Original Article

A study of variation in cardiocirculatory parameters with different body positions during isometric exercise in young adult males

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Abstract

Introduction: To study the effects of exercise, how important it is to choose a posture? We aimed to characterize the possible impact of different body positions on cardiovascular parameters during and after sustained isometric handgrip (IHG) exercise.

Materials and Methods: Cross sectional study was carried out in 33 young adult males (mean age: 19.21±1.083 years). We recorded Blood Pressure (BP), Heart Rate (HR) and SpO_2 at rest, 1st minute of exercise, at 3rd minute of exercise or prior to failure and at 2 minutes after IHG exercise at 30% of Maximum voluntary contraction (MVC) in sitting, supine and standing positions. Mean arterial pressure (MAP), Pulse pressure (PP) and Rate pressure product (RPP) were calculated from BP and HR data.

Results: SBP, DBP, MAP, HR and RPP increased significantly during 1st and 3rd min of exercise and returned to resting level at 2 min after exercise in all three postures. During resting period and at 2 min after IHG exercise SBP and PP were significantly higher in supine compared with sitting and standing position, while DBP, HR and RPP were significantly increased in standing position. DBP, PP, MAP and HR changed significantly in supine, sitting and standing posture with time of exercise (two-way repeated measure ANOVA).

Conclusion: IHG exercise leads to an across the board increase of all the cardiovascular parameters. The effect of posture was more pronounced at rest and during initial duration of exercise. Thus, posture may be a factor to consider in testing initial response during IHG exercise, but not for studying effects of prolonged duration of exercise.

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Introduction

Our body has been evolved to work maximally in the upright position for around 16 hours a day. Postural changes have certain physiological, psychological and cognitive impacts on our bodies. (Van Dongen et al., 2003).

Exercise is a physically stressful event that is an important activity in day to day life. Depending on the type of physical exercise carried out it will influence

the heart rate and blood pressure. Cardiovascular responses to exercise have been utilized as major criteria in prescribing the right exercise regimen for both the patient and the healthy population (Laird et al., 1979).

To assess the left ventricular function, a cardiocirculatory challenge in a form of an isometric exercise is often utilized with the participants in the supine posture (Helfant et al., 1971; Fisher et al., 1973; Quarry and Spodick, 1974). Measuring effect of isometric exercise on the hemodynamic parameters as a function of the cardiac output is done in most of the studies in the sitting upright position (Lind and McNicol, 1967; Tuttle and Horvath, 1957).

A significant hemodynamic response to rhythmic exercise is well defined and demonstrated in human studies and has been compared between the sitting and supine posture (Spodick and Quarry-Pigott, 1973). But very limited data is available for the same parameters in the sitting, supine and standing posture during static exercise and the results are contradictory (Quarry and Spodick, 1974; Sagiv et al., 1992; Melrose, 2005; Kodzo et al., 2013). So it is desirable to elucidate hemodynamic responses to these exercises in different physiological body positions.

This study was undertaken among young adult males to evaluate how cardiovascular parameters are affected during and after isometric a.k.a static handgrip exercise in three different body positions, namely sitting, supine, and standing.

Materials and methods

Study design:

A cross sectional study was carried out in young healthy male participants from the S.B.K.M.I. and R.C., Sumandeep Vidyapeeth. The participants who gave informed consent were examined physically after taking history and were recruited in the study based on following criteria:

Inclusion criteria:

1. Age group: 18 to 22 years
2. Sex: Male
3. Healthy and normally active i.e. participants without history of hypertension, cardiovascular, renal, musculoskeletal,

neurological or any other disorders.
4. Normotensive (BP < 140/90 mmHg)
5. Non alcoholics
6. Non tobacco chewers
7. Individuals willing to sign the informed consent form and participate in the study.

Exclusion criteria:

1. Participants who are unable to perform the handgrip test, because of disability limiting the upper extremities to do the exercise.
2. Persons who are unable to co-operate.
3. Participants with an acute illness or on any kind of medication.
4. Trained athletes.

Sample size:

Based on the above criteria total 33 young healthy male participants were recruited. Sample size was calculated using mean differences of parameters by *Openepiinfo Software*. Sample was selected by random sampling.

Ethics:

All the participants willing to participate in the study were briefed about the nature, intent and the procedures and methods used in the study verbally in the language they understood prior to data collection. Written informed consent was obtained according to Institutional Ethics Committee Policy. This Study was approved by the Ethics committee for human subjects by SVIEC/ON/MEDI/SRP/14213 number.

