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Original Article Research

Increasing Anaerobic Endurance Using Strength Endurance Training and Continuous Running on Muscular Endurance

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Abstract

The aim of this study was to determine whether continuous running training, power endurance, and muscle endurance affect the increase in anaerobic endurance. This research method uses an experimental design. The sample used in this study were SSB Darma Sakti football athletes, Kuningan Regency, with a total of 16 people aged 17 years, taken using a non-probability technique, namely quota sampling. The research design uses a Two Group Pretest Posttest design. The first group was trained using continuous running exercises with power endurance and the second group used continuous running exercises with muscular endurance. The instrument in this study used a 300-meter running test to calculate lactacid anaerobic endurance in order to see changes before and after being given treatment. Processing of the data that has been obtained in the study is then processed using SPSS (Paired Sample T-Test) software. The results of the study showed that continuous running training with power endurance and continuous running with muscle endurance resulted in significant improvements in anaerobic endurance. This study contributes to the development of football-specific training models and provides a foundation for future research to explore longer training durations, varied age groups, or the integration of mental and tactical components alongside physical conditioning to further optimize anaerobic performance.

Keywords: Football, Continuous Running, Lactacide Anaerobic, Power Endurance, Muscular Endurance

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1. INTRODUCTION

Sport is important for the health of the body for everyone, one of the sports that is very much in demand, especially by Indonesian people is football, based on its characteristics in this sport, cooperation is needed in each position, each player must have an active role in playing, whether it is a forward, middle and back player (Maulana & Rusdiana, 2020). Football has faced many dynamic changes starting from a simple, primitive form to moving to the international level, currently football fans are increasing day by day and not only from the elderly but also children, parents, rich, poor, traders, farmers, employees, politicians, academics, especially women also like and participate in playing football games, this is influenced by the growth of the era and technology that has continued to grow rapidly lately, so that it often affects the growth of football games that millions of people are fascinated, according to Irfandi (2014: 1) in (Nufi Saidatus Tsaniyah et al., 2025). The game of football requires basic techniques and good physical condition, so improving football skills requires serious training (Hajarudin et al., 2024). According to (Bompa, Tudor & Buzzichelli, 2019), success in a match or championship is the result of planning, hard work, commitment, and training from athletes, which is und eniable.

Planned training, support and motivation from family and coaches, and infrastructure that facilitate training are essential (Romdona et al., 2024). Achieving the best performance influences the quality of athletes, that is influenced by various aspects, particularly internal and external factors. The influence of these factors includes physical strength, technique, tactics, and mental abilities, as well as external factors that can influence a coach, infrastructure, weather and climate, supporters, family, and so on (Alarfaj et al., 2024). To improve an athlete's performance, a coach must create a good training plan program, be regular in carrying out training, and with a good plan. This way, athletes can be helped to achieve more optimal performance results through structured training. A training program is a well-designed guide to support optimal athlete performance during the competition (Liu et al., 2025).

The dominant physical condition components in football are speed, strength, endurance, and power. Excellent physical condition can influence a player's performance (Romdona et al., 2025). Among the various components of physical fitness, anaerobic endurance serves as a critical foundation for football player performance, particularly in supporting repetitive high-intensity activities such as sprinting, ball contests, and rapid changes of direction (Turna et al., 2023). Specifically, lactacid anaerobic endurance relates to the body's ability to tolerate lactate accumulation resulting from high-intensity efforts lasting up to several minutes. To enhance this capacity, two commonly employed training approaches are strength endurance training and continuous running. Strength endurance training aims to improve the muscles' ability to sustain repeated contractions against resistance over time, directly contributing to muscular endurancea vital component for maintaining strength and technical stability until the end of a match. Meanwhile, continuous running at submaximal intensity primarily enhances cardiovascular efficiency and aerobic metabolism, which in turn supports faster recovery between bursts of anaerobic activity.

However, the urgency of this study arises from the lack of clarity regarding how these two training modalities either separately or in combination specifically influence improvements in lactacid anaerobic endurance. Does enhancing muscular endurance through strength endurance training yield a more significant impact on anaerobic endurance? Or is the physiological adaptation from continuous running more effective? Moreover, what happens when both methods are combined? Comparative understanding of the specific effects of each intervention remains limited, especially among adolescent football athletes. Therefore, this study was designed to experimentally examine and compare the effects of continuous running combined with strength endurance training versus continuous running combined with muscular endurance training on lactacid anaerobic endurance. The findings are expected to provide coaches with more evidence-based guidance for designing optimal training programs to enhance football players' anaerobic performance. Anaerobic and anaerobic endurance are crucial components for football players. Therefore, good anaerobic capacity and anaerobic endurance are essential for athletes to achieve peak condition. A well-planned and appropriate training program can improve anaerobic capacity and anaerobic endurance (Turna et al., 2023).

