International Journal of Academic Health and Medical Research (IJAHMR)
ISSN: 2643-9824
Vol. 9 Issue 2 February - 2025, Pages: 91-99

Impact of High Intensity Interval Training (Hitt) On Cardiovascular Diseases

Abideen, A. Adekanmi1, Uthman, Taiwo Adekanmi2, Lawal, Kola Ahmad3, Taoreed, A. Muraina4, Agbesanya, Oluwadare5, Adeola , Alice Alabi6,

1Department of Microbiology, University of Ibadan Ibadan Oyo State Nigeria E mail: yinklab1234@gmail.com
2Haematology Unit, Osun State University Teaching Hospital,Osogbo, Osun State, Nigeria
E mail: adekanmiuthman@gmail.com
3Department of Science Laboratory Technology, Osun State College of Technology, Esa-Oke, Osun Nigeria
E mail: ahmadlawal926@gmail.com
4Department of pharmaceutical Technology, Federal Polytechnic, Ede, Osun State, Nigeria
Department of Chemical Science and Technology, Federal Polytechnic, Ede, Osun State
Department of Chemical jScience, Redemeer's University, Ede, Osun State
E mail: adekunleade@gmail.com
5Department of Science and Laboratory Technology, Osun State College of Technology, Esa-Oke, Osun State, Nigeria
E mail: dareagbesanya@gmail.com
6Zankli Medical Centre, Utako, Abuja.
E mail: alabialice227@gmail.com

Corresponding Author: Name; Uthman, Taiwo Adekanmi, Phone; +2348063046293, E-mail; uthmanadekanmi@gmail.com

Abstract: *High-intensity interval training, for its characteristic of short-time high oxygen-consumption exercise interphase with periods of low-intensity training or rest for recovery, is easier to persist and execute in cardiac rehabilitation. As an exercise training protocol in comprehensive cardiac rehabilitation, time-efficient high-intensity interval training (HIIT) has been investigated other than guideline based moderate-intensity continuous training. The scientific background of this protocol is that higher intensity exercise works to yield more improvement in aerobic and metabolic function by giving more stimuli to cardiopulmonary system and skeletal muscle. In this mini review, we discussed the major risk factors of cardiovascular diseases, improvement of cardiovascular health through exercise, high-intensity interval training (HIIT) and heart failure and high-intensity interval training. For general health and primary and secondary cardiovascular prevention, high-intensity interval training (HIIT) has been recognized as an efficient exercise protocol with short exercise sessions. Given the availability of the numerous HIIT protocols, which can be classified into aerobic HIIT and anaerobic HIIT [usually called sprint interval training (SIT)], professionals in health-related fields, including primary physicians and cardiologists, may find it confusing when trying to select an appropriate protocol for their patients. High-intensity interval training (HIIT) has emerged as a potentially effective alternative that encompasses brief high-intensity bursts of exercise interspersed with bouts of recovery, aiming to maximize cardiovascular exercise intensity in a time-efficient manner. Understanding the HIIT protocols and adopting the correct type for each subject would lead to better improvements in* VO_2 *peak with higher adherence and less risk.*

Keywords: High-intensity interval training; cardiovascular diseases, Exercise; Training; Coronary artery disease and Peak O_2 consumption; Aerobic

1. INTRODUCTION

The World Health Organization (WHO), 2018 reports that the top cause of death worldwide is cardiovascular disease (CVD), which includes heart failure (HF) and coronary artery disease (CAD). Cardiovascular disease is still becoming more prevalent and killing more people worldwide (Du *et al*., 2021). About 17.9 million people worldwide passed away in 2019 as a result of cardiovascular disease or 32% of all deaths (Cardiovascular diseases, 2021). According to a report on cardiovascular health and illness released in 2020 by the National Center for Cardiovascular Disease, 11.4 million people in China are thought to have coronary artery disease (CAD) (Shengshou, 2021).

Regular physical activity and exercise are linked to amazing, widespread health benefits and are regarded as antidote for improve treatment and reduction in risk associated to CVD (Nystoriak & Bhatnagar, 2018). Increased physical activity has been linked to a fall in the risk of acquiring cardiovascular and respiratory diseases, according to several long-term studies. These findings also suggest that it may marginally extend life expectancy (Nystoriak & Bhatnagar, 2018). In line with this idea, it has been discovered that death rates for both men and women are inversely associated to levels of cardiorespiratory fitness, even when there are additional predictors of cardiovascular mortality present, such as smoking, hypertension, and hyperlipidemia (Moholdt et al., 2018).

Ageing and physical inactivity both raise the risk of cardiovascular disease, with only 25% of older persons in the UK fulfilling the minimum recommended exercise levels for health (McPhee *et al*., 2016). Cardiorespiratory fitness (CRF) is not only the "gold standard" measure of physical fitness but also a recognized indicator of cardiovascular health and a predictive indicator of both cardiovascular illness and untimely death (Gonzales *et al.*, 2021). Sarcopenia, the age-related decrease of muscle mass and function, is a significant additional risk factor for untimely mortality in aged individuals beyond fitness of cardiorespiration (Cruz-Jentoft et al., 2019).

Cardiac rehabilitation (CR) is a therapy strategy that plays a robust role in secondary prevention of cardiovascular disease. It comprises monitored exercise, lifestyle modifications, social and psychological support, and health education (Anderson *et al.*, 2018). Exercise-based rehabilitation of cardiac lowers cardiovascular risk from ailments such chronic systemic inflammation, which has steadily become a risk factor for cardiovascular disease, in addition to the traditional cardiovascular risk factors (Fiuza-Luces and colleagues, 2018). Exercise is linked to positive anti-inflammatory effects, lower blood levels of C-reactive protein, and enhanced cardiac output, stroke volume, and vascular endothelial function as well as decreased heart rate variability in those without cardiovascular disease (Pearson and Smart, 2018).

