
Increasing Cardiorespiratory Endurance Through Interval Training Method in Class X Students at SMK Negeri 6 Makassar

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Article History <i>Received: 05-08-2026;</i> <i>Reviewed: 19-08-2026;</i> <i>Accepted: 12-09-2026;</i> <i>Published: 22-09-2026;</i>	ABSTRACT Backgroud: This study examined the effect of an interval training method on cardiorespiratory endurance among tenth-grade students at SMK Negeri 6 Makassar. Methods: using a quantitative pre-experimental method with a one-group pretest-posttest design. Twenty-four students, selected through purposive sampling, completed a six-week interval running program (three sessions per week) during physical education and extracurricular sports sessions. Cardiorespiratory endurance was estimated via the Multistage Fitness Test (bleep test) and expressed as maximal oxygen uptake (VO ₂ max), with data analyzed using the Shapiro-Wilk normality test and paired sample t-test. Results: showed a significant increase in average VO ₂ max, from 36.42 ± 3.15 mL/kg/min to 40.87 ± 3.42 mL/kg/min ($t = 9.128$, $p = 0.000$, Cohen's $d = 1.86$, 95% CI 3.44–5.46 mL/kg/min). Conclusions: These findings suggest that a structured interval training program is associated with improved cardiorespiratory endurance among senior high school students, although the absence of a control group limits causal conclusions. Physical education teachers may consider incorporating periodized interval training into PJOK lessons and extracurricular sports programs to support students' cardiorespiratory fitness. Keywords: Interval training; Cardiorespiratory endurance; VO ₂ max; Physical education; Senior high school students
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INTRODUCTION

Physical education, sports, and health (PJOK) has a strategic role in shaping the physical fitness of students, one of which is through the development of cardiorespiratory endurance (Arga & Arfah, 2026). Cardiorespiratory endurance is the ability of the heart, lungs, and blood vessels to distribute oxygen to muscles that work efficiently for a relatively long period of time, and is one of the components of physical fitness that most determines students' ability to participate in physical activities and PJOK learning optimally (Akhtar et al., 2024; Kuk & Lee, 2020; Ridwan et al., 2025). Low cardiorespiratory endurance in high school age students can have an impact on easy fatigue during activities, decreased study concentration, and an increased risk of cardiometabolic health disorders in the future (Irfan et al., 2024).

Cardiorespiratory endurance is one of the important components of physical fitness because it is related to the body's ability to supply oxygen efficiently during physical activity. For students,

good physical fitness not only supports performance in sports activities, but also contributes to the body's readiness when participating in daily learning activities (Arga, 2025a) . However, in reality, there are still students who have a suboptimal level of cardiorespiratory endurance, which is characterized by getting tired quickly when doing physical activities with moderate to high intensity. This condition needs to be addressed through a systematic exercise approach and according to the characteristics of the student's age and ability (Arga, 2025b; Guo et al., 2023; Kuk & Lee, 2020) .

One of the training methods that can be used to increase cardiorespiratory endurance is interval training. This method combines the training phase with a certain intensity and the recovery phase in a measured time span (Hudain et al., 2025) . Through the application of interval training, the cardiovascular system and the work efficiency ability of the lungs can be stimulated to adapt, so that the endurance capacity increases gradually. In addition, the interval training method tends to be more structured and can be adjusted in intensity, allowing students to benefit from exercise without neglecting the safety and comfort aspects during the activity (Arslan et al., 2022; Hidayat et al., 2025; Irfan et al., 2023) .

This research focuses on increasing cardiorespiratory endurance through the application of the interval training method in grade X students at SMK Negeri 6 Makassar. The research was conducted to answer the need for effective exercise strategies in increasing students' cardiorespiratory endurance, as well as provide empirical evidence that can be used as a basis for learning Physical Education. Thus, the results of this study are expected to contribute to the development of exercise methods in the school environment, especially in designing fitness training programs that are more targeted, measurable, and sustainable (Fathir et al., 2025; Irfan et al., 2023; Sahabuddin et al., 2021) .

Various training methods have been developed to increase cardiorespiratory endurance, one of which is the interval training method. Interval training is a form of exercise that combines a period of high-intensity work interspersed with a recovery period with low intensity repeatedly, so as to provide effective physiological pressure on the cardiorespiratory system without requiring too long an exercise duration. This characteristic makes interval training very suitable for application in PJOK learning and extracurricular activities in schools that have limited face-to-face time.

International scientific evidence shows that high-intensity interval training (HIIT) integrated into school programs is effective in improving cardiorespiratory fitness while improving body composition in children and adolescents (Cao et al., 2022). Large-scale studies of high school adolescents who applied eight-week interval exercise in PJOK lesson hours also reported a significant increase in VO₂max, especially in the male student group, with effects that persisted over the follow-up period (Domaradzki et al., 2025). The findings reinforce the argument that short-duration interval exercise can provide significant physiological benefits when applied in a structured and progressive manner in a school setting.

