Effect of Baseline Status on Cardiovascular Responses Post-isometric Handgrip Exercise

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Abstract
Background: Isometric handgrip (IHG) exercise causes changes in heart rate variability (HRV) and hemodynamic responses with individual differences. We test the hypothesis that baseline measurements affect post-exercise outcomes.
Methods: In this cross-sectional study, 45 males aged 17 to 22 were enrolled from SMS Medical College, Jaipur, India. Hemodynamic and HRV data were collected at baseline, during, and after 5 minutes of IHG exercise. Nonparametric tests compared the absolute and relative responses before, during, and after the exercise. The relationship of baseline measurements with outcomes was evaluated using Pearson's correlation.
Results: The study showed a significant increase in the absolute values of hemodynamic parameters and LF/HF ratio during and after 5 minutes of IHG exercise compared to the baseline. However, a significant decrease and increase occurred in all the relative hemodynamic parameters and most HRV parameters, respectively, after rather than during the 5 minutes of IHG exercise. Hemodynamic parameters significantly correlated with baseline during and after 5 minutes of IHG exercise. Similarly, baseline affects all the HRV parameters during IHG exercise, but not after 5 minutes of IHG exercise.
Conclusion: The present study concludes that initial baseline status should be considered while evaluating the post-IHG exercise responses.

Keywords
baseline, blood pressure, cardiovascular, heart rate variability, isometric handgrip

Introduction

The isometric handgrip (IHG) exercise is a relatively simple test that measures the hemodynamic response to a "pressor" stimulus. However, the response is a function of multiple factors, including sympathetic and parasympathetic output, negative feedback baroreceptor loop, local factors, cardiac function, and feedforward central commands [1]. Isometric handgrip exercise increases cardiac output due to increased metabolic demands on the body. Multiple hemodynamic parameters govern cardiac output. Abnormal changes in hemodynamic parameters during IHG may reflect the early stages of cardiovascular disease [2]. In addition, the role of IHG in the management of hypertension has been envisaged; training for more than six weeks could reduce blood pressure and cause modulation of cardiac autonomic function [2, 4–6]. Further, the isometric handgrip (IHG) test might be an approach to the early detection of individuals prone to developing hypertension [7, 8]. The isometric handgrip exercise causes changes in hemodynamic parameters and heart rate variability, with individual differences. Heart rate variability is an effective procedure to evaluate cardiovascular autonomic dysfunction [9]. The present study aimed to delineate the effects of baseline measurements on post-exercise hemodynamic responses. Nowadays, machine learning models have been developed to predict various diseases [10, 11]. The baseline measurements, along with post-exercise hemodynamic responses, could be used as features in predicting cardiovascular disease.

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Material and Methods

In this hospital-based cross-sectional study, 45 male students aged between 17 to 22 years enrolled from SMS Medical College, Jaipur (Rajasthan, India) after approval from the Institutional Ethical Committee. The study evaluated the effect of baseline measurements on hemodynamic responses and heart rate variability after doing the IHG exercise.

To evaluate the effect of baseline status, measurement of absolute responses was followed by calculation of relative responses (see Data Analysis). The relationships between absolute and relative responses were evaluated using correlation.

1. Protocol

The participants avoided tea, coffee, and food for at least 2 hours before data collection. Researchers did the recording between 09:00 AM and 12:00 PM to prevent the effect of diurnal variation. They clinically examined participants to rule out any morbidity. If the participant was found healthy, researchers collected hemodynamic and heart rate variability data in three phases as follows:

Baseline: 5 minutes duration before performing IHG exercise,

Phase 1: 5 minutes duration after completion of the IHG exercise, and

Phase 2: Duration between 5 and 10 minutes after completing the IHG exercise.

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2. Isometric handgrip exercise

The participants were instructed to hold the hand dynamometer to provide a maximal voluntary contraction as a baseline. The tension was called maximal isometric tension (T_{max}). After a rest of one minute, the participants compressed the dynamometer to 30% of the maximal effort (T_{max}) for 5 minutes. Researchers measured the blood pressure, pulse rate, and ECG signals before, during, and after IHG exercise.

3. Recording of hemodynamic parameters

Researchers measured systolic and diastolic blood pressure and pulse rate (PR) in the participant's non-tested arm in all the phases. An automated digital device was used to avoid a manual error. Further, researchers calculated pulse pressure (PP), mean arterial pressure (MAP), and rate pressure product (RPP).

