# EFFECT OF ISOMETRIC HAND GRIP EXERCISE TRAINING ON CARDIOVASCULAR AND ECHOCARDIOGRAPHIC PARAMETERS AMONG HEALTHY YOUNG MALES

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**ABSTRACT**

Low level of physical fitness and sedentary life style is becoming one of the major risk factor of cardiovascular disease morbidity and mortality. Isometric hand grip exercise (IHG exercise) as a form of static resistance exercise has been shown to lower resting blood pressure and results in favorable cardiovascular remodeling. Still, its effect on cardiovascular, especially echocardiographic parameters has not been widely studied. Hence, the study was planned to evaluate the effect of IHG training of 5 weeks on cardiovascular parameters.

30 apparently healthy males of age group 23.57±1.83 years were included in the study. Relevant medical history and anthropometric variables were taken. They were asked to perform 4 IHG exercise at 30% of MVC for 3min with 5min rest in between for 4 days per week, for a period of 5 weeks. Cardiovascular parameters were recorded at the start, during the training and at the end of the training, while the echocardiographic parameters were recorded before and at the end of training.

Significant decrease was observed in SBP, DBP, MAP, HR, RPP (rate pressure product) both at rest and at 2min of IHG exercise. Heart rate recovery at 1min increased significantly after the training. Echocardiography showed significant increment in interventricular septum thickness, left ventricular posterior wall thickness and left ventricular ejection fraction; and significant decrement in left ventricular end systolic diameter and volume.

The study thus showed that IHG training resulted in positive morphological and functional adaptation of cardiovascular system, resulting decrease in stress on it both at rest and during exercise.

**KEYWORDS**

Isometric Hand Grip training, Cardiovascular system adaptation, Echocardiography.

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**INTRODUCTION:** Physical inactivity and sedentary life style is increasingly becoming the way of life both in developed & developing countries alike. It is a well-known fact that having a low level of physical fitness increases risk of cardiovascular disease morbidity and mortality.(1) Regular exercise and being physically active not only attenuate the risk of hypertension,(2,3) but also reduces the incidence of coronary events by 80%.(4)

Isometric hand grip exercise (IHG) is a form of static resistance exercise. Such exercises are characterized by a change in muscle tension while the muscle length remains constant. They induce different circulatory and metabolic adjustments in the body, depending upon their different types of action. As contrast to isotonic exercises, in isometric exercise, only small groups of muscles remain in contracted state, throughout the exercise, resulting in compression of blood vessels and occlusion of blood flow to the active muscle.(5)

IHG is a very simple form of exercise which requires little adjustment in daily routine & time. This may help to ease some of the barriers to exercise, and increase patient adherence. This form of exercise has been found to result similar reduction in resting arterial blood pressure as that of conventional aerobic therapy,(6) and have beneficial effects, on autonomic nervous system regulation of blood pressure,(7) in improving cerebral haemodynamics(8) and forearm vascular response.(9)

In spite of the above fact, very few studies have been conducted to evaluate the effect of IHG training on cardiovascular system, especially on cardiac morphology & functioning. Hence, the study was planned.

**MATERIALS AND METHODS:** The study was carried out in the Department of Physiology, Himalayan Institute of Medical Sciences, Swami Ram Nagar, Dehradun over a period of 12 months. Study group was recruited from the students, employees of SRHU and residents of Bhaniyawala. Subjects were recruited after taking written and informed consent. A sample size of 30 was obtained using the formula for differences of means at 90% power and α error of 0.05.(10) Following inclusion & exclusion criteria were followed:

i. **Inclusion Criteria:**
- Age group: 20 to 40yrs.
- Sex: Males.
- Non obese (BMI ≤ 30).
- Resting Blood pressure:
  Systolic <120 mm Hg.
  Diastolic <80 mm Hg.

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**ii. Exclusion Criteria:**

- Chronic alcoholic.
- Chronic smoker.
- Patients with history of medication for Diabetes Mellitus (DM).
- Patients with history of any chronic disease.
- History of typical or atypical chest pain.

The study was approved by the ethical committee of the institute.

Subjects were asked to report in the department of physiology at 9:00 am. They were asked to take light breakfast in the morning and avoid tea, coffee, heavy exercise, 2hrs before the reporting time. A structured case reporting form was designed to generate required data. Age (years), sex, height (in cm), body weight (in kg), BMI (in kg/m$^2$), relevant medical history and examination findings were recorded.