Studies with a similar protocol in high school students in Poland also showed that Tabata-based interval training carried out twice a week for eight weeks was able to increase aerobic capacity while reducing body fat percentage in adolescents with normal and excess weight (Domaradzki et al., 2025). In line with this, a study on basketball extracurricular participants at one of the vocational schools in Malang City found that interval training had a significant effect on increasing VO₂max endurance compared to the condition before being given treatment (Christy et al., 2022). These findings confirm that the interval training method has a strong evidence base, both in the context of international research and in the population of vocational high school students in Indonesia.

However, the level of physical fitness and cardiorespiratory endurance of students aged 14-16 years in Indonesia is still relatively low in most of the survey results conducted in various schools (Saputra et al., 2023) This is exacerbated by the limited allocation of PJOK learning time

and the lack of variation in training methods that are applied systematically and measurably in vocational high schools (SMK), which generally have a high burden of vocational practice hours so that there is less time for structured physical activity than in high school. Previous studies on interval training as described above have generally been conducted on adolescent populations in general or on certain sports extracurricular groups outside the context of vocational schools, so it is not widely known whether progressively designed short-term interval training programs are still effective in improving cardiorespiratory endurance when applied to vocational high school students with limited PJOK time allocation due to the high load of vocational practice hours. Research on the application of interval training methods specifically designed for grade X vocational school students, especially in the context of schools in Makassar City, is still limited. Based on these gaps, this study hypothesizes that a progressively designed six-week interval exercise program will have a significant influence on increasing the cardiorespiratory endurance (VO₂max) of class X students of SMK Negeri 6 Makassar.

The novelty of this study lies in the direct application of the interval training method that was progressively designed for six weeks in the population of class X students of SMK Negeri 6 Makassar, a group that has been underrepresented in the literature on interval training in the Indonesian vocational secondary education environment, as well as in the use of the Multistage Fitness Test (bleep test) instrument to estimate VO₂max objectively and easily applied in the context of PJOK learning in schools. Therefore, this study aims to determine the effect of interval training methods on increasing cardiorespiratory endurance in grade X students at SMK Negeri 6 Makassar, which was held in May-June 2026.

METHODS

This study is a quantitative research with a pre-experimental design method, using a one-group pretest-posttest design. This design was chosen to measure changes in cardiorespiratory endurance in one group of students before and after being treated in the form of an interval training program. The research was carried out at SMK Negeri 6 Makassar in May-June 2026, with a series of implementations including an initial test (pretest), provision of exercise treatment for six weeks with a frequency of three times per week, and final test (posttest) (Arga & Fitri, 2025).

The research population was all students in class X of SMK Negeri 6 Makassar who participated in PJOK learning and sports extracurricular activities. The research sample amounted to 24 students who were determined through purposive sampling techniques, with inclusion criteria aged 15-16 years, in good health and without injury to the lower limbs, no history of cardiovascular or respiratory diseases, and willing to participate in the entire series of training and measurement programs in full. The number of samples of 24 students was determined based on the calculation of the minimum sample size for the paired sample t-test with the assumption of medium to large effect size, significance level of 5%, and power of 80%, so that this number is considered adequate to detect statistically significant differences in average VO₂max.

Cardiorespiratory endurance was measured using the Multistage Fitness Test (bleep test), which is a 20-meter back-and-forth running test that follows the rhythm of the sound signal at a speed that gradually increases every minute. The level and number of shuttles that students successfully complete are converted to the estimated value of VO₂max (in ml/kg/minute) using a standardized bleep test conversion table. The Multistage Fitness Test is an instrument whose validity and reliability have been extensively tested to estimate VO₂max in the child and adolescent population, with good concurrent validity to direct VO₂max measurement through respiratory gas analysis and high test-retest reliability (Léger et al., 1988), making it suitable for use as a practical VO₂max estimation instrument in the context of PJOK learning in schools. Data were collected through three stages, namely (1) cardiorespiratory endurance pretest before the exercise program

began; (2) the provision of a six-week interval training program with a frequency of three sessions per week; and (3) posttest with a measurement procedure identical to the pretest.

