

Effect of isometric hand grip on heart rate in normotensive and hypertensive individuals during head up tilt (30⁰ and 60⁰)

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*Article History:

Received: 29/03/2017

Revised: 10/04/2017

Accepted: 12/04/2017

DOI: <https://dx.doi.org/10.7439/ijbar.v8i4.4064>

Abstract

Objective: To study the effect of isometric hand grip exercise at 20% on normotensive, treated hypertensive, and non treated hypertensive in supine position, and at 30⁰ and 60⁰ head up tilt.

Material and Methods: After recording heart rate in supine position, isometric hand grip exercise at 20% was conducted for 2 minutes with dominant hand and heart rate was recorded for 1 minute in all subjects after end of the exercise. The same maneuver was repeated before head up tilt in supine position and during head up tilt (30⁰ and 60⁰) in normotensive (n=104), treated hypertensive (n=76), and non treated (n=32) hypertensive individuals.

Result: Isometric hand grip exercise at 20% resulted in mild increase in heart rate which was within normal limits of heart rate in all study groups. Similarly decrease in heart rate was observed in the some of the age groups.

Conclusion: Isometric hand grip exercise at 20% caused marginal increase in heart rate in all study groups which was recorded within normal physiological range with decreased sympathetic stimulation and vagal modulation caused by isometric handgrip training.

Keywords: Isometric hand grip exercise, head up tilt, sympathetic stimulation, Vagal stimulation

1. Introduction

Isometric exercise is well suited to investigate short term control of the cardiovascular system by autonomic nervous system at any rate of maximum voluntary contractions (MVC) the static handgrip alters baroreceptor reflex functioning, causing increase in heart rate and arterial pressure. Dynamic handgrip exercise evaluates autonomic responses to physical activity.

Dynamic handgrip exercise at 60 % of maximal voluntary contraction (MVC), could result in significant sympathetic activation, mild to moderate exercise (from 20 % to 30 %) do not evoke sympathetic activation [1,2]. Very few studies have used heart rate variability as an index of parasympathetic responses to dynamic handgrip exercise.

Recent literature survey has indicated use of isometric handgrip exercise training as alternative

antihypertensive treatment. It is found that, isometric hand grip exercise systemic training can reduce the blood pressure to appreciable level, mainly systolic blood pressure and diastolic blood pressure [3] and mean arterial pressure [4]. The reduction in studied parameters is mainly due to decreased sympathetic stimulation and vagal modulation caused by isometric handgrip training [24].

Hence in present study an attempt is made to correlate isometric hand grip at moderate exercise (20%) on heart rate in normotensive and treated hypertensive, and non treated hypertensive individuals and parasympathetic response in study group.

2. Material and methods

2.1 Normotensive

Normotensive healthy subjects (n=104) were selected in age group of 15 – 65 years and above who fulfilled following criteria were included as control subjects in the study:

- No signs of cardiac, vascular or neurological involvement
- No history of diabetes mellitus, hypertension
- No history of drug treatment
- No history of systemic illness

Their normal blood pressure status was considered according to guidelines of, Seventh Report of the Joint National Committee (JNC7) on Prevention, Detection, Evaluation and Treatment of high blood pressure and Indian Hypertension Guidelines II, 2007 with optimal value as <120/<80 mmHg and further variation in systolic blood pressure was considered in the range of 120-139 mmHg. Similarly diastolic blood pressure variation was considered in the range of 80-89 mmHg. These recorded responses will help to understand the variation in these recorded parameters, when compared with treated hypertensive and non treated hypertensive patients.

2.2 Hypertensive group

Hypertensive patients were divided in to two groups as Treated Hypertensive (THTN) (n=76) and Non Treated Hypertensive (NHTN) (n=32).

i) Treated Hypertensive (THTN)

This category of patients was selected on OPD basis, which regularly attended Medicine OPD for their treatment and are considered as treated hypertensive patients. These subjects were under treatment or on blood pressure lowering medication with controlled hypertension (target blood pressure value 140/90). Their hypertensive status was determined by Medicine department and Family Medicine department.

