Kinestetik : Jurnal Ilmiah Pendidikan Jasmani 8 (4) (2024)
Kinestetik : Jurnal Ilmiah Pendidikan Jasmani
https://ejournal.unib.ac.id/index.php/kinestetik/index
DOI : 10.33369/jk.v8i4.38518

High Intensity Interval Training: Enhancing Health Outcomes for Individuals with Coronary Artery Disease

Ruslan *[1], Rusli [2], Sarifin G [3] Andi Sri Dewi Anggraeni. M[4]
[1,2,3,4] Physiotherapy Program, Faculty of Sports Science and Health, Universitas Negeri Makassar, Indonesia

Article Info

Article History :

Received : December 2024
Revised : December 2024
Accepted : December 2024

Keywords:

Coronary Artery Disease,
High Intensity Interval Training,
Quality of Life,

Abstract

Coronary artery disease (CAD) contributed to morbidity and mortality significantly in the world that is characterized by accumulation of atherosclerotic plaque within the arterial walls. Individuals with CAD often experience reduced functional capacity, lower quality of life (QoL), and elevated rates of depression This study aims to explore high-interval intensity training (HIIT) benefits in coronary artery disease patients. This study is a review literature that uses the existing database on PubMed and Google Scholar with the year 2019 to 2024 which specifically discusses High interval intensity training in coronary artery patients. The results of the study revealed that the benefits of high interval intensity training have an impact such as increasing physical capacity, namely VO2 and cardiovascular health and have a good impact on mental health. High interval intensity training is beneficial for people with coronary artery disease even though the first hour of exercise takes time for body adjustment. The implementation of high interval intensity training needs to involve professionals.

*Corresponding email : ruslan.r@unm.ac.id
ISSN 2685-6514 (Online)
ISSN 2477-331X (Print)

INTRODUCTION

Coronary artery disease (CAD) is the leading cause of significant morbidity and mortality both in the US and globally (Shahjehan et al., 2024). CAD is a widespread heart condition marked by the accumulation of atherosclerotic plaque within the arterial walls, which impedes blood flow and reduces oxygen supply to the heart muscle (Shahjehan et al., 2024). Individuals with CAD often experience reduced functional capacity, lower quality of life (QoL), and elevated rates of depression (Terada et al., 2022).

Exercise plays a vital role, as cardiorespiratory fitness (measured by peak oxygen consumption (VO2peak) has the greatest impact on cardiovascular outcomes (Taylor et al., 2020). Extensive research shows that aerobic capacity (VO2peak) is the strongest predictor of future health, all-cause mortality, and cardiovascular risk (Ito, 2019). For overall health and both primary and secondary cardiovascular prevention, high-intensity interval training (HIIT) is recognized as an effective exercise approach, offering short, intense workout sessions (Ito, 2019). Exercise training is a fundamental component of multidisciplinary rehabilitation for individuals with coronary artery disease (CAD) (McGregor et al., 2023). As a key element of modern secondary prevention strategies, exercise can enhance both physical and mental health (McGregor et al., 2023).

Interval training involves short bursts of intense activity that reach at least 90% of VO2max, more than 75% of maximal power, or supra-maximal effort, followed by rest or low-intensity exercise for recovery. One of the most common interval training approaches is high-intensity interval training (HIIT), which includes submaximal efforts that achieve ≥90% of ˙VO2max or exceed 75% of maximal power (Atakan et al., 2021).

The duration of HIIT sessions typically ranges from 30 seconds to several minutes. This type of training has been adapted for individuals with lifestyle-related conditions, including those with or without cardiac diseases (Ito, 2019). Recently proof-of-concept trials (including 2 large multi-center randomized controlled trials, RCTs) have been conducted by applying HIIT to patients with CAD and heart failure in cardiac rehabilitation which demonstrated generally positive effect (Keech et al. 2020)

Cardiac rehabilitation (CR) is a crucial element in the secondary prevention of CAD, demonstrating significant reductions in both cardiovascular and overall mortality (Taylor et al., 2020). However, current international cardiac rehabilitation (CR) guidelines emphasize the need for additional research into the feasibility, safety, and long-term adherence to HIIT (Taylor et al., 2020). This study aims to explore high-interval intensity training (HIIT) benefits in coronary artery disease patients through literature review, not only in VO2 and cardiovascular, but also mentally.

