The effect of aquarobics high intensity interval training in on interleukin-6 (IL-6) serum changes for over 8 weeks

by Siti Baitul

Submission date: 07-Jul-2023 09:30AM (UTC+0700)
Submission ID: 2127505917
File name: The_effect_of_aquarobics_high.pdf (348.64K)
Word count: 5718
Character count: 33667

Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 12), Art 394, pp. 3114-3121, December 2022
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

The effect of aquarobics high intensity interval training in on interleukin-6 (IL-6) serum changes for over 8 weeks

SITI BAITUL MUKARROMAH[1*], MOHAMMAD ARIF ALI[2], GUSTIANA MEGA ANGGITA[3], RONNY LESMANA[4], AZIIZ MARDANARIAN ROSDIANTO[5], KOMARUDIN[6], YULINGGA NANDA HANIEF[7], NGUNYEN TRA GIANG[8], SHANGHEON HENRY PARK[9]
[1,2,3] Department of Sport Science, Sports Science Faculty, Universitas Negeri Semarang, INDONESIA
[4,5]Department of Anatomy, Physiology, and Biology of Cell, Faculty of Medicine, Universitas Padjadjaran, INDONESIA
[6]Physical Education Health and Recreation, Sports Science Faculty, State University of Yogyakarta, INDONESIA
[7]Department of Sport Coaching, Faculty of Sport Science, Universitas Negeri Malang, INDONESIA
[8]Faculty of Sport Science and Technology, Bangkok Thonburi University, THAILAND
[9]Sports Biomechanics, Korea Institute of Sport Science, KOREA

Published online: December 25, 2022
(Accepted for publication December 15, 2022)
DOI:10.7752/jpes.2022.12394

Abstract:
Depending on the type of exercise, different activities will have different effects on pro-inflammatory cytokine levels in overweight and obese people. The health of both men and women has improved because of a number of moderate-intensity aerobic activities, which also resulted in decreased levels of pro-inflammatory cytokines. This aquarobics high intensity interval training is one of the physical exercises that has an impact on the cardiovascular and musculoskeletal system of the human body. Cardio exercise, also referred to as aerobic exercise, is one of the activities that provide wellness for body health. These are also frequently used to measure the effectiveness of a workout combined with aerobic activity. The design using a randomized experimental pre–post-test control group involved a study of 24 obese females aged 40 to 50 (BMI > 30 kg/m2) who were divided into two groups: aquarobics high- intensity training for eight weeks (n = 12); and a control group (n = 12). The subjects completed a questionnaire that asked for their age, last menstrual period, and menopausal status. All participants were made aware of the potential risks and read the study procedures before signing the informed consent form. The improvement in body health was further supported by changes in total cholesterol levels and body fitness levels before and after eight weeks of exercise. We observed a pattern that aquarobics high-intensity interval training had a favorable cellular signaling effect with a decrease in the level of IL-6, which is a pro-inflammatory cytokine that characterizes the detection of health disorders in the body, resulting in chronic inflammation, infectious diseases, and autoimmune diseases.
Key Words: IL-6, physical activity, BMI, and fitness.

Introduction

The immune system's response to harmful signals, such as infections, cell debris, poisonous substances, or irradiation, is inflammatory, and it functions by removing the unwanted stimuli and starting the healing process. In turn, this makes inflammation a necessary kind of defense. Cellular and molecular activity and interactions commonly successfully reduce the risk of harm or infection during acute inflammatory reactions. Both acute inflammation and the restoration of tissue homeostasis are facilitated by this mitigating mechanism. However, unchecked acute inflammation can turn chronic, leading to a number of chronic inflammatory diseases [Chan et al., 2010]. However, the immune system adapts as physiological systems age, leading to a continuous response to factors that cause a chronic inflammatory response, regardless of whether the disease is present or not. Surprisingly, everyone believes that exercise is a substitute for maintaining good health and can even help people who are physically or emotionally unwell [Burn et al., 2017]. Evidence shows that regular exercise has beneficial therapeutic effects and can be used to treat a number of chronic diseases. Skeletal muscle is classified as a secretory organ, which gives a foundation for understanding how muscles interact with various other body parts. Skeletal muscle produces several hundred myokines, some of which are triggered by muscle contraction and are managed differently in healthy and metabolically ill individuals [Donges CE, Duffield R, Drinkwater EJ.2010].