As a result of well-established clinical advantages and safety, moderate continuous exercise (MCT) is regarded as the most well-established type of recommended exercise training (Piepoli *et al.*, 2016). Moderate-intensity continuous training (MICT) has traditionally been a foundation of aerobic based exercise prescription resulting in short- and long-term clinical benefits for CVD patients (Piepoli et al., 2016). However, recent research demonstrates that high-intensity interval training (HIIT) as an exercise modality has had a similar or more substantial impact on outcome measures when employed as an addition or an alternative to continuous moderate exercise (Yu *et al.*, 2022). Interval training involving near-maximal efforts, either at intensity below VO2 peak, peak power output, or peak heart rate, is known as HIIT (Yu et al., 2022). Depending on how long each interval is, this exercise consists of short, medium, and long HIITs. Inexperienced users of these intervals, particularly cardiovascular patients, need to be closely supervised (Dun *et al.*, 2019).

Three types of interval training of high intensity have been developed, based on the lengths of exercise and recuperation (Yue *et al.*, 2022). In long-interval high intensity of training, there are four minutes of high-intensity exercise and three minutes of active or passive rest (Yue *et al.*, 2022). A medium-interval intensity of high training, workout consists of one to two minutes of high-intensity exercise and one to four minutes of low-intensity rest (Yue *et al.*, 2022). Short-interval high training intensity incorporates fifteen to sixty seconds of high-intensity exercise followed by fifteen to one hundred and twenty seconds of low-intensity recovery (Dun *et al.*, 2019).

Growing evidence of HIIT's effectiveness for enhancing metabolic and cardiovascular function in both healthy and populations with chronic illnesses has sparked an increase in interest in this type of exercise (Batacan *et al.*, 2017). Preliminary data indicates that many people express equal or greater satisfaction with interval training of high intensity and demonstrate at least similar overall training adherence when compared to MICT in a laboratory or clinical context. Interval training of high intensity also has the added benefit of being relatively time efficient when compared to MICT (Vella et al., 2017).

Although HIIT has been shown to be effective in treating CAD patients' problems with their aerobic capacity, blood pressure, body composition, and quality of life, as well as in CR, according to several reviewers (Quindry et al., 2019), only changes in peak VO2 have been studied in comparison to MICT, and there has been no work done and inconsistent results in the past regarding parameters of their cardiorespiratory, risk factor, and other systems (Du et al., 2021). Likewise, there is no clear consensus on the optimal HIIT prescriptive variables that elicit the greatest benefits for patients at high risk of or with overt CVD till this moment (Dun et al., 2019). Additionally, recent papers have additional pertinent related randomized control trials that have not yet been examined in the current review. The usefulness and efficacy of HIIT in CAD patients must therefore be further examined in order to address the aforementioned limitations. This will be advantageous and helpful in developing a more focused, effective, and result-oriented prescribing exercise and it will also contribute to additional alternative possibilities, which will be very helpful in managing CR. This systematic analysis focuses on the physical health benefits of HIIT with particular focus on cardiorespiratory fitness, heart rate, blood pressure, blood lipids, left ventricular function, and quality of life in CAD patients.

2. MAJOR RISK FACTORS OF CARDIOVASCULAR DISEASES

Globally, the number one cause of morbidity and mortality is cardiovascular disease (CVD) (Virani et al., 2018). Nearly half of all adults in the US have one or more major CVD risk factors, such as high blood pressure, high cholesterol, or smoking. Arrhythmias, dilated, hypertrophic, or idiopathic cardiomyopathies, heart failure, and atherosclerosis are just a few of the disorders classified as CVD that have an impact on the heart and vasculature (Blacks, 2018). These disorders may result in cardiac events that are potentially lethal, such as a heart attack, a stroke, or cardiac arrest (American Heart Association, 2019). So it is crucial to develop different therapeutic methods to stop or lower the occurrence of CVD (Virani et al., 2018).

2.1 Obesity

Despite the fact that there are many different causes of cardiovascular disease, obesity-related CVD is more common and this can happen for a number of reasons, one of which is that a high-fat diet or obesity can result in hypertension (Kivimaki et al., 2017). The renin-angiotensin system is activated in obesity by the release of angiotensin II and aldosterone by abdominal subcutaneous adipose tissue (Cabandugama et al., 2017). Angiotensin II stimulates the release of anti-diuretic hormone, which promotes water reabsorption in the kidneys, and produces vasoconstriction in arterioles, resulting in arteriolar resistance and raised systemic blood pressure (Schutten et al., 2017).

Blood pressure rises as a result of aldosterone's enhanced reabsorption of water and sodium into the blood, which raises the volume of extracellular fluid (Schutten et al., 2017). As a result of the renin-angiotensin system's inhibition of norepinephrine absorption in the pre-synaptic sympathetic nerve terminals, the resting norepinephrine concentration rises, this can raise resting heart rate and eventually lead to the development of hypertension (Jiang et al., 2016). Consequently, a positive feedback loop between the sympathetic nervous system and the renin-angiotensin system causes obese people to have higher blood pressure (Cabandugama et al., 2017).

2.2 Hypertension

Long-term hypertension increases left ventricular after load, making the left ventricle work harder (Halade et al., 2017). This causes pathologic ventricular wall hypertrophy and ventricular chamber dilation, which ultimately result in lowered myocardial function and the beginning of heart failure (Halade et al., 2017). Insufficient blood flow results from the circulatory system becoming compromised when cardiac function diminishes. The body is consequently unable to meet its physiological needs for oxygen and nutrition, which causes tachycardia, severe exhaustion, and other complications such lung congestion, fluid retention, and arrhythmias (Halade et al., 2017).

Heart metabolic overload, which can occur without hypertension, is another potential factor in obesity-related CVD. The heart is a "metabolic omnivore," but in the obesogenic condition and especially with insulin resistance, fatty acid absorption and utilization are noticeably increased (Taegtmeyer & Lubrano, 2014). Due the heart has a limited capacity for storage, this might result in inefficient b-oxidation and intramyocardial lipid accumulation. This causes "lipotoxicity," which worsens cardiac dysfunction because of the accumulation of excess lipids and toxic lipid metabolites (Fukushima and Lopaschuk, 2016). Patients with T2D who are not obese also have impaired cardiac metabolism. Similar to obesity, T2D is characterized by increased levels of circulating free fatty acids, increased myocardial fatty acid absorption and utilization, and myocardial insulin resistance, which reduces the heart's ability to absorb and use glucose (Brahma et al., 2017).