Optimal fitness is achieved through proper training, and athletes are required to consistently train to maintain physical condition and perfect technique (Mendes, 2016). Once athletes possess excellent technique and physical fitness, coaches are obligated to maintain their physical condition. This is a key factor in achieving athletic success. Physical abilities can be used as a benchmark for improving physical condition. Within sports training, physical conditioning training is essential for good fundamental movement skills, and this should begin early (Bartolo et al., 2024). Basically, someone who does physical exercise regularly will gain good benefits (Kerschan-Schindl et al., 2009). If they train regularly and continuously, football athletes will become accustomed to various conditions on the field (Iaia et al., 2009). Physical conditioning is essential for playing football. Therefore, coaches continue to develop training models to help athletes achieve desired results and achieve satisfactory results (Szedlak et al., 2025).

Endurance exercise performance is highly dependent on the interaction between biomechanical and physiological factors. Heart capacity is often considered a barrier to effective endurance training, hindering physical preparation for training focused on developing physiological qualities. Assessments that include components of muscle strength, such as speed or maximal oxygen uptake, and maximal anaerobic sprint speed, are now considered key performance indicators in the running population (Beattie et al., 2017). The ability to improve anaerobic performance can be achieved through repeated running programs, referring to the ability to execute three all-out sprint efforts separated by brief rest periods.. This is a complex quality related to several factors, including endurance capacity (e.g., VO2max and the speed at which VO2max is achieved) (Torres-Torrelo et al., 2018).

Anaerobic exercise requires rest intervals to regenerate adenosine triphosphate, allowing for continued activity. Anaerobic energy metabolism can occur without the presence of oxygen (Palar et al., 2015). During anaerobic activity, which involves optimal effort, the body works so hard that oxygen demand exceeds available levels. Therefore, muscles can perform activities depending on stored energy reserves. When muscles face oxygen deprivation, the body enters a state known as the anaerobic threshold or Onset of Blood Lactate Accumulation (OBLA) (Michaelides & Parpa, 2025). To achieve maximum performance, athletes are required to have anaerobic endurance as part of their physical abilities.. If an athlete has high anaerobic endurance, the lactate threshold they will reach will be higher (Bompa, T.O., & Haff, 2019).

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Anaerobic capacity, the fundamental maximum capacity limit, is the factor that determines the cessation of physical activity due to exhaustion. The presence of an anaerobic energy system enables humans to perform high-intensity physical activity. The anaerobic lactate energy system is used for anaerobic endurance physical activity (Entang Hermanu, 2009). Therefore, physical activity in football requires anaerobic endurance (anaerobic lactacyd) because with good anaerobic endurance, football athletes will not tire easily.

2. METHOD

This study employed an experimental method. Experimental research is considered to have the highest degree of certainty (not absolute). Researchers make predictions based on experimental research. Conditions are carefully regulated, treatment is administered to the subjects, the effects of the treatment are carefully measured, and potential external factors are controlled, with the hope of increasing the degree of certainty in the answers (Fraenkel, Jack. R., 2022).

2.1 Participants

Involved in this study were researchers, supervisors, coaches and 50 Darma Sakti football athletes. In this study, 16 people were sampled, 8 people from the continuous running and power endurance training group, and 8 people from the continuous running and muscle endurance training group. Therefore, the sampling technique used was non-probability sampling, namely quota sampling. This is because, based on the research requirements, the sample must first be classified. The classification referred to is athletes who are active in football and have participated in city/district level competitions and are aged 17 years.

2.2 Research Design

This study used a two-group pretest-posttest design, in which the sample was given a pretest first. Only one hypothesis was tested, namely that there was a difference between the pretest mean score and the posttest mean score. This two-group pretest-posttest study design compared two methods of continuous running training with power endurance and continuous running training with muscular endurance.

In this study, the test was conducted twice, before and after the treatment. The difference between the pretest and posttest is assumed to be the effect of the treatment, or the expected result of the treatment can be determined more accurately, because there is a comparison between the conditions before and after the treatment and it is known which method is more effective for increasing anaerobic lactate endurance.

2.3 Instruments

This This study employed a 300-meter sprint test to measure lactacid anaerobic endurance. The 300-meter sprint is a widely used field test for assessing anaerobic capacity, particularly the ability to sustain high-intensity effort over 30 60 seconds, which primarily relies on the glycolytic (lactacid) energy system (Moore & Murphy, 2003; Stangier et al., 2016). This test aligns with Schmolinsky's (1983) recommendation that speed endurance can be evaluated using distances of 150 m, 300 m, and 400 m.