4. Acquisition of heart rate variability

The ECG signals for heart rate variability (HRV) were recorded using RMS Polyrite D (version 1.0) after a supine rest for 15 minutes. The resting ECG was recorded at a sampling frequency of 256 Hz. The tachogram (RR-interval series) was constructed from ECG signals. Researchers calculated time and frequency domain measures using Kubois software. The time-domain measures include the standard deviation of all RR intervals (SDNN), the square root of the mean of the sum of the squares of differences between adjacent RR intervals (RMSSD), and pNN50, which is the percentage of consecutive RR intervals that differ by more than 50 milliseconds. The frequency-domain measures include total power, power in the high frequency (HF) band (0.15–0.40Hz), power in the low frequency (LF) band (0.04–0.15 Hz), and LF/HF ratio [12–14].

5. Data analysis

The absolute readings were further processed to find out the relative readings. Let the baseline, phase 1, and phase 2 values of parameter X be represented by bX, X1, and X2, respectively. Then, the relative value of X1 is given by $\Delta X1=X1-bX$.

Similarly, the relative value of X2 is given by $\Delta X2=X2-bX$.

6. Statistical analysis

Based on normality, the quantitative variables were expressed as mean (SD) or median (IQR). The comparison of absolute values of parameters during baseline (bX), phase1 (X1), and phase 2 (X2) were performed using the Friedman test. The relative values of parameters during phase 1($\Delta X1$) and phase 2 ($\Delta X2$) were compared using the Wilcoxon signed-rank test. Further, Pearson's coefficient measured the relationship between absolute and relative changes. The level of significance was considered at 5%. The JASP version 0.16.1.0 was used for statistical analysis (JASP Team) and MATLAB [15, 16].

Results

The study showed significant increase in the absolute SBP [W = 5.75 ; $p < 0.001$], DBP [W = 8.62; $p < 0.001$], HR [W = 8.52; $p < 0.001$], MAP [W = 8.90; $p < 0.001$] and RPP [W = 8.64; $p < 0.001$] during phase 1 as compared to the baseline values. However, absolute PP [W = 3.33; $p = 0.004$] showed significant decrease as compared to the baseline. Similarly, significant increase was observed in absolute SBP [W = 4.06; $p < 0.001$], DBP [W = 4.061; $p < 0.001$], HR [W = 5.39; $p < 0.001$], MAP [W = 4.77; $p < 0.001$] and RPP [W = 5.44; $p < 0.001$] during phase 2 as compared to the baseline. During phase 2, absolute DBP [W = 4.56; $p < 0.001$], HR [W = 3.13; $p = 0.007$], MAP [W = 4.13; $p < 0.001$] and RPP [W = 3.20; $p = 0.006$] were significantly lowered as compared to phase 1. However, absolute PP2 showed significant increase as compared to phase 1 PP [W = 2.63; $p = 0.03$] (Table 1). The comparison of absolute values of heart rate variability parameters showed no significant differences in SDNN, RMSSD, TP, and HF during phase 1 and phase 2 compared to the baseline. However, LF/HF ratio showed a significant increase in phase 1 and pN50 and LF/HF ratio showed significant increase in phase 2 compared to baseline. As compared to phase 1, RMSSD and pN50 showed a significant increase, while LF/HF ratio was decreased in phase 2 (Table 2).

Further, researchers compared relative cardiovascular responses and found a significant decrease in phase 2 compared to phase 1 (Table 3). Similarly, the relative change in all heart rate variability parameters, except LF/HF ratio, were higher during phase 2 as compared with phase 1 (Table 4).

To find the effect of baseline values on post-exercise responses, the authors calculated Pearson's correlation between absolute and relative responses. The study showed a significant effect of baseline values on the relative DBP, PP, and MAP in phases 1 and 2. However, baseline values had no significant impact on relative changes in SBP, HR, and RPP in phases 1 and 2 (Table 5). The relative values of all heart rate variability parameters in phase 1 were significantly correlated with baseline values. However, baseline values had no significant association with relative changes in phase 2 heart rate variability measures (Table 6).

