

HEALTH ASPECTS OF AEROBIC INTERVAL TRAINING IN THE REHABILITATION OF PATIENTS WITH CARDIOVASCULAR DISEASES: A SYSTEMATIC REVIEW

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ABSTRACT

Purpose: The aim of this study was to review the literature analyzing the effects of aerobic interval training in the rehabilitation of cardiovascular patients.

Methods: Research data was collected considering the inclusion and exclusion criteria of the research studies published in English. In order for the study to be included in the analysis, it had to meet the following criteria: year of publication (2004–2022), respondents were people with cardiovascular disease, and the studies included in this review must contain data on disease, training programme and outcomes. Papers without full texts available and systematic review studies were excluded. The first search identified 71 articles. In the initial assessment carried out in accordance with the inclusion and exclusion criteria, 15 articles were found suitable and were included in the study, while 20 studies were excluded for being duplicates, 28 studies excluded for not having the full text available and eight for non-compliance.

Results: The reviewed materials indicate that aerobic interval training has an impact on VO_2 max, functional abilities, VO_2 peak and functional capacity in the rehabilitation of cardiovascular diseases, especially in the elderly. The duration of the programme in most studies has a similar time range from 10 to 16 weeks. The programmes that showed the best effects are related to aerobic interval training, from 2 to 3 times per week with moderate (50–60% of VO_2 max) or high intensity (80–90% of VO_2 max).

Conclusion: *Studies indicate that properly dosed physical activity contributes to a better lifestyle for people with cardiovascular diseases. All 15 studies showed positive effects of aerobic interval training in cardiovascular disease rehabilitation.*

Keywords: *aerobic exercise, interval training, rehabilitation, cardiovascular diseases*

ZDRAVSTVENI VIDIKI AEROBNEGA INTERVALNEGA TRENINGA PRI REHABILITACIJI PACIENTOV S SRČNO-ŽILNIMI BOLEZNIMI: SISTEMATIČNI PREGLED

IZVLEČEK

Namen: *Namen raziskave je pripraviti pregled literature, v kateri so analizirani učinki aerobnega intervalnega treninga na rehabilitacijo pacientov s srčno-žilnimi boleznimi.*

Metode: *Podatki o raziskavah so bili zbrani ob upoštevanju meril za vključitev in izključitev, in sicer za raziskave, objavljene v angleškem jeziku. V analizo so bile vključene raziskave, ki so izpolnjevale naslednja merila: objavljene so bile med letoma 2004 in 2022, anketiranci so bili ljudje s srčno-žilnimi boleznimi, poleg tega so raziskave vključevale tudi podatke o bolezni, programu treninga in rezultatih. Po drugi strani v analizo niso bili vključeni raziskave, katerih besedilo ni bilo v celoti dostopno, in sistematični pregledi raziskav. S prvim iskanjem je bilo najdenih 71 člankov. V začetno oceno je bilo v skladu z merili za vključitev in izključitev vključenih 15 člankov, medtem ko je bilo 20 raziskav izključenih, ker so bile podvojene, 28 raziskav je izključenih, ker ni bilo na voljo celotnega besedila, osem pa jih je bilo izključenih zaradi neskladnosti.*

Rezultati: *Pregledana gradiva kažejo, da aerobni intervalni trening vpliva na maksimalno aerobno moč ($VO_2\text{max}$), funkcionalne sposobnosti, najvišjo vrednost porabe kisika ($VO_2\text{peak}$) in funkcionalne zmogljivosti pri rehabilitaciji v primeru srčno-žilnih bolezni, zlasti pri starejših. V večini raziskav programi trajajo od 10 do 16 tednov. Tisti, ki so se izkazali za najučinkovitejše, so povezani z aerobnim intervalnim treningom in se izvajajo od 2- do 3-krat tedensko z zmerno (50–60 % vrednosti $VO_2\text{max}$) ali visoko intenzivnostjo (80–90 % vrednosti $VO_2\text{max}$).*