Place:

The experimental trial was carried out in the Department of Physiology S.B.K.M.I. & R.C. Sumandeep Vidyapeeth University in the morning hours from 9:30 am to 12:30 pm after serving subjects a light breakfast (Martin et al., 1974) in the room with normal temperature and bright light (Clausen et al., 1973). After 30 minutes rest period the procedure was carried out (Quarry and Spodick, 1974).

Screening was done to ensure the normotensive blood pressure (<140/90 mmHg) requirement of the trial was met.

Recording of Maximal Voluntary Contraction (MVC):

Maximal isometric voluntary contraction (MVC) for the handgrip of the participants was recorded by the calibrated spring-loaded type dynamometer (INCO-AMBALA). The study participants were requested to exert maximal effort by their dominant hand and squeezing the bar of the handgrip dynamometer as hard as they can, maintain it for 2-3 seconds. Three trials were performed by the participants with a brief 10 second interval between each trial to avoid of the excessive fatigue (Melrose, 2005). The highest force output (kg) was established as the maximum voluntary contraction (MVC) and was selected from among the three trials. The MVC for all subjects was established at the same time as the anthropometric measurements.

Isometric handgrip test:

IHG exercise was performed at 30% of MVC in sitting, supine and standing position. 15 minutes rest was given in between the change of the posture. Participants were instructed to maintain *normal breathing* patterns during all trials to avoid any influence from the *Valsalva manoeuvre* (Martin et al., 1974). Blood Pressure was measured with calibrated mercury *sphygmomanometer* (Diamond Co.) while pulse rate and SpO_2 was recorded with Necklife Fingertip Pulse Oximeter (Nl-50d). These parameters were recorded at 1st minute of exercise, at 3rd minute of exercise or prior to failure and at 2 minutes after exercise. When muscle fatigue occurred, the participants were not able to continue the experiment, we considered it as a failure and end of exercise (Hietanen, 1984). Mean Arterial Pressure (MAP), Pulse Presure (PP) and Rate Pressure Product (RPP) was calculated by standard formula from Blood Pressure and Heart Rate data as per following equations:

PP = (SBP – DBP)

MAP = DBP + 1/3 (PP)

RPP = PULSE RATE X SBP

Statistical analysis:

 Data (mean ± SD) was analyzed using two-way repeated measured analysis of variance (ANOVA) and Post hoc analysis was done as data was approximately normally distributed. All statistical analysis was done by SPPS version 20 for windows. P-value ≤ 0.05 was considered as significant at 95% CI.

Results

Sample characteristics:-

Shapiro-Wilk's test (p>0.05), Visual inspection of their histogram, Normal Q-Q plots, Skewness And Kurtosis value showed that the data were approximately normally distributed (Cramer and Howitt, 2004; Razali and Wah, 2011; Hapiro and Wilk, 1965). Table 1 shows the general characteristics of the study sample.

Effect of submaximal isometric handgrip exercise on various parameters:

SBP, DBP, MAP, HR and RPP increased significantly during 1st and 3rd min of exercise and returned to resting level at 2 min after exercise in all three positions. PP increased significantly only at 3rd min of exercise in sitting and standing positions and remained unchanged in supine position. SpO_2 was maintained (and was steady) throughout IHG exercise in all three positions (Table 2).

Effect of Posture:

In resting and at 2 min after IHG exercise SBP and PP were significantly higher in supine position compared to sitting and standing position, while DBP, HR and RPP were significantly increased in standing position. At 1st min of exercise SBP and PP remained higher in supine position, HR, RPP and DBP values remained increased in standing position. At 3rd min or peak of exercise none of the parameters show any significant changes with varying posture with the exception of SBP and HR which were found to be higher in supine and standing posture, respectively. MAP and SpO_2 did not show any significant change with change in posture during resting and exercise (Table 2).

Interaction between posture and IHG exercise:

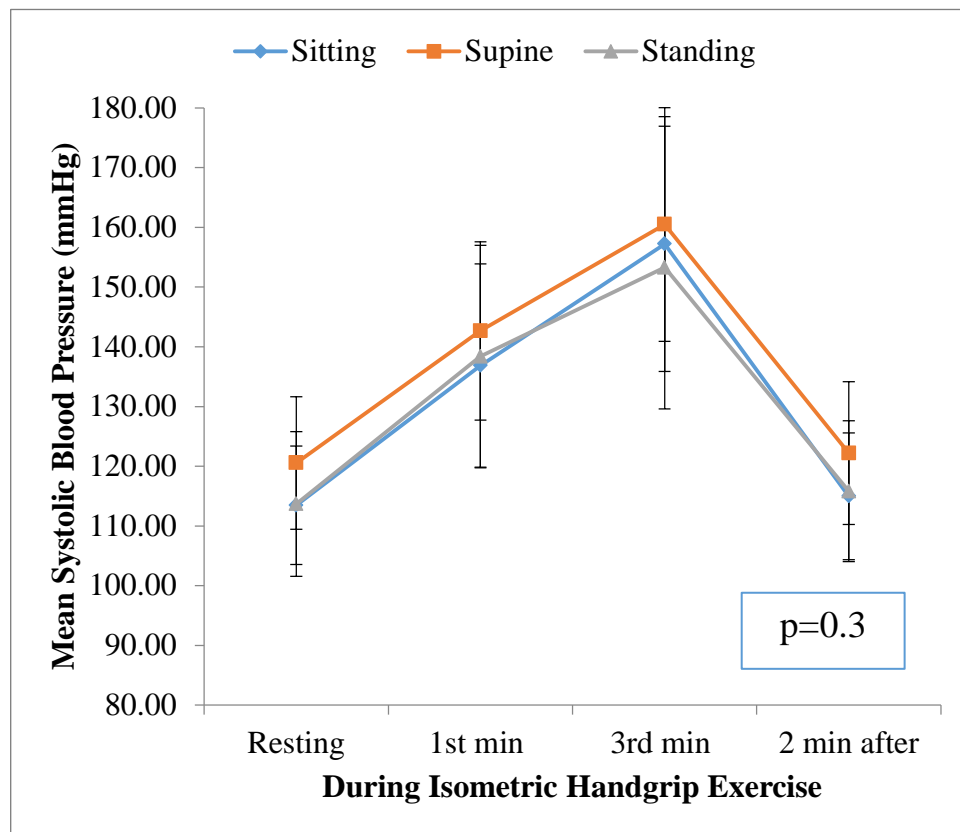On two-way repeated measure ANOVA there was significant correlation between posture and exercise

Fig.1. Systolic Blood Pressure changes during isometric exercise in different postures. (p value of 2-way repeated measure ANOVA)
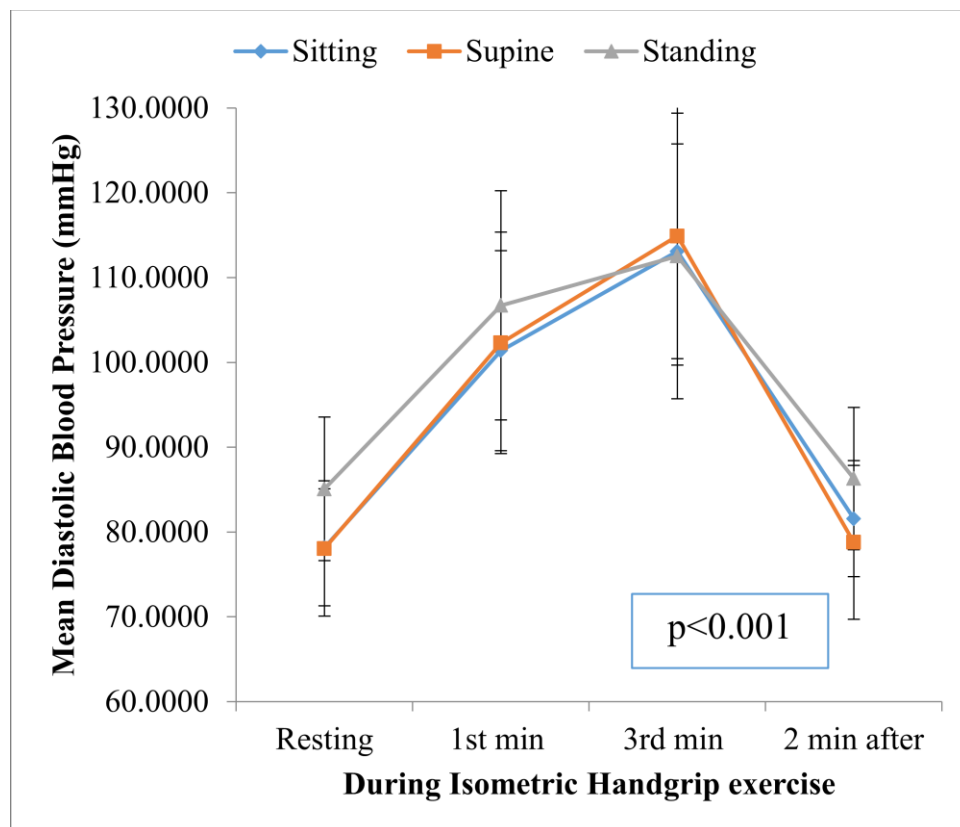