Patients suffering from major illness such as severe diabetic condition, congestive heart failure, coronary artery disease, arrhythmias or other diseases (e.g., renal diabetic neuropathy), or consuming tobacco, alcohol or having BMI >35 Kg/m², which may affect autonomic and CVS parameters, were excluded from the study.

Since, the pathophysiology of high blood pressure is unknown in most of the cases (95%) of essential hypertension. In secondary hypertension the exact cause of hypertension can be known.

2.3 Non treated hypertensive group (NHTN)

In this group, hypertension status was newly diagnosed and participants were not aware of their hypertension status. Similarly these subjects were not undergoing any medical treatment at the time of their participation in the study. Their uncontrolled hypertensive

status was considered with SBP > 140 to 160 mm Hg and DBP > 90 mmHg.

Same exclusion criteria were used to include the hypertensive patients in this group as applied in treated hypertensive group such as patients suffering from diabetes mellitus, congestive cardiac failure, symptomatic coronary artery disease, atrial fibrillation; frequent ectopic beats were excluded from the study.

Head up tilt testing (HUTT) is best suited to understand the haemodynamic and parasympathetic responses at different angles of head up tilt, as compared with treated hypertensive group.

The all participants were included in the study from out-patient unit of the Department of Medicine, Family Medicine of Rural Medical College, Pravara Institute of Medical Sciences (DU), Loni.

All subjects were divided into six groups according to their age i.e., 15-24, 25-34, 35-44, 45-54, 55-64, 65 years and above. In subsequent age group individuals with higher age (e.g., 25.2 years etc., in 25-34 years) were included.

While selecting different age groups it was noted that, hypertension is also reported at very young age [6-8].

All subjects were called with appointment in the laboratory, 2 hours after light breakfast in the morning (09.00am-12.00pm). Subjects were instructed not to consume caffeinated beverage and to avoid smoking before 12 hours of the test. Subjects were reassured in detail about study protocol and it was explained to them about recording parameters, which will not interfere with their present health status. This reassurance helped for better coordination from all participants.

2.3 Sustained or isometric hand grip test:

This test was conducted in supine position as well as in tilting position [5]. Initially basal heart rate was recorded in supine position and at selected tilt position, before performing handgrip test. During head up tilt patient was tilted to required angle and after recording head up tilt table was brought to horizontal position for further recording.

After instructions, about use of the hand grip dynamometer (INCO Ambala), subject was asked to use dominant hand and apply maximum voluntary contraction (MVC or maximum voluntary force) for few seconds. This manoeuvre was repeated thrice and maximum of this reading was considered as maximum voluntary contraction (MVC). MVC cause sympathetic stimulation which results either in increase in blood pressure (BP) or increase in heart rate (HR).

Immediately after this, subject was told to perform handgrip exercise at 20 % of MVC. The test was continued for 2 minutes. The two minutes period was selected to standardize length of contraction, since previous study

reported [9], 2 minutes was the longest contraction period. Heart rate was recorded immediately after the test. Blood pressure was not recorded during handgrip test, since it may influence heart rate.

Heart rate (HR) was recorded at 20 % of MVC, since it caused sympathetic withdrawal and indicated possible role of parasympathetic stimulation to decrease HR

and BP, as reported in some of the studies. While performing IHG tests subjects were instructed not to clench teeth or apply any extra effort, which can affect recording parameter.

Results were tabulated and analysed by applying student t-test.