Discussion

Isometric exercise is defined as a sustained muscular contraction with no joint movements. Conventionally, no work was done during the exercise. The oxygen consumption is moderate compared to isotonic exercise. The cardiovascular effects of static or isometric exercise primarily reflect the response to increased afterload or blood pressure. In contrast, the response to isotonic exercise is due to volume overload on the heart [12]. The high muscle tension and reduced blood flow produce a unique "pressor" reflex increase in systemic arterial pressure [17]. The reflex increases sympathetic activity in the heart and vessels and decreases parasympathetic activity, increasing BP, heart rate, and total peripheral resistance through arteriolar constriction. The sympathetic output varies in contracting and non-contracting skeletal muscle and is differentially controlled by a central command and the metaboreflex in healthy conditions. Further, studies on animals and humans showed the effect of cardiovascular diseases, such as diabetes, hypertension,

Table 1 - One-way repeated-measures ANOVA to compare various absolute hemodynamic parameters before (baseline), during (phase 1), and after 5 minutes (phase 2) of handgrip exercise

Repeated measures ANOVA using Friedman Test						Conover's post hoc comparisons			
Hemodynamic Variable	Levels	Median	IQR	Test statistic	*p*	Level 1	Level 2	T-Stat	p_{bonf}
SBP	bSBP	114	10	34.785	< .001	bSBP	SBP1	5.747	< .001
	SBP1	120	12			bSBP	SBP2	4.057	< .001
	SBP2	120	12			SBP1	SBP2	1.69	0.284
DBP	bDBP	78	10	74.235	< .001	bDBP	DBP1	8.622	< .001
	DBP1	90	14			bDBP	DBP2	4.061	< .001
	DBP2	80	10			DBP1	DBP2	4.561	< .001
HR	bHR	80	19	74.279	< .001	bHR	HR1	8.523	< .001
	HR1	86	20			bHR	HR2	5.394	< .001
	HR2	86	18			HR1	HR2	3.129	0.007
PP	bPP	38	12	12.358	0.002	bPP	PP1	3.335	0.004
	PP1	31	12			bPP	PP2	0.699	1
	PP2	37	12			PP1	PP2	2.635	0.03
MAP	bMAP	89.333	10	79.416	< .001	bMAP	MAP1	8.905	< .001
	MAP1	99.333	13.333			bMAP	MAP2	4.771	< .001
	MAP2	94	10.667			MAP1	MAP2	4.135	< .001
RPP	bRPP	92.4	17.84	76.227	< .001	bRPP	RPP1	8.637	< .001
	RPP1	107.1	24.84			bRPP	RPP2	5.438	< .001
	RPP2	101.48	18.63			RPP1	RPP2	3.199	0.006

Table 2 - One-way repeated-measures ANOVA to compare various absolute heart rate variability measures before (baseline), during (phase 1), and after 5 minutes (phase 2) of handgrip exercise

Repeated measures ANOVA using Friedman Test						Conover's post hoc comparisons			
	Levels	Median	IQR	Test statistic	*p*	Level 1	Level 2	T-Stat	p_{bonf}
SDNN	bSDNN	0.059	0.04	7.112	0.029	bSDNN	SDNN1	0.159	1
	SDNN1	0.064	0.039			bSDNN	SDNN2	2.385	0.058
	SDNN2	0.073	0.059			SDNN1	SDNN2	2.226	0.086
RMSSD	bRMSSD	0.067	0.058	9.911	0.007	bRMSSD	RMSSD1	0.527	1
	RMSSD1	0.061	0.066			bRMSSD	RMSSD2	2.424	0.052
	RMSSD2	0.068	0.071			RMSSD1	RMSSD2	2.951	0.012
pN50	bpN50	0.211	0.374	11.227	0.004	bpN50	pN501	0.427	1
	pN501	0.26	0.268			bpN51	pN502	2.666	0.027
	pN502	0.378	0.46			pN501	pN502	3.092	0.008
TP	bTP	1087	2077.8	4.844	0.089	bTP	TP1	0.211	1
	TP1	1204	2390.5			bTP	TP2	2.003	0.145
	TP2	1427	3198			TP1	TP2	1.792	0.23
HF	bHF	322.08	826.42	5.404	0.067	bHF	HF1	0.742	1
	HF1	356.4	832.54			bHF	HF2	1.537	0.384
	HF2	534.79	967.96			HF1	HF2	2.279	0.075
LF/HF	bLF/HF	0.66	0.46	70.136	< .001	bLF/HF	LF/HF1	8.21	< .001
	LF/HF1	1.1	1.05			bLF/HF	LF/HF2	5.545	< .001
	LF/HF2	0.9	0.78			LF/HF1	LF/HF2	2.666	0.027

Table 3 - Comparison of relative hemodynamic parameters during (phase 1) and after 5 minutes (phase 2) of IHG exercise