Fig.2. Diastolic Blood Pressure changes during isometric exercise in different postures. (p value of 2-way repeated measure ANOVA)
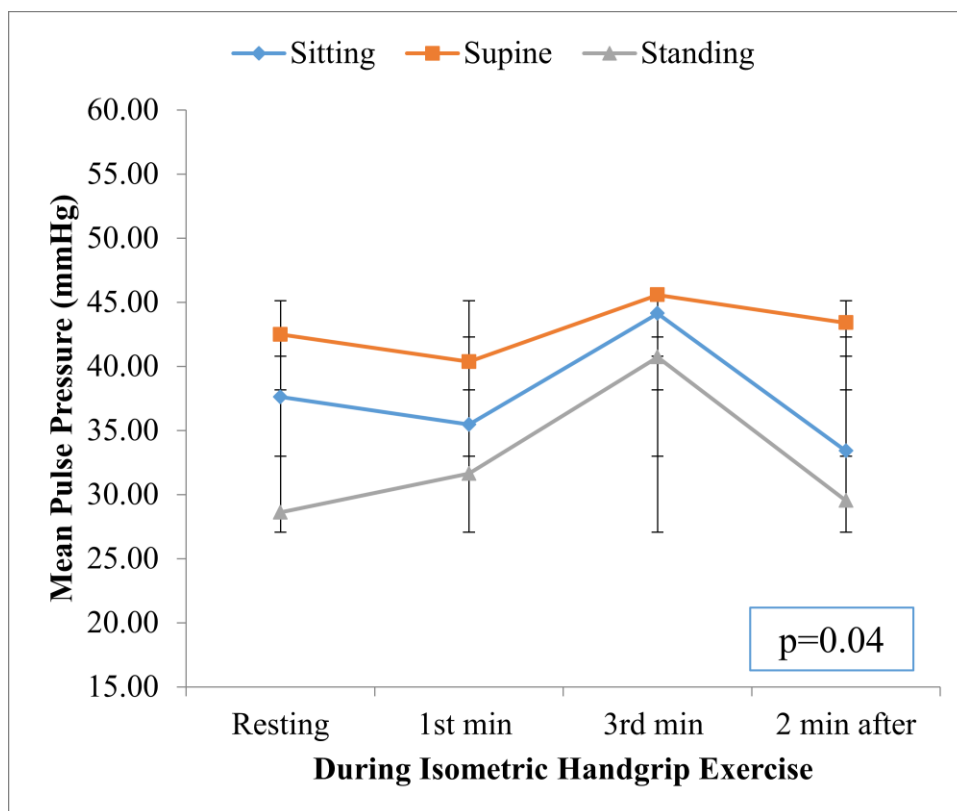
Fig.3. Pulse Pressure changes during isometric exercise in different postures. (p value of 2-way repeated measure ANOVA)
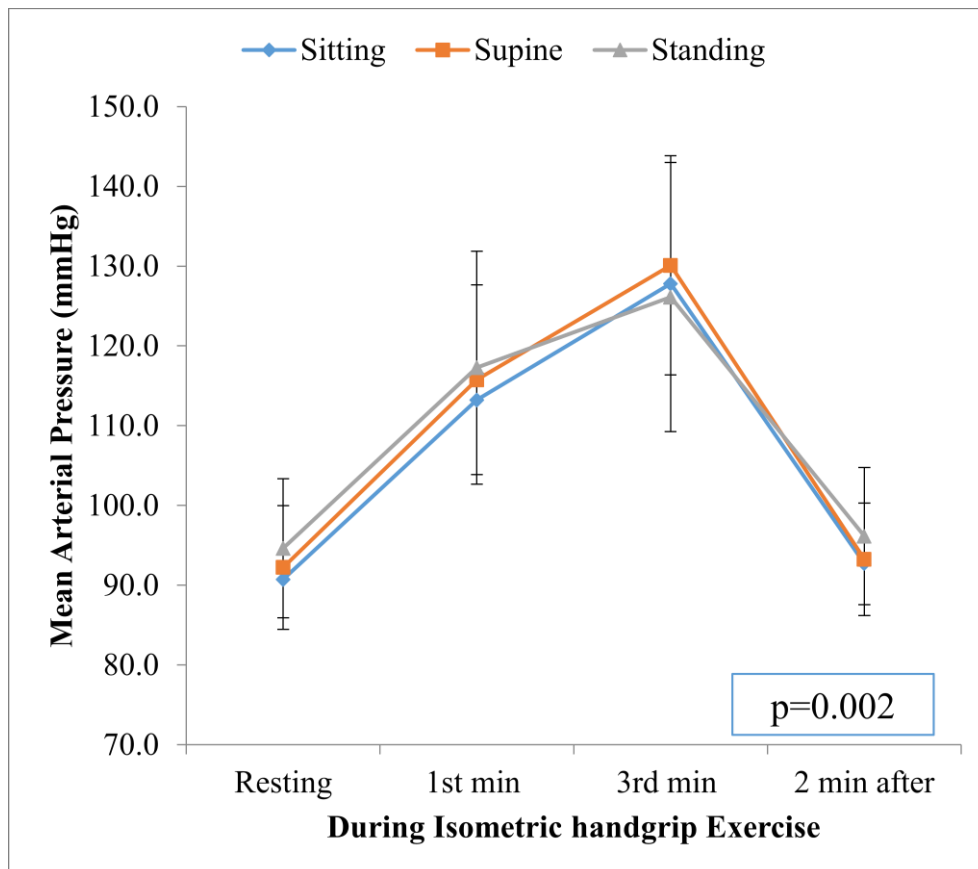

