JSSF (12) (1) (2026)

Journal of Sport Sciences and Fitness

https://journal.unnes.ac.id/journals/jssf



Cardiorespiratory Fitness Analysis Based on Sex Aad Age Among Students at SMK Bina Nusantara Ungaran

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Article's Info

Article's History:
Submitted Feb 23, 2026
Revised April 2, 2026
Accepted April 6, 2026

Keywords:
vo2max; cardiorespiratory fitness; vocational students; adolescenct health; physical education

DOI:
https://doi.org/10.15294/jssf.v12i1.44533

Abstract

Introduction: cardiovascular and respiratory fitness (CRF) is a critical health indicator linked to students metabolic well being and funcional capacity to perform physical activities. Despite its importance, empirical evidence regarding the distribution of maximum oxygen consumption (VO2MAX), particularly among vocational high school students, remains limited. **Objectives:** the purpose of this study is to analyze the descriptive statistical profile and categorical distribution of vo2max among students at smk bina nusantara ungaran, grouped by age and biological sex. **Method:** this study employed a quantitative descriptive design involving 298 students (223 males and 75 famales). Vo2max was measured using the 1.6km rockport walk test, and the data were analyzed using descriptive statistics, including mean, standard deviation, and frequency distribution. **Result:** the resuts of the study showed that male students achived an average vo2max value of 35.02 ± 5.07 ml/kg/min, while female students showed a lower average value of 27.35 ± 3.10 ml/kg/min. Specifically, categorical analysis revealed a significant fitness gap, with 32.73% of male students and 70.66% of female students falling into the into the poor and very poor categories. **Conclusion:** in conclusion, the majority of students, particularly female students, exhibit suboptimal levels of cardiovascular and respiratory fitness, wjich may affect their readines to enter the workforce in the future. These findings underscore the urgent need for gender inclosive physical activity interventions and policy adjustments in vocational education to improve long term health and industrial productivity.

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PISSN 2252-6528
EISSN 2745-5718

INTRODUCTION

According to regulation of the minister of education and culture of the republic of indonesia no. 8 of 2024, physical education (PE) is an integral component of the curriculum design to develop physical fitness and healthy lifestyle behaviors (Kemenpora RI, 2022). Recent research emphasizes that PE is crucial for fostering not only motor skills but also physical endurance (Salahudin et al., 2025). In the modern professional landscape, vocational high school(SMK) students face unique demands where industrial productivity is directly linked to physical fitness. Therefore, maintaining optimal health is a proffesional necessity for SMK students to meet strict industry standards (Tasya et al., 2025).

Cardiovascular fitness (CRF), as measured by vo2max, is an important indicatorof aerobic capacity and long term metabolic health (Raghuveer et al., 2020). As the gold standard for assessing cardiovascular efficiency, higher vo2max levels are associated with a reduced risk chronic diseases in adulthood (Srivastava et al., 2024). Conversely, low vo2max serves as a significant predictor of mortality and cardiovascular complications even as early as adolescence (García-Hermoso et al., 2020). Although direct gas analysis is the most accurate measurements, field based assessments such as the 1.6km rockport walk test offer a cost effective and valid alternative for large-scale evaluations (Budiman et al., 2017).

The physiological capacity of vo2max is strongly influenced by maturation processes related to age and biological sex. Between the ages of 14 and 17, adolescents undergo a criticsl growth phase that enhances physical capabilities and levels of maturity (Gantarialdha, 2021; Jalili et al., 2018). Supporting this longitudinal evidence indicates that oxygen uptake efficiency develops significantly during the transition from early to late adolescence, with distinct functional trajectories emerging as biological age increases (Armstrong & Welsman, 2019). Recent evidence confirms that male adolescents generally exhibit a higher increase in vo2max due to increases in lean muss and hemoglobin levels, whereas trends in female adolescents tend to plateau or fluctuate due to higher body fat percentages during pubertal development (Bati et al., 2024). Consequently, poor cardiovascular fitness during this formative period is strongly associated with an increased risk of metabolic disorders later in life (García-Hermoso et al., 2020).