3. Results

Table 1: Age wise distribution of the subjects

S. N	Age group (completed in yrs)	Normotensive (NT=104)	Hypertensive (HTN=76)	Non treated Hypertensive (NTHTN=32)	Total (212)
1	15-24	27 (25.96) [*]	2 (2.63)	4 (12.5)	33 (15.56)
2	25-34	28 (26.92%)	5 (6.58)	5 (15.62)	38 (17.92)
3	35-44	29 (27.88)	21 (27.63)	6 (18.75)	56 (26.41)
4	45-54	16 (15.38)	21 (27.63)	7 (21.87)	44 (20.74)
5	55-64	2 (1.92)	22 (28.45)	7 (21.87)	31 (14.62)
6	65 & above	2 (1.92)	5 (6.58)	3 (9.37)	10 (4.72)
Total		104	76	32	212

*: values in parenthesis indicate percentage distribution of the subjects in each study group

Table 2: Anthropometric characteristics in normotensive, treated hypertensive, non treated hypertensive subjects

SN	Age (yrs)	Height (cm)	Body weight (Kg)	BMI (Kg/m ²)
1	15-24	166.81±.44	53.67±2.01	19.41±0.77
2	25-34	160.68±2.01	53.54±1.79	20.23±1.79
3	35-44	163.93±.13	57.15±1.75	21.40±0.55
4	45-54	162.00±.71	57.94±2.25	22.39±.58
5	55-64	155.00±.00	56.00±1.00	23.32±0.13
6	65 & above	167.50±.50	62.50±2.50	22.29±0.50

Table 3: Anthropometric characteristics in treated hypertensive subjects

SN	Age (yrs)	Height (cm)	Body weight (Kg)	BMI (Kg/m ²)
1	15-24	171.00±9.00	65.50±15.50	22.03±2.97
2	25-34	169.62±1.77	70.38 ±1.93	24.50±0.60
3	35-44	169.62±8.10	70.38±8.84 ^{‡‡}	24.50±2.73 ^{‡‡‡}
4	45-54	165.09±1.66	66.95 ± 2.27	25.27±0.86 ^{‡‡}
5	55-64	162.04±1.12	61.59 ± 2.10	23.43 ± 0.73
6	65 & above	158.20±2.27	58.20 ±7.38	23.32 ± 2.75

Values are Mean ± SE. (Unpaired t-test between normotensive and non treated hypertensive individuals: [‡]P<0.05 significant, ^{‡‡}P<0.01 highly significant, ^{‡‡‡} very highly significant)

Table 4: Anthropometric characteristics in non treated hypertensive subjects

SN	Age (yrs)	Height (cm)	Body weight (Kg)	BMI (Kg/m ²)
1	15-24	174.50±1.45	84.00±7.42 ^{‡‡‡}	27.49±2.01 ^{‡‡‡}
2	25-34	168.00±2.65	64.50±2.52	22.88±0.69
3	35-44	161.50±5.57	62.50±4.70	22.42±1.57
4	45-54	161.50±4.33 [‡]	62.50±1.67	23.25±0.83
5	55-64	161.50±1.00 [‡]	72.50±5.90	23.43±2.04
6	65 & above	162.50 ± 3.93	57.00±3.33	21.54±0.34

Values are Mean ± SE. (Unpaired t-test between normotensive and non treated hypertensive individuals: [‡]P<0.05 significant, ^{‡‡}P<0.01 highly significant, ^{‡‡‡} very highly significant)

Table 4: Test: Effect of Isometric Hand Grip (IHG) on heart rate/min at different postures in normotensive

SN	Age (yrs)	Posture					
		Supine (H.R/MIN without IHG)	Supine (H.R/MIN with IHG)	30 ⁰ (H.R/MIN without IHG)	30 ⁰ (H.R/MIN with IHG)	60 ⁰ (H.R/MIN without IHG)	60 ⁰ (H.R/MIN with IHG)
1	15-24	74.24±2.20	74.92±2.27	81.81±2.41	82.16±2.27 ^{***@}	95.59±2.48	99.84±2.70 ^{***@®®} †††
2	25-34	73.21±2.73	72.71±2.10	80.11±2.35	82.50±2.11 ^{***}	90.15±1.85	92.89±2.53 ^{***†††}
3	35-44	70.83±2.04	71.76±2.04	74.34±2.31	76.45±2.14	85.66 ±2.47	83.86±2.78
4	45-54	72.81±2.48	72.81±1.91	77.81±4.73	78.19±2.57 ^{***}	87.25±5.48	88.94±3.12 †††
5	55-64	73.50±6.50	76.50±10.5	73.50±8.65	75.50±6.5	82.00±6.00	87.0 ±6.00
6	65 yrs & above	66.50±0.50	79.50±0.50	71.00±2.00	72.50±0.50	74.50 ±3.50	76.5±1.50

