3962-Article Text-16080-1-4-20250531.docx

by Turnitin Ku

Journal Physical Health Recreation (JPHR)
Volume * Nomor * ; Bulan ****
https://jurnal.stokbinaguna.ac.id/index.php/JP
e-ISSN : 2747- 013X

A Comprehensive Review: The Correlation Between Intensive Aerobix Exercise and Maximum Heart Rate in Athletes

Harvina Mukrim [1], Muslim Bin Ilyas [2]

{harvina.mukrim@unm.ac.id[1], muslim.bin.ilyas@unm.ac.id[2]}

Department of Physiotherapy and Department of Physical Education Health and Recreation, Faculty of Sports and Health Sciences, Makssar State University, Jl. Wijaya Kusuma No.14, Banta-Bantaeng, Kec. Rappocini, Kota Makassar, Sulawesi Selatan 90222[1], Department of Physiotherapy and Department of Physical Education Health and Recreation, Faculty of Sports and Health Sciences, Makssar State University, Jl. Wijaya Kusuma No.14, Banta-Bantaeng, Kec. Rappocini, Kota Makassar, Sulawesi Selatan 90222[2]

Abstract. This article examines the relationship between intensive aerobic exercise and Maximum Heart Rate (MHR) in athletes, focusing on cardiovascular adaptation and its implications for athletes' performance. Through the analysis of current research, this study shows the significant impact of intensive aerobic exercise on heart rate dynamics and cardiovascular efficiency in trained athletes. This study uses a systematic and comprehensive literature review method related to the relationship between intensive aerobic exercise and maximum heart rate in athletes.

Keywords: Maximum Heart Rate, Aerobic exercise, athletes, cardiovascular

1 Introduction

Exercise is defined as any form of physical movement that is carried out with a certain pattern or technique to shape the body with intensity, time limits, and has a specific purpose. While exercise is a form of physical activity that is carried out regularly and repeatedly for a long period of time, with an increase in load that is carried out gradually according to the ability of each individual with the aim of improving and developing physiological and psychological functions.

Physical fitness is the body's ability to operate efficiently during work or activity and still have sufficient energy reserves to deal with emergency situations that may occur. Aerobic exercise is an activity that relies on oxygen to help with the process of burning energy. Aerobic exercise requires optimal work from the body's organs such as the heart, lungs, and blood vessels to transport oxygen so that energy burning can run well. This exercise is a sport that is done with low to moderate intensity that can be done continuously for a long time, such as walking, cycling, and jogging.

Correspondence author: First Author/Second Author/Third Author, Medan State University, Indonesia.
Email:

Regular aerobic exercise has a significant influence on the cardiovascular system of athletes. When an athlete performs aerobic exercise consistently, the heart undergoes a physiological adaptation called "*athletic heart syndrome*" or athlete heart syndrome. This adaptation is characterized by structural and functional changes in the heart that result in better cardiac work efficiency

Research conducted by Sharma et al. (2015) in "*Exercise and the Heart: The Good, the Bad, and the Ugly*" showed that athletes who were aerobically trained had a larger *stroke volume* and lower resting heart rate than non-athletes. This indicates that their hearts can pump blood more efficiently with minimal effort.

10

Related to *Maximum Heart Rate* (MHR), research published in *the Journal of Applied Physiology by Tanaka et al*. (2018) found that the traditional "220 – age" formula for calculating MHR is not always accurate for trained athletes. Athletes with high levels of aerobic fitness often have different MHRs than the general population, and this correlates with their level of cardiovascular adaptation.

Furthermore, a longitudinal study conducted by Wilson and Tanaka (2020) revealed that aerobically trained athletes had the ability to maintain a higher intensity of exercise at the same percentage of MHR than untrained individuals, there was a slower decrease in MHR with age in athletes who consistently performed aerobic exercise and post-workout heart rate recovery took place faster in trained athletes. Another interesting is the findings from Booth et al.'s (2019) research in "*Cardiovascular Adaptations to Aerobic Training*" which shows that regular aerobic exercise can improve the efficiency of myocardial oxygen use, meaning the heart can work at a higher intensity with lower oxygen consumption.

