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Effectiveness of Interval Training Based on Maximum Aerobic Speed (MAS) to Improve Aerobic Capacity

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Abstract

This study aimed to investigate the impact of personalized interval training (short and long) based on Maximum Aerobic Rate (MAS) on improving athletes' aerobic capacity. Using quantitative experimental method with 2x2 factorial design, 16 athletes were divided into four groups: SIT-MAS High, SIT-MAS Low, LIT-MAS High, and LIT-MAS Low. Although the Friedman test showed no statistically significant differences in aerobic improvements among the four groups overall, intragroup analysis showed mixed results. Statistically significant increases in aerobic capacity were found in the LIT-MAS High and SIT-MAS low groups, which supported the third and fifth hypotheses. In contrast, the improvements in the SIT-MAS High and LIT-MAS Low groups were not significant. There was also a significant difference between SIT and LIT in the low MAS group, but not in the high MAS group. This study concludes that personalization of interval training based on an individual's MAS profile is important, with LIT shown to be effective for low MAS athletes and SIT effective for high MAS athletes. Limitations of this study include the very small sample size (n=3 or n=4 per group), as well as external factors such as inconsistent training schedules, pressure from competition, and athlete injuries.

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INTRODUCTION

Aerobic fitness is one of the crucial components of sports performance, directly affecting an athlete›s endurance and ability to sustain high training intensity over a longer duration (Sidik & Rosdiana, 2023). A longitudinal study involving thousands of adult individuals showed that although participation in physical activity is increasing, the significant increase in population average Vo2 Max is only about 5-10% in the last decade, suggesting a stagnation in the optimization of aerobic capacity because many are still only doing traditional exercises that lack variety(Mutohir et al., 2023).

This highlights that traditional exercise approaches may not always be sufficient to induce the maximal physiological adaptations required to substantially increase aerobic capacity. Interval training has proven to be highly effective due to its intermittent nature, which involves high intensity intervals interspersed with recovery periods. This training pattern efficiently triggers superior physiological adaptations compared to continuous training.

These adaptations include increased cardiovascular efficiency, increased mitochondrial (cellular energy center) capacity, and optimization of oxygen use by the body. Interval training can, among other things, burn fat, increase metabolism, improve cardiovascular health, improve mood and mental health, and reduce body weight and body fat percentage (Al-khusaini et al., 2024). Furthermore, interval training also strengthens muscular endurance and minimizes premature fatigue, allowing athletes to maintain peak performance for longer (Haff & N.Triplett, 2016).

Interval Training involves different types of intervals 1. Short Interval Training with high intensity (95% of best performance standard) with exercise duration of 5-30 seconds with longer 15-150 second lathan intervals until return to warm-up rate (Haff & N.Triplett, 2016). Short interval training emphasizes alactacid anaerobic endurance training but some aerobic adaptations will also occur (Jin et al., 2025). SIT can also be adapted for different age groups and fitness levels, importance and intensity, and differently by beginners and professional athletes (Vollaard & Metcalfe, 2017), 2. Long interval training with intensity (85-90% of best performance standard) adheres to exercise duration of 2-5 minutes with exercise intervals of 2-8 minutes (Cress et al., 2015). Long Interval Training involves longer exercise durations, designed to improve cardiovascular endurance and aerobic capacity, increase lactate and VO2, and trigger physiological changes (Bermeo Guamán et al., 2023). Long interval training significantly improves performance quality, with athletes typically reaching 180-200 beats per minute during the training period, and 130-140 beats per minute during the recovery period. This increases oxygen consumption and blood pressure, thereby improving cardiovascular and skeletal muscle metabolism (Mølmen & Rønnestad, 2024).

This study aimed to optimize air capacity by developing a personalized exercise program based on individual maximum velocity (MAS) intensity and duration. This approach helps athletes achieve specific and timely target intervals, promotes optimal physiological stimulation, reduces deficient or excessive training conditions (Cetindemir & Cihan, 2022). Given the significant effectiveness of interval training in optimizing aerobic capacity, it is crucial to develop strategies to personalize exercise programs to achieve maximum efficiency and effectiveness. A prospective approach is to base interval intensity and duration on an individual›s maximum aerobic speed capacity (MAS) (Balasekaran et al., 2023).

