SYSTEMATIC REVIEW/META ANALYSIS

Effect of Physical Exercise on LVEF, Health Related Quality of Life and Other Cardiopulmonary Parameters in Heart Patients: A Systematic Review and Meta-Analysis

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DOI: 10.55489/njcm.150920244162

ABSTRACT

Introduction: This study aims to determine the effect of high-intensity physical exercise on various cardiopulmonary parameters and HRQOL in heart disease patients.

Methodology: We searched databases including PubMed, Scopus, Embase, and Google Scholar using the PRISMA checklist to find research publications between year 2004 and 2024. R software 4.3.0 was utilised to perform the meta-analysis, and Cochrane's ROB tool 2.0 was employed for the quality appraisal. Heterogeneity was assessed using I^2 statistics. A funnel plot and Egger's test were used to evaluate publication bias.

Results: 22 articles in this meta-analytic study discovered that there was a substantial difference in the two patient groups' LVEF [2.41, (−1.29; 6.12), p<0.01], resting systolic [-2.24, (−4.77; 0.29), p=0.87] and diastolic BP [0.28, (−1.34; 1.89), p=0.53], resting heart rate [-1.54, (−6.11; 3.03), p<0.01], peak oxygen uptake [1.13, (−0.36; 2.61), p<0.01], and HRQOL including physical [4.00, (−4.29; 12.29), p<0.01], mental [2.19, (−0.50; 4.87), p=0.01], emotional [1.67, (−2.34; 5.68, p=0.46) and social components [4.33, (0.23; 8.42), p=0.69].

Conclusion: In addition to improving LVEF, HRQOL, cardiac function, and peak oxygen uptake, cardiac rehabilitation training lowers the risk of CVD and lengthens life expectancy, all of which should be encouraged in the therapeutic context.

Keywords: Cardiac rehabilitation, Ejection fraction, Exercise, HRQOL

ARTICLE INFO

Financial Support: None declared
Conflict of Interest: None declared
Received: 17-05-2024, **Accepted**: 25-07-2024, **Published**: 01-09-2024
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How to cite this article: Gupta B, Gupta K, Goel R, Mittal A. Effect of Physical Exercise on LVEF, Health-Related Quality of Life and Other Cardiopulmonary Parameters in Heart Patients: A Systematic Review and Meta-Analysis. Natl J Community Med 2024;15(9):758-769. DOI: 10.55489/njcm.150920244162

www.njcmindia.com │pISSN: 0976-3325│eISSN: 2229-6816│Published by Medsci Publications

Introduction

The American Heart Association, the American College of Cardiology, and the European Society of Cardiology have all recommended cardiac rehabilitation (CR) programmes as a Class I component of the comprehensive care of patients with congestive heart failure (CHD). Exercise therapy has been repeatedly identified as a key component of these programmes.[1-4]

The goal of cardiac rehabilitation is to enhance the mental and physical health of individuals with heart disease through a comprehensive, multifaceted strategy that includes elements of education, behaviour modification, exercise training, and psychosocial treatment.[5] While exercise training is a stand-alone component of rehabilitation programmes, complete exercise-based rehabilitation programmes typically combine exercise training with additional therapies, especially psycho-educational elements.[5]

Patients with heart failure and those who have had heart surgery (i.e., bypass surgery, valve surgery, or both) are among the patient categories who are frequently advised to undergo cardiac rehabilitation.

Heart transplant recipients were prohibited from exercising for many years since it was thought that their new heart was still denervated, having a greater resting heart rate and a lower heart rate reaction (chronotropic incompetence). Nonetheless, a wealth of data shows that heart transplant recipients tolerate resistance and endurance training well. Although it's generally accepted that physical exercise can enhance autonomic nerve control and re-innervation, it's uncertain if the normalisation of chronotropic responses happens independently, in conjunction with training and other factors, or both.[6-7]

This study aims to find out the effect of high-intensity physical exercise on various cardiopulmonary parameters such as Left ventricular Ejection Fraction, Resting Systolic and Diastolic Pressure, Resting Heart rate, Peak oxygen consumption, and physical, mental, emotional, and social components of SF-36 Health-related quality of life index.

Methodology

This meta-analysis and systematic review were registered in Prospero- International Prospective Register of Systematic Reviews with registration number CRD42024521302. We conducted and reported this systematic review by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 reporting guidelines.

Eligibility criteria: Search limits used in the databases include English literature and the period starting from April 1, 2004, to April 1, 2024.

Information sources: On April 1, 2024, several databases, including PubMed, Scopus, Embase, and Google Scholar, were searched for randomised control trials that examined the impact of all forms of physical activity exercise-based cardiac rehabilitation on patients with heart conditions. To find more publications, we have also manually scanned the list of references for the included studies.

Search strategy: The keywords used for the search were "exercise", "cardiac rehabilitation" and "heart disease". The type of study was restricted to randomized control trials.

Selection process: Every author (Gupta B, Gupta K, Goel R, Mittal A) assessed each study's eligibility separately after finding it in the two databases. If there were any differences among these writers, they discussed them in detail to find a solution.

Data collection process: The initial author's name, publication year, research kinds, study nation, length of participant participation (in years), and population under study (age range and multiple cases) were extracted from the retrieved papers using a standardised form.

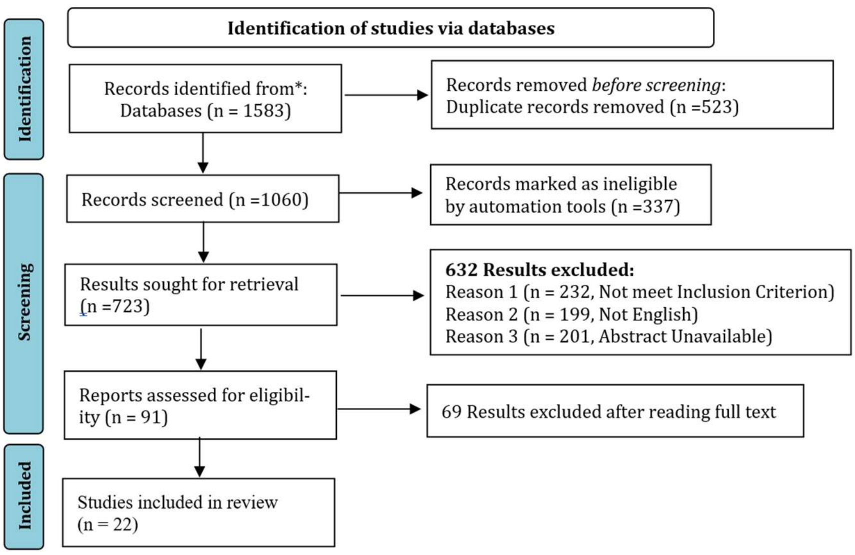

Figure 1: PRISMA Flow Diagram

Data items: A variety of cardio-pulmonary parameters, including peak oxygen consumption, resting heart rate, resting diastolic and systolic pressure, left ventricular ejection fraction, and the physical, mental, emotional, and social components of the SF-36 Health-related quality of life index, were measured as means of outcome following high-intensity physical training as the experimental condition and moderate or no physical training as the control.

Risk of bias assessment: The Cochrane Risk of Bias tool 2.0 was utilised to evaluate the risk of bias. For each randomised control trial that was a part of the meta-analysis, BG and RG assessed the possibility of bias.

Effect measures: Standardized mean difference values were pooled to find out the effect of various randomized control trials in the meta-analysis.

Synthesis methods: Version 4.3.0 of the R programme was used to conduct the meta-analysis. The standardised mean differences between the exposure and control groups for a variety of cardiopulmonary measures and the health-related quality of life index (SF-36) were pooled using the random effects model. Utilising I^2 values, heterogeneity was evaluated. Research with an I^2 of greater than 50% is regarded as having significant heterogeneity.