Although numerous studies have documented the fitness profiles of high school students and college students (Candra & Setiabudi, 2021), there is a significant lack of data focusing on vocational high school students. Unlike their peers in general education, smk students engage in specialized vocational practices-ranging from manual labor in automotive workshop to static endurance in textile laboratories which impose distinct physiological demands (Hamka, 2025). Currently, empirical data that simultaneously analyzes CRF by gender and age in vocational schools, particularly in areas such as ungaran, remains limited.

Based on background describe in the previous paragraphs, there is a clear need to conduct specific research to analyze the cardiovascular fitness of students at SMK Bina Nusantara Ungaran Based on gender and age. This resarch is very important to obtain relevant data that can be used as a basis for developing physical education and health programs. Since vo2max is a critical component of physical capacity which enable individuals to perform daily activies effectively and achieve a high quality of life assesing vo2max levels among vocational high school students is very important. This assessment will provide the necessary basis for designing targeted public health and sports programs to meet the specific needs of these students.

Based on the background describe above, this study aims to : 1) conduct quantitative descriptive statistical analysis to determine the distribution of vo2max categories among male

students at smk bina nusantara ungaran across different age groups, and 2) conduct quantitative descriptive statistical analysis to determine the distribution of vo2max categories among female students at smk bina nusantara ungaran across different age groups.

METHOD

This study used a survey method with a quantitative approach, specifically with a quantitative descriptive research. Cardiovascular fitness was measured using the rockport one mile walk test (RMWT), a sumaximal field test designed to estimate an individuals vo2max. The RMWT) tool showed high validity of r = 0.817 and reliable significance of p = 0.573, demonstrating its effectiveness as a predictive tool (Weiglein et al., 2011). Recent evidence supports the rmwt as a reliable predictor of vo2max, showing no statistically significant differences when compared to established protocols such as the McArdle Step Test in young adult populations (Kumar & Shivani, 2020).

The test was conducted on a flat, paved surface on the school's basketball court. To cover the required distance of 1.6 Km, the test is conducted on a school basketball court with a circumference of 86 meters.. participant are required to complete 10 laps to reach a total distance of 1,609 meters (1 mile). To ensure accucy, the route wa clearly marked, and lap counts were monitored by field assistants assigned to each participant to ensure safety, accuracy of lap counts, and adherence to the protocol. Measurement tools included a digital stopwatch and markers to define the track boundaries. Participants perform a 10-minute structured dynamic warm up before walking at their maximum sustainable pace.

The subjects of this study consisted of 10th and 11th grade students at smk bina nusantara ungaran, aged 14 to 18 years. The total population consisted of 298 students, including 223 males and 75 famales; total sampling technique was applied to cover the entire population. Ethical approval was obtained from the local community health center, the school principal, and the physical education teacher, and informed consent was obtained from all participants before the study began, to ensure that they understood the procedures to be conducted and their right to withdraw at any time.

The quantitative data collacted included gender, age, RMWT completion time. vo2max estimates were recorded in ml/kg/min, with fitness categories determined based on normative vo2max standards for the adolescent population. These categories were used to provide a clear picture of the students cardiovascular fitness, to be used as a basis for developing physical education and health curriculum.

Data collection involves vonducting an RMWT test, in which students walk or run 1,6km at their maximum achievable speed. Completion time is recorded in minute to calculate vo2max values. Each session begins with a structured warm up to minimize the risk of injury and ensure physical readiness. This method is highly recomended for large scale fitness assessments due to its safety, efficiency, ease of implementation, and low cost.