2 Method

This study applied a systematic literature review method to focus on cardiovascular adaptation to aerobic exercise, specifically examining the relationship between intensive aerobic exercise and *maximum heart rate* in athletes. The research was conducted by collecting several articles from various journal sources, including *Research Gate, Google Scholar,* and *Science Direct* by entering keywords written in full without abbreviations into the search. This analysis includes studies published between 2015 and 2024, with particular attention to longitudinal studies and meta-analyses.

3 Results

3.1 Cardiovascular Adaptation in Athletes

Cardiovascular adaptation in athletes is the result of regular and consistent aerobic exercise. This adaptation is known as "*Athletic Heart Syndrome*or athlete heart syndrome, which reflects the physiological changes of the heart in response to sustained exercise.

The structural changes that occur in the athlete's heart are significant. The heart volume increases in adaptation to the demands of high exercise. This is characterized by a proportional enlargement of the heart's chambers, allowing the heart to hold and pump more blood in a single contraction. Simultaneously, the ventricular wall undergoes a balanced thickening, which increases the strength of the heart's contractions without interfering with its normal functioning.

Capillary density also increases as an adaptive response. The small blood vessels that supply the heart muscle and skeletal muscle increase in number as new blood vessels form (*angiogenesis*), creating more complex vascular tissue. This allows for a more efficient distribution of oxygen and nutrients throughout the tissues in need. The function of the endothelium, which is the inner lining of blood vessels, has also improved, improving the ability of blood vessels to regulate blood flow as needed.

Based on the aspect of functional adaptation, the changes that occur are no less important. The volume of the *stroke* increases significantly, which means the heart can pump more blood in a single contraction. This increase is the result of greater heart volume and stronger contractility. As compensation for this increased efficiency, the athlete's resting heart rate becomes lower because the heart does not need to beat as fast as an untrained person to meet the needs of blood circulation.

The efficiency of myocardial oxygen use has also improved. The heart muscle becomes better at extracting and using available oxygen, allowing the heart to work harder with relatively lower oxygen consumption. This is very important for athletes' performance because it allows them to maintain a higher intensity of training for a longer period of time.

One of the most striking functional adaptations is the faster recovery of the heart rate after exercise. Trained athletes show a better ability to return the heart rate to normal levels after strenuous physical activity. It is an important indicator of cardiovascular fitness and the body's ability to recover from exercise stress.

All of these adaptations work synergistically to improve the overall efficiency of the cardiovascular system. The athlete's heart becomes stronger, more efficient, and more responsive to the demands of training. These changes do not occur instantaneously, but are the result of consistent and progressive practice over a long period of time.

3.2 Adaptation of the Nervous System in Athletes

Intensive aerobic exercise over time not only provides changes for the body in terms of cardiovascular adaptation, but also the adaptation of the nervous system that compensates and increases with the intensive aerobic exercise undergone by the athlete.

In the nervous system, adaptation begins with an increase in vagal tone which reflects the strengthening of the activity of the parasympathetic nervous system. This results in a decrease in resting heart rate and increased heart rate variability, signaling improved heart autonomic control. The sympathetic nervous system also undergoes modulation that allows for more efficient regulation in *the fight-or-flight* response and optimization of catecholamine release.

Baroflex, which plays a role in blood pressure regulation, is optimized through increased baroreceptor sensitivity. This results in more efficient blood pressure regulation and a faster response to changes in posture. Chemoreceptors also undergo increased sensitivity, allowing for better detection of changes in oxygen and carbon dioxide levels in the blood.

All of these adaptations work synergistically to result in an overall improvement in cardiovascular efficiency. The result is a lower resting heart rate, greater *volume stroke*, and more efficient *cardiac output*. The distribution of blood to various body tissues also becomes more optimal, supporting improved physical performance and faster recovery.

3.3. Adaptation of Intensive Aerobic Exercise to Physiological Processes in Athletes

In the early stages of exercise (0-4 weeks), the body begins to adapt to new physical activity characterized by changes in neural stimuli that result in increased activity of the sympathetic nervous system responsible for the "*fight or flight*" response. The sympathetic nervous system releases nerve ketcholamines such as epinephrine and norepinephrine that help increase heart rate and blood flow to the working muscles. In addition, modulation of vagal control also occurs to maintain a balance between sympathetic and parasympathetic neural activity.