METHODS

This study employs a literature review research method, where relevant journals and theoretical references related to the research topic are explored. The process involves searching for, analyzing, and synthesizing information to strengthen the analysis. Data for the study was collected from Google Scholar (18.200) and PubMed (88 articles) with 9 articles specifically explaining HIIT in coronary artery disease using the keywords "High-intensity interval training" and "coronary artery disease."

The articles selected for review were published between 2019 and 2024.

RESULTS AND DISCUSSION

The of the study based on the literature used revealed that high-intensity interval training with a duration of 30 seconds to several minutes can be applied both individuals with or without cardiovascular disease in general can increase VO2 peak as a predictor of health and risk factors for cardiovascular disease, as well as have an effect on improving the quality of life for patients with coronary artery disease. In addition to increasing VO2 peak, regular exercise has a positive impact that lowers the risk of cardiovascular disease and improves self-reported general health and vitality. High-intensity interval training also demonstrated impact on mental health such as reducing depression severity and increasing Brain-derived neurotrophic factor (BDNF) concentrations.

VO2

Cardiac rehabilitation (CR) exercise training guidelines specifically aim to enhance cardiorespiratory fitness, particularly peak oxygen uptake (VO2 peak), which is a key clinical outcome (McGregor et al., 2023). High-intensity interval training (HIIT) has demonstrated greater improvements in VO2 peak compared to moderate-intensity continuous training (MICT) in individuals with coronary artery disease (CAD) (Taylor et al., 2020).

In a previous randomized clinical trial, a 4-week high-intensity interval training (HIIT) program showed improvements in VO2 peak compared to moderate-intensity continuous training (MICT) in patients with coronary artery disease (CAD) participating in cardiac rehabilitation. However, at the 12-month follow-up, VO2 peak improvements were similar between the two groups. HIIT was both feasible and safe, with adherence rates comparable to MICT over the 12-month period. These findings support the inclusion of HIIT in cardiac rehabilitation programs as an adjunct or alternative to moderate-intensity exercise (Taylor et al., 2020).

In other studies, low-volume HIIT initially used with the intensity gradually increased once participants were able to complete all 10 × 1-minute intervals. The protocol included 10 high-intensity intervals (85–90% peak power output (PPO) achieved during cardiopulmonary exercise tests (CPET); >85% HRmax) alternated with 10 low-intensity intervals (20–25% PPO) (McGregor et al., 2023). The intensity shifts were achieved by adjusting cadence, ensuring that participants maintained a perceived exertion (RPE) of less than 17 during the final two high-intensity intervals. Results showed that the HIIT intervention led to a 35% greater improvement in VO2 peak compared to moderate-intensity steady-state (MISS) training at the 8-week follow-up, suggesting a significant functional gain (McGregor et al., 2023). Furthermore, since there were no major differences in left ventricular structure or function between the groups, these results imply that the improvement in VO2 peak was likely due to peripheral adaptations rather than central system changes (McGregor et al., 2023).

A significant positive correlation was observed between changes in VO2 peak and quality of life markers, highlighting the role of cardiorespiratory fitness in improving quality of life (Kristiansen et al., 2022). Kristiansen et al (2022) demonstrated an improvement in quality of life following the 12-week HIIT intervention, in comparison to standard care. While it is well-established that exercise training enhances quality of life in CAD patients,

recent studies have explored whether HIIT or moderate-intensity continuous training differently affect quality of life (Kristiansen et al., 2022).