Values are mean ± SE .H.R/MIN:heart rate/min; (Student paired t – test: Comparison between HR recorded at rest and 30⁰ and 60⁰ head up tilt *P<0.05, ***P<0.001 significant, @P<0.05, ®P<0.01, @®P<0.001 for comparison between HR recorded without IHG and with IHG for 30⁰ and 60⁰ head up tilt, Comparison between HR recorded without IHG and IHG at supine, ††† P<0.001 significant for comparison between 30⁰ and 60⁰head up tilt)

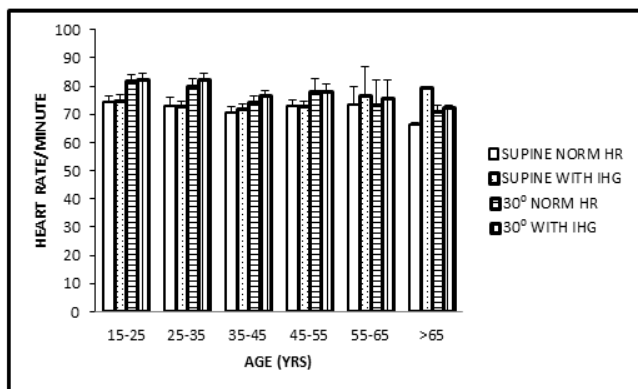


Fig.1.1: Effect of isometric hand grip exercise (IHG) at 20 % of MVC on heart rate in supine position and at 30° HUT in different age groups in normotensive subjects

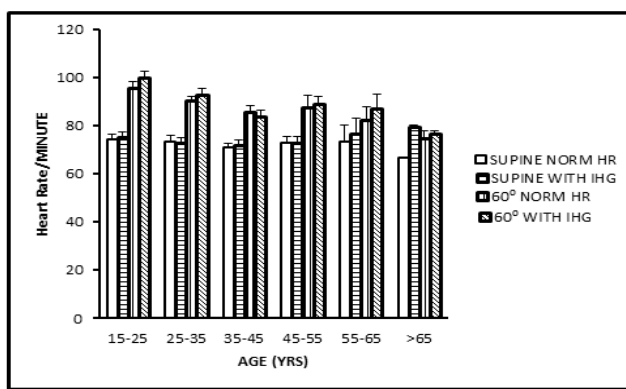


Fig.1.2: Effect of isometric hand grip exercise (IHG) at 20 % of MVC on heart rate in supine position and at 60° HUT in different age groups in normotensive subjects

Table 5: Effect of Isometric Hand Grip (IHG) on heart rate/min at different postures in treated hypertensive

SN	Age (yrs)	Posture					
		Supine (H.R/MIN without IHG)	Supine (H.R/MIN with IHG)	30° (H.R/MIN without IHG)	30° (H.R/MIN with IHG)	60° (H.R/MIN without IHG)	60° (H.R/MIN with IHG)
1	15-24	74.24±2.20	74.92±2.27	81.81±2.41	82.16±2.27***®	95.59±2.48	99.84±2.70 ***®®® †††
2	25-34	73.21±2.73	72.71±2.10	80.11±2.35	82.50±2.11***	90.15±1.85	92.89±2.53 ***†††
3	35-44	70.83±2.04	71.76±2.04	74.34±2.31	76.45±2.14	85.66 ±2.47	83.86±2.78
4	45-54	72.81±2.48	72.81±1.91	77.81±4.73	78.19±2.57***	87.25±5.48	88.94±3.12 †††
5	55-64	73.50±6.50	76.50±10.5	73.50±8.65	75.50±6.5	82.00±6.00	87.0 ±6.00
6	65 yrs & above	66.50±0.50	79.50±0.50	71.00±2.00	72.50±0.50	74.50 ±3.50	76.5±1.50