2.3 Atherosclerosis

The most prevalent kind of CVD is atherosclerosis, which develops slowly in response to ongoing exposure to an unhealthy, sedentary lifestyle, including obesity (Pinckard et al., 2019). When a person is obese, their blood triglyceride and LDL cholesterol levels are elevated, which causes tiny plaques to develop under the endothelial cells that line the inner surface of artery walls (Pinckard et al., 2019). Normal endothelial cells can prevent leukocytes from adhering to these plaques, but in obese people, LDL molecules are oxidized, which causes endothelial cells to express adhesion molecules and chemoattractants instead (Tsoupras et al., 2018).

As a result, oxidized LDL is taken up by macrophages, which then change into foam cells that concentrate on the fatty plaques in the arteries and produce substances that encourage plaque formation (Bobryshev et al., 2016). The resulting plaques thicken and stiffen artery walls, reducing blood flow (Patzelt et al., 2015). The restriction of blood flow can result in ischemia conditions and cardiac events such as stroke, myocardial infarction (MI), or cardiac arrest, all of which can be deadly, if the plaques grow large enough or thrombosis develops (Pinckard et al., 2019)

2.4 Coronary Heart Disease (CHD)

Myocardial infarction (MI) is most frequently caused by the underlying coronary heart disease (CHD) brought on by atherosclerosis. 14.9 million deaths worldwide are related to CHD, and those fatalities increased 19% between 2006 and 2016 (Naghavi et al., 2017). CHD surpassed lower respiratory infections in a 2017 systematic study for the Global Burden of Disease Study to take the top spot for years lost to early death (Naghavi et al., 2017).

Despite the fact that CHD mortality seems to be declining in industrialized nations, the world's aging population, expansion, and longer-term survival rates from acute myocardial infarction (MI) are adding to the financial burden on the world. In the coming ten years, it is expected that CHD deaths will continue to rise (Johansson et al., 2017). The effectiveness of secondary prevention is of utmost importance because death rates, years of life lost, and the financial burden caused by CHD are critical global health issues (Johansson et al., 2017).

2.5 Heart failure

Heart failure currently affects about 920 000 people in the UK, mostly older people, with incidence and prevalence rising sharply with age (Conrad et al., 2018). The typical diagnosis age is 77 years old (Conrad et al., 2018). Breathlessness, fluid retention, weariness, and a significant decrease in exercise tolerance are just a few of the symptoms that heart failure patients encounter (Callum et al., 2020). The negative impact of these symptoms on day-to-day functioning, health-related quality of life, hospital admission rate, and death all lead to greater healthcare expenses (Ziaeian and Fonarow, 2016). Currently, it is estimated that the entire yearly cost of heart failure to the UK NHS is roughly $1 billion, with hospitalization accounting for about 70% of this expenditure.

3. Improvement of Cardiovascular Health through Exercise

Sedentary behavior is one of the risk factors that is most strongly linked to the development and progression of CVD (American Heart Association, 2019). Two signs of a sedentary lifestyle are obesity and persistently low levels of physical exercise (Young et al., 2016). The majority of non-congenital kinds of CVD can be treated with lifestyle therapies that increase physical activity and decrease obesity (Young et al., 2016).

3.1 Reduction of Cardiovascular Risk Factors by physical activity

The development and progression of obesity, T_2D, and CVD can be slowed down by engaging in regular physical activity (Vega et al., 2017). Numerous randomized clinical trials have shown that lifestyle changes, such as moderate physical activity and a nutritious diet, enhance cardiovascular health in risk populations (Miele & Headley, 2017). Individuals with metabolic syndrome who underwent a 4-month program of either dietary (calorie restriction) or physical activity intervention had reduced adiposity, decreased systolic, diastolic, and mean arterial blood pressure, and lower total and low-density lipoprotein (LDL) cholesterol lipid profiles in comparison to the control group (Pinckard et al., 2019).

The cardiovascular outcomes are improved to a similar level by the diet and exercise interventions (Pinckard et al., 2019). Previous studies that looked at the effects of diet and exercise on metabolic and cardiovascular health found that diet, exercise, or a combination of diet and exercise causes weight loss, reduces visceral adiposity, lowers plasma triglycerides, plasma glucose, HDL levels, and blood pressure, and raises VO2max (Dandanell et al., 2017). Importantly, a number of these health advantages of exercise are observable even without weight loss (Lean et al., 2018).

In lean and overweight normoglycemic people, exercise has a similar positive impact on cardiovascular health. In a 1-year trial of non-obese people, a 16–20% increase in energy expenditure (of any type of exercise) without dietary intervention led to a 22.3% decrease in body fat mass and decreased levels of LDL cholesterol, total cholesterol/HDL ratio, and C-reactive protein, all risk factors for CVD ((Anderson et al., 2016). Walking 19 km per week at 40–55% of one's maximum oxygen uptake (VO2peak) for 7-9 months significantly improved cardiorespiratory fitness in overweight people compared to those who were inactive (Anderson et al., 2016).

3.2 Exercise Enhances Cardiovascular Function in CVD Patients

Exercise is a crucial therapy component for people with cardiovascular disorders (Vega et al., 2017). Exercise-based cardiac rehabilitation increased cardiovascular function, according to a study of 63 researches (Anderson et al., 2016). These trials involved a variety of aerobic exercise types performed over a wide range of intensities (from 50 to 95% VO2) and time frames (1–47 months). Overall, physical activity significantly enhanced quality of life, decreased risk of MI, and CVD-related death (Anderson et al., 2016). Another study focused on individuals who had undergone revascularization surgery and had atherosclerosis.

For patients who experienced an acute myocardial infarction for a year following coronary intervention surgery, a recent study offered tailored aerobic exercise rehabilitation programs (Zhang et al., 2018). Six months after beginning the exercise rehabilitation program, the patients' ejection fraction increased (to 60.81 vs. 53 % in the control group), and their capacity for activity increased, and their cardiovascular risk factors decreased (Zhang et al., 2018).

Exercise intolerance is one of the characteristics of heart failure, and until the 1950s, individuals with this condition were advised to stay in bed (Alvarez et al., 2016). However, it has now been established that a well supervised rehabilitation program involving moderate intensity exercise is safe for those with heart failure, and this has now emerged as a key therapy treatment those with heart failure (Haykowsky et al., 2016). Meta-analyses and systematic reviews have demonstrated that exercise training improves quality of life, lowers the risk of hospitalization, and lowers long-term death rates in patients with heart failure (Sagar et al., 2015).