MAS represents the highest speed of movement that can be sustained exclusively through the aerobic energy system. By classifying athletes based on their MAS profile-both in the high and low categories-it is possible to design more specific and precise short and long interval training targets (Baker & Heaney, 2015). This methodology facilitates precise adjustment of training load, which is essential for inducing optimal physiological stimulation, preventing under- or over-training, and optimizing aerobic adaptation in each individual (Widiatmika, 2015).

The relationship between interval training and grouping by Maximum Aerobic Speed (MAS) is at the core of personalizing training targets for aerobic capacity improvement. MAS, as an individual measure of the highest running speed that can be aerobically sustained, provides a quantitative basis for determining optimal training intensity (Balasekaran et al., 2023).

By grouping athletes based on their MAS profile, either in the high MAS or low MAS category, coaches can develop very specific interval training programs. Athletes with higher MAS may be able to tolerate and benefit more from intervals of slightly longer duration or higher intensity within each rep, maximizing stimulation to the cardiovascular and mitochondrial systems (Cerezuela-Espejo et al., 2018). Conversely, individuals with lower MAS may require shorter interval durations, slightly more moderate intensities, or longer recovery periods to ensure quality exercise and prevent overexertion, which can hinder adaptation (Rini Ismalasari et al., 2024).

This personalized approach is crucial as it allows for precise adjustment of training load. This not only optimizes the physiological stimulation required for aerobic capacity improvement-such as increased cardiac stroke volume, capillary density, and oxidative enzyme activity-but also effectively prevents under-training or over-training. Thus, integrating MAS groupings into interval training designs will lead to more efficient, safe, and sustainable aerobic capacity improvements for each individual (Hernani et al., 2024).

This study aimed to determine the effect of applying the Interval Training method and Maximum Aerobic Speed (MAS) capacity on improving aerobic capacity. Specifically, this study investigated whether the combination of different types of interval training (short and long interval) with different levels of MAS (high and low) had a significant impact on the aerobic capacity of individuals. This study also sought to identify the differences in effects between short interval training and long interval training methods in both high and low MAS groups.

The hypotheses proposed in this study are as follows: 1. The application of Interval Training method and Maximum Aerobic Speed capacity significantly increases aerobic capacity, 2. Short Interval Training method with high MAS capacity has a significant effect on increasing aerobic capacity, 3. Long Interval Training method with high MAS capacity has a significant effect on increasing aerobic capacity, 4. Short Interval Training method with low MAS capacity also has a significant effect on increasing aerobic capacity, 5. Long Interval Training method with low MAS capacity has a significant effect on increasing aerobic capacity, 6. There is a difference in effect between the application of short interval training and long interval training methods on low MAS capacity. 7. There is a difference in effect between the application of short interval training and long interval training methods on high MAS capacity.

This study introduces a novel approach to interval training by personalizing short and long intervals based on an individual›s MAprofile. The goal is to identify the most effective interval training combinations for athletes with different MAS levels, providing more specific and efficient guidance for designing training programs. With this formulation, this study is expected to provide an empirical understanding of the effectiveness of various combinations of interval training methods and MAS levels in developing optimal aerobic capacity. These findings are expected to be a reference in the preparation of science-based physical training programs for the achievement of maximum athletic performance.

METHOD

This study applied a quantitative experimental method with a 2x2 factorial design to evaluate the interaction of two independent variables and their impact on the dependent variable (Oliveira et al., 2018), (i.e. Short Interval Training and Long interval training) and the level of Maximum Aerobic Speed capacity (high MAS and low MAS) on aerobic improvement. Using the sampling technique, namely purposive sampling and obtained 16 athletes from a total population of 24 athletes. Data analysis techniques used Friedman test with SPSS 31 program.

Table 1. Research Design

	SIT	LIT
MAS high	SIT- MAS high	LIT – MAS high
MAS low	SIT- MAS low	LIT- MAS low
	Aerobic	

Researchers conducted research on female futsal atlete who fit the criteria and obtained 16 people from 24 athletes. The stage begins with a pre-test with the Balke test research instrument. The results are used to determine the MAS of each athlete. Sort by MAS group using the formula MAS = distance (meters) / 900 seconds based on the Balke Test results (Giriwijoyo, S., & Sidik, 2009). determining the sample, dividing into 4 groups (SIT-High, SIT-Low, LITHigh, and LIT-Low), then conducting treatment Short Interval Training (SIT): This training uses running volumes of 5–30 seconds at very high intensity, around 95% of peak performance. Long Interval Training (LIT): This training has longer running volumes, ranging from 120–300 seconds (2–5 minutes), at an intensity of 85–90% of peak performance..finally held a post-test.