Values are mean ± SE .H.R/MIN: heart rate/min; (Student paired t – test: Comparison between HR recorded at rest and 30° and 60° head up tilt *P<0.05, ***P<0.001 significant, ®P<0.05, ®® P<0.01, ®®®P<0.001 for comparison between HR recorded without IHG and with IHG for 30° and 60° head up tilt, Comparison between HR recorded without IHG and IHG at supine, ††† P<0.001 significant for comparison between 30° and 60° head up tilt)

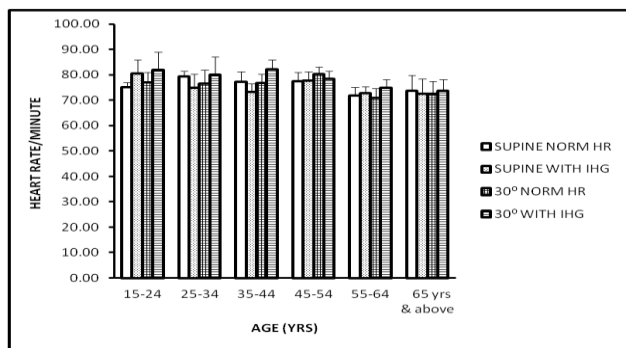


Fig.1.4: Effect of isometric hand grip exercise (IHG) at 20 % of MVC on heart rate in supine position and at 30° HUT in different age groups in treated hypertensive patients

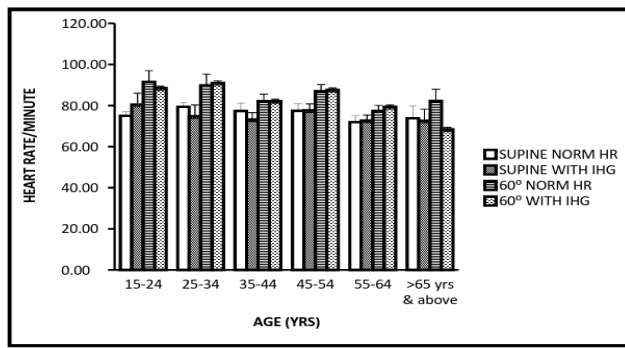


Fig.1.5: Effect of isometric hand grip exercise (IHG) at 20 % of MVC on heart rate in supine position and at 60° HUT in different age groups in non treated hypertensive patients

Table 6: Effect of Isometric Hand Grip (IHG) on heart rate/min at different postures in non treated hypertensive

SN	Age (yrs)	Posture					
		Supine (H.R/MIN Without IHG)	Supine (H.R/MIN WITH IHG)	30° (H.R/MIN WITHOUT IHG)	30° (H.R/MIN WITH IHG)	60° (H.R/MIN WITHOUT IHG)	60° (H.R/MIN WITH IHG)
1	15-24	79.00 ± 6.51	84.67± 3.53	80.33± 2.33	82.67 ± 3.76	88.00 ± 2.31	92.33 ± 1.20
2	25-34	76.00 ± 7.81	74.00 ± 5.03	75.50± 5.63	74.67 ± 4.33	86.25 ± 5.66	80.33 ± 4.67
3	35-44	70.40 ± 4.03	70.80 ± 2.74	75.00± 3.89	75.00±2.37	81.00 ± 3.00	78.80 ± 3.31*†
4	45-54	68.00 ± 4.95	67.83 ± 4.45	72.00± 5.17	68.33±4.70	76.17 ± 4.77	73.33 ± 5.55†
5	55-64	66.67 ± 4.18	69.67 ± 4.75	70.71 ± 2.77	73.33 ±3.68 ***	78.00 ± 3.25	75.67±3.02***
6	65 & above	75.67 ± 5.36	76.17 ± 5.68	79.29± 5.81	77.83 ± 7.18	83.71 ± 6.29	82.83 ± 7.86†