Zaključek: *Raziskave kažejo, da ustrezná količina telesne dejavnosti prispeva k boljšemu življenjskemu slogu oseb s srčno-žilnimi boleznimi. Vseh 15 raziskav je pokazalo pozitivne učinke aerobnega intervalnega treninga pri rehabilitaciji v primeru srčno-žilnih bolezni.*

Ključne besede: *aerobni, intervalni trening, rehabilitacija, srčno-žilne bolezni*

INTRODUCTION

Cardiovascular disease (CVD) remains the leading cause of mortality worldwide and in Europe (Lozano et al., 2012). It is estimated that 13 million deaths worldwide are caused by CVD. In Europe, more than 80% of all CVD mortality occurs in developing countries. Both mortality and disability caused by CVD remain extremely high and thereby CVD is still the leading somatic cause of loss of productivity (Van Camp, 2014). Exercise-based cardiac rehabilitation has been established as a beneficial treatment approach for patients with cardiovascular diseases (CVDs). However, optimal exercise characteristics that elicit the most favourable effects for CVD patients are still a matter of controversy (Vanhees, Rauch, Piepoli, & van Buuren, 2012).

The “traditional” approach to prescribing exercise intensity for cardiac rehabilitation is between 60–80% of VO_2 max, resulting in an average increase of 20% of VO_2 max. Intensity appears to be a significant predictor of rehabilitation programme efficacy, as higher intensity leads to greater improvements in VO_2 max, even after adjusting for other training-related variables (Rankin, Rankin, MacIntyre, & Hillis, 2012). However, higher intensity is difficult to sustain over a longer period; therefore, Mezzani et al. (2013) suggest an interval structure that refers to shorter exercise sessions with high to severe intensity (60–95% of VO_2 max) with duration from 3 to 20 minutes.

Several studies have demonstrated the beneficial effects of physical activity in the prevention, treatment and rehabilitation of cardiovascular diseases (Scrutino, Bellotto, Lagioia, & Passantino, 2005; Secco, Paffenberger, & Lee, 2000; Šuščević et al., 2011). Physical activity was not previously recognized as having a significant impact on the prevention and rehabilitation of CVDs. However, in recent years, significant changes have occurred due to the emergence of strong evidence of the effectiveness of primary and secondary prevention (Fletcher et al., 2013). It has been established that physical activity has a powerful and beneficial effect on human health, particularly in the pathogenesis of diseases that make up metabolic syndrome, including CVDs (Ades & Coello, 2000). Physical activity is part of a multifactorial concept that, in addition to reducing risk factors, lifestyle changes and therapy, leads to a reduction in cardiovascular risk (Šuščević et al., 2011). In contrast, physical inactivity is one of the main risk factors and causes two million deaths annually (Petković-Košćal, Damjanov, Jevtović, Jovanović & Pantović, 2007).

Considering previous studies, there is a need for further and more detailed analysis of the implementation of aerobic interval training in the rehabilitation of patients with cardiovascular disease. Although there are many studies

investigating aerobic interval training in the rehabilitation of CVDs, to be able to draw a conclusion on this topic there is a need for a systematic review of studies that employ different structures, intensity and frequency of this kind of training in practice. Research in this direction will make it possible to obtain information about health aspects of aerobic interval training in the rehabilitation of CVD patients. Therefore, the aim of this study was to review the literature analyzing the effects of aerobic interval training in the rehabilitation of cardiovascular patients.

METHODS

This research was designed using the systematic review technique. Research data was collected considering the inclusion and exclusion criteria of the research published, as a result of a search made by using the keywords “aerobic, interval, training, rehabilitation, cardiovascular diseases” in English. The search string was related to aerobic interval training with the following combination of keywords used in all databases: “aerobic interval training” AND “rehabilitation” AND “cardiovascular diseases”. The search was performed on the Web of Science, Google Scholar and PubMed databases. In accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines, a systematic review of the available literature was undertaken (Moher et al., 2009) (Figure 1.). The first search identified 71 articles. In the initial assessment carried out in accordance with the inclusion and exclusion criteria, 15 articles were found suitable and were included in the study, while 56 studies were excluded. In order for a study to be included in the analysis, it had to meet the following criteria: year of publication (2004–2022), respondents were people with cardiovascular disease, and the studies included in this review must contain data on disease, the training programme and outcomes. Papers without the full text available and systematic review studies were excluded. References from all papers were reviewed in order to find more studies that deal with a topic that is interesting and related to our review paper.

