adolescent students majoring in Information and Network Technology at State Vocational High School 2, Salatiga. A total of 82 students were invited to participate, coordinated by physical education teachers and homeroom teachers. After screening based on the criteria, 70 students (32 males and 38 females) aged 15-17 years old met the inclusion criteria and were willing to participate voluntarily as respondents. Inclusion criteria included active students in the Information and Network Technology expertise program, healthy physical condition, and willingness to sign an informed consent form. Exclusion criteria included

students who were absent during data collection, had medical conditions that limited physical activity, or refused to participate. A total of 12 students did not participate due to personal reasons or health conditions. Demographic data, including age and gender, were collected through a short questionnaire to describe participant characteristics and control for potential confounding influences. These second variables were considered covariates in the statistical analysis because they are known to influence VO<sub>2</sub>max values. Body Mass Index (BMI) was not collected in this study because the primary focus was on behavioral factors (screen time and physical activity), rather than anthropometric variables. Sample size calculations and power analysis were performed using G-Power version 3.1, with a medium effect size ( $r = 0.30$ ) and a significance level of  $\alpha = 0.05$ . The calculation results showed that a minimum of 67 students was required as respondents, so the 70 students participating met the statistical power requirements for correlation and regression analysis.

### Research Instruments

This research uses three instruments: the screen time instrument using QUEST (Questionnaire for Screen Time of Adolescents) with the reliability values of the ICC tests ranging from 0.41 (95% CI 0.24–0.56) for video to 0.76 (95% CI 0.66–0.83) for social media/chat applications on weekdays; and from 0.24 (95% CI 0.04–0.41) for video to 0.67 (95% CI 0.54–0.77) (Knebel et al., 2022), the physical activity instrument using GPAQ v2.0 (Global Physical Activity Questionnaire), and the VO<sub>2</sub>max instrument using the Multistage Fitness Test (MFT) 20 meters Cardiorespiratory endurance (VO<sub>2</sub>max) was measured using the 20-m Multistage Fitness Test (MFT). Participants ran back and forth between two lines 20 m apart in time with audio signals. The test ended when the participant failed to reach the line on two consecutive beeps. The final level and shuttle number achieved were recorded and converted to estimated VO<sub>2</sub>max (ml·kg<sup>-1</sup>·min<sup>-1</sup>) using the regression equation proposed:

$VO_2\max = 31.025 + 3.238 \times V - 3.248 \times A + 0.1536 \times V \times A$ , where V is the running speed (km/h) at the final completed stage, and A is the participant's age (years) (Lager & Lambert, 1982; Ramsbottom et al., 1988).

### Procedure

Data collection in this research was conducted with permission from the school and was accompanied by a physical education teacher. The first stage of the screen time assessment was conducted based on participants' responses and the time spent using media (laptop, computer, television, and smartphone). The questionnaire questions consisted of 1) time spent studying, reading, or doing school work using, 2) time spent watching learning videos, 3) time spent doing work-related activities using 4) time spent watching TV shows, films, soap operas, sports news or other videos, 5) time spent playing video games, 6) time spent using social media (Facebook, Instagram, Twitter, Whats App, Telegram, Messenger). The second stage of collecting physical activity data was based on participants' responses to the GPAQ v2.0 questionnaire. The questionnaire consists of 16 questions, which are divided into 1) activity at work (code: P1-P6), 2) travel to and from the place (code: P7-P9), 3) recreational activities (code: P10-P12), 4) physical activity (recreational activity) (code: P13-P15), 5) Sedentary behavior (code: P16). The assessment is done by calculating the number of METs (Metabolic Equivalent). The third stage is collecting VO<sub>2</sub>max data using a 20-meter MFT test. The MFT (Multistage Fitness Test) is an instrument used to measure a person's physical fitness through their VO<sub>2</sub>max. The test is carried out by running a distance of 20 meters back and forth, starting with a slow pace that gradually increases in speed.