Regarding validity, the 300-meter sprint demonstrates strong construct validity as it directly reflects the physiological demands of repeated high-intensity efforts in football, particularly lactate tolerance and buffering capacity (Zagatto et al., 2011). Moore & Murphy (2003) further validated this test against laboratory-based anaerobic capacity measures (e.g., maximal accumulated oxygen deficit), reporting a high correlation (r = 0.82–0.89), supporting its criterion-related validity for field-based anaerobic assessment.

In terms of reliability, Moore & Murphy (2003) reported an intraclass correlation coefficient (ICC) of 0.94 for test-retest reliability of the 300-meter sprint among trained athletes, indicating excellent consistency. Similarly, Stangier et al. (2016) observed a coefficient of variation (CV) of <3% across repeated trials under standardized conditions, confirming high reliability when protocols (e.g., rest, warm-up, timing method) are strictly controlledas implemented in this study.

To ensure reliability in this research, all tests were conducted on the same synthetic track, at the same time of day (late afternoon), with identical warmup routines and timing procedures using digital stopwatches calibrated before each session.

2.4 Procedures

The procedures for conducting the speed endurance test using the 300-meter sprint test begin with equipment preparation, including a stopwatch, blank paper and writing utensils, and a running track. During test implementation, the subject stands behind the starting line in a flying start position. Upon the command "yes," the subject must attempt to run as fast as possible until completing the 300-meter distance. Assessment is conducted by recording the best time achieved in the 300-meter sprint, where the results of this speed endurance test are expressed in seconds (s).

Overall, the research procedures were carried out through several systematic phases according to the design used. The first phase involved conducting a field study to determine the population and sample that would serve as the research subjects. Subsequently, a pre-test on anaerobic lactate endurance was administered to the research samples. Following this, an exercise/treatment program was provided to the samples according to their designated groups. After the intervention period, a post-test on anaerobic lactate endurance was conducted on the same samples. The collected data were then processed and statistically analyzed. The final stage involved drawing conclusions based on the results of the data analysis. This research uses a training program that includes a macro cycle and can be described in a micro cycle training program as well as in the table below:

Table 1.

Training Program Macros

MACRO TRAINING PROGRAM							
STAGE: TPU						MACRO KE-1	
VOLUME:							
INTENSITY:							
SESSION	Day						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Afternoon		CR&PE CR&DTO			CR&PE CR&DTO		CR&PE CR&DTO

Table 2.

Micro Training Program

MICRO TRAINING PROGRAM						
STAGE: TPU					MIKRO KE-1	
VOLUME:						
INTENSITY:						
Day	Sunday					
	1	2	3	4	5	6
Tuesday	CR40& PE	CR45&PE	CR50&PE	CR55& PE	CR60 &PE	CR65& PE
	CR40&ME	CR45&ME	CR50&ME	CR55&DTO	CR60 & ME	CR65 & ME
Friday	CR40&PE	CR45&PE	CR50 & PE	CR 55 & PE	CR60 &PE	CR65& PE
	CR40&ME	CR45&ME	CR50&ME	CR55&DTO	CR60& ME	CR65 & ME
Sunday	CR40 & PE	CR45&PE	CR50&PE	CR 55& PE	CR60 &PE	CR65 & PE
	CR40&ME	CR45&ME	CR50&ME	CR55&ME	CR 60& ME	CR65 & ME

Description:

CR: Continuous Running

ME: Muscle Endurance

PE: Power Endurance

The two macro and micro cycles mentioned above serve to facilitate understanding in research that considers a single macro cycle with a one-month duration. A micro cycle itself is a training cycle that uses a weekly timeframe, also known as weekly training (Lorenz & Morrison, 2015). This study used continuous running with power endurance and continuous running with muscular endurance. Continuous running lasted for 40 minutes, with each subsequent week adding 5 minutes. As stated by (Busyairi & Ray, 2018), continuous running for more than 30 minutes at a moderate pace below the anaerobic threshold will result in good anaerobic adaptation.

Muscle endurance is involved in this study, which is found in the research treatment where athletes try the wall-sit movement with as much time as possible for each athlete, as stated by (Nourollahnajafabadi et al., 2013). The wall sit position of a person is measured as someone sitting on a chair with their back against the wall, their hands hanging beside their body. To avoid knee injuries, the knee position is adjusted by the trainer based on the appropriate position, and the person maintains this with all their strength or until standing.

This study uses continuous running training treatment with power endurance and for power endurance, using hurdle jumps, which are calculated as long as the athlete is still strong enough to perform the hurdle jump movement. The execution time, as stated by (Juskhia John; Dikdik Zafar Sidik, 2017), The event begins with the athlete standing on one side of the hurdle with both feet parallel on the ground and their body perpendicular to the hurdle. The time is measured from the moment the first movement is made. The athlete jumps with both feet simultaneously, lands with both feet on the other side of the hurdle, and then returns.