Fig.4. Mean Arterial Pressure changes during isometric exercise in different postures. (p value of 2-way repeated measure ANOVA)
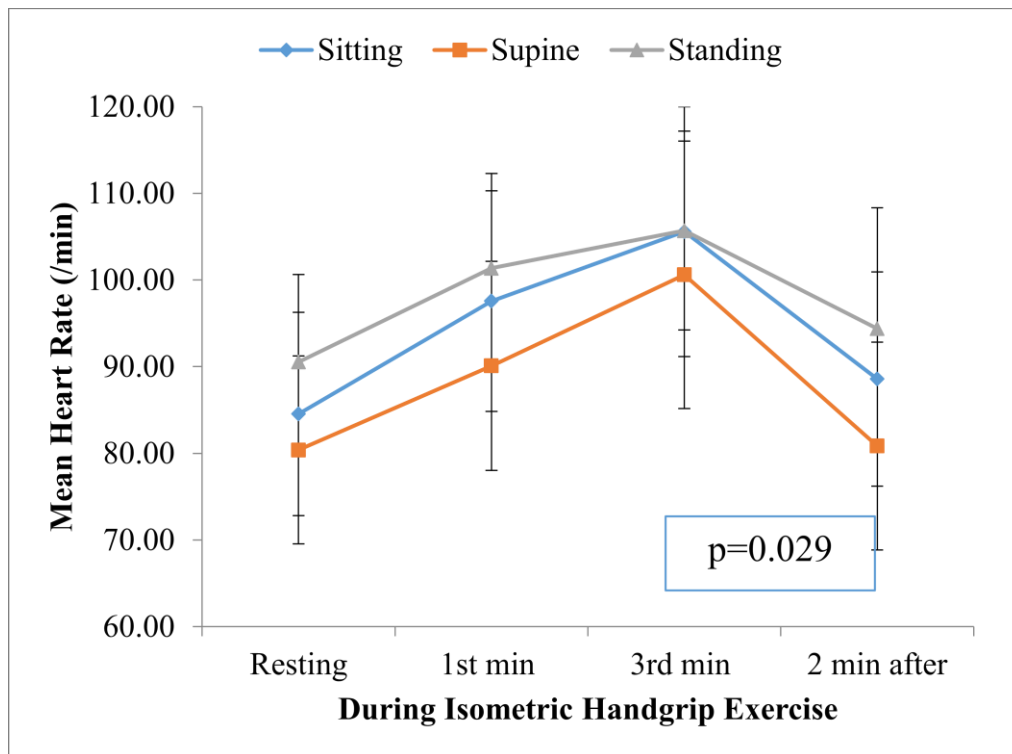
Fig.5. Heart rate changes during isometric exercise in different postures. (p value of 2-way repeated measure ANOVA)
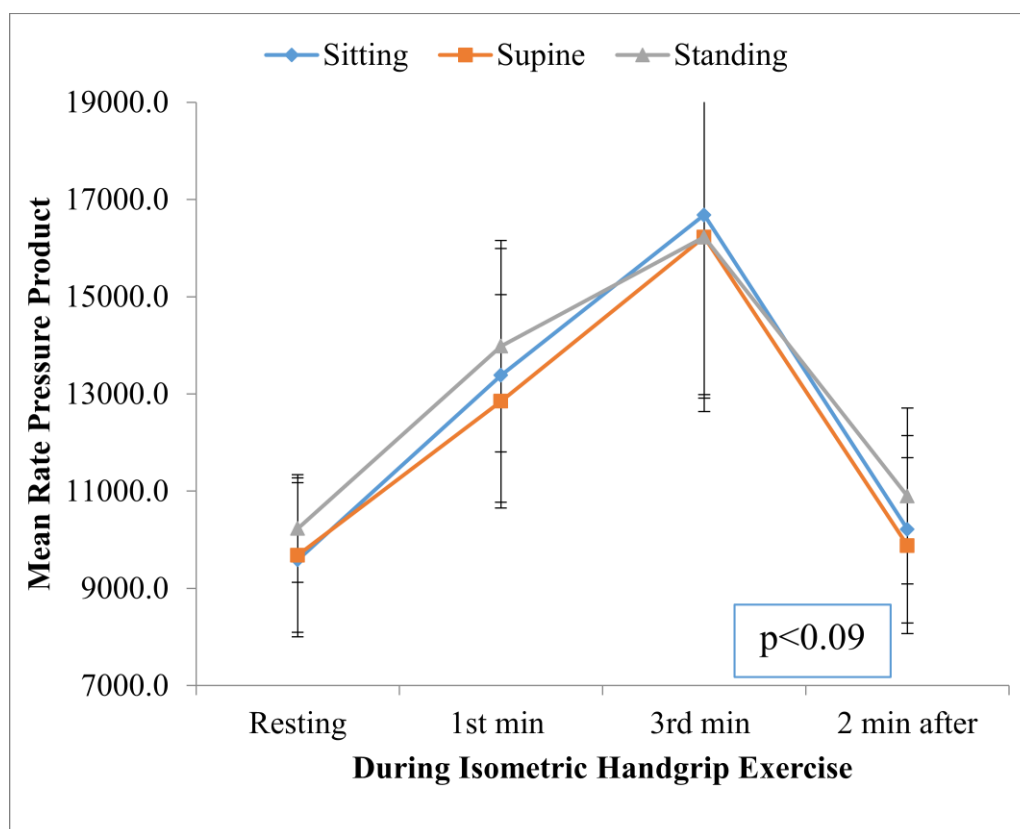