As with many paradigm-shifting discoveries, the discovery of muscle-derived IL-6 has been somewhat coincidental. Twenty years ago, we discovered that plasma levels of IL-6 increased dramatically in response to a single bout of exercise while looking for a mechanism to explain exercise's impact on the immune system. Interleukin-6 (IL-6) is a cytokine produced by neutrophils, macrophages, fibroblasts, endothelial cells, damaged

Corresponding Author: SITI BAITUL MUKARROMAH, E-mail: sitibaitul@mail.unnes.ac.id

muscle cells, fat cells, and cancer cells. It has been discovered to influence immune defense processes as well as hematopoies. IL-6 is a solubility mediator that has a variety of effects on the inflammatory response, immunological activation, and hematopoiesis [Li, L., Huang, C.2021] Muscle cells that contract produce and release IL-6. Exercise causes a nearly linear increase in plasma IL-6 concentrations. The maximum level of IL-6 is reached near the end of the session or shortly after, resulting in a rapid decline to prior levels. Following a workout, the amount of IL-6 in the blood may increase by up to 100-fold. As the primary mediator of the inflammatory process, IL-6 has been linked to a number of medical disorders, including cardiovascular disease, diabetes, cancer, rheumatoid arthritis, and mental illness Increased systemic IL-6 levels have also been linked to the severity of clinical outcomes associated with viral infections in human and animal studies. Humans with the Andes virus, influenza virus, hepatitis C virus, HIV, and Chikungunya virus had higher levels of IL-6 in their blood. As a result, IL-6 may be crucial during viral infections [Wang Y, Zhou M, Lam KSL, Xu A. 2009; Behrendt, T., 2021; Leuchtmann, A. B., 2022].

The increase in plasma IL-6 is influenced by the amount of muscle mass involved in the activity and the duration of the exercise. Intensity of training is also important, especially if the exercise depletes intramuscular glycogen stores. As a result, studies have revealed that depleting muscle glycogen significantly increases IL-6 production from working muscles. For the same power output, blood lactate levels are lower in trained athletes. The same is true for IL-6, which is most likely due to trained individuals having higher muscle glycogen concentrations than untrained individuals [Pedersen BK, Steensberg A, Schjerling P. 2001]. Multiple studies have found that long-distance testing, such as a long race and; quarter; or long cycling, increases the level of proinflammatory cytokines released in the bloodstream. Chronic exercise, on the other hand, may reduce IL-6 secretion [Soares, V., et. al. 2020; Da Silva, C., et. al. 2020]. Furthermore, in the recent pandemic state, it has been found that exercise training and a high level of cardiorespiratory fitness are likely to be immune protective in patients who contract SARS-CoV2 due to the positive effects on select immune markers associated with many comorbid diseases [Filgueira, T., et al. 2021; Arazi, H., Falahati, A., & Suzuki, K. 2021].

Previous studies on aquatic high- intensity interval training (n = 261) and a control group (n = 215) were compared in a previous study that contained a meta-analysis of 242 articles made up of 18 studies (13 trials). Aquatic high-intensity interval training (AHIIT) was chosen in a randomized controlled experiment (RCT) to investigate its benefit as a measure of cardiovascular health in women. As a result, women's cardiometabolic and physical health were found to be moderately improved by aquatic high-intensity interval training; [Kwok MMY, Ng SSM, Man SS, So BCL.2022]. Another study looked at the impact of aquatic high-intensity interval training on strength, body composition, and aerobic capacity in a group of non-athletes. Through May 2018, a thorough examination of six databases was conducted. Trials qualified for inclusion if they evaluated the impact of A-HIIT in a population of non-athletes in comparison to a control group that underwent no exercise regimen. Two separate reviewers independently extracted the data, and a random effects model was used in a meta-analysis to obtain standardized mean difference (SMD) and 95% confidence intervals (CIs). The Cochrane risk of the bias tool was used to evaluate the bias risk. The quality of reporting for each study was rated using the Physiotherapy Evidence Database (PEDro) and Consensus for Exercise Reporting Template (CERT) scales. [Depiazzi JE, Forbes RA, Gibson N, et al. 2019]. Regarding the uniqueness of this study when compared to other studies, this study's direct application of aquarobics high-intensity training has emerged as a viable alternative as a game-changing workout regimen to increase fitness, and no prior research of this kind has been conducted. Aquarobics is an alternate kind of exercise type that combines aerobic exercise choreography performed in water and is referred to as aquarobics high- intensity interval training. Previous research employed aquatic workouts and produced a review paper.

While the relationship between individual health behaviours and IL-6 is well established in some populations, no research has examined the impact of elevated IL-6 on the combined effect of these health behaviours in obese patients with a high BMI who are at risk for poor health behaviours and for whom IL-6 is a significant prognostic marker. Aquatic exercise is frequently used to maintain or improve muscle and joint function, particularly in osteoarthritis patients. Using water as an exercise medium can reduce the risk of muscle and joint injury [Verhargen, A.P., Cardoso, J.R., & Bierma Zeinstra, S.M.A.2012]. Aquarobics benefits have the same impact on body changes as land exercise, with the same intensity, duration, and frequency. Based on the increase in heart rate after 11 weeks of exercise, there was no significant difference between aerobic exercise in water and aerobic exercise on land. Exercise in the water has advantages in terms of buoyancy, temperature, and exercise variety. [Gappmaier, E., Lake, W., Nelson, A. G., & Fisher, A. G., 2006]. Water exercises are recommended for people who are overweight. One water fitness activity that can be done as an alternative to exercising on land to for losing weight is aqua jogging. According to Very Well Fit, aqua jogging is a combination of running and swimming that is beneficial for heart and blood vessel endurance. Because the feet are not burdened by supporting the body when stepping, this exercise is also beneficial for recovering from injuries. [Irandoust K, Taheri M., 2015].