Reporting bias assessment: Egger's regression tests and a funnel plot inspection were used to evaluate potential publication bias.[8-9]

RESULTS

Study selection: 305 of the 1,583 articles that were originally identified were from registers, while 1,278 were obtained from the database. Following the removal of 860 duplicate articles, 337 records were flagged as ineligible by automated tools, 632 non-compliant articles were further eliminated after reading the abstract and title; 69 articles were eliminated after reading the entire text; and, at last, 22 articles that satisfied the inclusion criteria were included.[10-31] The retrieval process is shown in Figure 1, and the basic information of the included literature is shown in Table 1.

Study characteristics: Various characteristics of the studies included are mentioned in Table 1.

Risk of bias in studies: The overall risk of Bias was low (Figures 2.1 and 2.2).

Results of syntheses and individual studies

Left ventricular ejection fraction: 275 participants in the experimental group and 250 patients in the control group had their left ventricular ejection fraction assessed. It was revealed by the heterogeneity test that I^2=91% and P<0.01. After that, the REM was employed for analysis. The meta-analysis showed that MD: 2.41, 95% CI: −1.29 to 6.12, P<0.01. As a result, following training at various intensities, there was a significant difference (P<0.01) in left ventricular ejection fraction between the two patient groups. In Figure 3, the forest plot is displayed. The symmetrical funnel chart in Figure 12 indicates that the publication bias successfully ensured that patient left ventricular ejection fraction findings at varying exercise intensities were above 5k +10=95. Additionally, the majority of data points corresponded to points inside the 95% confidence interval.

Resting systolic BP: In the experimental group, 328 patients had their resting systolic blood pressure monitored, while in the control group, 340 patients participated. After that, analysis was done using the REM. The meta-analysis results showed that MD: -2.24, 95% CI: −4.77 to 0.29, P=0.87. Therefore, following high-intensity exercise, a group of patients experienced a considerable increase in their resting systolic blood pressure. In Figure 4, the forest plot is displayed. The symmetrical funnel chart in Figure 13 shows that the publication bias was successful in ensuring that the resting systolic blood pressure readings of patients at varying training intensities were greater than 5k + 10=95. Additionally, the majority of the data matched to points inside the 95% confidence interval.

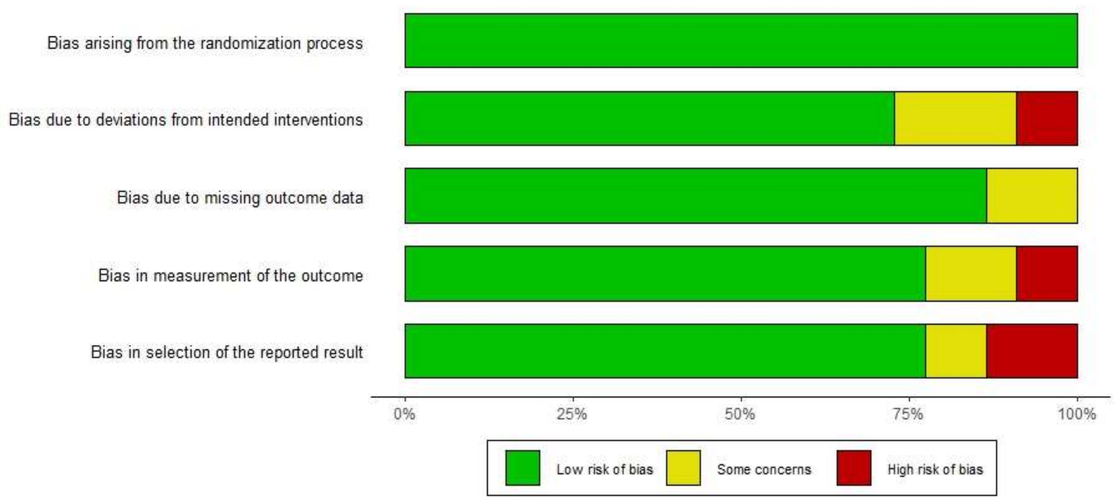

Figure 2.1: Risk of bias assessment of included literature

Table 1: Characteristics of the included studies

Author and year of publication	Country and sample size	Major findings
G. McGregor et al,[10] 2023	United Kingdom, 382	Low-volume HIIT increased cardiorespiratory fitness in stable CAD patients above MISS by a clinically important amount. A safe tolerated well, and therapeutically useful technique that improves cardiorespiratory fitness temporarily is low-volume high-intensity interval training (HIIT). All CR programmes ought to take it into account as a supplement or substitute for MISS.
Saidi et al,[11] 2023	Iran, 57	According to these results, resistance training at a 50% 1-repetition maximum had a more positive impact on heart rate variation in chronic heart failure than did exercise at a 75% 1-repetition maximum.
Terada et al,[12] 2022	Canada, 130	HIIT, MICT, and NW for twelve weeks improve functional ability, quality of life, and depressive symptoms over time. Nonetheless, NW provided extra advantages by boosting functional capability. By week 26, the 12-week exercise program's effects were still present.
J.L. Reed et al,[13] 2021	Canada, 86	In patients with chronic and permanent AF, twice-weekly 23-minute HIIT was found to be just as effective as twice-weekly 60-minute CR for enhancing functional ability, overall and disease-specific QOL, resting heart rate, and PA levels. This was a randomised clinical trial.
Khadanga S et al,[14] 2021	USA, 56	When compared to regular CR exercise training, an exercise strategy that combined HIIT and rigorous lower extremity RT improved the response to exercise training for women in CR. Peak VO2 and strength in the legs improved considerably more in women who were randomised to HIIT during CR.
Nakaya Y et al,[15] 2021	Japan, 75	Regardless of the kind of heart failure, elderly individuals with acute decompensated heart failure underwent increased physical performance with a multimodal intervention added to regular cardiac rehabilitation.
Nagyova I et al,[16] 2020	Slovakia, 83	Above and beyond traditional cardiovascular rehabilitation, a three-week training programme improved the cardiovascular and functional performance of patients with coronary artery disease in a clinically significant way.
B. Deng et al,[17] 2020	China, 70	In cardiac rehabilitation, CPET-based exercise can safely improve these patients' exercise tolerance and quality of life.
Taylor JL et al,[18] 2020	Australia, 93	In patients with CAD undergoing cardiac rehabilitation, a 4-week HIIT programme increased VO2 peak in comparison with MICT, according to this randomised clinical research. Nonetheless, both groups' increases in VO2 peak at 12 months were comparable. HIIT proved safe and practicable, and after a year, it adhered to MICT guidelines almost exactly. These results provide credence to the use of HIIT as a supplement or substitute for moderate-intensity exercise in cardiac rehabilitation programmes.
Tsai et al,[19] 2020	USA, 25	The findings imply that exercise rehabilitation strategies are workable in terms of VO2 max improvement as well as safety, retention, and satisfaction.
Koldobika VJ et al,[20] 2019	Spain, 72	When HIIT was administered to individuals with low-risk chronic ischemic heart disease, VO2 peak, and ME at VT1 improved more than when MCT was used. Furthermore, ME at VT2 and VO2 peak increased significantly only when HIIT was applied.
Sayegh ALC et al,[21] 2019	Brazil, 22	After endocardial excision surgery, physical therapy is a non-pharmacological strategy that improves heart volumes, functional ability, and quality of life in individuals with endocarditis. To further enhance the clinical state of EMF patients, rehabilitation through exercise should be recommended.
Rengo et al,[22] 2019	USA, 124	Patients with HFrEF who complete CR should anticipate improvements in their depressive symptoms, muscular strength, and aerobic capacity, regardless of the source of referral.
F. Besnier et al,[23] 2019	France, 31	In this brief rehabilitation programme, HIIT greatly outperformed the traditional MICT programme in terms of improving peak oxygen uptake and parasympathetic tone.
Opotowsky et al,[24] 2018	USA, 28	When compared to SOC, cardiac rehabilitation is secure and linked to improvements in self-reported health status and aerobic capacity in persons with congestive heart failure.
Chen et al,[25] 2018	Taiwan, 75	The greatest improvements in functional ability, quality of life, and a lower rate of admission within 90 days were seen with home-based cardiac rehabilitation.
Ellingson et al,[26] 2017	Norway, 261	When it came to altering left ventricular remodeling or aerobic capacity, HIIT did not outperform MCT, and its viability in individuals with heart failure is still up for debate.
D. Acanfora et al,[27] 2016	Italy, 123	Shortly following a sudden onset of cardiac decompensation, exercise training improves pulmonary function and cardiac performance indicators in middle-aged and elderly heart failure patients.
Tang et al,[28] 2015	Canada, 50	Exercise at a high intensity enhanced early myocardial relaxation and right-sided function.
Belardinelli et al,[29] 2012	Italy, 123	When compared to NT patients, moderately supervised ET administered twice a week for ten years results in a persistent enhancement of quality of life and a functional capacity that is greater than 60% of maximal VO2. These long-term gains are linked to a decline in significant cardiovascular events, such as heart failure hospitalisations and cardiac deaths.
Osbak et al,[30] 2011	Denmark, 49	Exercise training for twelve weeks resulted in a substantial drop-in resting pulse rate and an increase in capacity for exercise and 6MWT in AF patients. The MLHF-Q, a measure connected to cardiology, showed a significant increase in overall quality of life.
Smith et al,[31] 2004	Canada, 222	According to this follow-up study, patients who are low-risk and whose Cardiac Rehabilitation programme is started at home may have a higher chance of long-term good changes in their physical and mental health than those whose programme is initially conducted in an institution.

