META ANALYSIS

Effects of interval training on haemodynamic variables after coronary artery bypass graft: A meta-analysis

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Abstract

Objective: To assess the combined impact of interval training programme on haemodynamic variables, specifically blood pressure and heart rate, in patients having undergone coronary artery bypass graft surgery.

Methods: The meta-analysis was conducted from October to December 2022, and comprised search on PubMed, MEDLINE, Web of Science, PeDro, EMBASE, Science Direct, Cochrane Central Register of Controlled Clinical Trials, Google Scholar and Scopus electronic databases by two researchers independently for literature published between 2009 and 2020 related to the effects of interval training on coronary artery bypass graft patients. Meta-analysis was then performed to analyse the effects of an interval training on systolic blood pressure, diastolic blood pressure, and heart rate. The meta-analysis was performed in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines.

Results: Of the 122 studies initially located, 7 were related to the effects of different forms of interval trainings and their impact on systolic and diastolic blood pressure of the patients, and 5 studies analysing the effects of interval trainings on heart rate. Interval training showed mild improvement in decreasing SBP compared to control groups. Standardized mean difference suggested an effect size of -0.226 in random effect model (I2=52.01; *p*=0.064). Similarly, a small effect size of 0.136 (I2=39.19%, p=0.14) was observed for diastolic blood pressure. Also, there was a small effect size of 0.155 (I2= 28.08, *p*=0.23) observed for heart rate.

Conclusion: Interval training programmes, including high-intensity interval training, low-volume interval training, and aerobic interval training, had a small effect on systolic blood pressure, whereas continuous training protocols had a similarly small effect size on diastolic blood pressure and heart rate.

Keywords: Coronary artery bypass, Haemodynamics, Heart rate, Exercise. (JPMA 74: 528; 2024)

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Introduction

Cardiovascular disease is a leading cause of premature death worldwide, with a considerable healthcare cost.[1] The disease burden has almost doubled, from 271 million patients in 1990 to 523 million in 2019.[2] According to a World Health Organisation (WHO) report, 21% of deaths occur annually due to coronary artery disease (CAD) globally.[3] Various causes are being identified and reported for the spread of the disease, including a sedentary lifestyle, obesity, ageing, dyslipidaemia, hypertension (HTN), diabetes mellitus (DM) and previous family history.[4,5] Despite the cumulative use of percutaneous coronary intervention (PCI), coronary artery bypass graft (CABG) surgery remains the treatment of choice for patients with intricate multivessel conditions.[6,7] Approximately 400,000 CABG surgeries are performed annually, making it the most commonly performed surgical procedure to remove an atheromatous blockage in a patient with ischaemic myocardium.[8,9] Like other surgical procedures, CABG is associated with a wide range of complications, including decreased cardiac output, pain, loss of muscle mass, and weakness,[10,11] that can easily be managed by incorporating early mobilisation in patients after surgery.[12,13] Multiple exercise-based management approaches have been developed to overcome post-surgical prolonged bed rest complications, of which 'cardiac rehab phase 1, 2 and 3' is considered the most widely acceptable rehabilitation-based protocol to overcome post-surgical complications.[14,15] Besides, evidence is also available in which variously modified forms of exercises are being incorporated during different cardiac rehabilitation phases to achieve more desirable goals of rehabilitation based on the patient's need and condition.[16,17] With a recent increase in demand for post-surgery cardiac rehabilitation, several training programmes are designed to tailor a prolonged cardiac rehabilitation plan to match the individual patient's needs. Various forms of interval training programmes have recently been used and their effectiveness is determined by outcome measures like the six-minute walk test (6MWT), aerobic capacity, maximal oxygen consumption (Vo2-max), systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR).[18] Nevertheless, the results are

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conflicting and require further evidence. The current meta-analysis was planned to determine the cumulative effects of the findings of different randomised controlled trials (RCTs) in which the effects of interval training programmes were identified in post-CABG patients on haemodynamic variables, including SBP, DBP and HR.

Materials and Methods

The current meta-analysis from October to December 2022, comprised search on PubMed, MEDLINE, PeDro, Web of Science, EMBASE, Science Direct, Cochrane Central Register of Controlled Clinical Trials, Google Scholar and Scopus electronic databases for literature published between 2009 and 2020 related to the effects of interval training on CABG patients. The search was conducted by two independent researchers using key words including 'high-intensity interval training', 'aerobic exercise', 'systolic blood pressure', 'diastolic blood pressure', 'heart rate' and 'coronary artery bypass graft'.