Aquarobics-which uses the high-intensity interval training exercise design, is expected to be a weight-loss alternative to exercising in water. Aquarobics can be a very appropriate formula for morning or evening

physical exercise, especially for sports scientists in this field and the public, who have been shown to play a role in the application of various exercise methodologies via education and research. The negative impact of changes in lifestyle that are all practical and instant, particularly in big cities, is an increase in the prevalence rate of atherosclerotic cardiovascular disease (PKVAS), which is mediated by physiological changes in the body, particularly blood composition, as the world's leading cause of death [Nangle EF et al. 2007]. The goal of this study was to determine if there was a link between aquarobics high- intensity interval training and serum IL-6 levels in people with different cholesterol levels and in different BMI categories after they completed an 8-week exercise program.

Material & methods

Participants

First, 24 obese females aged 40 to 50 (BMI > 30 kg/m2) were divided into two groups: one received aquarobics HIIT for eight weeks (n = 12), and the other was the control group (n = 12). The subjects completed a questionnaire that asked for their age, last menstrual period, and menopausal status (the last menstrual period was 8 months). All participants were made aware of the potential risks and read the study procedures before signing the informed consent form. The Indonesian Research Ethics Committee, Kariadi Hospital, Diponegoro University, Semarang (No.519/EC/FK/RSDK/2021) approved this study.

Aquarobics Exercise

Aquarobics high-intensity interval training (HIIT) is a combination of exercises that describes training that alternates between bursts of intense activity and steady periods of less intense activity or with short-term rest and is used to create an effective and efficient weight loss program. Aquarobic high-intensity interval training is an exercise method that aims to train the cardiovascular system using high-intensity exercises that can be completed in a short period of time, typically 10–30 min per workout. It is believed that after performing this exercise, the body's metabolism will increase, and the body will continue to burn fat even while at rest. Aquarobics high-intensity interval training is a water-based cardio exercise that combines high-intensity exercise with moderate or low intensity at regular intervals. Regular high-intensity interval training exercise can raise HDL levels in the blood while lowering total cholesterol, LDL, and triglycerides. [Nagle EF, et. al. 2007; Tang S, et. al. 2022; Kwok MMY, et. al. 2022] Aquarobics is an aerobic exercise performed in a standing body position in the water, while the person is submerged with the water depth at chest level and with; feet touching the bottom of the pool, and it involves performing rhythmic movements against water resistance, following an the instructor. This exercise is also known as a low-impact aerobic exercise that involves rhythmic movements of the large muscles of the entire body that is performed in water to the beat of music at a tempo of 140 beats per minute. Figure 1 is the design for the aquarobics high-intensity interval training.

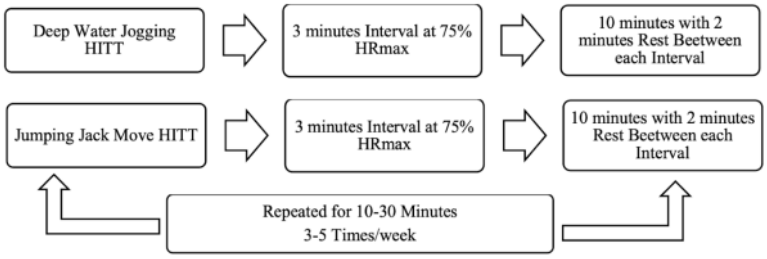

Figure 1. Aquarobics High Intensity Interval Training Design

Monitoring of Heart Rate

Monitoring heart rate during exercise is a critical component of meeting fitness improvement goals, particularly in sports training aimed at improving cardiovascular health and weight loss. It is critical to establish training zones in the preparation of an exercise program, i.e; the zones where the best benefits of aerobic exercise and fat burning occur, . without first determining our target heart rate training zone before beginning an exercise program. [Astorino TA, Allen RP, Roberson DW, and Jurancich M.2012]. Heart rates range from 85 to 150 beats per minute in 40-45 year olds, 80 to 145 beats per minute in 50-55 year olds, 75 to 135 beats per minute in 60-65 year olds, and 75 to 130 beats per minute in 70 year olds. [Ozemek C, Whaley MH, Finch WH, Kaminsky LA. 2017; Jensen MT. 2019]. Raising the heart rate while exercising in the water is more difficult than when exercising on land. Water comprises 65–95% of all body cells. During the exercise session, heart rate monitors were used every five minutes. Participants in aqua jogging completed four moderately intense (75% HRmax) sessions over the course of eight weeks.