Fig.6. Rate Pressure Product changes during isometric exercise in different postures. (p value of 2-way repeated measure ANOVA)
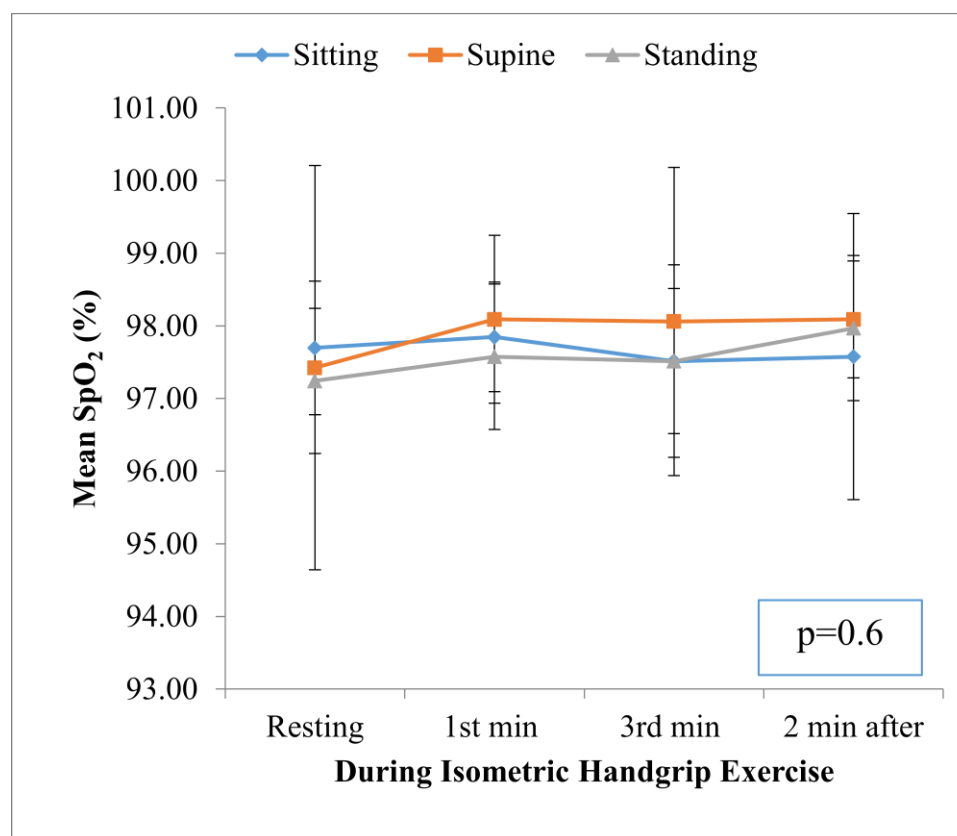
Fig.7. SpO_2 changes during isometric exercise in different postures. (p value of 2-way repeated measure ANOVA)

