JSSF (12) (1) (2026)

Journal of Sport Sciences and Fitness

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

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

Mohammad Ibnu Aldi*, Wiga Nurlatifa Romadhoni, Ana Nurlatifah

Sports Coaching Education, Universitas Negeri Semarang, Semarang City, Indonesia

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

Background: 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.

*Correspondence E-mail: ibnualdi12@students.unnes.ac.id

PISSN 2252-6528
EISSN 2745-5718

INTRODUCTION

According to Regulation No. 8 of 2024 of the Minister of Education and Culture of the Republic of Indonesia, 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 in which industrial productivity is directly linked to physical fitness. Therefore, maintaining optimal health is a professional necessity for SMK students to meet strict industry standards (Tasya et al., 2025).

Cardiovascular fitness (CRF), as measured by VO2max, is an important indicator of 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 of 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 measurement, 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 critical 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 greater increase in VO2max, driven by increases in lean mass and hemoglobin levels. In contrast, 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 and college students (Candra & Setiabudi, 2021), there is a significant lack of data on vocational high school students. Unlike their peers in general education, SMK students engage in specialized vocational practices, ranging from manual labor in automotive workshops to static endurance in textile laboratories, which place distinct physiological demands on them (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 the background described in the previous paragraphs, there is a clear need to conduct targeted research to analyze students' cardiovascular fitness at SMK Bina Nusantara Ungaran, by gender and age. This research is very important for obtaining relevant data that can serve as a basis for developing physical education and health programs. Since VO2max is a critical component of physical capacity, which enables individuals to perform daily activities effectively and achieve a high quality of life, assessing 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 described 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 a quantitative descriptive research design. Cardiovascular fitness was measured using the Rockport One-Mile Walk Test (RMWT), a maximal field test designed to estimate an individual's VO2max. The RMWT) The tool showed high validity (r = 0.817) and high reliability (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 compared with 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. Participants must complete 10 laps to reach a total distance of 1,609 meters (1 mile). To ensure accuracy, the route was clearly marked, and lap counts were monitored by field assistants assigned to each participant to ensure safety, accurate 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 were 10th- and 11th-grade students at BSMK Bina Nusantara Ungaran, aged 14 to 18 years. The total population consisted of 298 students, including 223 males and 75 females; a 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 they understood the procedures and their right to withdraw at any time.

The quantitative data collected included gender, age, and 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 and to serve as a basis for developing the physical education and health curriculum.

Data collection involves conducting an RMWT test, in which students walk or run 1.6 km at their maximum achievable speed. Completion time is recorded in minutes to calculate VO2max values. Each session begins with a structured warm-up to minimize injury risk and ensure physical readiness. This method is highly recommended for large-scale fitness assessments due to its safety, efficiency, ease of implementation, and low cost.

VO2max calculations are based on the following RMWT 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 following 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).

The calculated VO2max values (ml/kg/min) were then classified into fitness categories (excellent, good, average, poor, very poor) according to the normative standards for adolescents established by the Kemenkes RI.

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

Data analysis was performed using Microsoft Excel. The analysis technique used was descriptive, including calculating the mean, median, and standard deviation (SD) of VO2max, as well as the frequency distribution of cardiovascular fitness categories by gender. The statistical significance level was set at $\alpha = 0.05$ to maintain consistency and accuracy in interpreting the results of the data analysis.

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 students at SMK Bina Nusantara Ungaran. The main purpose of this analysis was to determine the average cardiovascular

fitness level, categorized by fitness distribution, and to analyze the influence of gender and age variables. The research results are presented sequentially, beginning with descriptive statistical analysis.

This study presents the results of statistical analysis of RVO2max data estimated using the Rockport One-Mile TWalk test from a total of N = 298 students at SMK NBina Nusantara Ungaran. This analysis examines the descriptive profile of cardiovascular fitness, its distribution across fitness categories, and the influence of gender and age. The findings are presented sequentially, beginning with descriptive statistics.