When the exercise starts, the heart rate increases to pump blood faster throughout the body. An increase in cardiac output or the amount of blood pumped by the heart per minute also occurs. The blood vessels undergo vasodilation or dilation to increase blood flow to the active muscles.

In the intermediate adaptation phase (4-12 weeks), the body begins to make structural and functional adaptations to improve efficiency and performance. The initiation of myocardial hypertrophy or enlargement of the heart muscle occurs to increase the heart's pumping capacity. The body also begins to form new capillaries in a process called *angiogenesis*, which increases the blood supply to the muscles. The increased density of mitochondria in cells results in more energy.

The occurrence of functional adaptation in the form of strokes the volume or amount of blood pumped by the heart per beat increases. The efficiency of oxygen use by the muscles is also increased, allowing the muscles to work longer without getting tired quickly.

In the advanced adaptation phase (>12 weeks), the body's adaptation has reached a more stable level. Myocardial hypertrophy reaches a stable level allowing the heart to pump blood much more efficiently. The capillary tissue that forms in the muscles matures so that it increases the supply of nutrients and oxygen to the muscles.

In this advanced adaptation phase, there is also an increase in aerobic enzymes in the muscles, helping in a more efficient process of energy metabolism. The body becomes more efficient in using energy from carbohydrates and fats. The utilization of the energy substrate is optimized, so that the body can make better use of available energy sources. The body's oxidative capacity or ability to produce energy through oxidative processes increases, which allows high-intensity exercise to be performed for longer.

4 Conclusion

Based on research with a comprehensive review, it can be concluded that the correlation between intensive aerobic exercise plays a major role in increasing the maximum heart rate (MHR) in athletes. Through instinctive aerobic exercise undertaken by athletes, it allows for the body's adaptation such as cardiovascular adaptation, structural changes, and physiological and nervous system adaptations. These adaptations allow athletes to perform training at higher intensity and longer durations, as well as improve their overall performance and endurance.

References

Bellenger, C. R., et al. (2016). "Monitoring Athletic Training Status Through Autonomic

Heart Rate Regulation: A Systematic Review and Meta-Analysis." Sports Medicine, 46(10), 1461-1486.

Bishop, D. J., et al. (2019). "High-Intensity Exercise and Mitochondrial Biogenesis: Current Controversies and Future Research Directions." Physiology, 34(1), 56-70.

Bouchard, C., et al. (2011). "Genomic predictors of the maximal O_2 uptake response to standardized exercise training programs." Journal of Applied Physiology, 110(5), 1160-1170.

Green, D. J., et al. (2017). "Exercise training and cardiovascular adaptation: molecular mechanisms." Exercise and Sport Sciences Reviews, 45(2), 73-79.

Halson, S. L. (2014). "Monitoring Training Load to Understand Fatigue in Athletes." Sports Medicine, 44(2), 139-147.

Hawley, J. A., et al. (2018). "Integrative biology of exercise." Cell, 159(4), 738-749.

Hellsten, Y., & Nyberg, M. (2016). "Cardiovascular adaptations to exercise training." Comprehensive Physiology, 6(1), 1-32.

Hellsten, Y., et al. (2015). Cardiovascular Adaptations to Aerobic Training. Compr Physiol.

Hood, D. A., et al. (2019). "Maintenance of Skeletal Muscle Mitochondria in Health, Exercise, and Aging." Annual Review of Physiology, 81, 19-41.

Kellmann, M., et al. (2018). "Recovery and Performance in Sport: Consensus Statement." International Journal of Sports Physiology and Performance, 13(2), 240-245.

Lundby, C., & Jacobs, R. A. (2016). "Adaptations of skeletal muscle mitochondria to exercise training." Experimental Physiology, 101(1), 17-22.

MacInnis, M. J., & Gibala, M. J. (2017). "Physiological adaptations to interval training and the role of exercise intensity." The Journal of Physiology, 595(9), 2915-2930.

Meeusen, R., et al. (2013). "Prevention, diagnosis and treatment of the overtraining syndrome: joint consensus statement of the European College of Sport Science and the American College of Sports Medicine," European Journal of Sport Science, 13(1), 1-14.

Michael, S., et al. (2017). "Heart rate variability adaptations to long-term endurance exercise." Sports Medicine, 47(12), 2533-2551.

Mitchell, J. H. (2013). "Neural circulatory control during exercise: early insights." Experimental Physiology, 98(4), 867-878.