Variable	Phase ΔX=X-baselineX	Mean/ Median	SD/IQR	Statistic	*p*
SBP	ΔSBP1	6	12	413	0.018
	ΔSBP2	4	7		
DBP	ΔDBP1	12	10	736	< .001
	ΔDBP1	6	8		
HR	ΔHR1	7	6	694.5	< .001
	ΔHR2	4	4		
PP	ΔPP1	-5.333	9.677	-3.964	< .001
	ΔPP2	-1.378	7.779		
MAP	ΔMAP1	9.667	7.667	916	< .001
	ΔMAP2	4.667	7.333		
RPP	ΔRPP1	13.057	7.909	3.769	< .001
	ΔRPP2	9.647	6.083		

 # Mean and SD were calculated for PP and RPP, and paired Student t test was used for comparison. For others median and IQR were calculated, and Wilcoxon signed-rank test was used for comparison

Table 4 - Comparison of various relative heart rate variability parameters during (phase 1) and after 5 minutes (phase 2) of IHG exercise

Variable	Phase ΔX=X-baselineX	Median	IQR	Statistic[#]	*p*
RMSSD	ΔRMSSD1	-0.001	0.032	314	0.022
	ΔRMSSD2	0.01	0.046		
pN50	ΔpN501	0	0.11	213	0.002
	ΔpN502	0.049	0.129		
SDNN	ΔSDNN1	0	0.021	269	0.005
	ΔSDNN2	0.006	0.032		
TP	ΔTP1	-2.7	1067.8	334	0.038
	ΔTP2	557.5	2461		
HF	ΔHF1	-34.32	433.16	309	0.03
	ΔHF2	101.9	572.9		
LF/HF	ΔLF/HF1	0.47	0.57	715	< .001
	ΔLF/HF2	0.24	0.27		

[#] Wilcoxon signed-rank test was used for comparison

and heart failure, on altered "pressor" reflex function [18]. The hemodynamic response to isometric handgrip exercise results from a complex interaction of multiple factors, including sympathetic and parasympathetic output, norepinephrine uptake, baroreceptor loop, cardiac function, central commands, and age [1, 19]. Most studies showed the effect of IHG exercise on cardiovascular responses. The present study evaluated changes in absolute and relative responses compared to baseline measurements.

Similar to the present study, Laird et al. showed the effect of submaximal (25% maximal) IHG in 32 normal adolescents. They found significant increases in mean heart rate, systolic, diastolic, and mean blood pressures [20]. Aminoff et al. reported increased heart rate and blood pressure during sustained IHG were partly due to central command and partly due to activation of the afferent limb reflex arc from contraction of muscles. At least a 15 mmHg increase in diastolic pressure was considered normal [21]. The present study enrolled only males within a narrow range of age to eliminate the effects of age on post-exercise responses. Cauwenberghs et al. observed a positive correlation of age with blood pressure and pulse pressure changes in 3 minutes of 40% maximal IHG. They showed significantly higher heart rate and diastolic BP after exercise in males compared to females [2]. In addition, Goulopoulou et al. showed greater mean arterial pressure responses in adults compared to children ($p < 0.05$) after doing IHG. However, heart rate variability measures were not significantly different in adults and children ($p > 0.05$) [22]. The causes of post-exercise response might be multifactorial. In a study by Watanabe et al., 39 healthy subjects performed a 1-minute IHG exercise at 50% of maximal voluntary contraction followed by a 4-minute post-exercise muscle ischemia period to selectively

Table 5 - Relationship between absolute and relative changes in hemodynamic parameters before (baseline), during (phase 1), and after 5 minutes (phase 2) of isometric handgrip exercise

Variable	Parameter 1	Parameter 2	Pearson's correlation coefficient	*p*
SBP	bSBP	ΔSBP1	-0.17	0.264
	bSBP	ΔSBP2	-0.158	0.299
	SBP1	ΔSBP1	0.594	< .001
	SBP2	ΔSBP2	0.497	< .001
DBP	bDBP	ΔDBP1	-0.41	0.005
	bDBP	ΔDBP2	-0.367	0.013
	DBP1	ΔDBP1	0.397	0.007
	DBP2	ΔDBP2	0.362	0.015
HR	bHR	ΔHR1	-0.197	0.195
	bHR	ΔHR2	-0.274	0.069
	HR1	ΔHR1	0.09	0.557
	HR2	ΔHR2	-0.054	0.724
PP	bPP	ΔPP1	-0.408	0.005
	bPP	ΔPP2	-0.339	0.023
	PP1	ΔPP1	0.594	< .001
	PP2	ΔPP2	0.492	< .001
MAP	bMAP	ΔMAP1	-0.317	0.034
	bMAP	ΔMAP2	-0.304	0.042
	MAP1	ΔMAP1	0.401	0.006
	MAP2	ΔMAP2	0.363	0.014
RPP	bRPP	ΔRPP1	-0.077	0.615
	bRPP	ΔRPP2	-0.147	0.336
	RPP1	ΔRPP1	0.401	0.006
	RPP2	ΔRPP2	0.244	0.107

