Journal of Architectural Research and Education
Journal homepage:https://ejournal.upi.edu/index.php/jare

Relationship between An-Aerobic Threshold, Lactic Acid, and VO2 Max. during the General Preparation Period with the Long Distance Running Performance of Sea Games Athletes

Pretty Sihite[1], Berliana Berliana[2], Eka Nugraha3, Geraldi Novian4

[1,2,3]Sports Education Study Program, Postgraduate School, Indonesian Education University, Bandung, Indonesia
[4]Sports Physical Coaching Study Program, Faculty of Sports and Health Education, Indonesian Education University, Bandung, Indonesia
*Correspondence: E-mail:prettysihite84@gmail.com

ABSTRACT

This study aims to examine the significant relationship between an-aerobic threshold, lactic acid, and VO2 Max during the general preparation period and the long-distance running performance of SEA Games athletes. The method used in this research is a descriptive method which provides an overview of the variables studied and does not provide research treatment to the sample. The research design used is a correlational design by correlating or connecting the variables studied. The sample in this study was 6 athletes from the 2023 Cambodia SEA Games Indonesian National Training Center in long distance running. Instruments in the form of tests carried out at the FPOK UPI Sport Science Laboratory were given once to samples in December 2022 in the form of: a treadmill to measure VO2 max, an anaerobic threshold indicator in the form of a Polar to measure the anaerobic threshold, and a lactate meter to measure lactic acid. Data in the form of long distance running times for each athlete in the Athletics Championship competition held in November-December 2022 in Thailand and the Athletics Invitation and National Selection SEA Games held in January 2023 in Jakarta were collected. Data analysis was carried out using SPSS version 24 software. The results showed that an-aerobic threshold, lactic acid, and VO2 Max during the general preparation period had a significant relationship with the long-distance running performance of SEA Games athletes. Based on the conclusions above, this research provides implications that lactic acid, an-aerobic threshold, and VO2 Max. The periodization period for the general preparation stage is an important thing that long distance running athletes must pay attention to.

ARTICLEINFO

Article History:
Submitted/Received 27 June 2023
First Revised September 20, 2023
Accepted 25 October 2023
First Available online 1 October 2023
Publication Date 1 November 2023

Keywords:
An-Aerobic Threshold,
Lactic acid,
VO2 Max,
general preparation,
Long Distance Running Performance

1. INTRODUCTION

The word "athletics" comes from the Greek, athlon or athlum, which means race or competition. In America and parts of Europe and Asia, the term track and field is often used for athletics. Meanwhile in Germany, athletic leicht; and Dutch athletiek. Athletics is a physical or physical activity that consists of basic movements that are dynamic and harmonious, namely, walking, running, jumping and throwing. Athletics – walking, running, jumping and throwing – is also called the “mother of all sports”. Because the movements or physical activities in athletics reflect human life in ancient times. They unconsciously carry out walking, running, jumping and throwing activities in an effort to maintain and develop their lives. In fact, this activity is used to save oneself from the disturbances of the natural surroundings. (Purnomo & Dapan, 2011).

The All Indonesian Athletics Association or known as PASI is the parent institutional organization which is fully responsible for gathering, developing athletes and coordinating all athletic activities in Indonesia. Athletics has a coaching forum at the national level known as the General Board of the Indonesian Athletics Association (PB PASI) which is located in Jakarta (Alamanda & Wulandari, 2021).

The numbers contested in athletics are: a) short distance running ranging from 60 to 400 meters, b) middle distance running from 800 meters to 1500 meters, and c) long-distance running starting from distance from 3000 meters to 42,195 km (marathon) (Basuki, 2016). The throwing numbers consist of javelin throw, discus throw, hammer throw, and shot put. Road numbers consist of 3000m (for youth), 5000m (for juniors), and 10,000m, 20,000m (for seniors). Jumping consists of the high jump, long jump, triple jump, and high pole jump. Long-distance running events starting from 3000m steeplechase are carried out on the track, for distances of 5,000 to 10,000 meters it can be done on the stadium track or highway, while the marathon is held on the highway. To become a long-distance runner, some aspects influence success, such as technical, physical, and mental aspects.