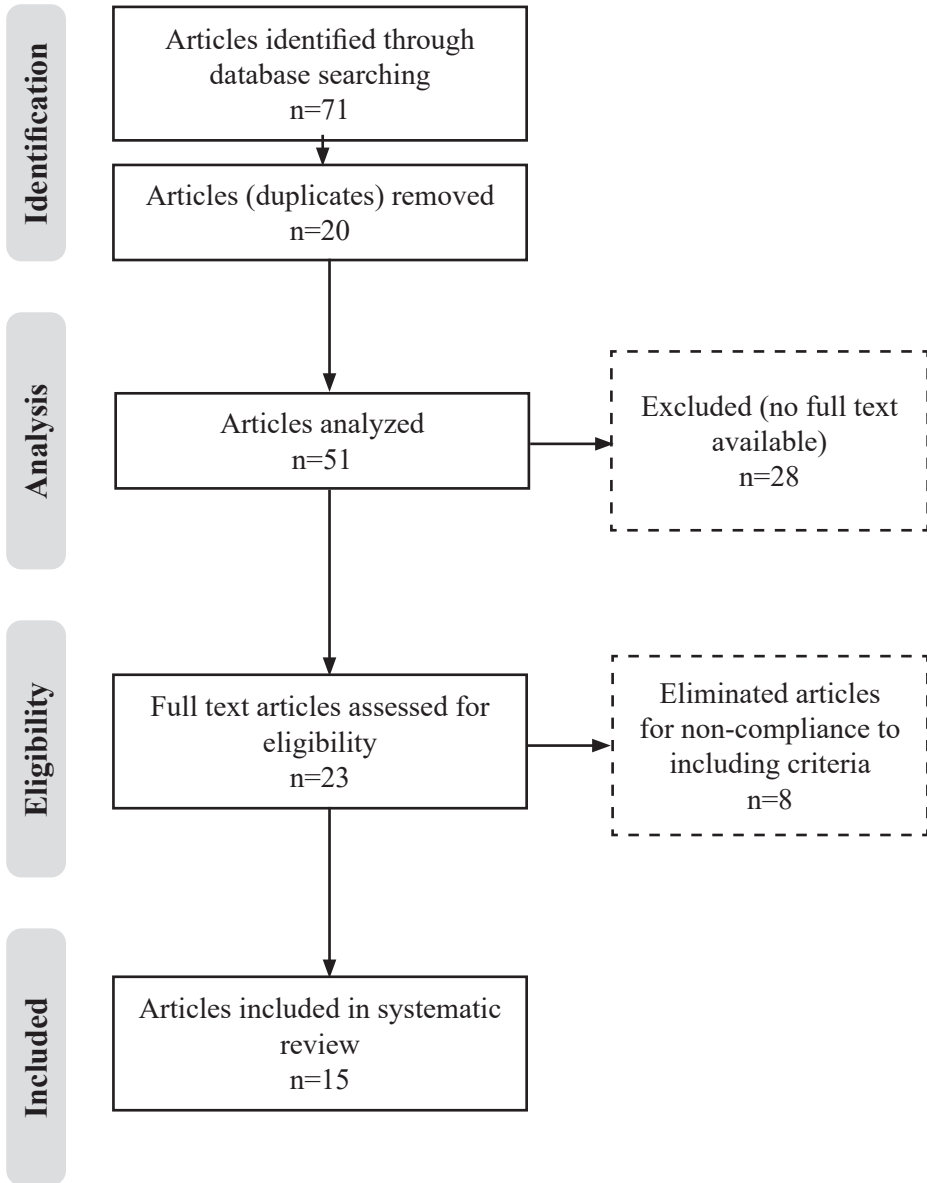


Figure 1. PRISMA flow chart of the article selection process

RESULTS

In this part, 15 original scientific studies will be presented on the topic of the influence of physical activity on the arterial blood pressure of the elderly in Table 1.