1. Statistics of cardiovascular fitness by age and Sex

Cardiovascular fitness (CRF) profiles were analyzed 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 year-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 upward 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 significant aerobic profile across all age groups. The mean -year-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 suggests that biological maturation alone does not significantly enhance cardiovascular endurance in 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 students by vo2max level provides a practical overview of their endurance capacity. The following tables show the frequency distributions for male and female students, respectively.

Table 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 achieved 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 although 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 female students at SMK Bina Nusantara Ungaran, revealing certain trends within each age group:

Table 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 are at a lower fitness level. Overall, 70.66% of female students were classified 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 across age groups consistently exhibit low cardiovascular endurance.

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: the majority fall into the “poor” and “very poor” categories. These findings suggest that, despite being in the peak phase of their development, the students’ aerobic capacity has not developed optimally.

Low fitness levels during adolescence pose a significant risk of poor metabolic health outcomes later in life. As discussed earlier in the introduction, research shows that poor cardiovascular fitness is closely linked to an increased risk of metabolic disorders, such as hypertension and cardiovascular problems, even at a young age (García-Hermoso et al., 2020). Therefore, these findings emphasize the urgent need to map fitness as a strategic foundation for designing physical activity interventions in school settings.

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 environmental factors. adolescent girls often have lower participation rates in moderate-to-vigorous 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 students in 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 (WHO) (World Health Organization [WHO], 2020).

Implication For Workface 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 directly, 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 education 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 recommended as a time-efficient intervention that aligns with the demanding vocational high school curriculum (Liu et al., 2024). This approach aligns with Regulation No. 8 of 2024 of the Minister of Education of the Republic of Indonesia, which mandates integrating a curriculum that supports students' graduation competencies not only academically but also physically. The 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 roles of age and biological sex in determining VO2max levels. The main contribution of this study is the identification of a significant "fitness gap," particularly among 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-specific physical interventions. These findings provide a strategic foundation for vocational schools to align physical education with the high-endurance demands of the industrial workforce, ensuring students are physically prepared for their future professional environments.

Despite these practical findings, this study acknowledges several limitations. 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 limiting the ability to draw definitive causal conclusions regarding long-term physiological changes. Therefore, future research should adopt a longitudinal design to track VO2max development 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 recommended that vocational education institutions modernize their physical education curricula by integrating time-efficient models, such as high-intensity interval training (HIIT) or active breaks during lengthy practical workshop sessions. Special attention should be given to female students through inclusive, engaging aerobic programs to address the observed fitness gap effectively. 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.

REFERENCES

Armstrong, N., & Welsman, J. (2019). Sex-Speci fi c Longitudinal Modeling of Youth Peak Oxygen Uptake. Human KINETICS, 204–212. https://doi.org/10.1123/pes.2018-0175

Bati, A. R., Saputro, Y. D., & Artanty, A. (2024). Gender Differences in Physical Activity Levels among Male and Female Students in Extracurricular Sports Activities at Katolik. Jp.Jok (Jurnal Pendidikan Jasmani, Olahraga Dan Kesehatan), 8(1), 46–54. https://doi.org/10.33503/jp.jok.v8i1.2044

Budiman, I., Aprijana, I., & Iskandar, D. (2017). Penggunaan Tes Lapangan 1,6 Km Metoda Rockport Untuk Pengukuran Kebugaran Jantung-Paru Dengan Baku Emas Treadmill Metoda Bruce. Jurnal Sains Keolahragaan Dan Kesehatan, 2(2), 38. https://doi.org/10.5614/jskk.2017.2.2.2

Candra, A. T., & Setiabudi, M. A. (2021). Analisis Tingkat Volume Oksigen Maksimal (VO 2 Max) Camaba Prodi PJKR. 7(1), 10–17.

Gantarialdha, N. (2021). Hubungan Indeks Massa Tubuh Terhadap Ketahanan Kardiorespirasi Dinyatakan Dalam VO2MAX. Jurnal Medika Hutama, 02(04), 1162–1168.