The achievements in athletics in Indonesia are increasing from year to year. More and more athletes, especially long-distance runners, are achieving well at national and international levels, including a. Tianingsi b. Rini Budiarti c. Agus Prayogo is an Indonesian athlete who is a long-distance runner. Until now, the national record has not been broken. However, if we look specifically at the 5000-meter event, there are no Indonesian athletes who have shown achievements that are close to their records, both at the national championship and at the Sea Games championship level.

Improving physical condition is still an obstacle for athletes in developing countries, including Indonesia. This can be seen from the results of physical tests for multi-event sporting achievements such as the Asian Games and Sea Games which show that the athlete's physical condition is still inadequate (Sidik, 2019). Good performance is always supported by good performance. An athlete's performance is one of the factors caused by fatigue, the higher the activity carried out, the faster fatigue will arise (Giriwijiyo, 2010).

Endurance is one of the basic ability factors in physical condition which is very important for sports that last for a relatively long time(Sidik et al., 2010), especially intermediate running, long-distance, fast walking, and marathon events. (Harsono, 2016) states that endurance is a state or condition of the body that can train for a long time, without experiencing excessive fatigue after completing training.

This endurance is often referred to as aerobic endurance. This means that in aerobic endurance training the oxygen supply is still sufficient to meet the intensity of the exercise

DOI:https://doi.org/10.17509/jare.v5i1.59898
p- ISSN2776-9909e- ISSN2580-1279

being carried out. In contrast to anaerobic endurance, in anaerobic endurance training where the training is heavier/intensity, the oxygen supply is insufficient (Harsono, 2016)

Several factors are related to success in sports performance and Exercise is a major part of it. An athlete's endurance, according to the type of training, is influenced by factors such as aerobic strength, efficiency, biomechanics, neuromuscular and cardiovascular adaptations, anaerobic strength, lactate threshold, and endocrine system adaptations (Smart, NA and M. Steele, 2012; Ribeiro, C., LT et al, 2012). Many physiological differences between elite and novice endurance athletes depend on the training methods they use (Casamichana, D., J. Castellano and A. Dellal, 2013; Borzykh, AA, et al, 2012). Aerobic interval training is one of the most common training methods to improve athletes' endurance and performance in the pre-competition season (Borel, B., et al. 2011). Continuous run training can increase Vo2max, capillary density, oxidative enzyme activity and plasma volume in untrained individuals but is not effective in athletes where interval training is more efficient (Baquet, G., FX et al, 2010).

However, the influence of resistance training on endurance is also an issue that has received great attention in recent years. Some evidence suggests that adding resistance training for athletes, changing physiological stress and improving neuromuscular characteristics has a positive impact on athletes' endurance (Daussin, F.N., et al., 2008, Shabkhiz, F., et al., 2008).

According to (Harsono 2018) continuous run training without rest, to increase aerobic endurance a person must train in a training area of 70-80% of MHR. Maximum heart rate is 140-160 DNM. Continuous exercise with low to high intensity is around 80%-90% of MHR so around 160-180 DNM. In Harsono's 2018 book, p. 14, Martin and Lumsden's opinion is that aerobic activity must be "sufficiently vigorous" (enough intensity) to produce a training effect or make the exercise feel useful. Athletes must feel "almost tired" and "breathing heavily" but still be able to "talk" during training.

Interval training or intermittent training is training that is characterized by work intervals interspersed with rest (recovery) intervals. The implementation is run-rest-run again-rest-run again - and so on. In the book (Harsono 2016) there are 3 types of interval training, namely, Long interval training, namely intensity 80-90% of maximum ability, intermediate interval training intensity 90-95% of maximum ability, short interval training intensity 95 % of maximum capability.