maintain activation of the muscle metaboreflex. Researchers hypothesized an inverse correlation between changes in cardiac output (CO) and total peripheral vascular resistance (TPR) during IHG [r = - 0.751; p = 0.01] but showed CO and TPR were positively correlated with corresponding responses during post-exercise muscle ischemia [r = 0.568 and 0.512, respectively, p =0.01][23]. Clark et al. evaluated the effect of omega-3 polyunsaturated fatty acid consumption on cardiovascular responses at the onset of IHG exercise. Fourteen young and fifteen old subjects ingested 4 g of fish oil daily for 12 weeks. Participants performed 15-second bouts of IHG at 10%, 30%, 50%, and 70% maximal voluntary contraction. The systolic and diastolic blood pressure and heart rate were recorded before and after the intervention. Researchers found that fish oil supplementation attenuates MAP and DBP increases at the onset of IHG exercise in young and older subjects [change from baseline during 70% MVC handgrip pre-and post-intervention: young ΔMAP =14 ± 2mmHg versus 10 ± 2mmHg, older ΔMAP =14 ± 3mmHg versus 11 ± 2mmHg; young ΔDBP =12 ± 1mmHg versus 7 ± 2mmHg, older ΔDBP = 12 ± 1mmHg versus 7 ± 1mmHg; p < 0.05] [24]. Chaney et al. calculated the predictor variables for systolic BP response [age, gender, resting systolic BP, and maximal treadmill systolic BP, yielded 70% predictability] and diastolic BP response [handgrip strength, resting diastolic BP, treadmill HR, systolic BP, and diastolic PB allowed 66% prediction] [25].

The present study evaluated the effects of IHG exercise on heart rate variability parameters. Kluess et al., in a study on 34 participants (age, 20 ± 1 year), compared heart rate variability parameters during spontaneous breathing, venous-occluded exercise (60% maximal voluntary contraction, 0.5 Hz), and immediate postexercise arterial occlusion. Similar to the present study, researchers found increased LFnu (+9.39 ± 16.83%) and MAP (+25.40 ± 17.55 mm Hg) after exercise. On the contrary, mean R-R interval (-230.73 ± 125.79 msec) and SDNN (-38.54 ± 36.02 msec) showed decrease (P < 0.05). During forearm arterial occlusion, SDNN (-17.89 ± 64.41 msec) and LFnu (9.89 ± 21.01%) showed recovery (P < 0.05) [26]. Farah et al. did a systematic review and meta-analysis of seven randomized controlled trials with 86 participants. Mean difference (MD) and 95% confidence interval (95% CI) were calculated using an inverse variance method with a random-effects model. The results showed no significant effects of IHG exercise on heart rate variability parameters [4 trials to SDNN: MD = −1.44 ms and 95% CI = −8.02, 5.14 ms; RMSSD: MD = −1.48 ms and 95% CI = −9.41, 6.45 ms; pNN50: MD = 0.85% and 95% CI = −1.10, 2.81%; 7 trials to LF: −0.17 nu. and 95% CI = −6.32, 5.98 nu.; HF: MD = 0.17 nu. and 95% CI = −5.97, 6.30 nu.; and LF/HF: MD = 0.13 and 95% CI = −0.34, 0.59] [27]. Kurita et al. studied the effect of IHG on frequency domain heart rate variability in healthy and coronary artery disease patients.