Recent studies have looked at how people with heart failure respond to high-intensity exercise. In a recent study, it was discovered that 12 weeks of high intensity interval training (HIIT) had similar effects to those of moderate continuous exercise (MCE) training on left ventricular remodeling and aerobic capacity in heart failure patients with lower ejection fraction (Ellingsen et al., 2017). In contrast to both pre-training values and the MCE group, a different study demonstrated that 4 weeks of HIIT in heart failure patients with intact ejection fraction increased VO2peak and decreased diastolic dysfunction (Angadi et al., 2015).

According to this research, heart failure patients who engage in both low- and high-intensity exercise training have improved cardiovascular function, most likely as a result of increased endothelium-dependent vasodilation and higher aerobic capacity (Pearson & Smart, 2017).

4. High-intensity interval training (HIIT)

Izumi Tabata first recommended HIIT to Japanese Olympic skaters. In the present, HIIT workouts alternate between short bursts of high-intensity activity and routines of moderate to low intensity. Randomized clinical trials with small samples have indicated that the technique is better to traditional continuous training for raising peak oxygen consumption (VO2 peak) (Hannan et al., 2018). High intensity interval training (HIIT) used in physical education sessions has been shown to have positive benefits by Bond et al. (2017).

Cardiovascular disease (CVD) risk can be reduced using HIIT in a time-efficient manner. Adolescents' improvements in cardiorespiratory fitness and body composition are favourably impacted by HIIT intervention. In comparison to moderate-intensity continuous training, high-intensity interval training also has the advantages of being relatively time-efficient, being able to produce satisfaction that is at least as great, and demonstrating equivalent training adherence in both laboratory and clinical settings (Vella et al, 2017).

4.1 Physiological Mechanisms by which HIIT contributes to Improved peak VO2

HIIT is a proven method to enhance peak VO2 in both with and without CVD, however the precise processes underlying this improvement in peak VO2 in these patients are not well understood despite the overwhelming evidence to the contrary (Van De Heyning et al., 2018). Peak VO2 is primarily determined by the systems that transport and use oxygen, including the respiratory (oxygen uptake from the atmosphere), heart (oxygen transport), peripheral vasculature (oxygen transport, tissue perfusion, and tissue diffusion), and skeletal muscle (oxygen extraction and utilization) (Van De Heyning et al., 2018).

4.1.1 Impact of HIIT on the respiratory system

Exercise intolerance is a prevalent symptom of individuals with CVD, particularly older patients with HF, and respiratory muscle dysfunction is one of these manifestations (Smith et al., 2017). In elderly individuals with HF, Tasoulis et al. (2010) showed that 12 weeks of HIIT dramatically enhanced respiratory muscle performance. Furthermore, it was shown that 4 weeks of both HIIT and MICT resulted in significant improvements in respiratory muscle function (HIIT 43%, MICT 25%), with a higher improvement with HIIT

4.1.2 Impact of HIIT on the cardiovascular system

An increase (improvement) in HRV has been identified as one of the early cardiac adaptations in response to exercise training likely due to improvement of intrinsic heart rate (SA node) and vagal activity (parasympathetic activity) (Rave & Fortrat, 2016).. Alansare et al. (2018) demonstrated that 8 sessions of short-interval HIIT is superior to MICT at improving HRV in sedentary adults. These studies suggest that HIIT may have a greater effect on improving cardiovascular and autonomic nervous system function than MICT in sedentary adults; however, additional research is warranted to extend these findings to older patients with CVD in the CR setting (Alansare et al., 2018).

Peak VO_2 and flow-mediated dilation (FMD), an indication of endothelial function, are tightly correlated; people with lower FMD have lower peak VO2 levels. According to a meta-analysis by Ramos et al. (2015), 12 weeks of MICT and long-interval HIIT both increased brachial artery FMD by 2.15 and 4.31%, respectively, with HIIT showing a larger improvement. Furthermore, Mora et al. (2018) recently showed that long-interval HIIT reduced arterial stiffness in individuals with metabolic syndrome after 6 months of treatment. So, even though the evidence to far indicate that HIIT has the potential to improve vascular function, further research is required to completely understand the effect of HIIT on vascular function in older patients undergoing CR (Mora et al., 2018).

4.1.3 The impact of HIIT on the skeletal muscle system

Exercise tolerance is significantly influenced by skeletal muscle's total fiber number and type proportions, capillary density, mitochondrial content, and function, all of which play a part in regulating the effectiveness of oxygen extraction and utilization of energy substrates like fat and glucose (Baum et al., 2016). A seminal study by Simoneau et al. (1985) revealed that HIIT significantly increased total muscle fiber quantity, the proportion of type I fibers, and decreased the proportion of type IIb fibers, while the proportion of type IIa fibers remained unchanged in the vastus lateralis muscle of healthy adults. This study was the first to examine the effect of HIIT on skeletal muscle fiber type changes.

The results of a recent study by Tan et al. (2018) also demonstrated that 18 sessions of short-interval HIIT spread out over six weeks increased the total number of type I and II muscle fibers, capillary density, and the protein expression of cytochrome oxidase IV (a marker of skeletal muscle oxidative capacity) in overweight women. Several studies (Guadalupe-Grau et al., 2018; De Matos et al., 2018) show that HIIT improves skeletal muscle deoxygenation, a sign of oxygen extraction, as well as the content and activity of markers for glucose and fat oxidative metabolism in patients with obesity and HF (Guadalupe-Grau et al., 2018; De Matos et al., 2018).

In conclusion, HIIT is an effective method for enhancing the proportions of all types of skeletal muscle fibers, capillary density, and mitochondrial content. The findings must be expanded to older patients in the CR environment, although there have been very few studies in this field specifically focused on older patients with CVD (Dun et al., 2019).

4.2 Safety of High-intensity interval training

Clinical professionals are worried about the safety of HIIT and acute exercise, according to anecdotal evidence. According to studies, an acute exercise session may raise the chance of a CVD event, which could activate platelets and result in arterial thrombosis (Whittaker et al., 2013). A study by Haynes et al. (2018) found no evidence of platelet activation during an acute bout of exercise, but that there was vasodilation lasting up to an hour after exercise. According to a paper, this might be the result of the epithelium activating as a result of compensatory shear, which might counteract the effects of platelet activation. However, this was based on a small sample of healthy middle-aged people.