Anthropometric Measurements

The body mass index was measured in kilograms (kg), and the height was measured in meters using a 150kg capacity digital platform scale (OMRON B511) with a precision of 0.5 kg and a stiff tape measure of 2 m

and 50 cm (m). The Body Mass Index (BMI-kg/m^2) was calculated using body mass and height measurements (low BMI was defined as a BMI of 18.5 kg/m^2, normal was a BMI of 18.5–24.9 kg/m^2, overweight was a BMI > 25–29.9 kg/m^2, obesity was a BMI > 30–34.9 kg/m^2, and obesity grade II was a BMI of 35 kg/m^2).

Blood Serum Interleukin-6

Interleukin-6 levels in fresh blood serum samples were measured. The enzyme-linked immunosorbent assay measurement method was used. The Human IL-6 ELISA Kit [invitrogen®, for research use only, not for diagnostic or therapeutic procedures] was used.

Statistical analysis

Continuous variables are presented quantitatively (Mean SD), whereas explanatory variables are presented as percentages. The independent Mann–-Whitney U and Kruskal-Wallis tests were used to demonstrate differences between participant profile factors, behavior changes to physical activity and fitness, and serum IL-6 levels for continuous variables. The significance level was set at P=0.05. For statistical analysis, GraphPad Prism 8.1.2 software was used.

Results

Age and Body Mass Index (BMI) for the aquarobics high- intensity interval training group did not differ before treatment. However, after treatment, there was a significant difference between control and the training group, which was due to weight loss from exercise. This study's findings revealed that eight weeks of aquarobics high- intensity interval training reduced body mass index (p = 0.00).

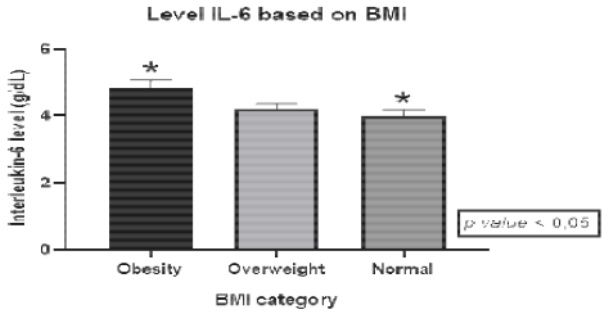

Figure 2. Interleukin-6 levels for each BMI category.

Figure 2 indicates a substantial lowering trend of blood IL-6 levels for each BMI category for those that completed the aquarobics high-intensity interval training for eight weeks. The findings also demonstrated significant variations in the levels of serum IL-6, which rose in cases of obesity and fell in cases with normal BMI.

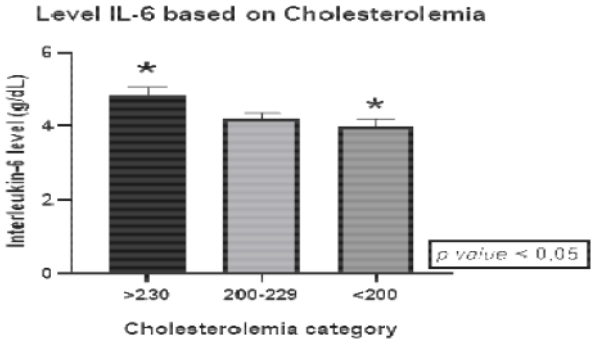

Figure 3. Serum IL-6 levels by levels of serum cholesterol.

As previously shown, Figure 3 shows the results after eight weeks of following the exercise program, which shows a significant decrease in serum IL-6 levels based on the respective serum total cholesterol levels. It This indicates an improvement in blood cholesterol levels with regular exercise.

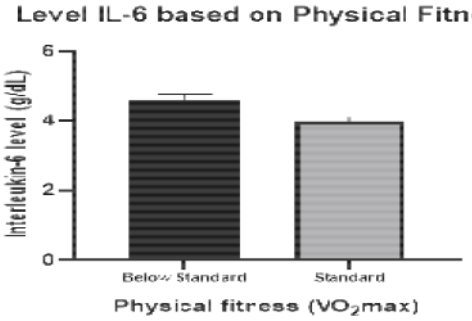

Figure 4. Serum IL-6 levels based on cardiorespiratory fitness

Despite the changes shown in Figure;3, they did not show a statistical significance. After eight weeks of the exercise program, there was a good decrease in serum IL-6 levels as a function of cardiorespiratory fitness with standard VO_2max levels.