Meta analysis research found that HIIT induces an overall significantly larger increase in VO_{2peak} (1.92 mL/kg/min, 95%CI [1.30, 2.53], $p < 0.01$) than MICT with low heterogeneity ($p = 0.35$, $I^2 = 9\%$) (Du et al., 2021). HIIT places maximal stress on the oxygen uptake, transport, and utilization systems, thereby offering the most potent stimulus for improving VO2peak (Buccheit et al, 2013; Du et al., 2021) A 6 month follow-up of HIIT and MICT in coronary artery bypass patients revealed that aerobic capacity improved to a greater extent following HIIT (Moholdt et al., 2009; Quindry et al., 2019). Pattyn et al., conducted a 12 month follow-up after a similar HIIT-MICT multi-site randomized controlled trial, which showed that HIIT and MICT patients exhibited similar benefits in cardiorespiratory fitness, endothelial function, coronary risk factors, and quality of life (Pattyn et al., 2016; Quindry et al., 2019)

Previous randomized controlled trials (RCTs) comparing HIIT and moderate continuous training (MCT) for CAD patients, aimed at improving aerobic capacity, have shown mixed results. The protocols and number of studies demonstrating HIIT's superiority over MCT. Among the protocols, the 4 × 4-minute protocol was the most commonly used, with a success rate of 70.2% for CAD patients. Other protocols, with exercise durations of 30 seconds, 2 minutes, and 3 minutes, also showed effectiveness in a limited number of studies (Ito, 2019). VO2peak showed a significant increase after 10 weeks of training, with a greater improvement in the high-intensity group. The high-intensity aerobic exercise group completed a 5-minute warm-up consisting of treadmill walking at an intensity corresponding to 50–60% of VO2peak (65–75% of HR peak), followed by four 4-minute intervals of walking at 80–90% of VO2peak (85–95% of HR peak) (Rogmo et al., 2004). However, exercise testing should be conducted under the supervision of a physician prior to engaging in vigorous activity, particularly for patients with cardiovascular conditions (Thompson et al., 2003; Rogmo et al., 2004). For patients with coronary artery disease (CAD), it is recommended to engage in aerobic exercise at least three times a week, for a minimum of 20 minutes, at an intensity of at least 40% of VO2peak to enhance exercise capacity (American College of Sports Medicine Position Stand; Rogmo et al., 2004).

In addition to the positive impact on quality of life, HIIT also improved self-reported general health and vitality, which has been supported by other exercise training studies involving patient groups. These factors are crucial for exercise motivation, adherence, and continuation, suggesting that HIIT may be a sustainable training modality for CAD patients (Kristiansen et al., 2022).

Cardiovascular Fitness

Regular exercise reduces the risk of cardiovascular disease and mortality in healthy, elderly individuals (Kristiansen et al., 2022). A large retrospective study indicated that cardiac rehabilitation is linked to lower mortality in elderly CAD patients (>65 years old), although the precise mechanisms remain largely unclear (Kristiansen et al., 2022). One possible explanation for the observed improvements in cardiovascular health among elderly individuals engaging in regular exercise is the enhanced responsiveness of the β-adrenergic receptor, which deteriorates with aging

(Kristiansen et al., 2022). Regular exercise reduces the risk of cardiovascular disease and mortality in healthy, elderly individuals (Kristiansen et al., 2022). A large retrospective study indicated that cardiac rehabilitation is linked to lower mortality in elderly CAD patients (>65 years old), although the precise mechanisms remain largely unclear (Kristiansen et al., 2022). One possible explanation for the observed improvements in cardiovascular health among elderly individuals engaging in regular exercise is the enhanced responsiveness of the β-adrenergic receptor, which deteriorates with aging (Kristiansen et al., 2022).

Patients with CAD are at a higher risk of atherothrombotic events, which may partly be due to a procoagulant state (Kosuta et al., 2024). Coagulation biomarkers and hemostatic potentials are elevated in CAD patients, suggesting that the balance between coagulation and fibrinolysis shifts towards increased coagulation (Antovic, 2010; Kosuta et al., 2024). Higher baseline levels of overall hemostatic potential (OHP) and overall coagulation potential (OCP), along with lower baseline levels of overall fibrinolytic potential (OFP), confirming the existence of a procoagulant state in CAD patients (Antovic, 2010; Kosuta et al., 2024).