The interval training program was carried out three sessions per week for six weeks (18 sessions total), integrated into PJOK learning hours and sports extracurricular activities. Each session began with a 10-minute dynamic warm-up, followed by core training in the form of interval running on straight tracks and school grounds, with a work-to-rest ratio of 1:1 in the first and second weeks (high-intensity running of 80-85% maximum pulse rate for 2 minutes, interspersed with low-intensity recovery jogging for 2 minutes, 6 reps), increasing to a work-to-rest ratio of 2:1 in the third and fourth weeks (3-minute run, 1.5-minute recovery, 6 reps), and reaching a peak intensity of 85-90% maximum pulse rate with an increase of reps to 8 reps in the fifth and sixth weeks, following the principle of progressive overload. Each session ended with a 10-minute cool-down and stretch. Exercise intensity was monitored through manual pulse calculation in the first 15 seconds after work reps, which were then converted to pulses per minute. To minimize the influence of additional physical activity outside of the study program, all students were asked not to participate in other structured physical exercise programs during the six-week study period and were asked to report daily physical activity performed outside of school through a simple logbook that was periodically checked by the researchers. However, student adherence to these instructions could not be strictly monitored for 24 hours, so the possible influence of physical activity outside of the program remained one of the limitations of the study outlined in the discussion section.

Data were analyzed using the Shapiro-Wilk normality test to ensure that the distribution of pretest and posttest data was distributed normally, followed by a paired sample t-test to determine the significance of the average difference before and after treatment. The magnitude of the influence was calculated using Cohen's d (Cohen, 1988). Data analysis was carried out with a significance level of 5% ($p < 0.05$).

RESEARCH RESULTS

1. The results of the normality test of pretest and posttest data for the cardiorespiratory endurance variable (VO2max) are presented in Table 1.

Table 1. Shapiro-Wilk Normality Test Results (VO2max)

Data Groups	Sig. (Shapiro-Wilk)	Remarks
Pretest	0,364	Normal
Posttest	0,298	Normal

Source: Results of research data processing, June 2026.

Based on Table 1, the significance value (p) in the Shapiro-Wilk test for the pretest and posttest data is greater than 0.05, so that the VO2max data is declared to be normally distributed. Thus, the hypothesis test is continued using a paired sample t-test.

Table 2. Paired Sample T-Test (VO2max) Test Results

Rerata Pretest	Rerata Posttest	Differences	t-count	Sig. (2-tailed)
36,42 ± 3,15	40,87 ± 3,42	4,45	9,128	0,000

Source: Results of research data processing, June 2026.

The results of the analysis in Table 2 showed an increase in the average VO2max from 36.42 ± 3.15 ml/kg/min in the pretest to 40.87 ± 3.42 ml/kg/min in the posttest, with a t-count value

of 9.128 and a significance of 0.000 ($p < 0.05$), which means that there was a significant increase in cardiorespiratory endurance after the administration of the interval exercise program. This increase is equivalent to a 12.22% increase in the pretest value, with a magnitude of influence (Cohen's d) of 1.86 and a 95% confidence interval of 3.44; 5.46 ml/kg/min, which is classified as a large effect. The comparison of the average VO₂max of the pretest and posttest is presented in Figure 1.

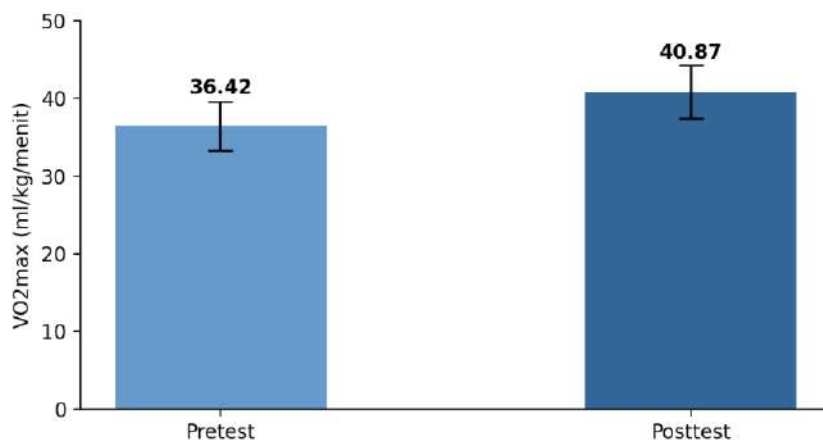


Figure 1. Comparison of Average VO₂max in Pretest and Posttest

These findings show that a six-week interval training program integrated into PJOK learning and extracurricular activities has a positive and significant influence on increasing the cardiorespiratory endurance of class X students of SMK Negeri 6 Makassar.

DISCUSSION

The results of this study show that the interval exercise method significantly improves students' cardiorespiratory endurance, in line with the findings of experimental research on high school students who applied eight weeks of high-intensity interval exercise in a school-based physical education program, which reported a significant increase in VO₂max and persisted in the follow-up period (Domaradzki et al., 2025). The increase in VO₂max in this study was also consistent with the results of studies in adolescents with normal and excess weight which showed that eight weeks of Tabata-based interval training in PJOK lesson hours was effective in increasing aerobic capacity compared to pre-treatment conditions (Domaradzki et al., 2025).