Discussions

IL-6 is a cytokine that regulates the immune and musculoskeletal systems and is a pro-inflammatory cytokine involved in inflammatory responses. When produced in excess, it can cause unwanted inflammation. This situation is potentially dangerous, especially when combined with chronic diseases characterized by high levels of inflammation (Behrendt, T., et. al., 2021; Atakan, M. M., et. al., 2021). The findings of this study (Fig. 2) showed a lower trend of IL-6 decline as a function of BMI. Higher IL-6 levels were found in the obesity BMI category (p-0.05). This was followed by the lowest level in the normal BMI category (p-0.05). Therefore, the decrease in serum IL-6 levels after the aquarobics high- intensity interval training program for 8 weeks is thought to have implications for BMI. In another investigation, the measured serum levels of IL-6 were significantly lower after moderate exercise than before exercise. It has been reported in previous studies that depending on the intensity of the exercise, the levels of this cytokine can decrease drastically with various forms of exercise, such as cycling, swimming, ball, mountain running, and sports. The prevalence of obesity is inversely correlated with the rise in circulating levels of IL-6. Increased levels have the potential to cause cardiovascular diseases, such as atherosclerosis and coronary heart disease, either directly or indirectly. (Knudsen, J. G., et al., 2017; Fonseca, T. R., et al., 2021). According to the findings shown in Figures 2 and 3, obesity-related BMI circumstances and hypercholesterolemic situations both showed a trend of considerable increases in measured IL-6 levels.

Aquarobics high- intensity interval training was used in this study for 8 weeks. The findings of this study showed that the significant reduction in IL-6 levels was liniear with normal serum cholesterol levels ($p > 0.05$), which was consistent with the findings of other in vivo studies. Xiang et al. and Amin et al. found that obese mice treated with moderate-intensity exercise had lower IL-6 levels after exercise than sedentary mice. Aquarobics high- intensity interval training for 8 weeks can keep IL-6 levels in check while improving overall health [Mukarromah, SB. 2014]. This study also looked at IL-6 levels in relation to physical fitness (VO_2max). The findings of this study (Fig. 4) revealed that an increase in fitness following 8 weeks of his type of training resulted in a decrease in IL-6 levels, which is known as a leading indicator of adverse chronic disease conditions. Patients with chronic diseases have higher levels of IL-6 than healthy people. These people can reduce inflammation by exercising regularly and eating a nutritious diet. When the same patient participates in incapacitated intensive training, IL-6 levels rise, worsening the disease condition. [N. Khosravi et al. 2021; R. S. Metcalfe et al. 2021] According to the findings shown in Figures 2 and 3, the trend of a significant increase in IL-6 levels proved to be measurable in for the categories of BMI, obesity, and hypercholesterolemia. Furthermore, the findings revealed that the decrease in IL-6 levels was related to improved BMI conditions, followed by normal serum cholesterol levels because of the exercise program.

Aquarobics high- intensity interval training is a combination of aerobic dance movements performed in water with water acting as a natural training load. Water pressure has a positive effect on the body, including stress reduction, weight loss, increased fitness, and muscle strength. [Farinha et al. 2022; Kim, J. H., Ha, M. S., Ha, S. M., and Kim, D. Y. 2021]. Movements are performed in water by moving against the current, deep water running HITT, and scissor movements. The basic moves activate the muscles, increasing blood flow to the lungs, heart, and rest of the body. The increased load caused by aquarobics high-intensity interval training places excessive stress on muscles and joints, but the gravity created by the water pressure allows for a wider range of motion. This allows the body's excess heat to be controlled, including changes in IL-6 levels, and aquarobics high-intensity interval training is an alternative to traditional water exercise that can effectively stimulate muscle adaptation. (Carraça, E. V., et al. Hsu, Y. J., Lee, M. C., Huang, C. C., and Ho, C. S.2021).

Conclusions

High-intensity interval training in aquarobics provides an friendly environment that promotes body thermoregulation, comfort, safety, and a different training environment, allowing instructors to impose a higher training intensity during movement execution with more repetitions. While conducting an exercise along the vertical direction of the water surface, the unsteady flow increases, which maximizes resistance due to water drag force, designed to allow instructors to strengthen the active muscles in a reduced weight-bearing condition because of buoyancy of the water imposes less impact force, enables the athlete to avoid injury. Thus, aquatic training provides a similar, if not better, training effect than land training with less risk of injury, allowing instructors and trainers to choose this training as a better alternative to land-based training (Mukarromah SB, et.all. 2022). High-intensity interval training in aquarobics provides instructors to significant advancement because it involves more muscular strength and joints at once, resulting in a higher energy cost than other training methods. Previous study, Even though water is 800 times denser than air, the resistance to movement in water is significantly greater than on land. Jumping horizontally in water, with or without a weighted vest, requires more effort to overcome water resistance, which helps an athlete strengthen muscles. Plyometric training with added weight in aquatic mediums has become popular in modern training, and instructors frequently use this training method in their sessions with athletes.(Raji Bismas, Sandip Sankar Ghosh, 2022)