Coaches and athletes are always looking for traditional training methods to improve athletes' physical abilities even more. Therefore, different training methods have been developed and used based on physiology and exercise science. Continuous running and interval training have long been used in training to increase athletes' aerobic and anaerobic capacity. Continuous run training, which has a longer history than interval training, is usually used to increase the aerobic capacity and endurance of the cardio-respiratory system (Casamichana, D., J. Castellano and A. Dellal, 2013). An example of continuous run training is when an athlete runs continuously without stopping for a long distance during a certain exercise or runs continuously for a specified time. The advantages of this type of training are improving and increasing the capacity of various cardiovascular and respiratory sources, increasing maximum oxygen uptake, increasing the capillary network, and increasing mitochondrial enzymes in the aerobic energy system as well as increasing enzymes in the energy-producing system in general (Smart, NA and M. Steele, 2012).

Another common type of exercise used in various sports is interval training. This training method is alternate periods of exercise - rest - exercise - rest. These exercises are performed with greater intensity than continuous exercise and the anaerobic energy-

DOI:https://doi.org/10.17509/jare.v5i1.59898
p- ISSN2776-9909e- ISSN2580-1279

producing system is stressed as well as the aerobic system in this kind of exercise. Also because of the rest time between workouts, there is time for energy sources such as creatine phosphate (CP) and adenosine triphosphate (ATP) to be replaced and the athlete can continue with less fatigue. Many benefits can be obtained by doing interval training, namely increasing the level of anaerobic capacity, lactate pathway enzymes, and anaerobic energy-making enzymes (Borel, B., et. Al., 2011; Daussin, et. Al., 2008).

In previous research, many have examined high-intensity interval training and continuous running to improve health parameters (Kemi and Wisloff, 2010; Weston et al., 2013; Wisløff et al., 2007) and reduce body weight (Gibala & Jones, 2013; Gibala & McGee, 2008) (Boutcher,2011; Ladder, Chisholm, Friend, & Shopkeeper,2008). A review of the literature shows that many trials have examined physiological factors but little research has focused on fitness training (Shabkhiz, F., et. Al., 2008- Mahmoud, 2010).

2. RESEARCH METHODS

In every research, a method is needed. The use of research methods is adjusted to the problem and research objectives. The method used in this research is a descriptive method which provides an overview of the variables studied and does not provide research treatment to the sample. The use of this method was chosen because it felt appropriate to the topic of this research. The research design used is correlational (Fraenkel et al., 2012) by correlating or connecting the variables studied. The sampling technique used in this research is a total sampling technique, which means taking the entire population as a sample. So the sample in this study was 6 athletes from the Indonesian National Training Center for the Cambodia SEA Games in 2023 in long-distance running. The reason the author chose the sample is because the sample was specially prepared to take part in competitions and races, and it is not uncommon for them to be members of regional or national teams.

Fraenkel et al. (2012) stated that a research instrument is "Any procedure or device for systematically collecting data", this opinion means that a research instrument is a procedure or device for collecting data systematically. The author used instruments in the form of tests carried out at the FPOK UPI Sport Science Laboratory which were given once to the sample in December 2022 in the form of a treadmill to measure VO2 max, an anaerobic threshold indicator in the form of a Polar to measure the anaerobic threshold, and a lactate meter to measure lactic acid. Apart from that, the author collected data in the form of records of long-distance running times for each athlete in the Athletics Championship competition which was held in November-December 2022 in Thailand, and the Athletics Invitation and National Selection SEA Games which was held in January 2023 in Jakarta. After the data is obtained, the data will be processed and analyzed using SPSS version 24 software.

3. RESULTS AND DISCUSSION

The author presents the research findings in table form, statistical descriptions can be seen in Table 1.

Table 1. Statistical Description

Variable	N	Mean	Std. Deviation
Lactic Acid (mMol/l)	6	4.13	2,676
An-Aerobic Threshold(bpm)	6	171.67	13,515
VO2 Max. (ml/kg/min)	6	62.84	5,332
Running Results Record (seconds)	6	1243.88	721,143

DOI:https://doi.org/10.17509/jare.v5i1.59898
p- ISSN2776-9909e- ISSN2580-1279

Variable	N	Mean	Std. Deviation
Event-1 (second)	6	1342.05	780,801
Event-2 (second)	6	1145.71	715,069