More recently, 23 trials with 1117 people with CAD and HF were analyzed as part of a systematic review by Wewege et al. (2018) looking into the safety of HIIT. The authors came to the conclusion that HIIT has a low rate of significant cardiovascular events during CR after reporting one major cardiovascular incident every 17,083 training sessions (11,333 hours).

5. HEART FAILURE AND HIGH-INTENSITY INTERVAL TRAINING

In patients with heart failure and a low ejection fraction, systematic reviews have demonstrated that high-intensity interval training is both safe and superior to moderate-intensity continuous training in terms of improving VO2peak (Gomes Neto et al., 2018; Wewege et al., 2018). The largest of these evaluations, by Gomes Neto et al. (2018), compared high-intensity intermittent exercise with moderate-intensity continuous training in patients with heart failure with reduced ejection fraction, looking at 13 randomised controlled trials up to October 2017. When compared to moderate-intensity continuous training, meta-analyses showed that high-intensity interval training significantly increased VO2peak (Callum et al., 2020).

Five of these studies used the Minnesota Living with Heart Failure Questionnaire to assess health-related quality of life; four of these studies were included in a meta-analysis that revealed no significant differences between the high-intensity interval training and moderate-intensity continuous training groups (1.2 at 95% CI). In spite of this, both groups' results did improve (high-intensity interval training 30.7 to 24.8, and moderate-intensity continuous training 31.8 to 24). It is important to keep in mind that just one study reported training intensities together with the protocol intensities that were specified when evaluating the findings from this systematic review. Ellingsen et al. conducted this study, which was the largest one in the systematic review and meta-analyses (2017).

According to Ellingsen et al. (2017), 51% of patients in the high-intensity interval training group exercised below their target level, compared to 80% of patients in the moderate-intensity continuous training group who exercised above it. The actual exercise intensity was only altered by 10% as a result. Despite not being frequently reported, the exercise intensities in either moderate-intensity continuous training or high-intensity interval training are crucial factors to take into account when interpreting data, creating protocols, and prescribing high-intensity interval training. The outcomes revealed by Gomes Neto et al. (2018) are in line with a previous meta-analysis that included seven randomized controlled trials.

Randomised controlled trials for high-intensity interval training interventions in patients with heart failure include a wide variety of high-intensity interval training protocols, differing modes of intervention and various durations of prescribed programmes. High-intensity interval training protocols range from 30 seconds of intense exercise with 30 seconds of rest to a maximum of 4 minutes of intense exercise followed by 4 minutes rest, with other protocols lying in between.

With a total of 19 studies, including 10 that were only concerned with heart failure, Ballesta Garcia et al. (2018) did a meta-analysis to ascertain the ideal dose of high-intensity interval training for patients with coronary heart disease and heart failure. The results showed no difference between programs with short or long exercise intervals, or between high-intensity interval training programs lasting more than 12 weeks compared to less than 12 weeks. It was suggested that training sessions for patients with heart failure should be held at least three times per week with an active recovery of more than 40% VO2peak because there was no discernible difference in VO2peak for protocols done less than two days per week.

Patients with heart failure who might not be able to maintain longer durations of activity could find high-intensity interval training to be an intriguing option (Callum et al., 2020). As a result of their severe deconditioning and VO2peak levels that are considerably below threshold levels, patients with heart failure frequently require near-maximal or maximal effort to complete many daily tasks (Callum et al., 2020). For instance, Kitzman et al. (2002) discovered that a patient with heart failure's oxygen expenditure when vacuuming was equivalent to 89% of maximum exertion. The majority of research to date on time-efficient high-intensity interval training has tested "all-out" sprint protocols, which require a lot of drive and are not strictly high-intensity interval training protocols because they are not defined as maximal effort. This highlights the need for more study in this area.

It is unknown whether all-out, high-intensity interval training is feasible or transferable to the heart failure population. Contrary to moderate-intensity continuous training, individuals with heart failure may be able to accumulate more time at higher intensity if they conduct brief bursts of exercise at a higher relative intensity followed by a period of rest or lower-intensity activity (Callum et al 2020). Uncertainty exists over the ideal high-intensity interval training regimen for patients with heart failure in terms of interval length and intensity. Despite its obvious advantages, high-intensity interval training may not be appropriate for all patients with heart failure; however, current recommendations suggest that it may offer another choice for those patients who believe it is feasible and appropriate for them (NICE, 2018).

Although results support high-intensity interval training as a form of cardiac rehabilitation for patients with heart failure, the application and usefulness in a real-world setting are less clear in the current trials for high-intensity interval training in a heart failure population, which have mostly been lab- or center-based (Callum et al 2020). Before beginning cardiac rehabilitation with high-intensity interval training, patients may need to undergo a cardiopulmonary exercise test, but many centers may not have access to this technology, especially in cases of more community-based cardiac rehabilitation programs (Callum et al., 2020). In order to meet patient needs and maximize participation in cardiac rehabilitation for patients with heart failure, it is imperative to look into alternative delivery methods and environments. This also includes figuring out how high-intensity interval training protocols created in a lab can be used in "real-world settings" (Callum et al., 2020).

6. CONCLUSION

Exercise is also an important therapeutic treatment for patients who have cardiovascular diseases further demonstrating the protective and restorative properties of exercise. In patients with CVD, exercise improved endothelium-dependent vasodilatation, increased ejection fraction and exercise tolerance, improved quality of life, and reduced CVD-related mortality Thus far, aerobic HIIT (submaximal intensity) could be feasible and has a low risk for people with lifestyle-related diseases, obesity, sedentary lifestyle, old age, or cardiac disorders when performed, at their own individual intensity. HIIT can not only effectively improve the exercise capacity of patients with CAD but also improve the prognosis of patients with CAD and HF. HIIT is a well-received, safe and feasible exercise program within CR settings. All patients were satisfied with HIIT and most patients found the program to be challenging and improved their confidence to exercise

REFERENCES

Alansare A, Alford K, Lee S, Church T, Jung HC. The Effects of High-Intensity Interval Training vs. Moderate-Intensity Continuous Training on Heart Rate Variability in Physically Inactive Adults. Int J Environ Res Public Health 2018;15(7):e1508. [PubMed: 30018242

Alvarez P, Hannawi B, Guha A. Exercise and heart failure: advancing knowledge and improving care. Methodist Debakey Cardiovasc J. (2016) 12:110–5. doi: 10.14797/mdcj-12-2-110

American Heart Association (2018). 32. Division for Heart Disease and Stroke Prevention. Heart Disease Fact Sheet Centers for Disease Control and Prevention (2017). (accessed January 19, 2019).