Table 1: General characteristics of the study group

	Mean	SD	Range
Age (years)	19.21	1.083	18-22
Height (cm)	171.48	6.31	160-190.5
Weight (kg)	64.15	10.84	45-89
Body Mass Index (kg/m^2)	21.81	3.52	16.76-31.29
Maximum Voluntary Contraction (kg)	33.55	7.98	17-45
30% MVC (kg)	10.06	2.4	5-13.5

for DBP, PP, MAP and HR values. These parameters changed significantly in supine, sitting and standing posture with time of exercise as shown in Figures 2 to 5.

Discussion

We explored whether posture could potentially have any effect on cardiovascular parameters during IHG exercise among apparently healthy young adult male participants. We selected only the young adult (18-22 yrs) male participants, so there will be no confounding effect as a result of menstrual cycles. Autonomic nervous system is associated strongly with two different phases of menstrual cycle i.e. parasympathetic dominance in follicular phase and sympathetic dominance in luteal phase (Mehta and Chakrabarty, 1993). So, in order to avoid possible confounding effect of menstrual cycle on exercise in both positions are associated with

Table 2. Cardio-vascular parameters along isometric handgrip exercise during different posture. (n=33) (values are mean ± SD)

	Posture	Measurements along Isometric Exercise				
		Resting	1st min during	3rd min during	2 min after exercise	p value
Systolic Blood Pressure (mmHg)	Supine	120.55 ±11.11	142.67±14.93*	160.48 ±19.57*^	122.18 ±11.95	<0.001
	Sitting	113.45±9.90[a]	136.85±17.08* [a]	157.21 ±21.34*^	114.97 ±10.60 [a]	<0.001
	Standing	113.70 ±12.11[a]	138.35±18.62* [a]	153.27 ±23.67*^ [a]	115.82 ±11.80 [a]	<0.001
	p value	<0.001	0.008	0.02	<0.001	
Diastolic Blood Pressure (mmHg)	Supine	78.06±7.96	102.30±13.04*	114.91 ±15.24*^	78.79 ±9.06	<0.001
	Sitting	78.18±6.89	101.39±11.79*	113.09 ±12.65*^	81.58 ±6.83*	<0.001
	Standing	85.09±8.42[ab]	106.73±13.51*	112.55 ±16.82*	86.30±8.38 [ab]	<0.001
	p value	<0.001	0.03	0.5	<0.001	
Pulse Pressure (mmHg)	Supine	42.48±10.45	40.35±12.75	45.58±17.83	43.39 ±12.74	0.1
	Sitting	37.61 ±14.37	35.45 ±14.65	44.12 ±17.75^	33.39 ±9.19 [a]	0.006
	Standing	28.61 ±9.70[ab]	31.64±10.50 [a]	40.73 ±20.23*^	29.52 ±9.35[ab]	<0.001
	p value	<0.001	<0.001	0.2	<0.001	
Mean Arterial Pressure (mmHg)	Supine	92.21 ±7.63	115.76±12.35*	130.04 ±14.49*^	93.17 ±8.05	<0.001
	Sitting	90.71 ±7.74	113.21±11.89*	127.79 ±13.72*^	92.70 ±7.05	<0.001
	Standing	94.65 ±8.70	117.28±14.56*	126.13 ±16.82*^	96.10 ±8.70	<0.001
	p value	0.06	0.08	0.1	0.07	
Heart Rate (/min)	Supine	80.39 ±10.84	90.09±12.04*	100.61 ±15.42*^	80.85 ±11.99	<0.001
	Sitting	84.55 ±11.73[a]	97.58±12.73* [a]	105.58 ±14.40*^	88.58 ±12.37* [a]	<0.001
	Standing	90.55 ±10.09[ab]	101.36±10.94* [a]	105.70 ±11.46*	94.39 ±13.94[ab]	<0.001
	p value	<0.001	<0.001	0.04	<0.001	
Rate Pressure Product (bpm x mmHg)	Supine	9683.64 ±1590.02	12849.52 ±2196.66*	16226.73±3586.91*^	9879.45 ±1806.07	<0.001
	Sitting	9588.30 ±1585.47	13384.18 ±2610.08*	16681.27±3768.25*^	10216.79±1929.31*	<0.001
	Standing	10232.61±1107.85[b]	13983.33 ±2177.07* [a]	16226.73±3239.81*^	10899.45±1809.30[a]	<0.001
	p value	0.01	<0.001	0.6	0.002	
SpO₂ (%)	Supine	97.42±2.78	98.09±1.15	98.06 ±2.12	98.09 ±0.80	0.3
	Sitting	97.7 ±0.92	97.85 ±0.75	97.52 ±1.32	97.58 ±1.96	0.6
	Standing	97.84±1.22	97.57±1.14	97.51 ±1.25	97.96 ±0.80	0.1
	p value	0.5	0.06	0.2	0.1	