2.5 Data Analysis

Data was obtained at the beginning of the experiment as baseline data and at the end of the experiment as final data. The test data was then analysed using SPSS software version 24, using the Paired Samples T-test. In this study, the researchers aimed to determine whether there was a significant difference in exercise performance in improving anaerobic lactate endurance. The data processing steps were as follows: Collection of experimental data using pre-tests and post-tests, Manual entry of pre-test and post-test results into Microsoft Excel format, Following the assessment guidelines for each instrument. The data were processed using SPSS version 24 to draw conclusions from the study.

3. RESULTS

The data processing using the Paired Sample T-Test can be seen in the table

Table 3.

Paired sample T-Test

Continuous Running dan Power Endurance

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. deviation	Std. Error Mean	Lower	Upper	t	df	sig.(2-tailed)
pre-test post-test	3.63375	3.18951	1.12766	.96725	6.30025	3.222	7	.015

According to the table, the obtained t-value is 3.222 with a significance level of $p = 0.015 < 0.05$, indicating that Ho is rejected. This shows a significant improvement in the outcomes of continuous running training focused on power endurance.

Table 4.

Paired Sample T-Test

Continuous Running dan Daya Tahan Otot

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig.(2-tailed)
pre tes post tes	1.71500	.68650	.24272	1.14107	2.28893	7.066	7	.000

And for the table above, it is known that t is 7.066 with a sig value (p) of $0.000<0.05$, namely Ho is rejected, so there is a significant increase in the results of continuous running training with muscle endurance.

4. DISCUSSIONS

In this discussion, this study seeks to examine how continuous running training for power endurance and continuous running training for muscular endurance influence the enhancement of anaerobic lactacid endurance In light of the problems outlined earlier, implementing continuous running programs with both power and muscular endurance emphases is considered a potential approach to address the challenges observed in the field.

Judging from this study itself, A significant impact is observed from the continuous running training method with power endurance on increasing anaerobic lactid endurance, which experienced a percentage increase of 6.39%, while continuous running training with muscular endurance experienced a percentage increase of 2.93%. According to existing research by A. Zagatto et al. (2011) entitled "Anaerobic contribution during maximal anaerobic running test: correlation with maximal accumulated oxygen deficit." This study aims to measure the energy system and its contribution in the maximal anaerobic running test. The results of this study concluded that the anaerobic lactase system is the primary system involved in maximal anaerobic running efforts, and this test concluded that it did not increase significantly with the accumulation of maximal anaerobic deficit.

This is similar to the study by A. M. Zagatto et al. (2013), entitled "Anaerobic running capacity determined from the critical velocity model is not significantly associated with maximal accumulated oxygen deficit in army runners." This study aimed to verify the value of anaerobic lactase running capacity in army runners. The sample consisted of eleven trained middle-distance runners who were members of the armed forces. The results obtained by these researchers showed no difference in the effect of anaerobic running capacity (ARC) on maximal accumulated oxygen deficit (MAOD), This should not be regarded as an indicator of short-term anaerobic capacity. The hypothesis in this study is that there is a significant impact on increasing anaerobic lactid endurance of Darma Sakti SSB athletes after being given treatment in the form of continuous running training with power endurance, there is a significant impact on increasing anaerobic lactid endurance of Darma Sakti SSB athletes after being given treatment in the form of continuous running training with muscle endurance, and there is a percentage increase in anaerobic lactid endurance of football athletes in continuous running training with power endurance and muscle endurance.

The findings show a notable improvement in anaerobic lactate endurance following the implementation of continuous running training emphasizing power endurance, there is a significant impact on increasing anaerobic lactid endurance of Darma Sakti SSB athletes after being given treatment in the form of continuous running training with muscle endurance, and there is a percentage increase in anaerobic lactid endurance of football athletes in continuous running training with power endurance by 6.39% and continuous running training with muscle endurance by 2.93% during the training program. This has been proven by processing the analyzed data. This study is similar to the research described above, and previous research described in the background also showed an increase in anaerobic lactase after undergoing a training program. This study sampled 16 SSB DARMA SAKTI football athletes. This study lacked the duration of the training, the test, and the athletes' mental state during the test. It is hoped that future research will include a longer period of time and better test implementation to help athletes better prepare for future training programs.

5. CONCLUSIONS

Based on the analysis and data processing, the author can conclude that this conclusion also answers the stated research questions. Based on the results obtained, it can be concluded that:

Continuous running and power endurance training has an effect on increasing anaerobic lactate endurance, with a score of 6.39% from the initial test, Continuous running and muscle endurance training has an effect on increasing anaerobic lactate endurance, with a score of 2.93% from the initial test, The exercise with the greatest effect on increasing anaerobic lactate endurance is continuous running and power endurance training.

The main conclusions must be clearly outlined, with a focus on their value and relevance to the field. You can also explain the limitations, implications, and contributions of this research for future research.

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