RESULTS AND DISCUSSION

This study analyzed the impact of short interval training (SIT) and long interval training (LIT) applications, personalized based on high and low maximum aerobic velocities (MAS), on improving athletes' aerobic capacity. The results obtained showed significant variations in physiological adaptations between groups, indicating that personalization of interval training based on individual MAS profiles indeed plays a crucial role in optimizing aerobic fitness responses. This discussion will elaborate on the key findings, compare the effectiveness of SIT and LIT in high and low MAS groups, and interpret the implications for the design of more effective and efficient training programs for athletes.

For the aerobic capacity improvement data in the High MAS group, the significance value (Sig.) was 0.022. Since this value is smaller than the significance level (α=0.05), it can be concluded that this data is not normally distributed. Similarly, for the aerobic capacity improvement data in the Low MAS group, the significance value (Sig.) was 0.021. As this value is also smaller than the significance level (α =0.05), this data is also not normally distributed. The implication of this finding is that any comparative statistical analysis involving the High MAS and Low MAS groups should utilize non-parametric statistical tests to ensure the validity of the results, as the assumption of normality was not met.

Table 2. Rank results for each group

Ranks	
	Mean Rank
SIT_MASTigh	1.88
SIT_MASLow	2.38
LIT_MASTHigh	2.50
LIT_MASLow	3.25

By comparing the significance value (Sig. = 0.497) with the general significance level (α=0.05), we find that 0.497>0.05. This means there is no statistically significant difference in aerobic improvement between the four conditions/groups tested (SIT_MASTHigh, SIT_MASLow, LIT_MASTHigh, and LIT_MASLow). In other words, our first hypothesis fails to reject the null hypothesis.

To answer the second, third, and fifth problems, the following table shows the results of the parametric test (Paired T-Test).

The significance value (p-value) generated from the paired sample t-test is smaller than 0.05, it can be concluded that there is a statistically significant average difference between the two conditions (pre-test and post-test), so the null hypothesis (no difference) is rejected and the alternative hypothesis (there is a difference) is accepted. Conversely, if the p-value is greater than 0.05, then there is no statistically significant difference and the null hypothesis is accepted(Rahmani et al., 2025). The above data includes: SIT MAS High yielded a two-sided significance value (p-value) of 0.166. LIT MAS High yielded a two-sided significance value (p-value) of 0.018. Low LIT MAS resulted in a two-sided significance value (p-value) of 0.076.

Based on the paired sample t-test analysis, the High LIT MAS group showed the most significant difference between the pre-test and post-test conditions on aerobic improvement. Their two-sided p-value was 0.018, which is well below the 0.05 threshold. This indicates that the intervention given to this group produced a statistically significant effect, so the null hypothesis (no difference) can be rejected and the alternative hypothesis (there is a difference) accepted.

The High SIT MAS group had a two-sided significance value of 0.166. Since this value is greater than 0.05, it can be concluded that there is no statistically significant difference between the pretest and post-test. In other words, the applied intervention did not have a significant impact on this group, so the null hypothesis (no difference) is accepted. Meanwhile, the Low MAS LIT group showed a two-sided significance value of 0.076. Although this value is smaller than the SIT MAS High group, it is still greater than 0.05. Therefore, just like the SIT MAS High group, no statistically significant difference was found in this group. This means that the intervention provided did not result in significant changes in the Low SIT MAS group.

To answer the fourth problem formulation, the results of the nonparametric test (Wilcoxon Signed Ranks Test).

Based on the data presented, the Wilcoxon Signed Ranks Test results show a significance value (p-value) of 0.109. This value is greater than the general significance level used, which is 0.05. Therefore, it can be concluded that there is no statistically significant difference between the "pre" and "post" results. In other words, SIT at low MAS showed no significant effect on aerobic improvement.