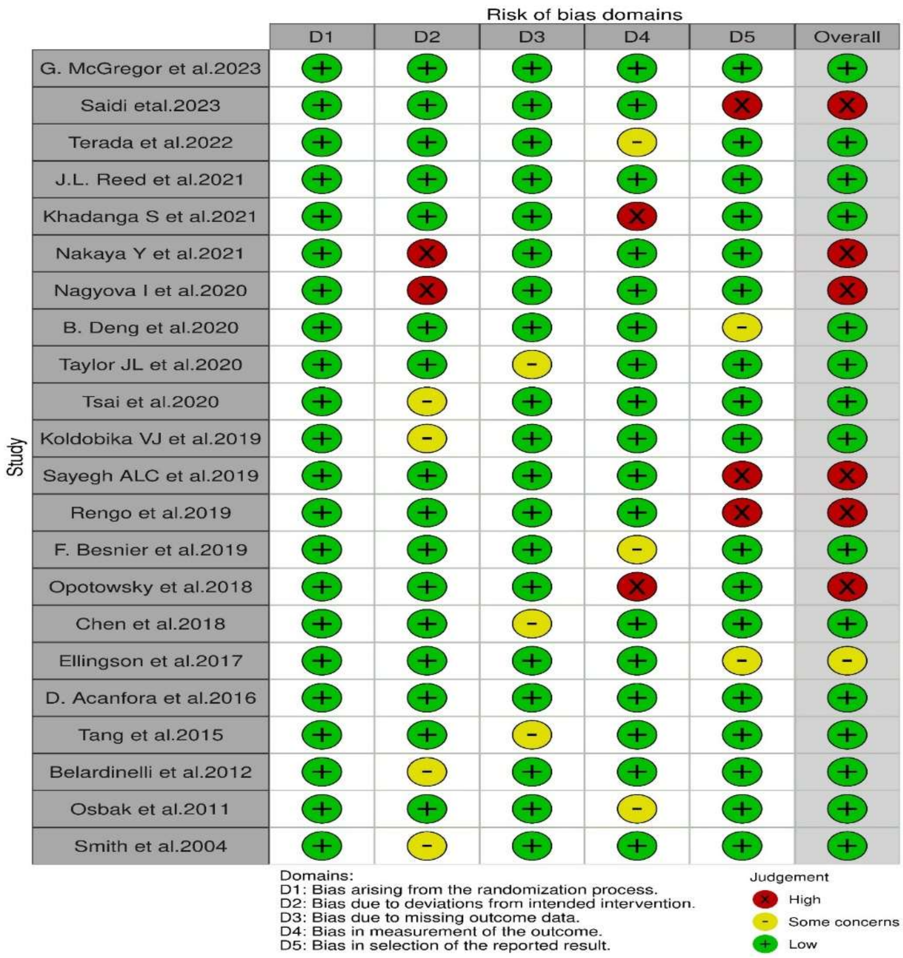

Figure 2.2: Traffic plot showing the risk of bias in individual studies

Resting diastolic BP: 344 participants in the experimental group and 347 patients in the control group had their resting diastolic blood pressure monitored. Analysis was then conducted using the REM. The meta-analysis showed that MD: 0.28, 95% CI: −1.34 to 1.89, P=0.53. As a result, following training at various intensities, there was a substantial difference in Resting Diastolic Blood Pressure between the two patient groups. In Figure 5, the forest plot is displayed. The symmetrical funnel chart in Figure 14 indicates that the publishing bias was successful in ensuring that the resting diastolic blood pressure readings of patients at varying training intensities were greater than 5k + 10=95. Additionally, the majority of the data matched points inside the 95% confidence interval.

Resting Heart Rate: 377 patients in the control group and 372 patients in the experimental group had their resting heart rates assessed. According to the heterogeneity test, I^2=83% and P<0.01). After that, the REM was employed for analysis. The meta-analysis results showed that MD: -1.54, 95% CI: −6.11 to 3.03, P<0.01. As a result, following training at varying intensities, there was a significant difference in the two patient groups' resting heart rates (P<0.01). In Figure 6, the forest plot is displayed. The symmetrical funnel chart in Figure 15 and the majority of the data points falling inside the 95% confidence interval suggest that the publishing bias was successful in ensuring that patient resting heart rate measurements at varying training intensities were greater than 5k + 10=95.

Peak oxygen uptake: Peak oxygen uptake data were collected from 443 individuals in the treatment group and 436 individuals in the untreated group. The results of the heterogeneity test revealed that I^2=93% and P<0.01, indicating a clear heterogeneity in the literature. After that, the REM was employed for analysis. The meta-analysis showed that MD: 1.13, 95% CI: −0.36 to 2.61, P<0.01. Consequently, following training at varying intensities, there was a significant difference (P<0.01) in peak myocardial oxygen uptake between the two patient groups. In Figure 7, the forest plot is displayed. The funnel chart was symmetrical, as seen in Figure 16, and the majority of the data corresponded to points inside the 95% confidence interval, suggesting that publication bias was successful.

Quality of Life

Physical component: A total of 202 patients in the control group and 201 patients in the experimental group had it measured. According to the heterogeneity test, P<0.01) and I^2=80% were found. Analysis was then conducted using the REM. The meta-analysis showed that MD: 4.00, 95% CI: −4.29 to

12.29, P<0.01. Consequently, following training at varying intensities, there was a significant difference (P<0.01) in the physical component of the SF36 Health-related quality of life index between the two patient groups. In Figure 8, the forest plot is displayed. The symmetrical funnel chart in Figure 17 indicates that the publication bias was effective in ensuring that the physical component of the SF36 Health-related quality of life index of patients at varying training intensities had results above 5k +10=95. Additionally, the majority of the data corresponded to points within the 95% CI.

Mental component: In the experimental group, 321 patients had it measured, while in the control group, 327 patients did. I2=66% and P=0.01, according to the heterogeneity test. After that, the REM was examined. The meta-analysis showed that MD: 2.19, 95% CI: −0.50 to 4.87, P=0.01. Consequently, following training at varying intensities, there was a significant difference (P=0.01) in the mental component of the SF36 Health-related quality of life index between the two patient groups. In Figure 9, the forest plot is displayed. The symmetrical funnel chart in Figure 18 indicates that the publication bias was successful in raising the results of the mental component of the SF36 Health-related quality of life index of patients at varying training intensities to above 5k +10=95. The majority of the data also corresponded to points within the 95% CI.