Vo2max calculation are based on the following RMWT the procedure: 1) time measurement begins when the whistle blows and stops when the participant crosses the finish line. 2) the main data used is the participants completion time. 3) time is recorded in minutes and seconds. 4) participants are declared successful if they complete the distance and unsuccessful if they do not. 5) the completion time is then converted into a vo2max value using the followig formula:

$$METs = 2.5043 + \left(\frac{0.85}{h}\right)$$

$$VO_2max = METs \times 3.5$$

Where:

- **METs**: Metabolic Equivalents (1 MET = 3.5 ml O_2/kg/min).
- **h**: Completion time in hours (Time in minutes ÷ 60).

Male

Age	<20	21-30	31-40	41-50	51-60	60+
Excellent	>52	>56	>56	>48	>44	>40
Above Average	48-51	52-55	48-51	47-44	40-43	36-39
Average	40-47	44-51	40-47	36-43	32-39	28-35
Below Average	35-39	39-43	35-39	31-35	27-31	23-27
Poor	<35	<39	<35	<31	<27	<23

Female

Age	<20	21-30	31-40	41-50	51-60	60+
Excellent	>48	>50	>48	>46	>44	>42
Above Average	42-47	44-49	42-47	40-45	38-43	38-43
Average	32-41	34-43	32-41	30-39	28-37	26-35
Below Average	27-31	30-33	27-31	24-29	21-27	18-25
Poor	<27	<30	<27	<24	<21	<18

The calculated vo2max values (ml/kg/min) were then classified into fitness categories (excelent, good, average, poor, very poor) according to the normative standards for adolescents established by kemenkes RI.

Data analysis was performed using microsoft excel statistical software. The analysis technique used was descriptive analysis, which included calculating the mean, median, and standard deviation (SD) of vo2max, as well as the frequncy distribution of cardiovascular fitness categories based on gender. The statistical significance level was set $\alpha = 0.05$ to maintain consistency and accuracy n interpreting the data analysis results.

RESULT AND DISCUSSION

Result

Based on the research conducted, statistical analysis was performed on vo2max estimate data obtained from the rockport one mile walk test (RMWT) on N = 298 sudents at smk bina nusantara ungaran. The main purpose of this analysis was to determine the avarage cardiovascular fitness level, categorized based on fitness distribution, while also analyzing the influence of gender and age vaiables. The research results are presented sequentially, beginning with descriptive statistical analysis.

This study presents the results of statistical analysis conducted on vo2max data estimated using the rockport one mile walk test from a total of N = 298 students at smk bina nusantara ungaran. This analysis aims to examine the descriptive profile of cardiovascular fitness, its distribution across various fitness categories, and influence of gender and age variables. The findings are presented sequentially, beginning with descriptive statistics.

1. Statistics of cardiovascular fitness by age and Sex

Cardiovascular fitness (CRF) profiles were analzed based on the distribution of vo2max across various age groups, for both male and female students. This descriptive approach provides a detailed overview of physical capacity within each demographic segment.

Table 1. Mean, Median, and Standard Deviation of VO_2max by Sex and age.

By Sex	Age	N	Mean (VO2Max)	Median (VO2Max)	SD (VO2Max)
Male	14-15	90	34,24	34,25	5,17
	16-17	126	35,28	34,24	4,86
	18	7	39,97	41,70	3,47
Female	14-15	45	27,34	27,10	2,92
	16-17	30	27,36	27,10	3,31
	18	-	-	-	-

Data for male students show a clear upward trend in cardiovascular capacity with increasing age. The mean vo2max value rose from 34.24 ml/kg/min in the 14-15 years old age group to 35.28 ml/kg/min in the 16-17 year old age group, and peaked at 39.97 ml/kg/min in 18 year old students. This upwar trajectory suggests that physiological maturation, characterized by increases in muscle mass and cardiac output during late adolescence, plays a key role in enhancing aerobic capacity. The relatively low standard deviation (SD = 3.47) in the 18 year old group indicates a more homogeneous level of fitness as they reach physical maturity.