Inclusion criteria comprised studies identifying the effects of interval trainings on SBP, DBP and HR in patients enrolled in a rehabilitation programme post-CABG procedure. Meta-analysis was subsequently performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines.[19]

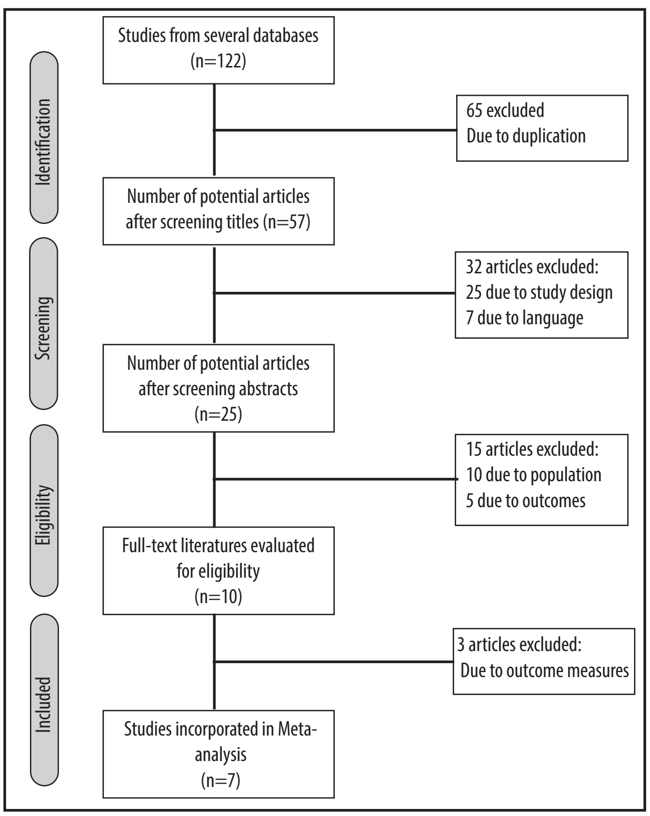

Figure: Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow chart.

Trials that were based on training protocol other than interval training along with all evidences that were not available in English Language, and studies for which open accesses was not available even after emailing the corresponding authors were excluded. A data-mining form was designed for extracting information, such as authors' name, publication year, targetted population, and treatment duration.

Cochrane tool parameters were used for the assessment of risk of biasness in the studies shortlisted for detailed analyses.[20] Assessment for risk of allocation was performed on the basis of randomisation and concealing, blinding (participation and outcome), data assessment (incomplete and selective reporting), and biasness based on authors' judgment.

Quantitative analysis was done using MedCalc 20.112. Continuous measure analysis was performed to determine the pooled effect based on standardized mean difference (SMD) at 95% confidence interval (CI). The effect size was estimated using Cohen's rule of thumb[21] that categorises an effect size on 3 parameters; small with effect size 0.2-0.5, moderate with effect size 0.5-0.8 and large with effect size >0.8. For heterogeneity level, the value of I2 was used in order to make interpretation on the basis of random and fixed effect model (I2<50=fixed effect, I2>50= random effect, *p*<0.05).

Results

Of the 122 studies initially located, 7 studies, with 279 participants (Table 1)[22-28] were related to the effects of different forms of interval trainings and their impact on SBP and DBP of the patients, and 5 studies, with 161 (Table)[22,25-28] participants, analysed the effects of interval trainings on HR.

The findings RCTs revealed that the interval training shown mild improvement in decreasing SBP in comparison to the controls. SMD showed an effect size of -0.226 in random effect model (I2=52.01; *p*=0.064), depicting a small effect size and suggesting beneficial effects of interval training on SBP among CABG patients (Table 2).

On DBP, interval training produced no significant impact and the pool effect favoured control group with a small effect size of 0.136 (I2=39.19%, p=0.14) (Table 3).

Interval training had no impact on HR of the patient compared to the controls, as indicated by a small effect size of 0.155 (I2= 28.08, *p*=0.23) (Table 4).

Randomisation sequence and allocation concealment analyses suggested that all 7 studies revealed low risk of bias[22-28] while 5 studies[22-25,28] considered participants' blinding. Outcome assessment blinding was done by 4 studies,[22-24,28] 2 studies[26,27] reflected high risk, and in 1(%) study[25] showed unknown risk. Incomplete outcome data was found in 3 studies,[23,24,26] while 4 were in the low-risk category.[22,25,27,28] Finally, Reporting selection bias reflected low risk across all the studies (Table 5).[22-28]

Discussion

The findings revealed that different forms of interval training, such as high-intensity interval training (HIIT), interval training, low-volume interval training and aerobic interval training, produced mild effect on SBP, but not on DBP and HR when compared to the controlled group.

Table-1: Studies subjected to meta-analysis.