Kosuta et al (2024) found that levels of OHP, OCP, fibrinogen, D-dimer, and von Willebrand factor increased after exercise, while OFP showed a mild decrease. This hemostatic pattern reflects a shift towards coagulation, consistent with previous findings in healthy individuals. Transient exercise-induced increase in procoagulant markers may help explain the heightened risk of atherothrombotic events immediately following exercise. During the recovery period post-exercise, coagulation biomarkers and OHP returned to baseline levels, suggesting that the procoagulant effects of exercise in CAD patients are temporary, typically lasting no more than an hour (Kosuta et al., 2024).

Transient shift include stress responses such as adrenergic stimulation, endothelial-dependent and inflammation-mediated coagulation (Elsen et al. 2021; Kosuta et al., 2024). Acute exercise bouts increase sympathetic activity, which in turn activates coagulation and fibrinolytic pathways, producing a net procoagulant effect. Additionally, transient endothelial dysfunction and inflammation-oxidation during high-intensity exercise could promote platelet activity and enhance procoagulant pathways. Plasma volume depletion during exercise may also lead to hemoconcentration, affecting coagulation biomarker measurements and potentially driving coagulation cascades. While these hemostatic responses to exercise in healthy individuals are thought to be an evolutionary adaptation to protect against bleeding during injuries, in CAD patients, the combination of baseline hypercoagulability and the exercise-induced procoagulant shift may be considered an unfavorable risk factor (Kosuta et al., 2024). In some cases, high intensity exercise has shown more beneficial effects on the cardiovascular system and EDR compared to low intensity exercise (Batacan et al., 2018; Tian & Meng. 2019). The advantage of high intensity intermittent exercise refers to the fact that shorter periods such as 3-4 sessions/week will produce significant changes (Kannan et al. 2014: Tian & Meng. 2019). However, there is a paradoxical disadvantage about anaerobic exercise that increased mortality and sudden death are caused by high intensity activity (Tian et al., 2019).

Mental Health

Mental health indicators can be classified into three broad categories: cognitive functioning (e.g., attention, perception, and memory), well-being (e.g., self-concept and eudaimonic well-being), and illness (e.g., depression and anxiety). (Costigan et al., 2016). In terms of cognition, the relationship between physical activity and tasks or task components that require a high degree of executive function (i.e., intentional environmental interaction components that require processes such as inhibition, working memory, and cognitive tinkering) (Hillman et al., 2014; Costigan et al., 2016)

The benefits of traditional cardiac rehabilitation (CR) using moderate-intensity continuous training (MICT) for patients with coronary artery disease (CAD) are well-documented in terms of both physical and mental health. In earlier studies, high-intensity interval training (HIIT) was conducted using either aerobic exercise equipment (such as treadmills, cycle ergometers, and ellipticals) or (ii) dance/movement-based routines. Each HIIT session lasted 45 minutes and followed a modified Norwegian aerobic HIIT protocol, which included: (i) a 10-minute warm-up at 60–70% peak heart rate (HR); (ii) four 4-minute high-intensity intervals at 85–95% peak HR, interspersed with 3-minute low-intensity recovery periods at 60–70% peak HR (totaling 28 minutes); and (iii) a 5–10-minute cooldown at 60–70% peak HR with strength and stretching exercises. These studies demonstrated the effectiveness of alternative exercise interventions (HIIT and Nordic walking) in improving functional capacity, reducing depression severity, increasing Brain-derived neurotrophic factor (BDNF) concentrations, and enhancing quality of life (QoL) in CAD patients who had recently undergone coronary revascularization procedures (Reed et al., 2021).