Emotional component: The experimental group comprised 104 patients, while the control group consisted of 104 patients. After that, analysis was done using the REM. The meta-analysis results showed that MD: 1.67, 95% CI: −2.34 to 5.68, P=0.46. Consequently, following varying levels of training, there was a noteworthy distinction in the emotional aspect of the SF36 Health-related quality of life index between the two patient groups. In Figure 10, the forest plot is displayed. The symmetrical funnel chart in Figure 19 indicates that the publication bias was successful in raising the results of the emotional component of the SF36 Health-related quality of life index of patients at varying training intensities to above 5k +10=95. The majority of the data also corresponded to points within the 95% CI.

Social component: 95 patients in the control group and 96 patients in the experimental group had it measured. After that, the REM was employed for analysis. The meta-analysis results showed that MD: 4.33, 95% CI: 0.23 to 8.42, P=0.69. Thus, following varying training intensities, there was a significant difference between the two patient groups in the social component of the SF36 Health-related quality of life index. In Figure 11, the forest plot is displayed. The symmetrical funnel chart in Figure 20 indicates that the publication bias was successful in raising the results of the social component of the SF36 Health-related quality of life index for individuals at various training intensities to above 5k +10=95. The majority of the data also corresponded to points within the 95% CI. Results were expressed using forest plots as shown in figures 3-11.

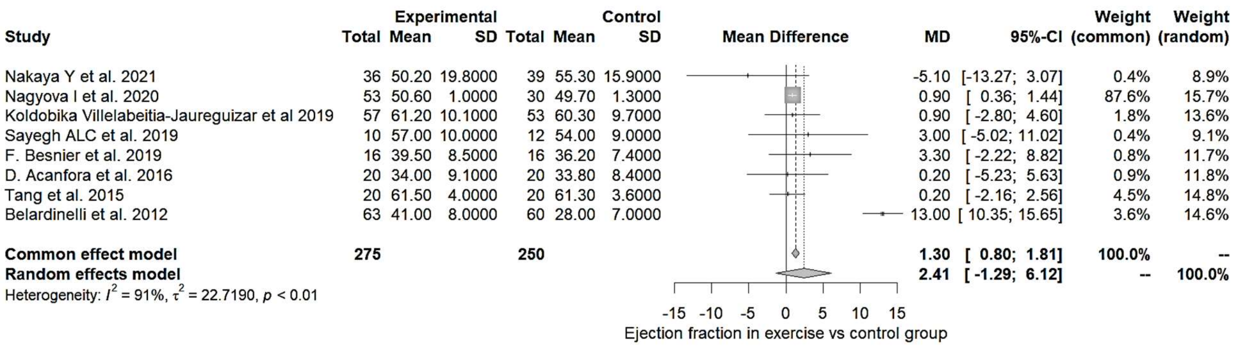

Figure 3: Forest plot of Left ventricular ejection fraction for the two groups of patients. CI, confidence interval; SD, standard deviation

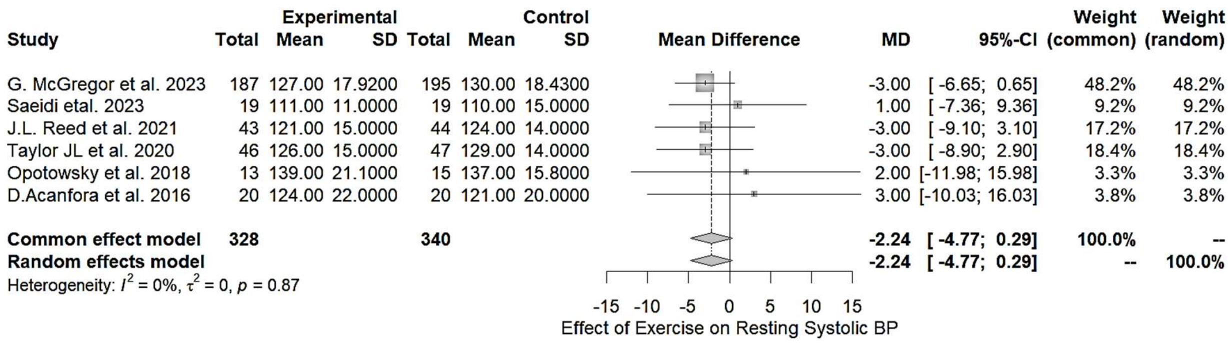

Figure 4: Forest plot of Resting Systolic BP for the two groups of patients. CI, confidence interval; SD, standard deviation

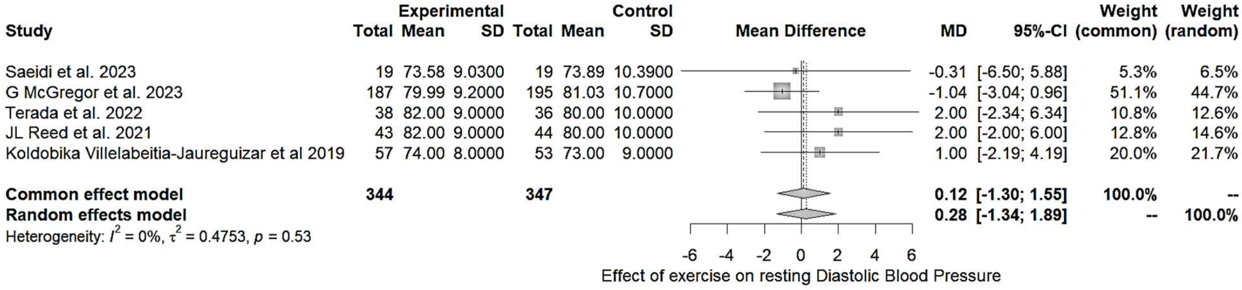

Figure 5. Forest plot of Resting Diastolic BP for the two groups of patients. CI, confidence interval; SD, standard deviation

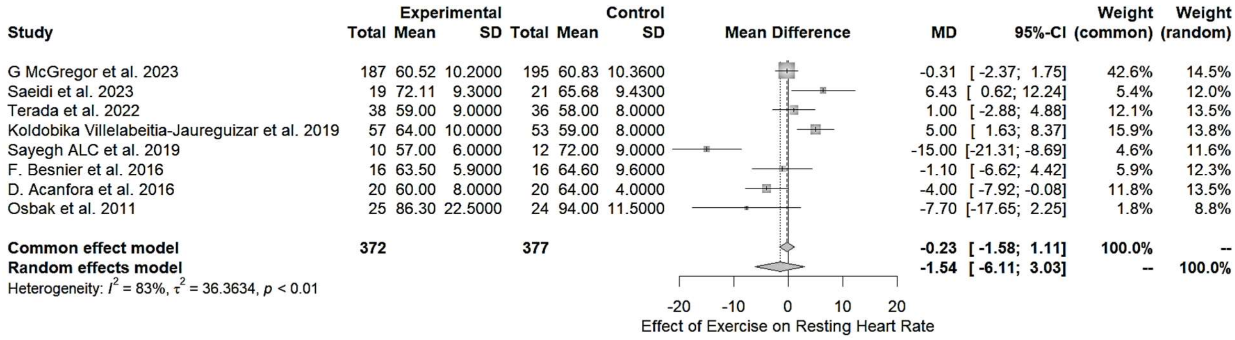

Figure 6. Forest plot of Resting Heart Rate for the two groups of patients. CI, confidence interval; SD, standard deviation