Physiologically, the increase in VO₂max found in this study is in line with the cardiorespiratory adaptations that generally accompany interval exercise, such as an increase in stroke volume and cardiac output, an increase in capillary density in actively working muscles, and an improvement in the muscles' ability to extract and utilize oxygen during high-intensity physical activity. The alternation of periods of high-intensity work and repeated recovery in interval training is known to stimulate central (heart and blood vessels) and peripheral adaptations (skeletal muscles) in the cardiorespiratory system, thereby increasing aerobic capacity overall. However, this study did not directly measure these physiological parameters, such as stroke volume, cardiac output, capillary density, or muscle oxidative enzyme activity, so the explanation of this adaptation mechanism is interpretive based on the literature and cannot be empirically confirmed to occur in this study subject.

The effectiveness of interval training in improving the cardiorespiratory fitness of children and adolescents was also strengthened by controlled experimental research on elementary school students with obesity conditions, which showed that a twelve-week high-intensity interval exercise

program integrated with a PJOK clock was able to significantly increase VO₂max compared to the control group (Cao et al., 2022). These findings are relevant to the results of this study which used a shorter duration, which is six weeks, but still resulted in a statistically significant increase in VO₂max, thus confirming that interval training is a time-efficient method to increase cardiorespiratory endurance in school environments that have limited allocation of instructional hours, especially in vocational high schools.

In addition, the increase in cardiorespiratory endurance in this study is also in line with the results of research on basketball extracurricular participants at one of the vocational schools in Malang City, which found that interval training has a significant influence on increasing students' VO₂max endurance (Christy et al., 2022). The similarity of the research population, namely vocational high school students, strengthens the relevance of interval training methods to be applied in the context of PJOK learning and extracurricular activities in the vocational school environment. These findings are also strengthened by the results of research on pencak silat athletes who showed that interval training contributed to a consistent improvement in endurance ability across all study subjects (Dhanireksa et al., 2023), as well as research on cardiovascular endurance using a combination of interval training and shuttle run which also reported a significant improvement after treatment (Nawir et al., 2023; Puriana et al., 2024).

Practically, these findings indicate that PJOK teachers, especially in vocational high schools such as SMK Negeri 6 Makassar, can consider the application of interval training methods as part of a structured and periodized learning program, to support the improvement of students' cardiorespiratory endurance amid limited PJOK learning time allocation. This is in line with the results of a survey that shows that the level of physical activity and physical fitness of students aged 14-16 years in Indonesia is still relatively low in most of the research sample (Saputra et al., 2023; Aurlia & Rerung, 2025) so that time-efficient exercise interventions such as interval training are relevant to be applied more widely.

This study has a number of limitations that need to be considered in interpreting the results. First, the one-group pretest-posttest design without a control group does not allow researchers to isolate the effect of interval training from the effects of other physical activity that students may do outside the research program, as well as from the learning effects of test-retest effect. Second, the relatively small number of samples ($n = 24$) limits the generalization of the findings and reduces the accuracy of the effect size estimate, even though the results of the analysis show a statistically large effect. Third, the measurement of VO₂max using the Multistage Fitness Test is indirect estimation, so the accuracy level is relatively lower than laboratory measurements using respiratory gas analysis. Fourth, this study only involved students from one school, so the findings could not necessarily be generalized to other vocational school students with different characteristics of learning programs or sports facilities. Therefore, the results of this study need to be interpreted carefully and should be further confirmed through research with a randomized controlled trial design, a larger sample number, and direct VO₂max measurement.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results and discussion, it can be concluded that the interval exercise method for six weeks has a significant influence on the increase in cardiorespiratory endurance of class X students of SMK Negeri 6 Makassar. The purpose of the study to determine the effect of interval training on cardiorespiratory endurance has been achieved, with a statistically significant increase in VO₂max ($p < 0.05$) and is classified as a major effect category.

For PJOK teachers and extracurricular coaches, the interval training method is recommended to be periodically integrated into PJOK learning and extracurricular training programs, with a progressive increase in intensity and work-rest ratio and consistent pulse monitoring to maintain the safety of the exercise. For schools and education policy makers, these

results can be considered in the preparation of the curriculum and the allocation of PJOK learning time in vocational schools, which are generally limited due to the tight hours of vocational practice. For subsequent researchers, it is recommended to use a randomized controlled trial research design, expand the number of samples and school coverage, and compare the effectiveness of interval training with other endurance training methods such as fartlek or continuous running in the vocational high school student population.

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