High-intensity interval training in aquarobics aims to improve health and well-being while increasing body fitness, which is characterized by a normal heart rate. Meanwhile, fat will be broken down through a process known as hydrolysis. This process generates fatty acids and glycerol, which are then converted into energy via glycolysis and other biochemical reactions. Aquarobics is a type of aquatic aerobic exercise that can increase fat burning via the lipolysis mechanism. Aquarobics training can be recommended as a non-pharmacological disease prevention strategy for obesity conditions, as water is an excellent medium for exercising. We conclude that aquarobics high-intensity interval training can reduce IL-6 levels, which is also associated with a lower BMI, lower serum cholesterol levels, and cardiorespiratory fitness (VO_2max) based on BMI, serum cholesterol levels, and cardiorespiratory fitness (VO_2max).

Acknowledgment

The authors would like to thank Falcon Scientific Editing (https://falconediting.com) for proofreading the English language in this paper.

References

Arazi, H., Falahati, A., & Suzuki, K. (2021). Moderate Intensity Aerobic Exercise Potential Favorable Effect Against COVID-19: The Role of Renin-Angiotensin System and Immunomodulatory Effects. *Frontiers in physiology*, *12*, 747200. https://doi.org/10.3389/fphys.2021.747200

Astorino TA, Allen RP, Roberson DW, & Jurancich M. 2012. Effect of HighIntensity Interval Training on Cardiovascular Function, VO2max, and Muscular Force. The Journal of Strength and Conditioning Research. [Internet].

Atakan, M. M., Koşar, Ş. N., Güzel, Y., Tin, H. T., & Yan, X. (2021). The Role of Exercise, Diet, and Cytokines in Preventing Obesity and Improving Adipose Tissue. *Nutrients*, *13*(5), 1459. https://doi.org/10.3390/nu13051459

Behrendt, T., Kirschnick, F., Kröger, L., Beileke, P., Rezepin, M., Brigadski, T., Leßmann, V., & Schega, L. (2021). Comparison of the effects of open vs. closed skill exercise on the acute and chronic BDNF, IGF-1 and IL-6 response in older healthy adults. *BMC neuroscience*, *22*(1), 71. https://doi.org/10.1186/s12868-021-00675-8

Burn N, Norton LH, Drummond C, Norton KI.Changes in Physical Activity Behaviour and Health Risk Factors Following a Randomised Controlled Pilot Workplace Exercise Intervention. 2017;4(2):189-201.

Carraça, E. V., Encantado, J., Battista, F., Beaulieu, K., Blundell, J. E., Busetto, L., van Baak, M., Dicker, D., Ermolao, A., Farpour-Lambert, N., Pramono, A., Woodward, E., Bellicha, A., & Oppert, J. M. (2021). Effect of exercise training on psychological outcomes in adults with overweight or obesity: A systematic review and meta-analysis. *Obesity reviews : an official journal of the International Association for the Study of Obesity*, *22 Suppl 4*(Suppl 4), e13261. https://doi.org/10.1111/obr.13261

Chan RSM, Woo J. Prevention of overweight and obesity: how effective is the current public health approach. Int J Environ Res Public Health.2010 Mar;7(3):765–783.

Da Silva, C. B., Vieira, D. A., de Melo, L. F., Chagas, A., Gomes, A. D., de Faria, C., Jr, Teixeira, R., de Magalhães Queiroz, D. M., Rocha, G. A., Soares, M., Bezerra, J., & Silva, L. D. (2020). Interleukin-6-174G/C polymorphism is associated with a decreased risk of type 2 diabetes in patients with chronic hepatitis C virus. *World journal of hepatology*, *12*(4), 137–148. https://doi.org/10.4254/wjh.v12.i4.137.

Dall CH, Gustafsson F, Christensen SB, Dela F, Langberg H, & Prescott Eva. 2015. Effect of Moderate Versus High Intensity Effect on Vascular Function, Biomarkers, adn Quality of Life in Heart Transplant Reiients; A Randomized Crossover Trial. The Journal of Heart and lung Tranplantation [Internet].

Donges CE, Duffield R, Drinkwater EJ. Effects of resistance or aerobic exercise training on interleukin-6, C-reactive protein, and body composition. Med Sci Sports Exerc. 2010 Feb;42(2):304–313.

Depiazzi JE, Forbes RA, Gibson N, et al. The effect of aquatic high-intensity interval training on aerobic performance, strength and body composition in a non-athletic population: systematic review and meta-analysis. Clinical Rehabilitation. 2019;33(2):157-170. doi:10.1177/0269215518792039]

Farinha, C., Santos, H., Serrano, J., Oliveiros, B., Silva, F. M., Cascante-Rusenhack, M., Teixeira, A. M., & Ferreira, J. P. (2022). The Impact of Aquatic Exercise Programs on the Intima-Media thickness of the Carotid Arteries, Hemodynamic Parameters, Lipid Profile and Chemokines of Community-Dwelling Older Persons: A Randomized Controlled Trial. *International journal of environmental research and public health*, *19*(6), 3377. https://doi.org/10.3390/ijerph19063377.