Anderson L, Oldridge N, Thompson DR, Zwisler A-D, Rees K, Martin N, (2016). Exercise-based cardiac rehabilitation for coronary heart disease: Cochrane systematic review and meta-analysis. J Am Coll Cardiol.;67(1):1–12.

Anderson L, Oldridge N, Thompson DR, Zwisler A-D, Rees K, Martin N (2018). Exercise-based cardiac rehabilitation for coronary heart disease. J Am Coll Cardiol. 67:1–12. doi: 10.1016/j.jacc.2015.10.044

Angadi SS, Mookadam F, Lee CD, Tucker WJ, Haykowsky MJ, Gaesser GA. High-intensity interval training vs. moderate-intensity continuous exercise training in heart failure with preserved ejection fraction: a pilot study. J Appl Physiol. (2015) 119:753–8. doi: 10.1152/japplphysiol. 00518.2014

Baekkerud FH, Solberg F, Leinan IM, Wisloff U, Karlsen T, Rognmo O. Comparison of Three Popular Exercise Modalities on V O2max in Overweight and Obese. Med Sci Sports Exerc 2016;48(3):491–498. [PubMed: 26440134]

Ballesta García I, Rubio Arias JÁ, Ramos Campo DJ, Martínez González-Moro I, Carrasco Poyatos M. High-intensity interval training dosage for heart failure and coronary artery disease cardiac rehabilitation. A systematic review and meta-analysis. Revista Española de Cardiología (English Edition). 2018;72(3):233–243. https://doi.org/10.1016/j.rec.2018.02.015

Batacan, R. B. J., Duncan, M. J., Dalbo, V. J., Tucker, P. S. & Fenning, A. S. Effects of high-intensity interval training on cardiometabolic health: A systematic review and meta-analysis of intervention studies. *Br. J. Sports Med.* **51**, 494–503 (2017).

Baum O, Torchetti E, Malik C, et al. Capillary ultrastructure and mitochondrial volume density in skeletal muscle in relation to reduced exercise capacity of patients with intermittent claudication. American Journal of Physiology-Regulatory Integrative and Comparative Physiology 2016;310(10):R943–R951.

Beatty, A., Magnusson, S., Fortney, J., Sayre, G., & Whooley, M. (2018). VA FitHeart, a Mobile App for Cardiac Rehabilitation: Usability Study. *Journal of Medical Internet Research Human Factors*, *5*(1), e3. https://doi.org/10.2196/humanfactors.8017 Physical Activity Resource Center For Public Health. (2020). *Accelerometers*. University of Pittsburgh. http://www.parcph.org/accDef.aspx

Blacks N. Heart Disease Statistics and Maps. (2018) (accessed January 6, 2019).

Bond, B., Weston, K. L., Williams, C. A. & Barker, A. R. Perspectives on high-intensity interval exercise for health promotion in children and adolescents. *Open Access J. Sports Med.* **8**, 243–265 (2017).

Brahma MK, Pepin ME, Wende AR. My sweetheart is broken: role of glucose in diabetic cardiomyopathy. Diabetes Metab J. (2017) 41:1– 9. doi: 10.4093/dmj.2017.41.1.1

Cabandugama PK, Gardner MJ, Sowers JR. The renin angiotensin aldosterone system in obesity and hypertension: roles in the cardiorenal metabolic syndrome. Med Clin North Am. (2017) 101:129–37. doi: 10.1016/j.mcna.2016.08.009

Callum KJ, Gorely T, Crabtree DR, Muggeridge DJ, Leslie SJ. High-intensity interval training in patients with heart failure. British Journal of Cardiac Nursing. 2020. https://doi. org/10.12968/bjca.2019.0058

Callum KJ, Gorely T, Crabtree DR, Muggeridge DJ, Leslie SJ. High-intensity interval training in patients with heart failure. British Journal of Cardiac Nursing. 2020. https://doi. org/10.12968/bjca.2019.0058

Cardiovascular diseases. (2019). Accessed: September 25, 2021: https://www.who.int/healthtopics/cardiovascular-diseases.

Cheng, Q., Church, J., Haas, M., Goodall, S., Sangster, J., & Furber, S. (2016). Cost- effectiveness of a Population-based Lifestyle Intervention to Promote Healthy Weight and Physical Activity in Non-attenders of Cardiac Rehabilitation. *Heart,Lung and Circulation, 25*(3), 265-274. https://doi.org/10.1016/j.hlc.2015.07.002

Conrad N, Judge A, Tran J et al. Temporal trends and patterns in heart failure incidence: a population-based study of 4 million individuals. Lancet. 2018;391(10120):572–580. https://doi.org/10.1016/ S0140-6736(17)32520-5

Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48:16–31.

Dandanell S, Skovborg C, Praest CB, Kristensen KB, Nielsen MG, Lionett S, et al. Maintaining a clinical weight loss after intensive lifestyle intervention is the key to cardiometabolic health. Obes Res Clin Pract. (2017) 11:489– 98. doi: 10.1016/j.orcp.2016.09.009

De Matos MA, Vieira DV, Pinhal KC, et al. High-Intensity Interval Training Improves Markers of Oxidative Metabolism in Skeletal Muscle of Individuals With Obesity and Insulin Resistance. Frontiers in Physiology 2018;9(10):e1451.

Du, L.; Zhang, X.; Chen, K.; Ren, X.; Chen, S.; He, Q. Effect of High-Intensity Interval Training on Physical Health in Coronary Artery Disease Patients: A Meta-Analysis of Randomized Controlled Trials. J. Cardiovasc. Dev. Dis. **2021**, 8, 158. https://doi.org/10.3390/jcdd8110158

Dun Y, Smith JR, Liu S, Olson TP (2019). High-intensity interval training in cardiac rehabilitation . Clin Geriatr Med. 2019, 35:469-87. 10.1016/j.cger.2019.07.011

Ellingsen O, Halle M, Conraads V, Stoylen A, Dalen H, Delagardelle C, et al. High-intensity interval training in patients with heart failure with reduced ejection fraction. Circulation. (2017) 135:839–49.