### Data Analysis

Data analysis was performed using Pearson correlation and multiple linear regression. Before the regression analysis, assumptions were tested, including a normality test (using the Kolmogorov–Smirnov test). The regression model used the enter method to determine the simultaneous effect of screen time

and physical activity on VO<sub>2</sub>max. This model did not include covariates such as gender, age, or body mass index (BMI). The statistical significance level was set at  $p < 0.05$  for all analyses.

## Results and Discussion

### Results

Based on the frequency distribution data from the research results, 70 respondents were identified, comprising 32 male students and 38 female students. This research examines the relationship between screen time, physical activity, and VO<sub>2</sub> max. The following table presents the distribution of respondents and the results of the Pearson correlation data processing. Based on [Table 1](#), the research participants, comprising 32 males and 38 females with an average age of 16 years, exhibited a high screen time category, with a percentage reaching 100% in each gender group. The average screen time duration in the male group was 11 hours and 12 minutes per day (Mean = 11.12; SD = 2.19), while in the female group, it was 10 hours and 11 minutes per day (Mean = 10.11; SD = 1.97). The results in the table indicate that both male and female students spend relatively long times in front of screens every day, exceeding the daily screen use recommendation limit suggested by the World Health Organization (WHO), which is less than two hours per day for adolescents. The average difference that emerged shows that males tend to have slightly higher screen time durations than females, even though both categories are high.

Table 1. Screen Time Descriptive Data

Gender	n	Age	Category	%	Total screen time	Mean ± SD
Male	32	16	High	100%	11 hours 12 minutes	11.12 ± 2.19
Female	38	16	High	100%	10 hours 11 minutes	10.11 ± 1.97

Table 2. Physical Activity Descriptive Data

Gender	n	Age	Mean ± SD (MET)	MET-min/week	Category
Male	32	16	2716.25 ± 1940.68	2,716	moderate-vigorous
Female	38	16	1350.53 ± 884.12	1,351	Moderate

Based on [Table 2](#), the physical activity levels of the study participants showed quite clear differences between the male and female groups. The male group, comprising 32 participants, had an average MET value of 2716.25 ± 1940.68 MET-min/week, which falls within the moderate to high level of physical activity category. Meanwhile, the female group with 38 participants had an average value of 1350.53 ± 884.12 MET-min/week, which is categorized as a moderate activity level. These findings suggest that males tend to be more physically active than females in the same age group, specifically those aged 16 years and older. The reasonably large standard deviation values in both groups also indicate variations in physical activity levels between individuals within each group. In general, these results reflect a tendency for gender differences to contribute to variations in physical activity levels, where males generally exhibit higher involvement in moderate-to-vigorous-intensity physical activities than females.

Table 3. VO<sub>2</sub>max Frequency Distribution

Category	Frequency	Percentage
Very deficient	8	11.4%
Deficient	20	28.5%
Average	25	35.7%
Good	13	18.5%
Very Good	1	1.4%
Excellent	3	4.2%

Table 3 shows the frequency distribution of VO<sub>2</sub>max based on the respondents' cardio-respiratory fitness category. Most respondents were in the Average category (25 people, 35.7%), followed by the Deficient category (20 people, 28.5%) and Good (13 people, 18.5%). A total of 8 people (11.4%) were in the Very Deficient category, while the Very Good and Excellent categories only included 1 person (1.4%) and 3 people (4.2%), respectively. This distribution shows that most respondents have an average to poor cardio-respiratory fitness level, with only a few reaching the Excellent or Very Good level. This finding reflects the need for increased physical activity to support higher VO<sub>2</sub> max, especially for those in the Deficient and Very Deficient categories. Intervention efforts focusing on active lifestyles are essential to improve overall cardio-respiratory fitness.

Table 4. Recapitulation of VO<sub>2</sub>max Based on Gender

Gender	n	Age	Mean ± SD (ml·kg <sup>-1</sup> ·min <sup>-1</sup> )
Male	32	16	41.85 ± 8.79
Female	38	16	31.10 ± 4.96

Table 4 shows that there are differences in VO<sub>2</sub>max values between male and female participants. The 32 male group with an average age of 16 years had an average VO<sub>2</sub>max of 41.85 ± 8.79 ml·kg<sup>-1</sup>·min<sup>-1</sup>, while the 38 female group of the same age showed an average VO<sub>2</sub>max of 31.10 ± 4.96 ml·kg<sup>-1</sup>·min<sup>-1</sup>. These results indicate that men have a higher aerobic capacity than women, which can be physiologically linked to differences in body composition, muscle mass, and cardiovascular system efficiency between the two sexes. The larger standard deviation value in the male group also indicates a greater variation in aerobic fitness levels compared to the female group.