*$p<0.05$ comparing with resting measurements, ^$p<0.05$ comparing with 1st min of exercise, [a]$p<0.05$ comparing with supine measurements, [b]$p<0.05$ comparing with sitting measurements.

cardiocirculatory parameters during and after IHG exercise with postural variation we included only male participants.

The results of our study suggest that in standing posture; HR, DBP, and RPP were increased during rest and 1st min of sub-maximal IHG exercise compared to sitting and supine postures. Our study

findings were consistent with some other studies. Sagiv et al. (1992) studied the effect of body position on after-load response during sustained exercise in males at 30% MVC in sitting upright and supine isometric exercise. They found no significant difference in MVC in supine compared to sitting upright positions. However, in comparison to rest,

both forms of isometric exercise are associated with significant increase in the SBP, DBP, MAP and RPP (Sagiv et al., 1992). Quary and Spodick et al. (1974) found increased HR in upright sitting posture compared to supine posture which remained steady during all levels of isometric exercise, but it showed no significant changes in DBP during 30% MVC (p<0.01) for sitting and supine postures which is not consistent with our findings (Quarry and Spodick, 1974). Don Melrose (2005) found DBP, MAP, and HR were significantly higher in the sitting position than in the supine position and that posture has a significant effect on cardiovascular response during sub-maximal IHG exercise. In the standing position, as a result of increased sympathetic outflow, baroreceptor reflex increases total peripheral resistance and chronotrophic effect on the heart, which is believed to account for increased HR, DBP and RPP (Melrose, 2005).

SBP and PP were found to be increased in supine posture at rest and during sub-maximal IHG exercise. Quarry and Spodick et al. (1974) had found no significant increase in SBP in supine posture at rest and there were no significant differences in systolic pressure values between the two postures and at the end points of all levels of exercise (Quarry and Spodick, 1974). A study by Kodzo K. K. et al. (2013) found no significant difference in any cardiovascular parameters with postural variation during isometric exercise (Kodzo et al., 2013). In the standing position, increased blood accumulation occurs in the lower extremities, which leads to the reducing of the preload to the left ventricle. Also, gravity causes disturbances in the pressure flow between the venous system and systemic venous return, leading to a decrease in the body's central blood volume and cardiac output. This process creates difficulties in maintaining the stroke volume. To maintain adequate cardiac output in standing position, heart rate must increase. The increase in the RPP reflects an increase in the myocardial oxygen uptake and coronary blood flow.

All the above-stated studies were done in the sitting upright and supine position, while our study took into account the possible effect of the standing posture on the same cardiovascular parameters during IHG exercise. We found a significant correlation between the posture and the duration of exercise in DBP, PP, MAP and HR. Although, the intensity of the exercise

as well as the duration of it increases all the cardiovascular parameters, the effect of posture could not be ignored and was more pronounced at rest and at the initiating point of exercise, But, as it progresses at the point of submaximal exercise, the effect of posture seems to disappear. The higher and more intense cardiovascular response later during exercise may be due to local fatigue which increases sympathetic nerve activity (Borg and Noble, 1974). Hence, for studying the effect of exercise on the cardiovascular system, it will be more productive if we obtain data within a longer period of physical exercise coupled with more intensity. (Quarry and Spodick, 1974), as the effect of posture seems to disappear with longer duration of exercise.

Conclusion

Posture may be a factor to consider for testing the initial response during IHG exercise, but not for studying effects of prolonged duration of exercise. The decreased HR and blood pressure during supine and sitting positions compared with the standing position must also be kept in mind when studying IHG exercise regimens and its effects on cardiovascular response.

Acknowledgment

Conflict of Interest

None declared.

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