The number of respondents did not vary much from study to study, where the lowest number of respondents (21) was seen in the study (Rognmo, Hetland, Helgerud, Hoff, & Slørdahl, 2004), while the highest number of respondents (200) was seen in the study (Conraads et al., 2015). The studies had either only male or only female population, except for study (Papathanasiou et al., 2020), which contained a mixed population. The age range did not vary much in the studies (mostly between 53–65 years), while the youngest population was seen in the study of Lee, Tsai, Oh and Brooks (2018), where there were respondents aged 30. All research studies had the same goal, examination of the impact of aerobic interval training (AIT) in the rehabilitation of cardiovascular disease (CVD) patients. The reviewed materials indicate that aerobic interval training has numerous health aspects in the rehabilitation of cardiovascular diseases, especially in the elderly. The duration of the programme in most studies had a similar time range from 10 to 16 weeks, and the programmes that showed the best effects are related to aerobic interval training, from 2 to 3 times a week with moderate (50–60% of VO_2 max) or high intensity (80–90% of VO_2 max).

Table 1. Systematic review of the studies

Authors	Participants	Purpose	Type of physical activity (intensity and frequency)	Results
Rognmo et al. (2004)	n=21 (M) age 57.1±5.1 (CVD)	The influence of different intensities of AIT in the rehabilitation of CVDs.	Supervised treadmill walking was performed at high intensity (80-90% VO ₂ peak) or moderate intensity (50-60% VO ₂ peak) three times a week for 10 weeks.	VO ₂ peak 17.9% ↑ in the high-intensity group and 7.9% ↑ in the moderate-intensity group (p=0.074)
Smart & WSteele (2012)	n=23 (M) age 66±7 (Congestive heart failure)	Health aspects of AIT in the rehabilitation of congestive heart disease	The participants were divided into two groups. These groups completed 16 weeks of stationary cycling at 70% VO ₂ max three times a week for 30 minutes continuously or 60 minutes (60sec work: 60sec rest).	VO ₂ max group one: 13%↑ (p = 0.12); group two 21%↑ (p=0.03).
Rankin et al. (2012)	n=31 (F) age 63±2 (Menopause with CVD)	Examination of the health aspects of AIT in the rehabilitation of CVD in women	Supervised treadmill walking was performed at high intensity (75-85% VO ₂ peak) or moderate intensity (45-55% VO ₂ peak) three times a week for 10 weeks.	High-intensity AIT showed that VO ₂ max ↑ (12%, p=0.085)
Madssen et al. (2014)	n=36 (M) age 50-63.5 (CVD)	The effects of two types of training on the rehabilitation of coronary heart disease	AIT (intervals at ≈90% of maximum heart rate) or MCT (continuous exercise at ≈70% of maximum heart rate) were performed three times a week for 12 weeks after the implantation of an intracoronary stent.	AIT↑ 13.2% (p=0.05) MCT↑ 12.7% (p=0.05).
Kim et al. (2015)	n=28 (F) Age 61±8 (Acute myocardial infarction)	The health aspects of AIT in acute myocardial infarctions in older women	AIT at 85-95% intensity or MCT at 70-85% intensity, three days a week for six weeks in a cardiac rehabilitation clinic.	AIT VO ₂ peak↑ 22.16% (p = 0.021) MCT VO ₂ peak 8.7% (p=0.021)