Table 5. Data Normality Test

Variable	Kolmogorov–Smirnov	Sig.(p)
Screen time (hours/day)	0.086	0.200
Physical activity (MET-min/week)	0.097	0.187
VO <sub>2</sub> max (ml·kg <sup>-1</sup> ·min <sup>-1</sup> )	0.082	0.200

Based on the results of the Kolmogorov–Smirnov normality test in Table 5, the significance value for screen time was 0.200, physical activity was 0.187, and VO<sub>2</sub>max was 0.200. All significance values were above the α = 0.05 limit, so it can be concluded that the data for all three variables were normally distributed.

Table 6. Pearson Correlation Test

Variable	VO <sub>2</sub> max
Screen Time	p < 0.498 r = 0.08
Physical Activity	p > 0.000 r = 0.45

Table 6 explains the significance value (p) of screen time with a VO<sub>2</sub> max of 0.498 > 0.05, meaning there is no relationship between screen time and the VO<sub>2</sub> max. Furthermore, the physical activity variable with VO<sub>2</sub>max is 0.000 < 0.05, explaining the relationship between physical activity and VO<sub>2</sub>max. Based on the Pearson correlation value, it is known that the calculated r score for the relationship between the screen time variable and VO<sub>2</sub>max is 0.08 < 0.231 r table, so it can be concluded that there is no relationship between the screen time and VO<sub>2</sub>max. Furthermore, the physical activity variable with VO<sub>2</sub>max is 0.45 > 0.231, which means that it can be concluded that there is a relationship between the physical activity and VO<sub>2</sub>max.

Table 7. Results of Multiple Linear Regression Analysis between Screen Time and Physical Activity on VO<sub>2</sub>max

Variabel	B	Std. Error	$\beta$ (Standardized)	p	95% CI
Screen time	-0.154	0.071	-0.286	0.34	[-0.296, -0.012]
Physical activity	0.276	0.084	0.412	0.002	[0.108, 0.444]

Based on Table 7, the screen time variable shows a p-value of 0.340 ( $> 0.05$ ), indicating no significant relationship between screen time duration and VO<sub>2</sub>max. Although the negative coefficient direction ( $B = -0.154$ ) suggests a tendency for increased screen time to be followed by a decrease in cardiorespiratory fitness, the relationship is not statistically strong enough. In contrast, physical activity has a p-value of 0.002 ( $< 0.05$ ) with a positive coefficient ( $B = 0.276$ ), which means that the higher the level of physical activity, the higher the VO<sub>2</sub>max value. Thus, only physical activity was proven to be a significant predictor of cardiorespiratory fitness of adolescents in this study.

Table 8. Regression model summary

Variable	R	R Square	F	Sig.
Screen time, Physical Activity, VO <sub>2</sub> max	0,458	0,210	8,894	0,000

In Table 8, it is known that the R<sup>2</sup> value is 0.210 or equal to 21%; this result means that the screen time and physical activity variables simultaneously influence the VO<sub>2</sub>max variable by 21% while the remaining 79% is influenced by the variable other than the research variables. The calculated F value is 8.894  $>$  3.15 table F value, meaning that screen time and physical activity simultaneously influence VO<sub>2</sub>max.