Participants in the experimental group received 8 treatment sessions, one per week, lasting 50–60 minutes, and supervised by a physiotherapist with over 10 years of experience. The HIIT combined with resistance exercises (HIIT + R) program was structured into warm-up (10–15 minutes, low intensity), active exercise (3-minute bouts × 10), and cool-down (10–15 minutes, low intensity) phases. The warm-up and cool-down included light-intensity walking (RPE 9–11; 3–5 minutes), range-of-motion movements for the upper and lower limbs, and light stretching. The active exercise bouts included 1 minute of high-intensity treadmill walking (85%–90% maximum HR), followed by 1 minute of low-intensity walking (60%–70% maximum HR), and then 1 minute of low-to-moderate-intensity resistance exercises (30%–50% of 1RM, 2 sets of 15 repetitions). The resistance exercises, designed to target major muscle groups, were rotated during each bout. Given the older age of the participants, safety was a key consideration, and a conservative approach was adopted by combining resistance exercises with aerobic activity in each bout to allow adequate rest before the high-intensity phase of the next bout. The intensity of the resistance exercises was kept between 30% and 50% of 1RM throughout the 8 weeks, with exercise intensity regulated by heart rate monitoring using a Polar HR monitor (FS2C; Polar Electro Oy, Kempele, Finland). Heart rate, blood pressure, and perceived exertion were measured before, during, and after each session (Deka et al., 2022).

Goncalves et al (2024) conducted a study comparing the effects of HIIT in 6 and 12 months found a significant pattern of improvement in social function, physical role and mental

activity, the HIIT group in 6 and 12 months post-intervention continued to show a decrease in anxiety and depression scores, while the control group maintained the previous increasing trend.

The current study also found that quality of life improved significantly after a 12-week HIIT intervention compared to standard care. Moreover, there was a strong positive correlation between changes in VO2 peak and improvements in quality of life markers, underscoring the importance of cardiorespiratory fitness in enhancing quality of life (Kristiansen et al., 2022). Previous research suggests that HIIT may benefit mental health, that showed with significant improvements in depression and anxiety severity in pre-post HIIT measurements (Martland et al., 2019). Even Though no systematic review has examined the impact of HIIT on individuals with diagnosed mental illnesses. Therefore, further research is needed across various mental disorders, including major depression, schizophrenia, and bipolar disorder, to determine whether HIIT can enhance health outcomes in these populations (Martland et al., 2019).

The decrease in physical activity might also play a role in the higher rates of mental health disorders (such as anxiety and depression) that develop during late adolescence (ages 15–19) (Beauchamp et al., 2018; Leahy et al., 2020). Engaging in physical exercise is believed to trigger neurobiological responses through the release of endogenous opioids, such as endorphins. The "endorphin hypothesis" attributes the improvement in mood following exercise to the increased release of β-endorphins (Saanijoki et al., 2017; Leahy et al., 2020)

CONCLUSION

High intensity interval training can increase VO2 peak, Regular exercise reduces the risk of cardiovascular disease and mortality in healthy, beneficial in reducing depression severity and increasing Brain-derived neurotrophic factor (BDNF) concentrations.

REFERENCES

Atakan, MM., Li, Y., Koşar, ŞN., Turnagöl, HH., Yan, X. (2021) Evidence-Based Effects of High-Intensity Interval Training on Exercise Capacity and Health: A Review with Historical Perspective. Int J Environ Res Public Health. 18(13):7201. doi: 10.3390/ijerph18137201. PMID: 34281138; PMCID: PMC8294064.

Reed, JL., Terada, T., Cotie, LM., Tulloch, HE., Leenen, FH., Mistura, M., Hans, H… & Pipe AL (2022). The effects of high-intensity interval training, Nordic walking and moderate-to-vigorous intensity continuous training on functional capacity, depression and quality of life in patients with coronary artery disease enrolled in cardiac rehabilitation: A randomized controlled trial (CRX study). Prog Cardiovasc Dis ;70:73-83. doi: 10.1016/j.pcad.2021.07.002. Epub 2021 Jul 7. PMID: 34245777.

McGregor, G., Powell, R., Begg, B., Birkett, S.T., Nichols, S., Ennis. S., … & Shave, R. (2022). High-intensity interval training in cardiac rehabilitation: a multi-centre randomized controlled trial. Eur J Prev Cardiol. 2023 Jul 12;30(9):745-755. doi: 10.1093/eurjpc/zwad039. PMID: 36753063

Taylor, J.L., Holland, D.J., Keating, S.E., Leveritt, M.D., Gomersall, S.R., Rowlands, A.V., … & Coombes JS. (2020). Short-term and Long-term Feasibility, Safety, and Efficacy of High-Intensity Interval Training in Cardiac Rehabilitation: The FITR Heart Study Randomized Clinical Trial. JAMA Cardiol, 5(12):1382-1389. doi: 10.1001/jamacardio.2020.3511. PMID: 32876655; PMCID: PMC7489382.