The results of Levene's test to check for equality of variance (homogeneity of variance) in the aerobic improvement data for the MAS Low and MAS High groups. Aerobic Improvement - Low MAS: The significance value (Sig.) is 0.022. Since this value is smaller than the general significance level (α =0.05), it can be concluded that the variance of the aerobic improvement data in the Low MAS group is not homogeneous (significantly different). Aerobic Improvement - High MAS: The significance value (Sig.) is 0.325. Since this value is greater than the general significance level (α =0.05), it can be concluded that the variance of aerobic improvement data in the High MAS group is homogeneous (not significantly different).

The assumption of homogeneity of variance is met for aerobic improvement data in the High MAS group, but not met in the Low MAS group. Answering the sixth hypothesis, in short interval training MAS low and long interval training MAS low there is a significant difference between them while in the seventh hypothesis short interval training MAS high and long interval training MAS high there is no significant difference between them.

Although the overall analysis (Friedman test) showed no significant differences between the four groups in general, the results of the intragroup analysis (comparison of pre-test and post-test) provided important findings. The argument states that adjusting interval training programs based on individual MAS profiles is essential to achieve significant improvements in aerobic capacity as the same approach is not effective for all athletes, which is consistent with previous research (Buchheit, 2008).

Statistically significant results, as seen in the High LIT-MAS and Low SIT-MAS groups, indicate real changes rather than chance. In the context of this study, "significant" means that the exercise intervention successfully produced a substantial increase in aerobic capacity in that group. Conversely, "non-significant" results (in the High SIT-MAS and Low LIT-MAS groups) indicate that the type of exercise applied did not produce a large enough effect to distinguish between pre-test and post-test results.

This reinforces the idea that not all interval training methods are suitable for every individual. The group with high MAS responded well to LIT, which involves longer exercise duration and high intensity. This aligns with previous research stating that athletes with high MAS can tolerate and benefit more from slightly longer intervals, maximizing stimulation of the cardiovascular system (MacInnis & Gibala, 2017).

In the context of comparison between training methods, the data showed that there was a significant difference between SIT and LIT in the low MAS group, which supported the sixth hypothesis. However, no significant difference was found between SIT and LIT in the high MAS group, so the seventh hypothesis was not supported. At low MAS, it is more suitable to perform LIT training because LIT still improves the athlete's aerobic ability supported by previous research (Fleck, 2011), while SIT is more focused on improving anaerobic ability. However, in the high MAS group, there is no significant difference because athletes may have already reached the limit of their aerobic ability, so the difference in aerobic capacity is not very noticeable (Stöggl, 2018).

CONCLUSION

Overall, these findings suggest that personalization of interval training based on MAS may yield mixed results. LIT was shown to be effective for low MAS, and SIT was effective for high MAS, suggesting the importance of considering individual MAS profiles in the design of exercise programs At low intensity, training with LIT is more significant because at low intensity, more endurance training is required to support aerobic improvement itself. Meanwhile, SIT training focuses more on improving speed, which will result in greater improvement in anaerobic capacity rather than aerobic capacity.

The difference in effect between SIT and LIT was also evident in the low MAS group, but not in the high MAS group. . This occurred because LIT focuses on improving aerobic capacity and SIT on anaerobic capacity. In the low MAS group, low-intensity programs can produce more significant improvements because they are better suited to the athletes' own adaptive abilities. The limitation of the very small sample size (N=3 or N=4 per group) should be acknowledged as it could potentially affect the statistical power and generalizability of the findings.

There are also external factors that affect the above results including, first athletes do not do treatment with the planned schedule. Second athletes do other exercises outside of treatment with high demands because they pursue matches in the middle of treatment and after treatment so that at least athletes have excessive pressure, some athletes suffered injuries after the match in the middle of treatment which caused less than optimal post-test results.

Research suggestions that can be proposed include replicating the study with a much larger sample size to improve the validity and generalization of the current limited findings (N=3 or N=4 per group). Additionally, it is important to design future studies with stricter control over external factors such as inconsistent training schedules, match pressure, and athlete injuries, which are known to influence outcomes. Further research could also investigate variations in the duration and intensity of interval training specific to each MAS group, as well as conduct more in-depth physiological analyses to understand the adaptive mechanisms at play, which were not fully measured in this study. Finally, long-term longitudinal studies are needed to assess the sustainability and retention of aerobic capacity improvements from this personalized training method

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