## Discussion

The results of this study indicate that physical activity has a significant relationship with VO<sub>2</sub>max, while screen time is not directly related to VO<sub>2</sub>max in adolescents. The findings suggest that adolescents' cardiorespiratory fitness levels are more influenced by their physical activity levels than by the duration of digital device use. These findings align with previous research suggesting that adolescent physical fitness is significantly influenced by the frequency and intensity of physical activity (D'Agostino & Neshteruk, 2023; Farren et al., 2016; Gutin et al., 2005). Other studies have confirmed that participation in organized physical activity, both individual and group, plays a significant role in increasing VO<sub>2</sub>max in children and adolescents (Landgraff et al., 2021; Nevill et al., 2020; Sharma et al., 2017). Similarly, research has shown that increasing exercise volume through monitoring daily steps can improve cardiorespiratory capacity and reduce fat mass (Rodríguez-Gutiérrez et al., 2025; Stojanović et al., 2024).

The finding that screen time was not significantly associated with VO<sub>2</sub>max in this study differs from most previous studies that have shown a negative relationship between the two (Dong et al., 2025; Potter et al., 2018). Several possible factors can explain this discrepancy. First, all respondents in this study were categorized as having "high" screen time, resulting in low inter-individual variability, which may lead to a ceiling effect that reduces the ability of statistical models to detect a significant relationship. Screen time measurements in this study were based on self-reports, which could potentially introduce perceptual bias or misestimation of screen time duration. This could impact the accuracy of the proper relationship between screen time and physical fitness. These findings are supported by previous research showing that patterns of physical activity, sleep time, and screen time duration tend to vary by gender and day of the week, so a single perceptually based measure may not fully represent actual habits (Hrafnkelsdottir et al., 2020; Sanz-Martín et al., 2022, 2023).

The respondents' social and academic contexts may also be essential factors. Most participants were students majoring in information technology, who typically use digital devices for learning. Therefore, students' screen time is not entirely passive or recreational, as in other research contexts, but rather serves an academic purpose that may not directly impact fitness decline. Nevertheless, the results of this study support previous findings, which consistently show that physical activity is positively associated with cardiorespiratory fitness (Bahls et al., 2021; Franklin et al., 2022, 2023). Regular physical activity has been shown to increase heart and lung capacity, strengthen the respiratory system, and reduce the risk of cardiovascular disease (Nystoriak & Bhatnagar, 2018; Wu et al., 2019).

In terms of practical implications, the findings of this study indicate the need for school interventions that focus not only on reducing screen time but also on increasing the intensity and frequency of students' physical activity. Fitness programs integrated into the curriculum, the use of activity monitoring technology, and a project-based approach can be effective strategies for improving adolescent physical fitness. However, this study has several limitations. Other factors, such as diet, sleep quality, body mass index, and genetics, were not included in the analysis model, although they can also influence VO<sub>2</sub>max values. Furthermore, this study was cross-sectional, which means it was unable to explain the causal relationship between the variables. The relatively small and homogeneous sample size also limits the generalizability of the results. For future research, it is recommended to use a longitudinal design to more accurately analyze causal relationships and combine objective and subjective measurements in assessing screen time and physical activity. Furthermore, control variables such as BMI, sleep patterns, and diet need to be included to obtain a more comprehensive picture of the factors influencing adolescent cardiorespiratory fitness.

## **Conclusions**

Based on the results obtained, it was concluded that physical activity has a significant relationship with VO<sub>2</sub>max, while screen time has no direct relationship with VO<sub>2</sub>max. This study contributes to a deeper understanding of the relationship between screen time, physical activity, and VO<sub>2</sub> max in adolescents. This study provides empirical evidence that can inform the design of school-based or community-based intervention programs aimed at increasing physical activity and reducing screen time among adolescents. The results of this study can serve as a reference for adolescents and parents on the importance of reducing screen time and increasing physical activity to support cardiorespiratory fitness. Recommendations for future research include employing longitudinal designs to elucidate causal relationships, combining objective and self-report measures to enhance data validity, and expanding the scope of variables examined, such as diet, sleep, and mental health. Research should also include larger and more diverse samples to increase generalizability and distinguish between types of screen time, thereby identifying specific effects on VO<sub>2</sub>max.

## **Authors' contributions**

CW and YEN contributed equally to the conceptualization and design of the study. Both authors were responsible for data collection and data analysis. CW and YEN drafted the manuscript and performed critical revisions for important intellectual content. All authors read and approved the final manuscript.

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## **Competing interests**

The authors declare no competing interests.

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