Authors and Year of Publication	Sample Size	Target Population	Study Design	Age in Years	Intervention		Outcome
					Intervention Group	Control Group	
Hashemzadeh et al, (2020)[22]	EG=12 CG=12	patients with CABG	Prospective quasi study	Mean age of 47.23	Interval Training	No intervention	SBP, DBP, HR
Reed et al, (2022)[23]	EG=43 CG=44	Patients with CAD who underwent PCI or CABG	RCT	40-70 years	High Intensity Interval Training	Moderate Intensity Continuous Training	SBP, DBP, HR
Lee LS et al, (2019)[24]	EG=17 CG=14	Female patients with CABG	RCT	≥50 years of age	Aerobic Interval Training	Moderate Intensity Continuous Exercise	SBP, DBP
Ghardashi-Afousi et al (2018)[25]	EG=14 CG=14	Male patients with CABG	RCT	Mean age of 58.80	High Intensity Interval Training	Moderate Intensity Continuous Training	SBP, DBP, HR
Keteyian et al, (2014)[26]	EG=15 CG=13	patients with CABG	RCT	Mean age of 58.80	High Intensity Interval Training	Moderate Intensity Continuous Training	SBP, DBP, HR
Currie et al, (2013)[27]	EG=11 CG=11	patients with CABG	RCT	Mean age of 68	Low-volume high-intensity interval exercise training	higher-volume moderate-intensity endurance exercise	SBP, DBP, HR
Moholdt et al, (2009)[28]	EG=28 CG=31	patients with CABG	RCT	Mean age of 60.2	Aerobic Interval Training	Moderate Intensity Continuous Training	HR

EG: Experimental group; CG: Control group; RCT: Randomised controlled trial; CABG: Coronary artery bypass graft; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate.

Table-2: Standardised mean difference (SMD) with 95% confidence interval (CI) and statistical heterogeneity for SBP.

Author's Name	N1	N2	Total	SMD	SE	CI at 95%	*t*-test	*p*-value	Weight (%)	
									Fixed	Random
Hashemzadeh et al 2020[22]	12	12	24	-1.404	0.443	-2.324 to -0.485			9.15	12.95
Reed JL et al 2022[23]	43	44	87	-0.353	0.214	-0.779 to 0.0730			39.16	24.26
Lee LS et al 2019[24]	17	14	31	0.0895	0.352	-0.630 to 0.809			14.53	16.72
Ghardashi-Afousi et al 2018[25]	14	14	28	-0.170	0.368	-0.925 to 0.586			13.30	15.98
Keteyian et al 2014[26]	15	13	28	0.166	0.369	-0.592 to 0.923			13.23	15.94
Currie et al 2013[27]	11	11	22	0.194	0.411	-0.664 to 1.052			10.63	14.15
Total (fixed effects)	112	108	220	-0.234	0.134	-0.498 to 0.0305	-1.743	0.083	100.00	100.00
Random Effect	112	108	220	-0.226	0.204	-0.629 to 0.177	-1.104	0.271	100.00	100.00
Test for Heterogeneity										
Value of Heterogeneity	10.41									
Degree of Freedom	5									
Significance	0.064									
I2 Inconsistency	52.01%									
I2 at 95% of CI	0.00 to 80.87									

SBP: Systolic blood pressure, SE: Standard error.

Table-3: Standardised mean difference (SMD) with 95% confidence interval (CI) and statistical heterogeneity for DBP.

Author's Name	N1	N2	Total	SMD	SE	CI at 95%	*t*-test	*p*-value	Weight (%)	
									Fixed	Random
Hashemzadeh et al 2020[22]	12	12	24	-0.610	0.404	-1.447 to 0.228			10.91	13.64
Reed JL et al 2022[23]	43	44	87	0.208	0.213	-0.216 to 0.632			39.18	27.03
Lee LS et al 2019[24]	17	14	31	0.0567	0.352	-0.662 to 0.776			14.40	16.36
Ghardashi-Afousi et al 2018[25]	14	14	28	-0.0473	0.367	-0.802 to 0.707			13.21	15.49
Keteyian et al 2014[26]	15	13	28	0.166	0.369	-0.592 to 0.923			13.10	15.41
Currie et al 2013[27]	11	11	22	1.058	0.440	0.140 to 1.976			9.19	12.08
Total (fixed effects)	112	108	220	0.136	0.133	-0.127 to 0.399	1.019	0.309	100.00	100.00
Random effect	112	108	220	0.128	0.180	-0.226 to 0.483	0.714	0.476	100.00	100.00
Test for Heterogeneity										
Value of Heterogeneity	8.22									
Degree of Freedom	5									
Significance	0.14									
I2 Inconsistency	39.19%									
I2 at 95% of CI	0.00 to 75.86									

DBP: Diastolic blood pressure, SE: Standard error.