García-Hermoso, A., Ramírez-Vélez, R., García-Alonso, Y., Alonso-Martínez, A. M., & Izquierdo, M. (2020). Association of Cardiorespiratory Fitness Levels During Youth With Health Risk Later in Life A Systematic Review and Meta-analysis. 1–9. https://doi.org/10.1001/jamapediatrics.2020.2400

Hamka, B. (2025). Kesiapan Fisik Remaja SMK Untuk Praktik Kerja : Tujuan Literatur Tentang Standar Pertumbuhan Kesehatan Fisik. 06(02), 94–101.

Jalili, M., Nazem, F., Sazvar, A., & Ranjbar, K. (2018). Prediction of Maximal Oxygen Uptake by Six-Minute Walk Test and Body Mass Index in Healthy Boys. The Journal of Pediatrics, 200, 155–159. https://doi.org/10.1016/j.jpeds.2018.04.026

Kemenpora RI. (2022). Olahraga , Daya Saing , dan Kebijakan.

Kumar, N., & Shivani, G. (2020). Comparison of Rockport one - mile walk test and McArdle step test for the prediction of VO 2 max. Saudi Journal of Sports Medicine, 2019–2022. https://doi.org/10.4103/sjsm.sjsm_2_20

Liu, Y., Barker, A. R., Adlam, A. R., Li, M., Duncombe, S. L., Agbaje, A. O., Gu, Y., Zhou, H., & Williams, C. A. (2024). intervention in adolescents : study randomised controlled trial. October. https://doi.org/10.3389/fped.2024.1458610

Pojskic, H., Eslami, B., & Clemente, F. M. (2018). Relationship Between Obesity , Physical Activity , and Cardiorespiratory Fitness Levels in Children and Adolescents in Bosnia and Herzegovina : An Analysis of Gender Differences. 9(November), 1–11. https://doi.org/10.3389/fphys.2018.01734

Raghuveer, G., Hartz, J., Lubans, D., Wiltz, J., Mietus-snyder, M., Perak, A., Baker-smith, C., Pietris, N., & Edwards, N. (2020). Cardiorespiratory Fitness in Youth – An Important Marker of Health: A Scientific Statement From the American Heart Association. 142(7). https://doi.org/10.1161/CIR.0000000000000866

Salahudin, Satriawan, R., & Muhammad. (2025). Membangun Karakter Positif melalui Pendidikan Jasmani di Sekolah : Sinergi antara Fisik dan Moral Fostering Positive Character through Physical Education in Schools : A Synergy between Physical and Moral Development. 4(1), 40–54. https://doi.org/10.36312/dpe.v4i1.2454

Srivastava, S., Tamrakar, S., Nallathambi, N., & Vrindavanam, S. A. (2024). Assessment of Maximal Oxygen Uptake (VO2 Max) in Athletes and Nonathletes Assessed in Sports Physiology Laboratory. 16(5). https://doi.org/10.7759/cureus.61124

Tasya, A., Zerlind, A., Zulaekah, S., Isnaeni, F. N., & Lathifah, N. (2025). Hubungan antara Asupan Fe dan Pengetahuan Gizi dengan Tingkat Kebugaran Jasmani pada Anggota UKM Futsal Universitas di Surakarta. 4(2), 1172–1181. https://doi.org/10.38035/jim.v4i2.1069

Weiglein, L., Herrick, J., Kirk, S., & Kirk, E. P. (2011). The 1-Mile Walk Test is a Valid Predictor of VO 2max and is a Reliable Alternative Fitness Test to the 1 . 5-Mile Run in U . S . Air Force Males. MILITARY MEDICINE, 176, 669–673. https://doi.org/10.7205/MILMED-D-10-00444

World Health Organization [WHO]. (2020). Who guidelines on physical activity and sedentary behaviour.

ty