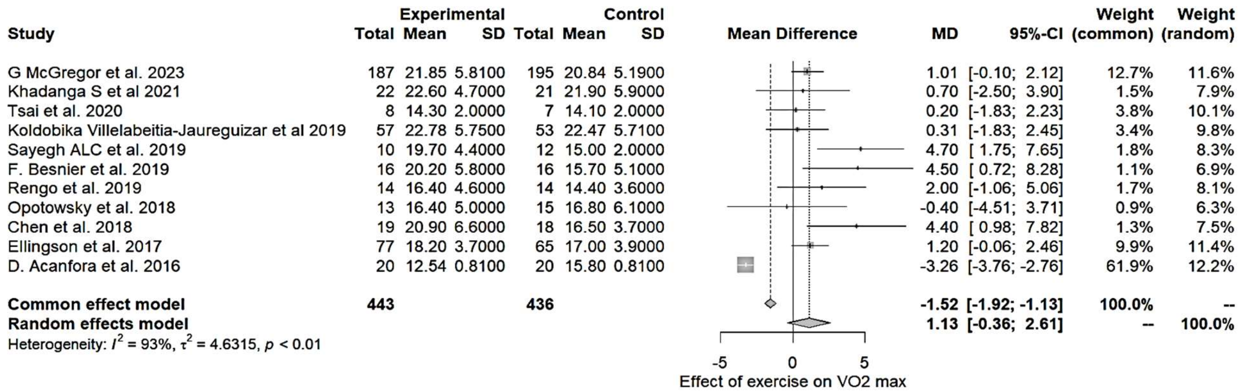

Figure 7. Forest plot of Peak VO^2 for the two groups of patients. CI, confidence interval; SD, standard deviation

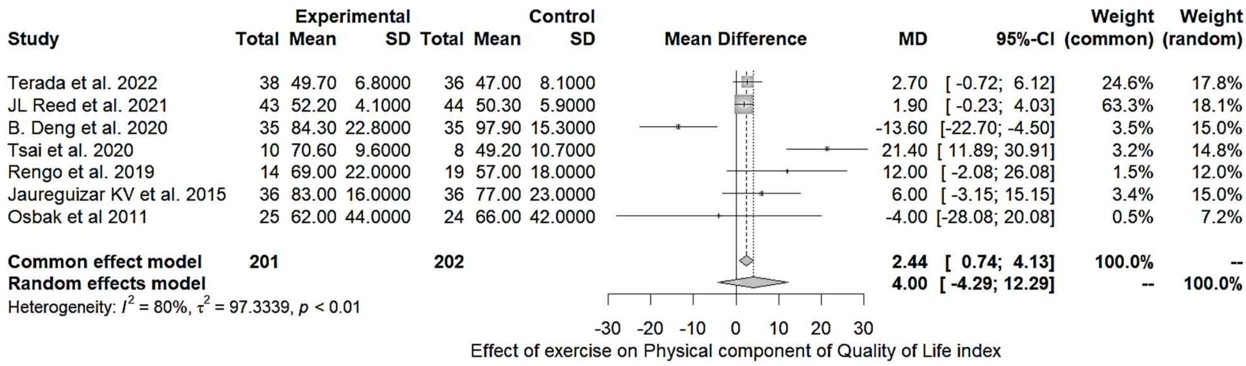

Figure 8: Forest plot of the physical component of HRQOL SF36 for the two groups of patients. CI, confidence interval; SD, standard deviation

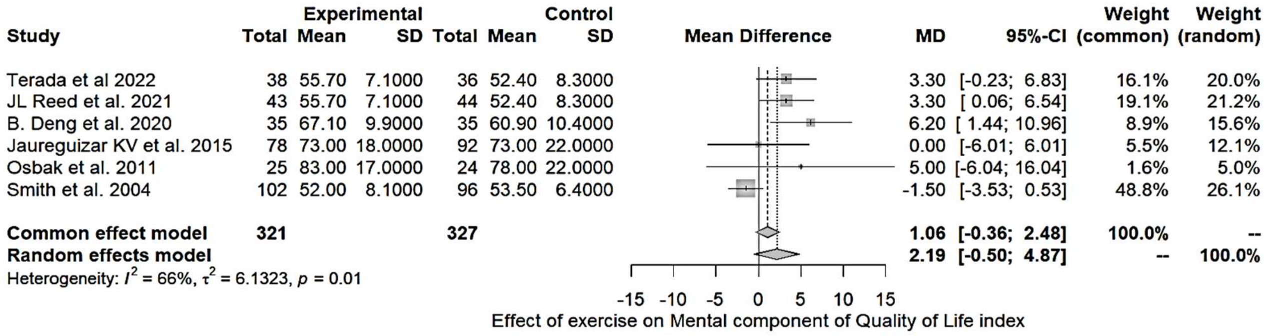

Figure 9. Forest plot of mental component of HRQOL SF36 for the two groups of patients. CI, confidence interval; SD, standard deviation

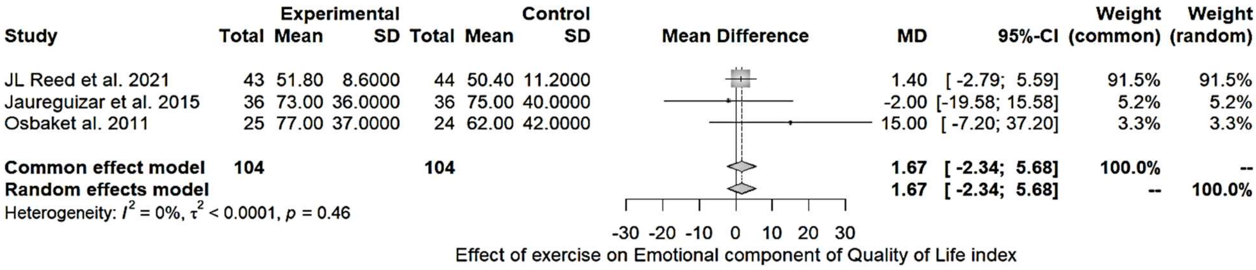

Figure 10: Forest plot of emotional component of HRQOL SF36 for the two groups of patients. CI, confidence interval; SD, standard deviation

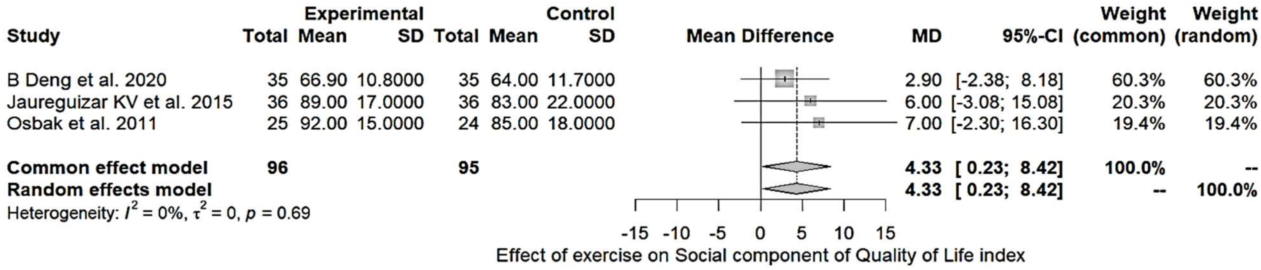

Figure 11: Forest plot of the social component of HRQOL SF36 for the two groups of patients. CI, confidence interval; SD, standard deviation

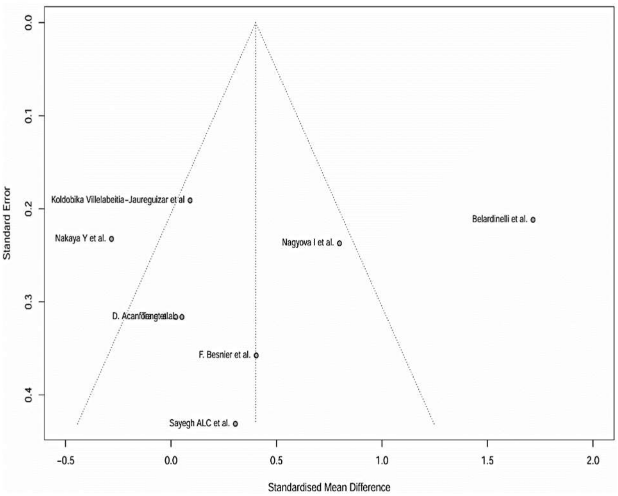

Figure 12: Funnel chart of LVEF of the two groups of patients. MD, mean different; SE, standard error