Table-4: Standardized mean difference (SMD) with 95% confidence interval (CI) and statistical heterogeneity for HR.

Author's Name	N1	N2	Total	SMD	SE	CI at 95%	*t*-test	*p*-value	Weight (%)	
									Fixed	Random
Hashemzadeh et al 2020[22]	12	12	24	-0.210	0.395	-1.029 to 0.610			15.42	17.02
Ghardashi-Afousi et al 2018[25]	14	14	28	-0.494	0.373	-1.261 to 0.272			17.33	18.58
Keteyian et al 2014[26]	15	13	28	0.166	0.369	-0.592 to 0.923			17.74	18.90
Currie et al 2013[27]	11	11	22	0.680	0.423	-0.202 to 1.562			13.48	15.34
Moholdt et al 2009[28]	28	31	59	0.282	0.259	-0.236 to 0.800			36.03	30.15
Total (fixed effects)	80	81	161	0.105	0.155	-0.202 to 0.411	0.674	0.501	100.00	100.00
Random effects	80	81	161	0.0932	0.187	-0.276 to 0.462	0.498	0.619	100.00	100.00
Test for Heterogeneity										
Value of Heterogeneity	5.56									
Degree of Freedom	4									
Significance	0.23									
I2 Inconsistency	28.08%									
I2 at 95% of CI	0.00 to 71.82									

HR: Heart rate, SE: Standard error.

Table-5: Assessment of risk of bias using a Cochrane Collaboration tool.

Studies	Random Allocation	Allocation Concealment	Participants Blinding	Outcome Assessment Blinding	Incomplete Outcome Data	Selective Reporting
Hashemzadeh et al 2020[22]	+	+	+	+	+	+
Reed JL et al 2022[23]	+	+	+	+	-	+
Lee LS et al 2019[24]	+	+	+	+	-	+
Ghardashi-Afousi et al 2018[25]	+	+	+	?	+	+
Keteyian et al 2014[26]	+	+	-	-	-	-
Currie et al 2013[27]	+	+	-	-	+	+
Moholdt et al 2009[28]	+	+	+	+	+	+

—: bias at high risk; +: low risk bias; ?: unknown risk of bias.

Hashemzadeh et al. in 2020 revealed that interval training performed on patients after CABG surgery over a period of a month based on 20-minute sessions had produced significant effects ($p<0.05$) on haemodynamic variables in both intragroup and intragroup comparisons. However, in the control group where no intervention was provided, the results revealed no significant finding.[19] In another study, the effectiveness of interval training was determined in comparison with moderate-intensity continuous training (MICT) protocol, and the findings revealed that interval training was effective in managing SBP and HR in comparison with continuous training, but the impact of MICT was better on DBP in comparison with interval training after 12 weeks of training protocol.[20]

Another study compared aerobic interval training protocol with MICT, and found that in improving haemodynamic variables, continuous training protocol had an edge over interval training lasting 24 weeks with 5 sessions per week.[21] A study conducted on CABG patients who were randomly divided into low-volume interval training group and MICT group, performed for 6 weeks, with 3 session per week, favoured the effects of low-volume interval training over continuous training.[22]

Keteyian et al. observed that MICT was significantly more effective than HIIT on both SBP and DBP of patients after CABG surgery.[23] Currie et al. compared low-volume HIIT with higher-volume MICT, and concluded that MICT was more effective than interval training on SBP, DBP and HR.[24] Moholdt et al. concluded that MICT had a better impact on HR compared to aerobic interval training.[25]

The studies included in the meta-analysis clearly indicated that MICT had an impact on DBP and HR compared to interval training, but the impact of interval training on SBP was found to be better than MICT.

Although the purpose of the current meta-analysis was to identify the impact of interval training programme on haemodynamic variables after CABG procedure, the lack of literature on search and conflicting findings in the available literature indicates the dire need of conducting more research in this critical area.

The current systematic review has limitations, such as heterogeneity in the included studies' designs, treatments, patient characteristics, and outcome measures. This heterogeneity may introduce variability in the data, making it difficult to draw firm conclusions. Interval training involves a wide range of exercise programmes, including variations in intensity, duration, frequency and form of exercise. The variability of interval training methods used across the studies can influence outcomes and confound data synthesis in meta-analysis.

Conclusion

Interval training programme of different types, like HIIT, low-volume interval training and aerobic interval training, had an impact on SBP with a small effect size, while continuous training protocol had an impact on DBP and HR.

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Author Contribution:

FZ: Conceived idea, designed the analysis and writing
SA: Data collection
MS: Data, analysis