**Age = 25.5±5,394 years*

Table 1 shows a statistical description of research data based on the variables studied. It can be seen that there are 6 valid data tested for each variable. The lactic acid variable has an average value of 4.13 with a standard deviation value of 2.676 mMol/l, the variablean-Aerobic threshold has an average value of 171.67 with a standard deviation value of 13.515 bpm, variable VO2 Max. has an average value of 62.84 with a standard deviation value of 5.332 ml/kg/min, overall running results have an average value of 1243.88 with a standard deviation value of 721.143 seconds, records of running results in events- 1 (Athletics Championship) has an average value of 1342.05 with a standard deviation value of 780.801, and the record of running results in event-2 (Athletics Invitation and SEA Games National Selection) has an average value of 1145.71 with The standard deviation value is 715.069. Furthermore, the results of the normality test can be seen in Table 2.

Table 2. Normality Test

Variable	Asymp. Sig. (2-tailed)	Information
Lactic acid	0.993	Normally distributed
An-Aerobic Threshold	0.254	Normally distributed
VO2 Max.	0.798	Normally distributed
Running Results Records	0.922	Normally distributed
Event-1	0.821	Normally distributed
Event-2	0.683	Normally distributed

Based on Table 2, it can be seen that all data has an Asymp value. Sig. (2-tailed) > 0.05, so that all data can be stated to be normally distributed. Therefore, the author uses a parametric approach to carry out correlation tests. The results of the correlation test can be seen in Table 3.

Table 4.3 Correlation Test

Variable		Running Results Record (Overall)	Record of Running Results Event-1 (Athletics Championship)	Record of Running Results for Event-2 (Athletics Invitation and SEA Games National Selection)
Lactic acid	Correlation Coefficient	0.168	0.237	0.268
	Sig. (2-tailed)	0.032	0.001	0.004
An-Aerobic Threshold	Correlation Coefficient	0.333	0.421	0.473
	Sig. (2-tailed)	0.028	0.011	0.017
VO2 Max.	Correlation Coefficient	0.198	0.221	0.298
	Sig. (2-tailed)	0.022	0.001	0.018

Table 4.3 shows the results of the correlation test using Pearson correlation. Based on the results of the correlation test, it was found that between lactic acid and the running results record (overall) it had a correlation coefficient value of 0.168 with a Sig value. (2-tailed) of 0.032 < 0.05 which means that H0 is rejected. The results of the correlation test between lactic acid and the running results recorded for Event-1 (Athletics Championship)

DOI:https://doi.org/10.17509/jare.v5i1.59898
p- ISSN2776-9909e- ISSN2580-1279

have a correlation coefficient value of 0.237 with a Sig value. (2-tailed) of 0.001 < 0.05 which means that H0 is rejected. The results of the correlation test between lactic acid and the track record for Event-2 (Athletics Invitation and SEA Games National Selection) have a correlation coefficient value of 0.268 with a Sig value. (2-tailed) of 0.004 < 0.05 which means that H0 is rejected.

Correlation test results betweenan-aerobic threshold with running results records (overall) has a correlation coefficient value of 0.333 with a Sig value. (2-tailed) of 0.028 < 0.05 which means that H0 is rejected. The results of the correlation test between the an-aerobic threshold and the running results recorded for Event-1 (Athletics Championship) have a correlation coefficient value of 0.421 with a Sig value. (2-tailed) of 0.011 < 0.05 which means that H0 is rejected. Correlation test results betweenan-aerobic threshold with recorded running results from Event-2 (Athletics Invitation and SEA Games National Selection) has a correlation coefficient value of 0.473 with a Sig. (2-tailed) is 0.017 < 0.05 which means that H0 is rejected.

Next, the results of the correlation test between VO2 Max. with the running results record the running results record (overall) has a correlation coefficient value of 0.198 with a Sig value. (2-tailed) of 0.022 < 0.05 which means that H0 is rejected. Correlation test results between VO2 Max. with a note that the running results of Event-1 (Athletics Championship) have a correlation coefficient value of 0.221 with a value of Sig. (2-tailed) of 0.001 < 0.05 which means that H0 is rejected. Correlation test results between VO2 Max. with a note that the results of Event-2 (Athletics Invitation and SEA Games National Selection) have a correlation coefficient value of 0.298 with a Sig. (2-tailed) of 0.018 < 0.05 which means that H0 is rejected.