Authors	Participants	Purpose	Type of physical activity (intensity and frequency)	Results
Cardozo et al. (2015)	n=71 (M) Age 56±12 (<i>CVD</i>)	The health aspects of AIT in the rehabilitation of CVD	EG performed 30 minutes of continuous aerobic exercise at 70-75% of maximum heart rate (HRmax), while HIIT performed 30-minute sessions divided into 2-minute alternating attacks at 60%/90% HRmax (three times a week for 16 weeks).	VO ₂ max↑ 22.5% (p<0.05)
Conraads et al. (2015)	n=200 (M) Age 58.4±9.1 (<i>Coronary artery disease</i>)	Examine the effects of AIT in the rehabilitation of CVD	A supervised 12-week cardiac rehabilitation programme of three weekly sessions or AIT (90-95% of peak heart rate) or MCT (70-75% of peak heart rate) on a bicycle.	VO ₂ max↑(AIT 22.7±17.6% versus MCT 20.3±15.3%). p<0.05
Jaureguizar et al. (2016)	n=72 (M) age 52-67 (<i>Ischaemic heart disease</i>)	Examine the health aspects of AIT in the rehabilitation of CHD	A supervised 8-week cardiac rehabilitation programme of three weekly sessions or AIT (80-90% of peak heart rate (HR)) on a bicycle.	VO ₂ max↑ 21% (p<0.05)
Ulbrich et al. (2016)	n=22 (M) Age 53.8±8 (<i>Chronic heart disease</i>)	Health aspects of AIT in participants with chronic heart disease	The participants underwent 12 weeks of supervised aerobic training, lasting 60 minutes, three times a week (60-70%)	AIT VO ₂ max↑ VO ₂ peak↑ 20.7% (p<0.01)
Anderson et al. (2016)	n=31 (F) Age 59.9±11.1 (<i>Coronary artery disease</i>)	The health aspects of HIIT were investigated in the rehabilitation of CVD in older women with coronary artery disease.	Aerobic interval training on a bicycle ergometer for 16 weeks, three times a week for 45-60 minutes, with a model of linear periodization and gradual increase every four weeks at 60-70% VO ₂ peak.	AIT VO ₂ peak↑ 20.8% (p<0.05)

Authors	Participants	Purpose	Type of physical activity (intensity and frequency)	Results
Lee et al. (2018)	n=72 Age 30-50 (CVD)	Examine the impact of AIT on CVD rehabilitation	Aerobic interval training on a stationary bicycle for 60 minutes, three times a week at 50-75% of maximum heart rate, for 10 weeks.	VO ₂ peak↑ (p<0.001); reduced the frequency of CVD by 3.13%.
Lee et al. (2019)	n=31 (F) Age 68.2±9.2 (Menopause with coronary artery disease)	Examine the impact of AIT on the rehabilitation of coronary artery disease	Four intervals of four minutes at 90-95% of maximum heart rate, three times a week + plus twice a week for 8 weeks.	VO ₂ max↑ 22.56% (p<0.05)
Silveira et al. (2020)	n=34 (F) Age 60±9 (CVD)	Investigate the benefits of HIIT in older women with CVD	A clinical trial with exercise three days a week for 12 weeks was conducted. Patients with CVD were randomly assigned to high-intensity interval training or moderate continuous training.	VO ₂ peak↑: HIIT 22% (p<0.05); MCT 11% (p<0.05).
Papathanasiou et al. (2020)	n=120 (M+F) Age 63.73±6.68 (CVD)	Examine the health aspects of HIIT in the rehabilitation of CVD in the older population	Participants were encouraged to pedal at a frequency of 65-80 revolutions per minute (rpm). The exercise ended when the pedal frequency dropped below 40 rpm and the participants were exhausted. Three times per week for 16 weeks.	HIIT↑ (p<0.001) in the rehabilitation of CVD in elderly participants
Liu et al. (2022)	n=24 (F) Age 64.2±4.2 (CVD)	Examining the health aspects of HIIT in the rehabilitation of CVD	Supervised treadmill walking was performed at high-intensity (80-90% VO ₂ peak) or moderate-intensity (50-60% VO ₂ peak) three times per week for 20 weeks.	HIIT↑VO ₂ peak (21.3%; p<0.05);

Legend: ↑ - improvement; CVD - cardiovascular diseases; AIT - aerobic interval training; HIIT - high-intensity interval training; M - male; F - female; n - number of participants; EG - experimental group.

DISCUSSION

The aim of the study was to perform a literature review of studies examining the health aspects of aerobic interval training for the rehabilitation of cardiovascular patients. The cardiorespiratory endurance of CVD patients improved in all studies that examined the effects of high- and moderate-intensity interval training, whereas high-intensity interval training produces greater cardiorespiratory adaptations, related to VO_2 max, than moderate-intensity interval training, according to the data (Table 1).