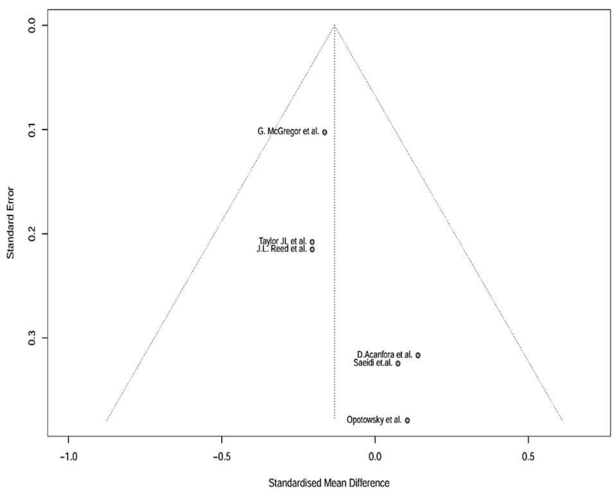

Figure 13: Funnel chart of Resting Systolic BP of the two groups of patients. MD, mean different; SE, standard error

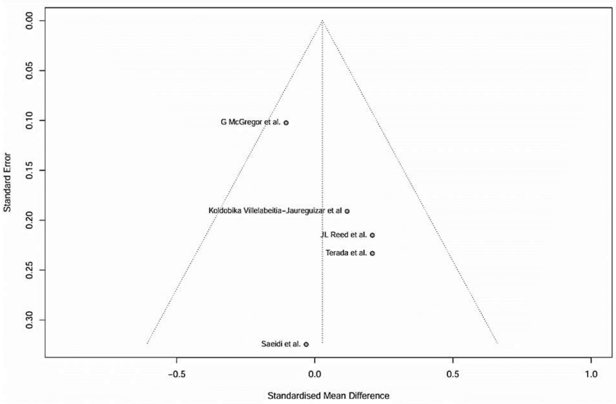

Figure 14: Funnel chart of Resting Diastolic BP of the two groups of patients. MD, mean different; SE, standard error

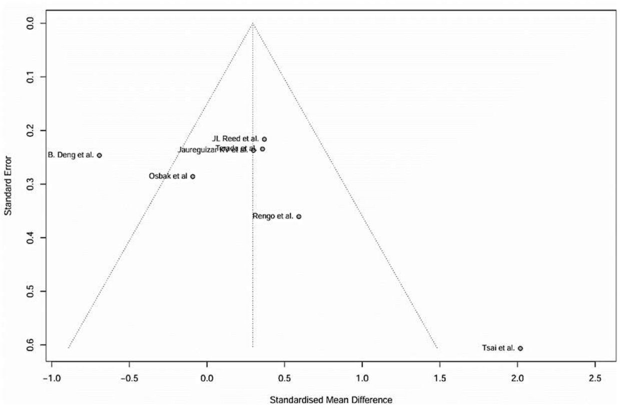

Figure 17. Funnel chart of Physical component of HRQOL index of the two groups of patients. MD, mean different; SE, standard error

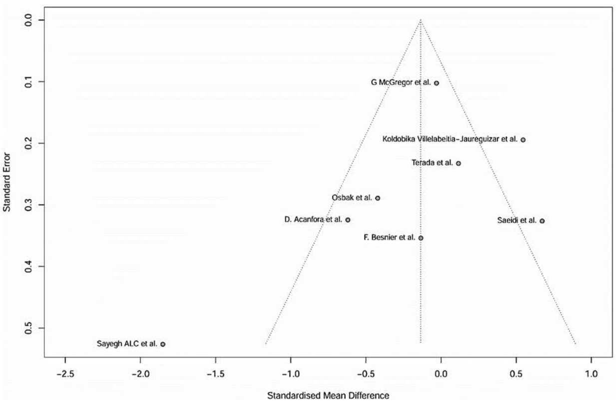

Figure 15: Funnel chart of Resting Heart Rate of the two groups of patients. MD, mean different; SE, standard error

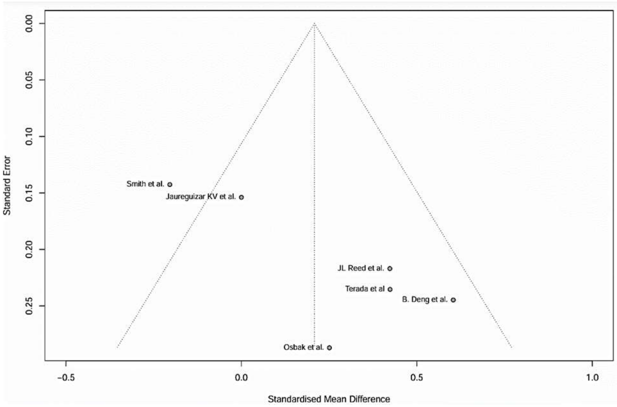

Figure 18: Funnel chart of the mental component of HRQOL index of the two groups of patients. MD, mean different; SE, standard error

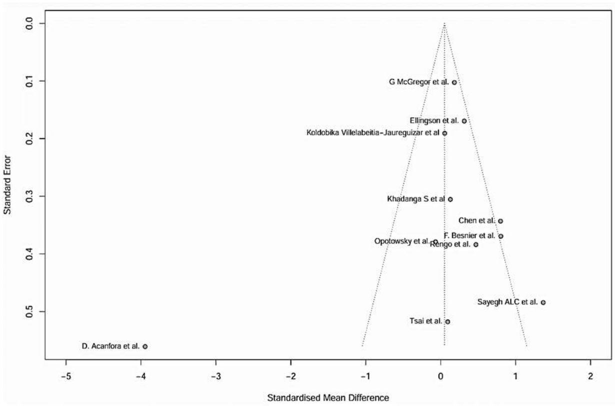

Figure 16: Funnel chart of peak oxygen uptake of the two groups of patients. MD, mean different; SE, standard error

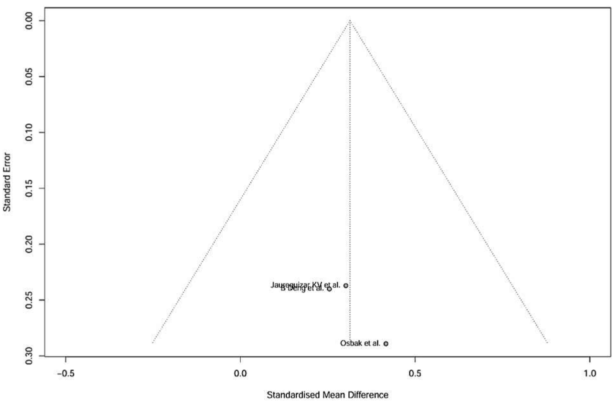

Figure 19: Funnel chart of the emotional component of HRQOL index of the two groups of patients. MD, mean different; SE, standard error

Effect of exercise on Quality of Life: The SF-36 is used for self-assessment of health-related QoL. The SF-36 comprises eight areas from which data can be summed into physical, mental, emotional, and social domains.

Certainty evidence: The sensitivity analysis examined whether a single study affected the combination's total outcomes, which could affect thorough research in the next two scenarios. First, the outcome will alter noticeably if a study is removed. When research is removed from the analysis without significantly altering the overall results, this suggests that the combined results are sensitive and unstable. Secondly, the findings demonstrate stability and sensitivity, and the conclusion is accurate.

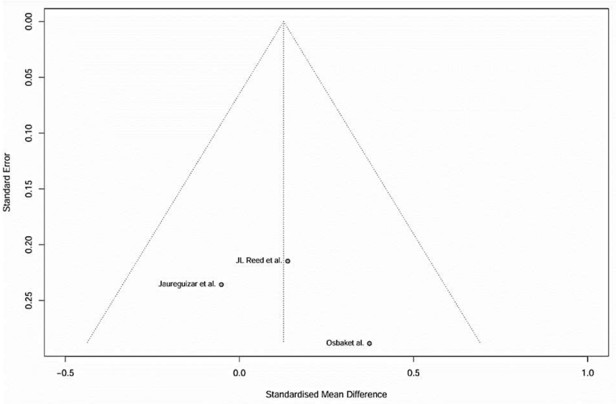

Figure 20: Funnel chart of the social component of the HRQOL index of the two groups of patients. MD, mean different; SE, standard error

Reporting biases: Publication bias was expressed using funnel plots as shown in figures 13-20.