Filgueira, T. O., Castoldi, A., Santos, L., de Amorim, G. J., de Sousa Fernandes, M. S., Anastácio, W., Campos, E. Z., Santos, T. M., & Souto, F. O. (2021). The Relevance of a Physical Active Lifestyle and Physical Fitness on Immune Defense: Mitigating Disease Burden, With Focus on COVID-19 Consequences. *Frontiers in immunology*, *12*, 587146. https://doi.org/10.3389/fimmu.2021.587146.

Fonseca, T. R., Mendes, T. T., Ramos, G. P., Cabido, C., Morandi, R. F., Ferraz, F. O., Miranda, A. S., Mendonça, V. A., Teixeira, A. L., Silami-Garcia, E., Nunes-Silva, A., & Teixeira, M. M. (2021). Aerobic Training Modulates the Increase in Plasma Concentrations of Cytokines in response to a Session of Exercise. *Journal of environmental and public health*, *2021*, 1304139. https://doi.org/10.1155/2021/1304139

Gappmaier, E., Lake, W., Nelson, A. G., & Fisher, A. G. 2006. Aerobic exercise in water versus walking on land: Effects on indices of fat reduction and weight loss of obese women. Journal of Sports Medicine and Physical Fitness, 46(4), 564).

Hsu, Y. J., Lee, M. C., Huang, C. C., & Ho, C. S. (2021). The effects of different types of aquatic exercise training interventions on a high-fructose diet-fed mice. *International journal of medical sciences*, *18*(3), 695–705. https://doi.org/10.7150/ijms.52347

Irandoust K, Taheri M. 2015. The effects of aquatic exercise on body composition and nonspecific low back pain in elderly males. J Phys Ther Sci;27:433-5.

Jensen MT. 2019. Resting heart rate and relation to disease and longevity: past, present and future. Scand J Clin Lab Invest. 79(1-2):108-16.

Khosravi, N., Hanson, E. D., Farajivafa, V., Evans, W. S., Lee, J. T., Danson, E., Wagoner, C. W., Harrell, E. P., Sullivan, S. A., Nyrop, K. A., Muss, H. B., Bartlett, D. B., Jensen, B. C., Haghighat, S., Shamsi, M. M., & Battaglini, C. L. (2021). Exercise-induced modulation of monocytes in breast cancer survivors. *Brain, behavior, & immunity - health*, *14*, 100216. https://doi.org/10.1016/j.bbih.2021.100216

Kim, J. H., Ha, M. S., Ha, S. M., & Kim, D. Y. (2021). Aquatic Exercise Positively Affects Physiological Frailty among Postmenopausal Women: A Randomized Controlled Clinical Trial. *Healthcare (Basel, Switzerland)*, *9*(4), 409. https://doi.org/10.3390/healthcare9040409.

Knudsen, J. G., Gudiksen, A., Bertholdt, L., Overby, P., Villesen, I., Schwartz, C. L., & Pilegaard, H. (2017). Skeletal muscle IL-6 regulates muscle substrate utilization and adipose tissue metabolism during recovery from an acute bout of exercise. *PloS one*, *12*(12), e0189301. https://doi.org/10.1371/journal.pone.0189301

Kwok MMY, So BCL, Heywood S, Lai MCY, Ng SSM. 2022. Effectiveness of Deep Water Running on Improving Cardiorespiratory Fitness, Physical Function and Quality of Life: A Systematic Review. Int J Environ Res Public Health. Aug 1;19(15):9434. doi: 10.3390/ijerph19159434. PMID: 35954790; PMCID: PMC9367787.

Kwok MMY, Ng SSM, Man SS, So BCL. The effect of aquatic High Intensity Interval Training on cardiometabolic and physical health markers in women: A systematic review and meta-analysis. J Exerc Sci Fit. 2022 Apr;20(2):113-127. doi: 10.1016/j.jesf.2022.02.001. Epub 2022 Feb 7. PMID: 35228847; PMCID: PMC8851250

Leuchtmann, A. B., Furrer, R., Steurer, S. A., Schneider-Heieck, K., Karrer-Cardel, B., Sagot, Y., & Handschin, C. (2022). Interleukin-6 potentiates endurance training adaptation and improves functional capacity in old mice. *Journal of cachexia, sarcopenia and muscle*, *13*(2), 1164–1176. https://doi.org/10.1002/jcsm.12949.

Li, L., Huang, C., Yin, H., Zhang, X., Wang, D., Ma, C., Li, J., Zhao, Y., & Li, X. (2021). Interleukin-6 mediated exercise-induced alleviation of adiposity and hepatic steatosis in mice. *BMJ open diabetes research & care*, *9*(1), e001431. https://doi.org/10.1136/bmjdrc-2020-001431.