Values are Mean ± SE; (Paired t- test:*P<0.05, **P<0.01, ***P<0.001, †P<0.05between 30° and 60°)

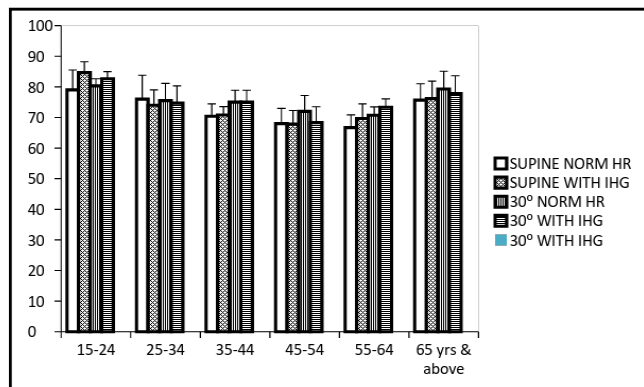


Fig.1.6: Effect of isometric hand grip exercise (IHG) at 20 % of MVC on heart rate in supine position and at 30° HUT in different age groups in non treated hypertensive patients

3.1 Sustained or isometric hand grip test (IHG)

A. Normotensive

In present study initially normal heart rate was recorded before performing IHG exercise in supine position and at 30° and 60° head up tilt. Similarly Isometric hand grip exercise at 20 % of maximum voluntary contraction was performed for two minutes and heart rate was recorded for one minute after end of the exercise. Blood pressure was not recorded, since it might have influenced heart rate (Table 4).

A marginal increase in heart rate was observed before performing isometric hand grip exercise at 30° and 60° head up tilt in all age groups. Similarly heart rate recorded after performing isometric hand grip exercise also recorded increase in all age groups at 30° and 60° head up tilt.

In 15 -24 years age group a significant increase in heart rate after performing isometric handgrip exercise was observed at 30° (*P<0.05) and 60° (**P<0.001) head up tilt as compared to basal heart rate recorded in supine position before performing isometric hand grip exercise. Similarly this increase was significant in 25 -34 years age group at 30° (**P<0.001) and 60° (**P<0.001). However, 45 -54 years age group recorded increase in heart rate at 30° (**P<0.001) head up tilt. Rest of the age groups recorded non-significant increase in heart rate.

B. Treated Hypertensive

Effect of 20 % isometric hand grip test was studied on heart rate in supine position and at 30° and 60° head up tilt. Heart rate recorded after performing isometric hand grip exercise was compared with heart rate recorded before performing isometric hand grip exercise in selected body position. In age group 15–24 years initially recorded increase in heart rate at 30° head up tilt and followed by decrease in heart rate at 60° head up tilt. In 25-34, 35-44 and 55-64 years age group gradual increase in heart rate was recorded at 30° and 60° head up tilt as compared with basal value recorded in supine position. In age group 45-54

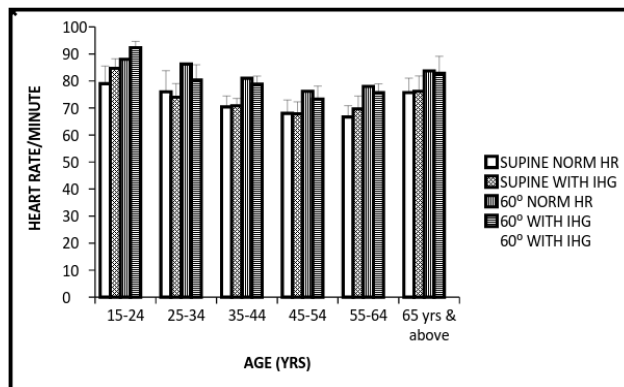


Fig.1.7: Effect of isometric hand grip exercise (IHG) at 20 % of MVC on heart rate in supine position and at 60° HUT in different age groups in non treated hypertensive patients

decrease in heart rate was recorded at 30° head up tilt, similarly a marginal increase in heart rate was recorded at 60° head up tilt. In age group 65 years and above age group initially increase in heart rate was recorded at 30° head up tilt and further decrease in heart rate was recorded at 60° head up tilt as compared with the value recorded in supine position.