Deka, P., Pathak, D., Klompstra, L., Sempere-Rubio, N., Querol-Giner, F., Marques-Sule, E. (2022). High-Intensity Interval and Resistance Training Improve Health Outcomes in Older Adults With Coronary Disease. J Am Med Dir Assoc, 23(1):60-65. doi: 10.1016/j.jamda.2021.05.034. Epub 2021 June 23. PMID: 34171293.

Kristiansen, J., Sjúrðarson, T., Grove, E.L., Rasmussen, J., Kristensen, S.D., Hvas, A.M., Mohr, M. (2022). Feasibility and impact of whole-body high-intensity interval training in patients with stable coronary artery disease: a randomised controlled trial. Sci Rep, 12(1):17295. doi: 10.1038/s41598-022-21655-w. PMID: 36241898; PMCID: PMC9568554.

Košuta, D., Novaković, M., Božič Mijovski, M., Jug. B. (2024). Acute effects of high intensity interval training versus moderate intensity continuous training on haemostasis in patients with coronary artery disease. Sci Rep, 14(1):1963. doi: 10.1038/s41598-024-52521-6. PMID: 38263210; PMCID: PMC10806221.

Terada, T., Cotie, L.M., Tulloch, H., Mistura, M., Vidal-Almela, S., O'Neill, C.D., … & Reed JL. (2022). Sustained Effects of Different Exercise Modalities on Physical and Mental Health in Patients With Coronary Artery Disease: A Randomized Clinical Trial. Can J Cardiol. 38(8):1235-1243. doi: 10.1016/j.cjca.2022.03.017. Epub 2022 Jun 15. PMID: 35961757.

Ito, S. (2019). High-intensity interval training for health benefits and care of cardiac diseases - The key to an efficient exercise protocol. World J Cardiol, 11(7):171-188. doi: 10.4330/wjc.v11.i7.171. PMID: 31565193; PMCID: PMC6763680.

Shahjehan, R.D., Sharma, S., Bhutta, B.S. (2024). Coronary Artery Disease. [Updated 2024 Oct 9]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing, Available from: https://www.ncbi.nlm.nih.gov/books/NBK564304/

Buchheit, M., Laursen., P.B. (2013). High-intensity interval training, solutions to the programming puzzle: Part I: Cardiopulmonary emphasis. Sports Med, 43, 313–338.

Du, L., Zhang, X., Chen, K., Ren, X., Chen, S., & He, Q. (2021). Effect of High-Intensity Interval Training on Physical Health in Coronary Artery Disease Patients: A Meta-Analysis of Randomized Controlled Trials. Journal of Cardiovascular Development and Disease, 8(11), 158. https://doi.org/10.3390/jcdd8110158

Quindry, John C., Franklin, B.A., Chapman, M., Humphrey, R., Mathis, S. (2019). Benefits and Risks of High-Intensity Interval Training in Patients With Coronary Artery Disease. The American

Journal of Cardiology, (), S0002914919301006–. doi:10.1016/j.amjcard.2019.01.00

Pattyn, N., Vanhees, L., Cornelissen, V.A., Coeckelberghs, E., De Maeyer, C., Goetschalckx, K., … & Beckers PJ. (2016). The long-term effects of a randomized trial comparing aerobic interval versus continuous training in coronary artery disease patients: 1-year data from the SAINTEX-CAD study. Eur J Prev Cardiol, 23:1154-1164

Moholdt, T.T., Amundsen, B.H., Rustad, L.A., Wahba, A., Lovo, K.T., Gullikstad, L.R., … & Slordahl, S.A. (2009). Aerobic interval training versus continuous moderate exercise after coronary artery bypass surgery: a randomized study of cardiovascular effects and quality of life. Am Heart J, 158:1031-1037

Gonçalves, C., Bravo, J., Abreu, A. et al. (2024). Comparing high-intensity versus moderate-intensity exercise training in coronary artery disease patients: a randomized controlled trial with 6- and 12-month follow-up. J Public Health (Berl.) https://doi.org/10.1007/s10389-024-02224-z