In contrast, female students exhibited a highly stgnant aerobic profile across all age groups. The mean vo2max value for the 14-15 year old group (27.36 ml/kg/min) was nearly identical to that of the 16-17 year old group (27.36 ml/kg/min). This lack of age related improvement suggessts that biological maturation alone does not significantly enhance the cardiovascular endurance of female vocational school students the stability of these low values across all age groups indicates a consistent pattern of physical inactivity or stagnation in physiological development related to aerobic fitness during those years.

2. Distribution of Cardiorespiratory Fitness Categories Among Male Students

Grouping stuents by vo2max level provides a practical overview of their endurance capacity. The following tables show the frequency distributions for male and famale students, respectively.

Tabel 2. Distribution of Cardiorespiratory Fitness Categories Among Male Students

CRF Categories	14-15 yrs(n)	16-17 yrs(n)	18 (n)	Frekuensi(n)	Presentase(%)
Excellent	18	37	6	61	27,35
Good	19	21	-	40	17,93
Fair	19	29	1	49	21,97
Poor	25	37	-	62	27,8
Very Poor	9	2	-	11	4,93
Total	90	126	7	223	100,00

As shown in table 2, the distribution of CRF scores among male students varies considerably across age groups. A significant finding is that 27.35% of male students achived a “very good” rating, with the highest concentration in the 16-17 age group (37 students). However, overall, 32.73% still fell into the “poor” and “very poor” categories. Interestingly, there is a striking shift in the 14-15 age group, where the “poor” category is the most common (25 students), whereas in the 16-17 age group, the “very good” and “poor” categories have the highest frequencies. This suggests that althogh physiological maturation in older students (16-18 years) contributes to higher aerobic peaks, the risk of a sedentary lifestyle remains prevalent among younger groups.

3. Distribution of Cardiorespiratory Fitness Categories Among Female Students

The distribution of cardiovascular and respiratory fitness (CRF) categories provides a comprehensive overview of the famale students at SMK Bina Nusantara Ungaran, revealing certain trends within each age group:

Tabel 3. Distribution of Cardiorespiratory Fitness Categories Among Female Students

CRF Categories	14-15 yrs (n)	16-17 yrs (n)	18 (n)	Frekuensi (n)	Presentase (%)
Excellent	3	4	-	7	9,33
Good	-	1	-	1	1,33
Fair	9	5	-	14	18,66
Poor	16	9	-	25	33,33
Very Poor	17	11	-	28	37,33
Total	45	30	-	75	100,00

The profile of female students (table 3) indicates an urgent need for attention, as the majority of them are at lower fitness level. Overall, 70.66% of famale students were classifed as “poor” or “very poor.” In the 14-15 age group, 17 students (37.7% of that age group) were categorized as “very poor.” This trend continued into the 16-17 age group, where the “very poor” category remained the most dominant (11 students). Across all age groups, only a very small percentage (9.33% for the “very good” category and 1.33% for the “good” category)

achieved the highest fitness level. This descriptive evidence indicates that female vocational school students, regardless of their age group, consistently exhibit a low cardiovascular endurance profile.

Discussion

Analysis Of Cardiorespiratory Fitness and Physiological Maturation

The cardiovascular fitness profile of students at SMK Bina Nusantara Ungaran, as indicated by their vo2max scores, shows an alarming trend, with the majority of students falling into the “poor” and “very poor” categories. These findigs suggest that, despite being in the peak phase of their development, the students aerobic capacity has not developed optimally.

Low fitness levels during asolescence pose a significant risk for poor metabolic healt outcomes in the future. As discussed earliner in the introduction, research shows that poor cardiovascular fitness is closely linked to increased risk of metabolic disorders, such as hypertension and cardiovascular problems, even at young age (García-Hermoso et al., 2020). Therefore, these findings emphasize the urgent need to map fitness as a strategic basic for designing physical activity intervention in school setting.