Based on the results of the data processing and analysis above, it can be stated as follows:

1) Lactic acid during the periodization of the general preparation stage has a significant relationship with the running results of SEA Games athletes.
2) *An-Aerobic threshold*The periodization period for the general preparation stage has a significant relationship with the running results of SEA Games athletes.
3) *VO2 Max*. The periodization period for the general preparation stage has a significant relationship with the running results of SEA Games athletes.

4. Conclusion

Based on the results of the research that has been carried out, the author can conclude several things, including:

1) There is a significant relationship between lactic acid during the general preparation stage and the running results of SEA Games athletes.
2) There is a significant relationship between the an-aerobic threshold during the periodization of the general preparation stage and the running results of SEA Games athletes.
3) There is a significant relationship between VO2 Max. periodization period for the general preparation stage with records of SEA Games athletes' running results

Based on the conclusions above, this research provides implications that lactic acid, an-aerobic threshold, and VO2 Max. The periodization period for the general preparation stage is an important thing that long distance running athletes must pay attention to. This is because these three things are important variables that support a long-distance athlete in getting the best running record. The author can provide several suggestions regarding the results of the research that has been carried out, namely: There is a need to measure

DOI:https://doi.org/10.17509/jare.v5i1.59898
p- ISSN2776-9909e- ISSN2580-1279

lactic acid, an-aerobic threshold, and VO2 Max. periodically, especially at different stages of periodization because it is a form of monitoring training progress that can help athletes. Next, there needs to be good education regarding lactic acid, an-aerobic threshold, and VO2 Max. to athletes and long-distance running coaches so they can pay better attention to these variables and their relationship to running results records. Apart from that, the author feels that there is a need for a collection of data in the form of structured records of running results because they can be used as evaluation and reference material for long-distance running athletes.

REFERENCES

Baquet, G., FX Gamelin, P. Mucci, D. Thevenet, 2006 E. Van Praagh and S. Berthoin, 2010. Continuous vs. Interval aerobic training in 8- to 11-year-old children. Journal of strength and conditioning research / National Strength and Conditioning Association, 24: 1381-1388.

Boutcher, S.H. (2011). High-intensity intermittent exercise and fat loss. Journal of Obesity, 2011,, 1–10. doi:10.1155/2011/ 868305

Borel, B., E. Leclair, D. Thevenet, L. Beghin, F. Gottrand and C. Fabre, 2011. Comparison of mechanical ventilatory constraints continuous and intermittent exercises in healthy prepubescent children. Pediatric pulmonology, Sciences, 3(S): 492-499. 46: 785-94.

Borzykh, AA, IV Kuz'min, AA. Mart'ianov, AS Borovik, AP Sharova, OS Tarasova and OL Vinogradova, 2012. Changes of rat respiratory and locomotor muscles during aerobic exercise training in continuous and interval regimens. Biophysics, 57S: 880-887. Casamichana, D., J. Castellano and A. Dellal 2013. Influence of different training regimes on physical and physiological demands during small-sided soccer games: continuous vs. continuous intermittent format. J. Strength Cond Res., 27: 690-697.

Capraro, R. M., & Capraro, M. M. (2002). Myers-briggs type indicator score reliability across studies: A meta-analytic reliability generalization study. Educational and Psychological Measurement, 62(4), 590–602. https://doi.org/10.1177/0013164402062004004

Daussin, F.N., J. Zoll, S.P. Dufour, E. Ponsot E. Lonsdorfer-Wolf, S. Doutreleau, B. Mettauer, A. Piquard, B. Geny and R. Richard, 2008. Effect of interval versus continuous training on cardiorespiratory and mitochondrial functions: relationship to aerobic performance improvements in sedentary subjects. American journal of physiology Regulatory, integrative and comparative physiology, 295: R264-272