Martland, Rebecca., Mondelli, Valeria., Gaughran, Fiona., Stubbs, Brendon. (2019). Can high-intensity interval training improve physical and mental health outcomes? A meta-review of 33 systematic reviews across the lifespan. Journal of Sports Sciences, (), 1–40. doi:10.1080/02640414.2019.170682

Antovic, A. (2010). The overall hemostasis potential: A laboratory tool for the investigation of global hemostasis. Semin. Thromb. Hemost, 36:772–779. doi: 10.1055/s-0030-1265294

Olsen, L.N., Fischer, M., Evans, P.A., Gliemann, L., Hellsten, Y. (2021). Does exercise influence the susceptibility to arterial thrombosis? An integrative perspective. Front. Physiol, 12:636027. doi: 10.3389/fphys.2021.636027

Rognmo, Olivind., Hetland, Eva., Helgerud, Jan., Hoff, Jan., Slordahl, Stig, A. (2004). High intensity aerobic interval exercise is superior to moderate intensity exercise for increasing aerobic capacity in patients with coronary artery disease. European Journal of Cardiovascular Prevention & Rehabilitation, 11(3), 216–222. doi:10.1097/01.hjr.0000131677.96

American College of Sports Medicine Position Stand. Exercise for patients with coronary artery disease. Med Sci Sports Exerc 1994; 26:i–v

Thompson, P.D., Buchner, D., Pina, I.L., Balady, G.J., Williams, M.A., Marcus, B.H., … & Wenger, N.K. (2003). Exercise and physical activity in the prevention and treatment of atherosclerotic cardiovascular disease: a statement from the Council on Clinical Cardiology (Subcommittee on Exercise, Rehabilitation, and Prevention) and the Council on Nutrition, Physical Activity, and Metabolism (Subcommittee on Physical Activity). Circulation. 107:3109–3116

Saanijoki, T., Tuominen, L., Tuulari, J.J., Nummenmaa, L., Arponen, E., Kalliokoski, K., Hirvonen, J. (2018). Opioid release after high-intensity interval training in healthy human subjects.

Neuropsychopharmacology, 43(2):246–54

Beauchamp, M.R., Puterman, E., Lubans, D.R. (2018). Physical inactivity and mental health in late adolescence. JAMA Psychiatry, 75(6):543–4

Leahy, A. A., Mavilidi, M. F., Smith, J. J., Hillman, C. H., Eather, N., Barker, D., & Lubans, D. R. (2020). Review of high-intensity interval training for cognitive and mental health in youth. Medicine & Science in Sports & Exercise, 52(10), 2224-2234.

BatacanR. B.Jr., Duncan M. J., Dalbo V. J., Buitrago G. L., and Fenning A. S., Effect of different intensities of physical activity on cardiometabolic markers and vascular and cardiac function in adult rats fed with a high-fat high-carbohydrate diet, Journal of Sport and Health Science. (2018) 7, no. 1, 109–119, https://doi.org/10.1016/j.jshs.2016.08.001, 2-s2.0-85009736184, 30356452.

Kannan U., Vasudevan K., Balasubramaniam K., Yerrabelli D., Shanmugavel K., and John N. A., Effect of exercise intensity on lipid profile in sedentary obese adults, Journal of Clinical and Diagnostic Research. (2014) 8, no. 7, BC08–BC10, https://doi.org/10.7860/JCDR/2014/8519.4611, 2-s2.0-84904802339,

Tian, D., & Meng, J. (2019). Exercise for prevention and relief of cardiovascular disease: prognoses, mechanisms, and approaches. Oxidative Medicine and Cellular Longevity, 2019(1), 3756750.

Keech, A., Holgate, K., Fildes, J., Indraratna, P., Cummins, L., Lewis, C., Jennifer Yu. (2020). High-intensity interval training for patients with coronary artery disease: Finding the optimal balance, International Journal of Cardiology, 298, ; 8-14, https://doi.org/10.1016/j.ijcard.2019.09.060.