Fiuza-Luces C, Santos-Lozano A, Joyner M, Carrera-Bastos P, Picazo O, Zugaza JL (2018) Exercise benefits in cardiovascular disease: beyond attenuation of traditional risk factors. Nat Rev Cardiol. 15:731– 43. doi: 10.1038/s41569-018-0065-1

Fukushima A, Lopaschuk GD. Cardiac fatty acid oxidation in heart failure associated with obesity and diabetes. Biochim Biophys Acta. (2016) 1861:1525–34. doi: 10.1016/j.bbalip.2016.03.020

Gomes-Neto M, Duraes AR, Reis H, Neves VR, Martinez BP, Carvalho VO. High-intensity interval training versus moderate-intensity continuous training on exercise capacity and quality of life in patients with coronary artery disease: a systematic review and meta-analysis. Eur J Prevent Cardiol. (2017) 24:1696–707. doi: 10.1177/2047487317728370

Gonzales TI, Westgate K, Strain T, Hollidge S, Jeon J, Christensen DL, et al. Cardiorespiratory fitness assessment using risk-stratified exercise testing and dose–response relationships with disease outcomes. Sci Rep. 2021;11:15315.

Guadalupe-Grau A, Fernandez-Elias VE, Ortega JF, Dela F, Helge JW, Mora-Rodriguez R. Effects of 6-month aerobic interval training on skeletal muscle metabolism in middle-aged metabolic syndrome patients. Scandinavian Journal of Medicine & Science in Sports 2018;28(2):585–595. [PubMed: 28321925]

Halade GV, Kain V. Obesity and Cardiometabolic Defects in Heart Failure Pathology. Compr Physiol. (2017) 7:1463–77. doi: 10.1002/cphy.c170011

Hannan AL, Hing W, Simas V, Climstein M, Coombes JS, Jayasinghe R, et al. High-intensity interval training versus moderate-intensity continuous training within cardiac rehabilitation: a systematic review and meta-analysis. Open Access J Sports Med. (2018) 9:1–17. doi: 10.2147/OAJSM.S150596

HaykowskyMJ, Daniel KM, Bhella PS, Sarma S, Kitzman DW. Heart Failure: Exercise-Based Cardiac Rehabilitation: who, when, and how intense? Can J Cardiol. (2016) 32(10 Suppl. 2):S382–7. doi: 10.1016/j.cjca.2016.06.001 96.

Haynes, A., Linden, M., Robey, E., Watts, G., Barrett, P., Naylor, L., & Green, D. (2018). Acute Impact of Different Exercise Modalities on Arterial and Platelet Function. *Medicine & Science in Sports & Exercise*, *50*(4), 785–791. https://doi.org/10.1249/MSS.0000000000001505

Johansson, S., Rosengren, A., Young, K., & Jennings, E. (2017). Mortality and morbidity trends after the first year in survivors of acute myocardial infarction: a systematic review. *BMC Cardiovascular Disorders, 17*(53). https://doi.org/doi:10.1186/s12872-017-0482-9

Kivimaki M, Kuosma E, Ferrie JE, Luukkonen R, Nyberg ST, Alfredsson L, et al. Overweight. obesity, and risk of cardiometabolic multimorbidity: pooled analysis of individual-level data for 120 813 adults from 16 cohort studies from the USA and Europe. Lancet Public Health. (2017) 2:e277–85. doi: 10.1016/S2468-2667(17) 30074-9

Lean ME, Leslie WS, Barnes AC, Brosnahan N, Thom G, McCombie L, et al. Primary care-led weight management for remission of type 2 diabetes (DiRECT): an open-label, cluster-randomised trial. Lancet. (2018) 391:541– 51. doi: 10.1016/S0140-6736(17)33102-1

McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. Biogerontol. 2016;17:567–80.

Miele EM, S.Headley AE. The effects of chronic aerobic exercise on cardiovascular risk factors in persons with diabetes mellitus. Curr Diab Rep. (2017) 17:97. doi: 10.1007/s11892-017-0927-7

Moholdt T, Lavie CJ, Nauman J. Sustained physical activity, not weight loss, associated with improved survival in coronary heart disease. J Am Coll Cardiol. (2018) 71:1094–101. doi: 10.1016/j.jacc.2018.01.011

Mora-Rodriguez R, Ramirez-Jimenez M, Fernandez-Elias VE, et al. Effects of aerobic interval training on arterial stiffness and microvascular function in patients with metabolic syndrome. Journal of Clinical Hypertension 2018;20(1):11–18. [PubMed: 29106772]

Naghavi, M., Abajobir, A. A., Abbafati, C., Abbas, K. M., Abd-Allah, F., Abera, S. F., Aboyans, V., Adetokunboh, O., Afshin, A., Agrawal, A., Ahmadi, A., Ahmed, M. B., Aichour, A. N., Aichour, M. T. E., Aichour, I., Aiyar, S., Alahdab, F., Al-Aly, Z., Alam, K., ..., & Murray, C. J. (2017, 2017/09/16/). Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet, 390*(10100), 1151-1210. https://doi.org/https://doi.org/10.1016/S0140-6736(17)32152-9

National Institute for Health and Care Excellence. Chronic heart failure in adults: diagnosis and management. 2018. https://www.nice.org.uk/guidance/ng106/resources/chronic-heart-failure-in-adults-diagnosis-and-management-pdf-66141541311685 (accessed 19 February 2020)

Nystoriak MA and Bhatnagar A (2018) Cardiovascular Effects and Benefits of Exercise. Front. Cardiovasc. Med. 5:135. doi: 10.3389/fcvm.2018.00135

Pearson MJ, Smart NA (2018). Exercise therapy and autonomic function in heart failure patients: a systematic review and meta-analysis. Heart Fail Rev. (2018) 23:91–108. doi: 10.1007/s10741-017-9662-z

Pearson MJ, Smart NA. Effect of exercise training on endothelial function in heart failure patients: a systematic review meta-analysis. Int J Cardiol. (2017) 231:234–43. doi: 10.1016/j.ijcard.2016.12.145

Piepoli MF, Hoes AW, Agewall S, (2016) European guidelines on cardiovascular disease prevention in clinical practice: the sixth joint task force of the European Society of Cardiology and other societies on cardiovascular disease prevention in clinical practice (constituted by representatives of 10 societies and by invited experts) Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). Eur Heart J. 2016, 37:2315-81. 10.1093/eurheartj/ehw106

Quindry, J.C.; Franklin, B.A.; Chapman, M.; Humphrey, R.; Mathis, S. Benefits and Risks of High-Intensity Interval Training in Patients with Coronary Artery Disease. Am. J. Cardiol. **2019**, 123, 1370–1377.