Table 6 - Relationship between absolute and relative changes in heart rate variability parameters before (baseline), during (phase 1), and after 5 minutes (phase 2) of isometric handgrip exercise

Variable	Parameter 1	Parameter 2	Pearson's correlation coefficient	*p*
TP	bTP	ΔTP1	-0.819	< .001
	bTP	ΔTP2	-0.163	0.286
	TP1	ΔTP1	0.206	0.174
	TP2	ΔTP2	0.59	< .001
HF	bHF	ΔHF1	-0.763	< .001
	bHF	ΔHF2	-0.116	0.447
	HF1	ΔHF1	0.224	0.139
	HF2	ΔHF2	0.544	< .001
LF/HF	bLF/HF	ΔLF/HF1	0.335	0.025
	bLF/HF	ΔLF/HF2	0.188	0.215
	LF/HF1	ΔLF/HF1	0.832	< .001
	LF/HF2	ΔLF/HF2	0.737	< .001
RMSSD	bRMSSD	ΔRMSSD1	-0.581	< .001
	bRMSSD	ΔRMSSD2	-0.078	0.611
	RMSSD1	ΔRMSSD1	0.347	0.02
	RMSSD2	ΔRMSSD2	0.605	< .001
pN50	bpN50	ΔSpN501	-0.524	< .001
	bpN50	ΔSpN502	-0.027	0.86
	pN501	ΔSpN501	0.193	0.203
	pN502	ΔSpN502	0.438	0.003
SDNN	bSDNN	ΔSDNN1	-0.634	< .001
	bSDNN	ΔSDNN2	-0.023	0.882
	SDNN1	ΔSDNN1	0.151	0.323
	SDNN2	ΔSDNN2	0.585	< .001

The authors found no significant differences in low-frequency (LF) spectra and LF/HF ratios during handgrip exercise, but HF spectra significantly increased from 10.1 ± 4.5 to 12.2 ± 7.0 ms ($P < 0.05$) in normal subjects. However, LF and LF/HF spectra showed significant ($P < 0.05$ and 0.01, respectively) increase in the CAD subjects, while HF spectra were not significantly changed by handgrip exercise [28].

The present study found that initial baseline status affects cardiovascular responses after IHG exercise. In a meta-analysis of seven randomized controlled trials, Yin et al. found the effect of isometric handgrip (IHG) training on resting BP and heart rate. They analyzed the association between IHG training and participants with different initial BP status. The participants in training groups showed significantly decrease in SBP [MD= -8.33, 95% CI: -11.19 to -5.46; P <0.01) and DBP (MD=-3.93, 95% CI: -6.14 to -1.72; P <0.01] compared to control group. In subgroup analysis, SBP, DBP, and HR significantly decreased in prehypertensive subjects ($P < 0.01$). However, medicated hypertensive subgroup showed a significant reduction in SBP and DBP ($P < 0.01$) [29]. Although researchers compared post-exercise outcomes in various studies, the intensities (that is, percentage of maximum voluntary contraction) used in different studies had not shown standardized protocols. The effect of exercise intensity was evaluated by Kluess et al. using repeated measures ANOVAs and found the effect of intensity of IHG on blood pressure and heart rate variability measures. Researchers found that the mean R-R interval responded to exercise in an intensity-dependent manner. However, SDNN decreased with IHG but did not correlate with exercise intensity [30].

The present study evaluated the acute effects of IHG exercise on cardiovascular responses. Many studies suggested IHG training as an intervention for hypertension. On the contrary, Moldoven et al. found that IHG training for 8–10 weeks had an impact on resting arterial blood pressure and heart rate variability in an investigation. However, blood pressure and heart rate variability parameters had no significant effects [$p > 0.05$] [27]. In a few instances, post-exercise dizziness and hypotension were observed. In a meta-analysis of 30 trials, Farinatti et al. proposed no role of autonomic dysfunction during post–resistance exercise hypotension [31], considering multiple factors in post–IHG exercise cardiovascular responses. The present study outlines the importance of initial baseline status in the development of post-exercise cardiodynamics.

Conclusion

The present study concludes that initial baseline status should be considered while evaluating the post–IHG exercise responses. The study showed a significant effect of baseline measurements on post–IHG exercise diastolic blood pressure, pulse pressure, and mean arterial pressure, and the heart rate variability parameters.

Study Limitations

The study enrolled only males aged between 17 to 22 years to limit the effects of gender and age. Many studies evaluating cardiovascular responses post–IHG exercise use different protocols; more research is required in the future, with studies using similar intensities of maximum voluntary contraction.

Research Quality and Ethics Statement

The present study was in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 2000. The approval of the Institutional Ethical Committee, SMS Medical College, Jaipur was through letter no 3433/MC/EC/2017 dated 7 Oct 2017.

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