Behavioral and Environmental Factors That Influence Fitness

The distribution of fitness categories shows striking differences between the two genders. While male students exhibit greater variation, female students are mostly at lower levels. This is not merely a biological phenomenon but is deeply rooted in behavioral and environtmental factors.adolescent girls often have lower participation rates in moderate to virgous physical activity due to psychosocial barriers and a lack of gender inclusive sport programs (Pojskic et al., 2018).

In addition, the vocational high school environment presents its own unique challenges. Unlike general high schools, SMK students often have to maintain a static posture for long periods during practical activities (e.g., in automotive or textile laboratories). Although these tasks are tiring, they do not involve the rhythmic movement and activation of large muscle groups necessary to stimulate cardiovascular adaptation (Hamka, 2025). The sedentary nature of digital-based study programs further exacerbates this issue, aligning with the global trend of insufficient physical activity identified by the World Health Organization (World Health Organization [WHO], 2020).

Implication for Workforce Readiness and Education Policy

The high prevalence of poor cardiovascular fitness among vocational school students has significant implications for both health and industrial productivity. For students preparing to enter the workforce, low VO2max levels directly hinder their work readiness. In sectors such as automotive and textiles, high job demands involve repetitive physical tasks and prolonged static postures, requiring strong endurance to prevent fatigue and workplace injuries.

Conversely, in the digital industry, low fitness levels exacerbate the negative impacts of sedentary behavior, including impaired concentration and declining mental health (Bati et al., 2024; World Health Organization [WHO], 2020).

To address this issue, physical educstion in vocational high schools must evolve beyond traditional models. By strengthening the link between research and national policy, the implementation of high intensity interval training (HIIT) is recomended as a time efficient intervention that aligns with the demanding vocatioanl high school curriculum (Liu et al., 2024). This approach aligns with regulation of the minister of education of the republic of indonesia no.8 of 2024, which mandates the integration of a curriculum that supports students graduation competemces not only academically, but also physically. PE program must be designed as work fitness preparation. Enabling students to enter the workforce in a healthy and productive condition (Kemenpora RI, 2022).

CONCLUSION

This study presents a comprehensive overview of cardiorespiratory fitness among students at SMK Bina Nusantara Ungarang, highlighting the important role of age and biological sex in determining vo2max levels. The main contribution of this study is identification of a significant "fitness gap," particularly amonog female students, 70.66% of whom fall into the poor and very poor categories. While male students demonstrated progressive improvements in aerobic capacity peaking at age 18, the stagnant profile observed among female students across all groups underscores the urgent need for gender spesific physical interventions. These findings serve as a strategic foundation for vocatioanal schools to align physical education with the high endurance demands of the industrial workforce, ensuring students are physically prepared for their future professional environtments.

Despite these practical findings, this study acknowledges several limitations that should be noted. The use of field estimates via the 1.6 km Rockport walk test, while efficient for a large sample of 298 students, may be less accurate compared to laboratory gas analysis. Furthermore, this cross sectional study design captures fitness levels at a single point in time, thereby limting the ability to draw definitive causal conclusions regarding long term physiological changes. Therefore, future research should consider a longitudinal approach to track the development of vo2max from the first to the final year of vocational school, while incorporating variables such as nutritional intake and daily physical activity duration to provide a more holistic understanding.

Based on these findings, it is recomended that vocational education institutions modernize their physical education curricula by integrating time efficient models, such us high intensity interval training (HIIT) or active breaks during lengthy practical workshop sessions. Special attention should be given to female students through inclusive and engaging aerobic programs to effectively address the observe fitness gap. By strengthening the link between

school based physical education and occupational health, educational policies can better support the graduation competencies of vocational students, enabling them to enter various industrial sectors in a healthy, fit, and productive state.

AI DISCLOSURE STATEMENT

The authors declare that no generative AI tools were used to generate, analyze, interpret, synthesize, or write the scientific content of this manuscript.

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