Ramos, J. S., Dalleck, L. C., Tjonna, A. E., Beetham, K. S., & Coombes, J. S. (2015). The Impact of High Intensity Training versus Moderate Intensity Continuous Training on Vascular Function: A Systematic Review and Meta-Analysis. *Sports Medicine, 45*(5), 679-692. https://doi.org/10.1007/s40279-015-0321-z

Rave G, Fortrat JO. Heart rate variability in the standing position reflects training adaptation in professional soccer players. Eur J Appl Physiol 2016;116(8):1575–1582. [PubMed: 27306381

Sagar VA, Davies EJ, Briscoe S, Coats AJ, Dalal HM, Lough F, et al. Exercisebased rehabilitation for heart failure: systematic review and meta-analysis.

Sangster, J., Furber, S., Phongsavan, P., Redfern, J., Mark, A., & Bauman, A. (2017). Effects of a Pedometer-Based Telephone Coaching Intervention on Physical Activity Among People with Cardiac Disease in Urban, Rural and Semi-Rural Settings: A Replication Study. *Heart,Lung and Circulation, 26*(4), 354-361. https://doi.org/10.1016/j.hlc.2016.07.004

Schutten MT, Houben AJ, de Leeuw PW, Stehouwer CD. The link between adipose tissue renin-angiotensin-aldosterone system signaling and obesity-associated hypertension. Physiology. (2017) 32:197–209. doi: 10.1152/physiol.00037.2016

Shengshou, H. Report on Cardiovascular Health and Diseases Burden in China: An Updated Summary of 2020. Chin. Circ. J. **2021**, 36, 521–545.

Simoneau JA, Lortie G, Boulay MR, Marcotte M, Thibault MC, Bouchard C. Human skeletal muscle fiber type alteration with high-intensity intermittent training. Eur J Appl Physiol Occup Physiol 1985;54(3):250–253. [PubMed: 4065109]

Smith JR, Hageman KS, Harms CA, Poole DC, Musch TI. Effect of chronic heart failure in older rats on respiratory muscle and hindlimb blood flow during submaximal exercise. Respir Physiol Neurobiol 2017;243(9):20–26.

Taegtmeyer H, Lubrano G. Rethinking cardiac metabolism: metabolic cycles to refuel and rebuild the failing heart. F1000Prime Rep. (2014) 6:90. doi: 10.12703/P6-90

Tan R, Nederveen JP, Gillen JB, et al. Skeletal muscle fiber-type-specific changes in markers of capillary and mitochondrial content after low-volume interval training in overweight women. Physiological Reports 2018;6(5):e13597.

Tsoupras A, Lordan R, Zabetakis I. Inflammation, not Cholesterol, Is a Cause of Chronic Disease. Nutrients. (2018) 10:604. doi: 10.3390/nu10050604

Van De Heyning CM, De Maeyer C, Pattyn N, et al. Impact of aerobic interval training and continuous training on left ventricular geometry and function: a SAINTEX-CAD substudy. Int J Cardiol 2018;257:193–198.

Vega RB, Konhilas JP, Kelly DP, Leinwand LA. Molecular mechanisms underlying cardiac adaptation to exercise. Cell Metab. (2017) 25:1012– 26. doi: 10.1016/j.cmet.2017.04.025

Vella CA, Taylor K, Drummer D.(2017). High-intensity interval and moderate-intensity continuous training elicit similar enjoyment and adherence levels in overweight and obese adults. Eur J Sport Sci.;17:1203–1211.

Virani SS Benjamin EJ, Callaway CW, Chang AR, Cheng S, Chiuve SE, et al. Heart Disease and Stroke Statistics 2018 At-a-Glance. American Heart Association (2018).

Wewege MA, Ahn D, Yu J, Liou K, Keech A. High-intensity interval training for patients with cardiovascular disease-is it safe? A systematic review. JAMA. 2018;7(21):e009305. https://doi. org/10.1161/JAHA.118.009305

Whittaker, J., Linden, M., & Coffey, V. (2013). Effect of Aerobic Interval Training and Caffeine on Blood Platelet Function. *Medicine & Science in Sports & Exercise*, *45*(2), 342-350. https://doi.org/10.1249/MSS.0b013e31827039db

WHO (2018). Global health estimates 2016: deaths by cause, age, sex, by country and by region, 2000–2016. 2015. Available at: http://www.who.int/healthinfo/ global_burden_disease/estimates/en/index1.html. Accessed March 24, 2018.

Young DR, Hivert MF, Alhassan S, Camhi SM, Ferguson JF, Katzmarzyk PT, et al. Sedentary behavior and cardiovascular morbidity and mortality: a science advisory from the american heart association. Circulation. (2016) 134:e262–79. doi: 10.1161/CIR.0000000000000440

Yu A D, Kilic F, Dhawan R, et al. (January 17, 2022) High-Intensity Interval Training Among Heart Failure Patients and Heart Transplant Recipients: A Systematic Review. Cureus 14(1): e21333. DOI 10.7759/cureus.21333

Yue T, Wang Y, Liu H, Kong Z and Qi F (2022) Effects of High-Intensity Interval vs. Moderate-Intensity Continuous Training on Cardiac Rehabilitation in Patients With Cardiovascular Disease: A Systematic Review and Meta-Analysis. Front. Cardiovasc. Med. 9:845225. doi: 10.3389/fcvm.2022.845225

Zhang Y, Cao H, Jiang P, Tang H. Cardiac rehabilitation in acute myocardial infarction patients after percutaneous coronary intervention: a communitybased study.Medicine. (2018) 97:e9785. doi: 10.1097/MD.0000000000009785

Ziaeian B, Fonarow GC. Epidemiology and aetiology of heart failure. Nat Rev Cardiol. 2016;13(6):368– 378. https://doi.org/10.1038/nrcardio.2016.25