Espen Tønnessen 1,*, Jonny Hisdal 2 and Bent R. Ronnestad 3, 2020. Influence of Interval Training Frequency on Time-Trial Performance in Elite Endurance Athletes. Int. J Environ. Res. Public Health 2020, 17, 3190; doi:10.3390/ijerph17093190

Fernando González-Mohíno1,3 • Jordan Santos-Concejero2 • Inmaculada Yustres1 • José M. González-Ravé1. The Effects of Interval and Continuous Training on the Oxygen Cost of Running in Recreational Runners: A Systematic Review and Meta-analysis. Sports Medicine https://doi.org/10.1007/s40279-019-01201-x

Fraenkel, J.R. (2012). How to Design and Evaluate Research in Education. McGraw-Hill.

Fraenkel, J.R., Wallen, N.E., & Hyun, H.H. (2012). How to Design and Evaluate research in education (8th ed.). New York: McGraw-HillCompanies.Inc.

Gibala, M. J., & Jones, A. M. (2013). Physiological and performance adaptations to high-intensity interval training. Nestle Nutrition Institute Workshop Series, 76, 51–60. doi:10.1159/ 000350256

Giriwijoyo Santoso. 2010. Sports Physiology (Human Body Functions in Sports for Health and Achievement). Bandung:Teenager Rosdakarya

Jèssica B. Bonet1 • José Magalhães2 • Ginés Viscor1 • Teresa Pagès1 • Casimiro Javierre3 •Joan R. Torrella1. (2020). High-intensity interval versus moderate-intensity continuous half-marathon training program for middle-aged women. European Journal of Applied Physiology https://doi.org/10.1007/s00421-020-04347-z.

Kemi, O., & Wisloff, U. (2010). High-intensity aerobic exercise training improves the heart's health and disease. Journal of Cardiopulmonary Rehabilitation and Prevention. doi:10.1097/ HCR.0b013e3181c56b89

Mahmoud Al Desouky Ahmed, K., 2010. The Effect of a Training Program on the Pulse Rate, Lactic Acid and Some Components of the Body of the Beginners of Judo. World Journal of Sport Sciences, 3(S): 492-499.

McCrae, R.R., & Costa, P.T. (1989). Reinterpreting the Myers-Briggs Type Indicator From the Perspective of the Five-Factor Model of Personality. Journal of Personality. https://doi.org/10.1111/j.1467-6494.1989.tb00759.x

Ribeiro, C., LT Cambri, RA Dalia, MB Araujo, AC Ghezzi, LP Moura, GA Gustavo, JD Botezelli and MAR Mello, 2012. Muscle protein metabolism in neonatal alloxan-administered rats: effects of continuous and intermittent swimming training. Diabetology and metabolic syndrome, 4: 5.

Shabkhiz, F., AA Ravasi, ZM Hassan, M. Taghikhani and T. Amininan Razavi, 2008. The Effect of Aerobic Continuous and Interval Training and Detraining on Some Indexes of the Cellular Immune System in Female Wistar Rats, 1: 17-26

Smart, NA and M. Steele, 2012. A comparison of 16 weeks of continuous vs intermittent exercise training in chronic heart failure patients. Congestive heart failure, 18: 205-211

Sugiyono. (2013) Educational Research Methods (Quantitative, Qualitative and R&D Approaches). Bandung: Alphabeta.

Sukma Prastiko Alamanda, Fifit Yeti Wulandari, 2021 evaluation of the development of the athletics association throughout Indonesia, Tulungagung Regency. Surabaya State University.

Sunarno Basuki. Lung Vital Capacity, Leg Length, Leg Muscle Strength And 800 meter running performance. JurnalVidyaKarya.Vol.31/No.1/April 2016: 64-71.

Zoran Milanovic´1 • Goran Sporisˇ2 • Matthew Weston3, 2015 Effectiveness of High-Intensity Interval Training (HIT) and Continuous Endurance Training for VO2max Improvements: A Systematic Review and Meta-Analysis of Controlled Trials. Springer International Publishing Switzer Sports Med DOI 10.1007/s40279-015-0365-0.

DOI:https://doi.org/10.17509/jare.v5i1.59898
p- ISSN2776-9909e- ISSN2580-1279