Metcalfe, R. S., Kemp, R., Heffernan, S. M., Churm, R., Chen, Y. C., Ruffino, J. S., Conway, G. E., Tornillo, G., & Orange, S. T. (2021). Anti-carcinogenic effects of exercise-conditioned human serum: evidence, relevance and opportunities. *European journal of applied physiology*, *121*(8), 2107–2124. https://doi.org/10.1007/s00421-021-04680-x.

Mukarromah SB. Development of Aquajogger as a Prospective Business Opportunity in the Field of Sports Fitness. Media Ilmu Keolahragaan Indonesia. 2014;4(2):105–13.

Mukarromah SB, et al (2022). Serum Dehydroepiandrosterone (DHEA) Concentration After Aquarobic Training in Premenopausal Women With Obesity. Journal of Physical Education and Sport ® (JPES),Vol 21 (Suppl. issue 4), Art 322 pp 2402 – 2407.

Nagle EF, Robertson RJ, Jakicic JJ, Otto AD, Ranalli JR, Chiapetta LB.2007. Effects of aquatic exercise and walking in sedentary obese women undergoing a behavioral weight loss intervention. Int J Aquatic Res Educ;1:43-56.

Ozemek C, Whaley MH, Finch WH, Kaminsky LA. 2017. Maximal heart rate declines linearly with age independent of cardiorespiratory fitness levels. Eur J Sport Sci.17(5):563-70.

Pedersen BK, Steensberg A, Schjerling P. Muscle-derived interleukin-6: possible biological effects. J Physiol .2001 Oct 15;536(Pt 2):329–337.

Raji Bismas, Sandip Sankar Ghosh (2022). Effect of Plyometric Training in Land Surface Aquatic Medium & Aquatic Medium With a Weighted Vest on The Aerobic Capacity of Athletes .Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 4), Art 118, pp. 930 – 940.

Soares, V., Silveira de Avelar, I., Espíndola Mota Venâncio, P., Pires-Oliveira, D., de Almeida Silva, P. H., Rodrigues Borges, A., Fonseca, G., & Noll, M. (2020). Acute Changes in Interleukin-6 Level During Four Days of Long-Distance Walking. *Journal of inflammation research*, *13*, 871–878. https://doi.org/10.2147/JIR.S281113.

Tang S, Huang W, Wang S, Wu Y, Guo L, Huang J, Hu M. 2022. Effects of aquatic high-intensity interval training and moderate-intensity continuous training on central hemodynamic parameters, endothelial function and aerobic fitness in inactive adults. J Exerc Sci Fit. Jul;20(3):256-262. doi: 10.1016/j.jesf.2022.04.004. Epub May 2. PMID: 35646132; PMCID: PMC9123277.

Verhargen, A.P., Cardoso, J.R., & BiermaZeinstra, S.M.A. (2012). Aquatic exercise & balneotherapy in musculoskeletal Conditions. Journal of Best Practice & Research Clinical Rheumatology, 26, 335– 343.

Wang Y, Zhou M, Lam KSL, Xu A. Protective roles of adiponectin in obesity- related fatty liver diseases: mechanisms and therapeutic implications. Arq Bras Endocrinol Metab. 2009;53:201–212.

WHO. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Public Health. 2004;363:157–63.

The effect of aquarobics high intensity interval training in on interleukin-6 (IL-6) serum changes for over 8 weeks

ORIGINALITY REPORT

19%	17%	9%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.efsupit.ro Internet Source	11%
2	bmcpublichealth.biomedcentral.com Internet Source	1%
3	espace.curtin.edu.au Internet Source	1%
4	Submitted to Universitas Negeri Jakarta Student Paper	1%
5	Submitted to Universitas Negeri Semarang Student Paper	1%
6	vdoc.pub Internet Source	1%
7	Sandip Sankar Ghosh, Raju Biswas. "Effect of Plyometric Training Conducted in Aquatic Medium on Speed and Explosive Strength of the Athletes", International Journal of Kinesiology and Sports Science, 2023 Publication	1%

8	link.springer.com Internet Source	1 %
9	Hermann Zbinden - Foncea, Marc Francaux, Louise Deldicque, John A. Hawley. "Does high cardiorespiratory fitness confer some protection against pro - inflammatory responses after infection by SARS - CoV - 2?", Obesity, 2020 Publication	1 %
10	Submitted to University of Limerick Student Paper	1 %
11	Guy E. Alvarez. "Obesity and Sympathetic Neural Activation", Medicine & Science in Sports & Exercise, 05/2004 Publication	1 %
12	medsci.org Internet Source	1 %

Exclude quotes	Off	Exclude matches	< 1%
Exclude bibliography	On		

The effect of aquarobics high intensity interval training in on interleukin-6 (IL-6) serum changes for over 8 weeks

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8