Discussion

Oldridge et al.[32] and O'Connor et al.[33] published the first systematic reviews and meta-analyses of exercise-based CR more than 20 years ago. Based on information from 22 randomised controlled trials (RCTs) involving more than 4,300 patients, they found a 20% to 25% decrease in all-cause and cardiovascular (CV) mortality.

Twenty-two articles including 2237 heart patients were included in our meta-analysis.[10-31] Majority of studies included in this meta-analysis belonged to USA (n=4), followed by Canada (n=4), Italy (n=2), Iran (n=1), Australia (n=1), Brazil (n=1), Denmark (n=1), Norway (n=1), Taiwan (n=1), France (n=1), Spain (n=1), China (n=1), Japan (n=1), United Kingdom (n=1), and, Slovakia (n=1).[10-31] Random grouping was utilised in all 22 articles to assign patients to the experimental and control groups.

The left ventricular ejection fraction of patients following various training intensities was reported in eight publications included in the current analysis. The meta-analysis found significant improvement in LVEF after physical exercise.

Six publications that were part of this analysis found increase in patients' resting systolic blood pressure following varying training intensities. The present study comprises five articles that present substantial difference in patients' resting diastolic blood pressure following varying training intensities.

The present study comprises eight articles that present the reduction in resting heart rate of individuals following varying training intensities

The current analysis includes eleven publications that described improvement in patients' peak myocardial oxygen consumption following varying intensities of training.

The physical component of the SF36 Health-related Quality of Life Index for individuals following varying training intensities was reported in seven publications that were part of the current investigation. The mental component of the SF36 Health-related Quality of Life Index of patients after varying training intensities was reported in six publications that were included in this investigation. The emotional aspect of patients' SF36 Health-related Quality of Life Index after varying training intensities was documented in three of the papers that made up the current study. The social component of patients' SF36 Health-related Quality of Life Index after varying training intensities was reported in three of the papers that made up the current study. Overall, all the components of HRQOL were found to be improved by physical exercise in heart patients.

Training in cardiac rehabilitation can greatly enhance heart function. To increase blood flow and myocardial support, cardiac rehabilitation training can first enhance the structure and function of endothelial progenitor cells in the coronary arteries, widen the coronary arteries, and create collateral circulation. Lanza GA et al.[34] showed in their study that CR significantly improves impaired endothelial function in these patients, which may contribute to the beneficial effects of CR on clinical outcomes.

In a similar meta-analysis, Anderson et al. (2016) reported that exercise-based CR lowers cardiovascular mortality and offers significant data indicating lower hospital admission rates and improved quality of life.[35]

In a related meta-analysis, Sibilitz KL et al. (2016) discovered that exercise-based rehabilitation may increase exercise capacity in persons who have had heart valve surgery as opposed to no activity at all.[36]

A similar meta-analysis conducted by Risom SS et al. (2017) revealed no clinically significant effect on health-related quality of life. The simulated result for physical exercise ability was positively impacted, according to pooled data.[37]

During a meta-analytic analysis, R.S. Taylor et al. (2018) discovered that among heart failure patients with lower ejection fraction, exercise-based cardiac rehabilitation did not significantly alter the risk of death or hospitalisation.[38]

Limitations

It was challenging to evaluate the methodological quality and, thus, the risk of bias of the included RCTs due to the generally low quality of reporting in these studies. We did discover some improvements in the reporting quality in studies that have been published more recently, though. Thankfully, our meta-analysis's conclusions held when we restricted it to research with a lesser chance of bias. Nevertheless, we believe this to be the most comprehensive review of evidence to date, summarizing the results of RCTs.

Conclusion and Recommendations

Following training at varying intensities, it was discovered that there was a substantial difference in the two patient groups' peak oxygen uptake, left ventricular ejection fraction, resting systolic and diastolic blood pressure, resting heart rate, and quality of life. In addition to improving left ventricular ejection fraction, HRQOL, cardiac function, and peak oxygen uptake, cardiac rehabilitation training lowers the risk of CVD and lengthens life expectancy, all of which should be encouraged in the therapeutic context.

Registration and Protocol

This meta-analysis was registered in PROSPERO with registration number CRD42024521302. The protocol submitted in PROSPERO is mentioned in supplementary files.

References

1. Balady GJ, Ades PA, Bittner VA, et al. Referral, enrolment, and delivery of cardiac rehabilitation/ secondary prevention programs at clinical centres and beyond a presidential advisory from the American Heart Association. Circulation 2011;124: 2951–60.
2. Smith SC Jr., Benjamin EJ, Bonow RO, et al. AHA/ACCF secondary prevention and risk reduction therapy for patients with coronary and other atherosclerotic vascular disease: 2011 update: a guideline from the American Heart Association and American College of Cardiology Foundation. J Am Coll Cardiol 2011; 58:2432–46.
3. Perk J, De Backer G, Gohlke H, et al. European guidelines on cardiovascular disease prevention in clinical practice (version 2012). The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts). Eur Heart J 2012; 33:1635–701.
4. Wenger NK, Froelicher ES, Smith LK, et al. Cardiac rehabilitation as secondary prevention. Agency for Health Care Policy and Research and National Heart, Lung, and Blood Institute. Clin Pract Guide Quick Ref Guide Clin 1995; 17:1–23.
5. Piepoli MF, Corra U, Benzer W, Bjarnason-Wehrens B, Dendale P, Gaita D, et al. Secondary prevention through cardiac rehabilitation: from knowledge to implementation. A position paper from the Cardiac Rehabilitation Section of the European Association of Cardiovascular Prevention and Rehabilitation. European Journal of Cardiovascular Prevention & Rehabilitation 2010; Vol. 17, issue 1:1–17. [DOI: 10.1097/HJR.0b013e3283313592]
6. Bernardi L, Radaelli A, Passino C, Falcone C, Auguadro C, Martinelli L, et al. Effects of physical training on cardiovascular control after heart transplantation. International Journal of Cardiology 2007;118(3):356–62.
7. Nytrøen K, Rustad LA, Gude E, Hallén J, Fiane AE, Rolid K, et al. Muscular exercise capacity and body fat predict VO2 peak in heart transplant recipients. European Journal of Preventive Cardiology 2014;21(1):21–9.
8. Ioannidis JP. Interpretation of tests of heterogeneity and bias in meta-analysis. J Eval Clin Pract. 2008; 14:951–7.
9. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997; 315:629–34.
10. McGregor G, Powell R, Begg B, Birkett ST, Nichols S, Ennis S, McGuire S, Prosser J, Fiassam O, Hee SW, Hamborg T. High-intensity interval training in cardiac rehabilitation: a multi-centre randomized controlled trial. European journal of preventive cardiology. 2023 Jul;30(9):745-55.
11. Saeidi M, Ravanbod R, Pourgharib-Shahi MH, Navid H, Goosheh B, Baradaran A, Torkaman G. The Acute Effects of 2 Different Intensities of Resistance Exercise on Autonomic Function in Heart Failure Patients: A Randomized Controlled Trial. Anatolian Journal of Cardiology. 2023 May;27(5):266.
12. Terada T, Cotie LM, Tulloch H, Mistura M, Vidal-Almela S, O'Neill CD, Reid RD, Pipe A, Reed JL. Sustained effects of different exercise modalities on physical and mental health in patients with coronary artery disease: a randomized clinical trial. Canadian Journal of Cardiology. 2022 Aug 1;38(8):1235-43.
13. Reed JL, Terada T, Vidal-Almela S, Tulloch HE, Mistura M, Birnie DH, Wells GA, Nair GM, Hans H, Way KL, Chirico D. Effect of high-intensity interval training in patients with atrial fibrillation: a randomized clinical trial. JAMA network open. 2022 Oct 3;5(10): e2239380-.
14. Khadanga S, Savage PD, Pecha A, Rengo J, Ades PA. Optimizing training response for women in cardiac rehabilitation: a randomized clinical trial. JAMA cardiology. 2022 Feb 1;7(2):215-8.
15. Nakaya Y, Akamatsu M, Ogimoto A, Kitaoka H. Early cardiac rehabilitation for acute decompensated heart failure safely improves physical function (PEARL study): a randomized controlled trial. European Journal of Physical and Rehabilitation Medicine. 2021 Jul 22;57(6):985-93.
16. Nagyova I, Jendrichovsky M, Kucinsky R, Lachytova M, Rus V. Effects of Nordic walking on cardiovascular performance and quality of life in coronary artery disease. European Journal of physical and rehabilitation Medicine. 2020 Jun 23;56(5):616-24.
17. Deng B, Shou X, Ren A, Liu X, Wang Q, Wang B, Wang Y, Yan T, Zhao X, Zhu L. Effect of aerobic training on exercise capacity and quality of life in patients older than 75 years with acute coronary syndrome undergoing percutaneous coronary intervention. Physiotherapy Theory and Practice. 2022 Sep 2;38(9):1135-44.
18. Taylor JL, Holland DJ, Keating SE, Leveritt MD, Gomersall SR, Rowlands AV, Bailey TG, Coombes JS. 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 cardiology. 2020 Dec 1;5(12):1382-9.
19. Tsai E, Mouhayar E, Lenihan D, Song J, Durand JB, Fadol A, Massey M, Harrison C, Basen-Engquist K. Feasibility and outcomes of an exercise intervention for chemotherapy-induced heart failure. Journal of cardiopulmonary rehabilitation and prevention. 2019 May 1;39(3):199-203.
20. Jaureguizar KV, Vicente-Campos D, Bautista LR, de la Peña CH, Gómez MJ, Rueda MJ, Mahillo IF. Effect of high-intensity interval versus continuous exercise training on functional capacity and quality of life in patients with coronary artery disease: a randomized clinical trial. Journal of cardiopulmonary rehabilitation and prevention. 2016 Mar 1;36(2):96-105.
21. Sayegh AL, Dos Santos MR, Rondon E, de Oliveira P, de Souza FR, Salemi VM, de NN Alves MJ, Mady C. Exercise Rehabilitation Improves Cardiac Volumes and Functional Capacity in Patients with Endomyocardial Fibrosis: A RANDOMIZED CONTROLLED TRIAL. Journal of cardiopulmonary rehabilitation and prevention. 2019 Nov 1;39(6):373-80.