Most of the studies presented in Table 1 investigated the impact of high- and moderate-intensity aerobic interval training on CVD patients (Rognmo et al., 2004; Rankin et al., 2012; Madssen et al., 2014; Kim, Choi, & Lim, 2015; Cardozo, Oliveira, & Farinatti, 2015; Conraads et al., 2015; Donelli da Silveira et al., 2020; Liu, Liu, Ji, Dai, & Han, 2022). Some studies showed that high-intensity interval training, ranging from 80–95% HRmax, induced significant improvements in VO_2 max ranging from 13–22% after a 6- (Kim et al., 2015), 10–12- (Rognmo et al., 2004; Rankin et al., 2012; Madssen et al., 2014; Conraads et al., 2015; Donelli da Silveira et al., 2020) and 16–20- (Cardozo et al., 2015; Liu et al., 2022) week experimental programme. Since all the studies showed significant cardiorespiratory adaptations it can be noted that the intensity variable plays crucial role in achieving those adaptations. However, it is worth mentioning that the studies presented in this paragraph also compared high- and moderate-intensity exercises. Considering the cardiorespiratory adaptations of moderate-intensity groups, improvements in VO_2 max ranged from 8–20% after a 6- (Kim et al., 2015), 10–12- (Rognmo et al., 2004; Rankin et al., 2012; Madssen et al., 2014; Conraads et al., 2015; Donelli da Silveira et al., 2020) and 16–20- (Cardozo et al., 2015; Liu et al., 2022) week experimental programme. Both high- and moderate-intensity exercise programme showed significant improvements in VO_2 max, although high-intensity interval training seemed to induce a slightly higher increment in cardiorespiratory indications than moderate training in CVDs patients.

Some of the studies examined only the impact of moderate-intensity aerobic interval training on CVD patients (Smart & Steele, 2012; Ulbrich et al., 2016; Anderson et al., 2016; Lee et al., 2018; Papathanasiou et al., 2020). The intensity in most of these studies ranges from 55–75% HRmax inducing a significant impact on VO_2 max of around of 20% after 10–12 (Ulbrich et al., 2016; Lee et al., 2018) and 16 (Smart & Steele, 2012; Anderson et al., 2016; Papathanasiou et al., 2020) weeks of moderate-intensity exercise. Since all of the studies showed improvements on the health aspects of aerobic interval training, it can

be seen that moderate-intensity training can also be used in rehabilitation with CVD patients.

A few studies investigated only the effect of high-intensity aerobic interval training on CVD patients (Jaureguizar et al., 2016; Lee, Tsai, Brooks, & Oh, 2019). In these studies the intensity ranged from 80–95% of HRmax that affected the improvement of VO_2 max 21–22% for 8 weeks (Jaureguizar et al., 2016; Lee et al., 2019). Both of the studies showed that this type of high-intensity interval training can be used to benefiting aspects of health in the rehabilitation of CVD patients.

All of the studies, that investigated the effects of high- and moderate-intensity interval training showed positive improvements of cardiorespiratory endurance in CVD patients. However, based on the data shown (Table 1), it can be noted that high-intensity interval training has a slightly better effect on cardiorespiratory adaptations, regarding VO_2 max, compared to moderate-intensity interval training.

Limitations of the study

This study has potential limitations. Firstly, the study's inclusion and exclusion criteria, which were quite restrictive, likely reduced the amount of literature retrieved. Secondly, only articles published in English were included in this systematic review.

CONCLUSION

The aim of this study was to systematize the literature that examines the health aspects of aerobic interval training in the rehabilitation of cardiovascular patients. In conclusion, this study showed that both high- and moderate-intensity interval training are valid interventions in cardiovascular rehabilitation, positively inducing cardiorespiratory adaptations. However, when comparing the data of the analyzed studies, we concluded that high-intensity interval training contributes slightly more to the health aspects regarding cardiorespiratory adaptations than moderate-intensity training does.

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Conflict of interest

The authors declare that there is no conflict of interest.

Future research

For future research, we recommend the inclusion of a larger number of studies in the systematic review.

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