In supine position age group 15-24, 55-64 years recorded a marginal increase in heart rate after performing isometric hand grip exercise, while other age groups recorded decrease in heart rate after performing isometric hand grip exercise as compared with heart rate recorded before performing isometric hand grip exercise (Table: 5).

Recorded increase in heart rate after performing isometric hand grip exercise was found within normal physiological limits.

In age group of 15-24, 55-64, 65 years and above increase in heart rate was recorded after performing isometric hand grip exercise in supine position. Rest of the age group recorded decrease in heart rate after performing isometric hand grip exercise as compared to basal value recorded in supine position.

C. Non Treated Hypertensive

Age group 15-24 years recorded increase in heart rate after performing isometric hand grip exercise at 30° head up tilt, however this increase was significant (P<0.001) in the age group of 55-64 years. Rest of the age groups of 25-34, 35-44, 45-54, 65 years and above recorded decrease in heart rate after performing isometric hand grip exercise at same angle of head up tilt.

At 60° head up tilt age group of 15-24 years recorded increase in heart rate after performing isometric hand grip exercise. Further age groups of 25-34, 35 – 44, 45 – 54, 55 – 64, 65 years and above recorded decrease in heart rate after performing isometric hand grip exercise. This decrease in heart rate was found significant in the age group of 35 – 45 (P<0.05) and 55-64 years (P<0.001) (Table 6).

4. Discussion

Isometric hand grip exercise is well suited to investigate short term control of cardiovascular system by the autonomic nervous system at any rate of maximum voluntary contractions (MVC) the static handgrip alters the baroreflex functioning, bringing about marked increases in heart rate and arterial pressure. The cardiovascular response within the first minute is caused in the heart through a rapid parasympathetic withdrawal, without consistent sympathetic activation. On the contrary, a vasodilation occurs in the non exercising forearm at the beginning of isometric exercise, due to cholinergic mechanisms, showing dissociation between sympathetic nerve activity and forearm vascular responses [10].

During isometric exercise, impulses from motor areas of the brain and muscle receptors cause a generalized increase in sympathetic outflow to blood vessels and the heart. These responses are usually studied during isometric handgrip, usually held at 30% of maximal voluntary contraction. During handgrip HR increases first as a result of vagal withdrawal and later due to both vagal withdrawal and sympathetic stimulation [11]. The amplified sympathetic outflow to the heart enhances cardiac contractility [11]. Vasoconstriction occurs in resistance and capacitance vessels, whereas vasodilatation occurs in cutaneous vessels [12]. Cardiac output increases, elevating both systolic and diastolic blood pressure, while the total peripheral resistance remains relatively constant [14]. Levels of plasma noradrenaline and adrenaline increase about twofold and fivefold, respectively [13]. Clinically, the response to isometric exercise issued as a measure of sympathetic integrity. A diminished blood pressure elevation in response to handgrip is considered indicative of sympathetic neuropathy.

Effect of isometric hand grip exercise (IHG) was studied at 20% of maximum voluntary contraction on heart rate in all study groups in supine position and at 30° and 60° head up tilt. Isometric hand grip at higher percentage of maximum voluntary contraction (i.e., 30% or 50%) caused either increase in blood pressure or heart rate, due to dominance of sympathetic activity [15-17] over parasympathetic activity. Maximum voluntary contraction exercise at lower percentage of maximum voluntary contraction is reported to cause decrease in heart rate due to sympathetic withdrawal and parasympathetic or vagal modulation [3].

Various studies have reported, sympathetic activation depends on duration and intensity of the exercise (from 20% to 30% of MVC); do not stimulate sympathetic activity on contrary to high-intensity exercise (i.e., 45 % of MVC) [19-22,17].

In present study IHG exercise affected heart rate in all three study groups at selected body postures. It varied between minimum to maximum range due to IHG exercise indicating maximum and minimum sympathetic stimulation activity as reported by other study [23].

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