22. Rengo JL, Savage PD, Barrett T, Ades PA. Participation rates and outcomes for heart failure patients in cardiac rehabilitation. Journal of cardiopulmonary rehabilitation and prevention. 2018 Jan;38(1):38.

23. Besnier F, Labrunée M, Richard L, Faggianelli F, Kerros H, Soukarié L, Bousquet M, Garcia JL, Pathak A, Gales C, Guiraud T. Short-term effects of a 3-week interval training program on heart rate variability in chronic heart failure. A randomised controlled trial. Annals of physical and rehabilitation medicine. 2019 Sep 1;62(5):321-8.

24. Opotowsky AR, Rhodes J, Landzberg MJ, Bhatt AB, Shafer KM, Yeh DD, Crouter SE, Ubeda Tikkanen A. A randomized trial comparing cardiac rehabilitation to standard of care for adults with congenital heart disease. World Journal for Pediatric and Congenital Heart Surgery. 2018 Mar;9(2):185-93.

25. Chen YW, Wang CY, Lai YH, Liao YC, Wen YK, Chang ST, Huang JL, Wu TJ. Home-based cardiac rehabilitation improves quality of life, aerobic capacity, and readmission rates in patients with chronic heart failure. Medicine. 2018 Jan 1;97(4): e9629.

26. Ellingsen Ø, Halle M, Conraads V, Støylen A, Dalen H, Delagardelle C, Larsen AI, Hole T, Mezzani A, Van Craenenbroeck EM, Videm V. High-intensity interval training in patients with heart failure with reduced ejection fraction. Circulation. 2017 Feb 28;135(9):839-49.

27. Acanfora D, Scicchitano P, Casucci G, Lanzillo B, Capuano N, Furgi G, Acanfora C, Longobardi M, Incalzi RA, Piscosquito G, Ciccone MM. Exercise training effects on elderly and middle-aged patients with chronic heart failure after acute decompensation: A randomized, controlled trial. International journal of cardiology. 2016 Dec 15; 225:313-23.

28. Tang A, Eng JJ, Krassioukov AV, Madden KM, Mohammadi A, Tsang MY, Tsang TS. Exercise-induced changes in cardiovascular function after stroke: a randomized controlled trial. International Journal of Stroke. 2014 Oct;9(7):883-9.

29. Belardinelli R, Georgiou D, Cianci G, Purcaro A. 10-year exercise training in chronic heart failure: a randomized controlled trial. Journal of the American College of Cardiology. 2012 Oct 16;60(16):1521-8.

30. Osbak PS, Mourier M, Kjaer A, Henriksen JH, Kofoed KF, Jensen GB. A randomized study of the effects of exercise training on patients with atrial fibrillation. American Heart Journal. 2011 Dec 1;162(6):1080-7.

31. Smith KM, Arthur HM, McKelvie RS, Kodis J. Differences in the sustainability of exercise and health-related quality of life outcomes following home or hospital-based cardiac rehabilitation. European Journal of Preventive Cardiology. 2004 Aug 1;11(4):313-9.

32. Oldridge NB, Guyatt GH, Fischer ME, et al. Cardiac rehabilitation after myocardial infarction. Combined experience of randomized clinical trials. JAMA 1988; 260:945–50.

33. O'Connor GT, Buring JE, Yusuf S, et al. An overview of randomized trials of rehabilitation with exercise after myocardial infarction. Circulation 1989; 80:234–44.

34. Lanza GA, Golino M, Villano A, Lanza O, Lamendola P, Fusco A, Leggio M. Cardiac Rehabilitation and Endothelial Function. J Clin Med. 2020 Aug 3;9(8):2487. doi: 10.3390/jcm9082487. PMID: 32756306; PMCID: PMC7463659.

35. Anderson L, Oldridge N, Thompson DR, Zwisler AD, Rees K, Martin N, Taylor RS. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease: Cochrane Systematic Review and Meta-Analysis. J Am Coll Cardiol. 2016 Jan 5;67(1):1-12. doi: 10.1016/j.jacc.2015.10.044. PMID: 26764059.

36. Sibilitz KL, Berg SK, Rasmussen TB, Risom SS, Thygesen LC, Tang L, Hansen TB, Johansen PP, Gluud C, Lindschou J, Schmid JP. Cardiac rehabilitation increases physical capacity but not mental health after heart valve surgery: a randomised clinical trial. Heart. 2016 Dec 15;102(24):1995-2003.

37. Risom SS, Zwisler AD, Johansen PP, Sibilitz KL, Lindschou J, Gluud C, Taylor RS, Svendsen JH, Berg SK. Exercise-based cardiac rehabilitation for adults with atrial fibrillation. Cochrane Database of Systematic Reviews. 2017(2).

38. Taylor, R.S., Walker, S., Smart, N.A., Piepoli, M.F., Warren, F.C., Ciani, O., O'Connor, C., Whellan, D., Keteyian, S.J., Coats, A. and Davos, C.H., 2018. Impact of exercise-based cardiac rehabilitation in patients with heart failure (ExTraMATCH II) on mortality and hospitalisation: an individual patient data meta-analysis of randomised trials. *European journal of heart failure*, *20*(12), pp.1735-1743.