Mujika, I., & Padilla, S. (2019). "Detraining: Loss of Training-Induced Physiological and Performance Adaptations." Sports Medicine, 50(2).

Perry, C. G., & Hawley, J. A. (2018). "Molecular basis of exercise-induced skeletal muscle mitochondrial biogenesis: Historical advances, current knowledge, and future challenges." Cold Spring Harbor Perspectives in Medicine, 8(9), a029686.

Seiler, S. (2010). "What is Best Practice for Training Intensity and Duration Distribution in Endurance Athletes?" International Journal of Sports Physiology and Performance, 5(3), 276-291.

Sharma, S., et al. (2015). Exercise and the Heart: The Good, the Bad, and the Ugly. Journal of Cardiovascular Medicine.

Soligard, T., et al. (2016). "How much is too much? (Part 1) International Olympic Committee consensus statement on load in sport and risk of injury." British Journal of Sports Medicine, 50(17), 1030-1041.

Tucker, R., & Collins, M. (2012). "What makes champions? A review of the relative contribution of genes and training to sporting success." British Journal of Sports Medicine, 46(8), 555-561.

White, D. W., & Raven, P. B. (2014). "Autonomic neural control of heart rate during dynamic exercise: revisited." The Journal of Physiology, 592(12), 2491-2500.

3962-Article Text-16080-1-4-20250531.docx

ORIGINALITY REPORT

12%	8%	7%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	ndl.ethernet.edu.et Internet Source	1%
2	www.ijmra.in Internet Source	1%
3	jurnal.stokbinaguna.ac.id Internet Source	1%
4	Dewangga Yudhistira, Muhammad Sukron Fauzi, Naheria Naheria, Didik Cahyono et al. "The Role of Virtual Reality in Optimizing Karate Performance: Scoping Review", Physical Education Theory and Methodology, 2025 Publication	1%
5	brightideas.houstontx.gov Internet Source	1%
6	A. Bukhari, S. As’ad, N.A. Taslim, M. Thaiyeb, I.Y. Chrissander, F.A. Pramudyo. "Dextrose 10% drink is superior to sodium-dextrose drink in increasing blood glucose and sprint speed in soccer players: A double-blinded randomized crossover trial study", Science & Sports, 2021 Publication	1%
7	Submitted to University of Surrey Student Paper	1%

8	Adika Fatahilah, Yusuf Hidayat, Komarudin Komarudin, Jajat Darajat Kusumah Negara. "The effect of brain gym on brain waves and levels athlete concentration", Jurnal Aisyah : Jurnal Ilmu Kesehatan, 2023 Publication	<1 %
9	www.frontiersin.org Internet Source	<1 %
10	Nino Nikolovski, Trishawna A. Fongwoo, Adam N. Di Salvo. "From strength to stamina: an examination of subsequent resistance and endurance training impact on mitochondrial adaptations and endurance performance", The Journal of Physiology, 2023 Publication	<1 %
11	Paul J. Ponganis, Birgitte I. McDonald. "Cardiovascular physiology in dolphins and other cetaceans", Elsevier BV, 2024 Publication	<1 %
12	Peter M. Tiidus, Rebecca E. K. MacPherson, Paul J. LeBlanc, Andrea R. Josse. "The Routledge Handbook on Biochemistry of Exercise", Routledge, 2020 Publication	<1 %
13	Ryan M. Curtis, Courteney L. Benjamin, Robert A. Huggins, Douglas J. Casa. "Elite Soccer Players - Maximizing Performance and Safety", Routledge, 2019 Publication	<1 %
14	ejurnal.ubharajaya.ac.id Internet Source	<1 %
	kipdf.com	

15	Internet Source	<1%
16	tmfv.com.ua Internet Source	<1%
17	Evans, Cliff, Tippins, Emma. "EBOOK: Foundations of Nursing: An Integrated Approach", EBOOK: Foundations of Nursing: An Integrated Approach, 2008 Publication	<1%
18	Youlian Hong. "Routledge Handbook of Ergonomics in Sport and Exercise", Routledge, 2013 Publication	<1%
19	Ian Jeffreys, Jeremy Moody. "Strength and Conditioning for Sports Performance", Routledge, 2021 Publication	<1%

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		