**Protocol for Isometric Hand Grip Exercise Training:** The subject was asked to squeeze a hand grip dynamometer (model no.105 INCO) with maximum isometric effort using the dominant hand, and maintained for at least 5 sec, for obtaining maximum voluntary contraction (MVC). MVC was determined as the highest value obtained on three attempts, separated by 1 minute rest periods. Subject was trained to perform sustained handgrip at 30% of MCV for 3 minutes for 4 times, separated by a rest of 5 minute period. He was asked to breathe continuously, during the exercise session. The above protocol was performed for 4 days per week for 5 weeks.[11]

**Cardiovascular Parameters:** On day 0$^{th}$, 8$^{th}$, 22$^{nd}$ and 36$^{th}$ of IHG exercise training following parameters were recorded:

1. In sitting position after 10 min of rest: systolic blood pressure (SBP in mmHg), diastolic blood pressure (DBP in mmHg), mean arterial pressure (MAP in mmHg), pulse pressure (PP in mmHg), heart rate (HR in bpm) and rate pressure product (RPP in mmHg per min).
2. At second min of IHG exercise: systolic blood pressure (SBP2M in mmHg), diastolic blood pressure (DBP2M in mmHg), heart rate (HR2M in bpm) and rate pressure product (RPP2M in mmHg per min).
3. After 1min of IHG exercise: heart rate (in bpm) and heart rate recovery (HRR in bpm).

Rate pressure product was calculated as systolic blood pressure multiplied by heart rate, and heart rate recovery was calculated as heart rate at second minute of exercise minus heart rate after 1 minute of exercise. Blood Pressure Apparatus (model no. EW 254 DC6V) was used.

**Echocardiographic Parameters:** On day 0$^{th}$ and 36$^{th}$ of IHG exercise training following parameters were recorded: resting Left atrium size (LA in cm), left ventricular end diastolic volume (LVED in ml), left ventricular end systolic volume (LVES in ml), left ventricular end diastolic diameter (EDD in cm), left ventricular end systolic diameter (ESD in cm), inter ventricular septum (IVS in cm), left ventricular ejection fraction (LVEF in %) and left ventricular post wall thickness (LVPW in cm). Echocardiograph (Model Philips HD11XE SNo.US 11270001) was used.

**Data Management and Statistical Analysis:** SPSS (Statistical Package for Social Science) version 20 software was used for data analysis. Standard descriptive statistics were determined. Repeated measure ANOVA with Bonferroni post hoc test was used to show the effect of training on cardiovascular parameters. Paired t test was used for the echocardiographic parameters comparison between the 0$^{th}$ day and the 36$^{th}$ day. The level of Significance was set at $P<0.05$.

**RESULTS:** The baseline (day 0$^{th}$) cardiovascular, and echocardiographic parameters are shown in table 1 & 2.

IHG exercise training of 5 weeks resulted in statistically very highly significant decrease in resting systolic blood, resting diastolic blood pressure, resting MAP, resting heart rate, and resting rate pressure product. However, resting pulse pressure increased, but was statistically insignificant (Table 3).

IHG exercise training of 5 weeks resulted in statistically very highly significant decrease in SBP at 2$^{nd}$ min of exercise, DBP at 2$^{nd}$ min of exercise, heart rate at 2$^{nd}$ min of exercise, RPP at 2$^{nd}$ min of exercise and heart rate after 1 min of exercise. There was very highly significant increase in heart rate recovery (Table 4).

IHG exercise training of 5 weeks resulted in statistically significant increase in interventricular septum thickness, highly significant increase in left ventricular posterior wall thickness and very highly significant increase in left ventricular ejection fraction. There was statistically very highly significant decrease in left ventricular end systolic diameter and left ventricular end systolic volume. Increase in left atrial size, left ventricular end diastolic diameter and left ventricular end diastolic volume was statistically insignificant (Table 5).

**DISCUSSION:** IHG exercise training resulted in statistically significant decrease in resting systolic blood pressure, resting diastolic blood pressure, resting MAP, resting heart rate, and resting rate pressure product. However, resting pulse pressure increased which was statistically insignificant (Table 3). The above findings were in agreement with earlier studies which reported significant decrease in resting systolic blood pressure, resting diastolic blood pressure, resting mean arterial pressure, resting heart rate and resting RPP after isometric exercise training in normotensive individuals.[12,13] One study even reported significant reduction in SBP, DBP and MAP after only 4 weeks of Isometric exercise training.[14] Ray CA and Carrasco DI on the other hand, noted significant decrease in resting diastolic and mean arterial pressure, but no change in resting systolic and resting heart rate after 5 weeks of isometric handgrip exercise training.[11] Significant reduction in resting rate pressure product as a result of strength training had also been reported.[15] Rate pressure product can be even lower following submaximal isometric handgrip training as compared to submaximal isotonic treadmill exercise in normotensive individuals.[16]

The IHG exercise training induced reduction in resting heart rate and resting blood pressure, may be due to increased parasympathetic activity and decreased sympathetic activity,[17] or increase in the activity of both the autonomic branches.[18] Training causes increase in eNOS (endothelium nitric oxide synthase) gene transcription, eNOS mRNA stability and eNOS protein translation, resulting in increased nitric oxide formation from its precursor L-arginine, which may be due to repetitive episodic increases in endothelial cells shear stress.[19] Training also results in decreased sensitivity to the vasoconstrictor effects of norepinephrine, possibly due to an endothelium-dependent mechanism involving alpha 2-adrenergic receptors.[20] This results in arteriole smooth muscle relaxation and vasodilatation, leading to reduction of total peripheral resistance. The decrease in total peripheral resistance may also be due to less vascular occlusion during muscular contraction, resulting from resistance training induced increase in maximal strength and hence decrease in percentage of maximal voluntary contraction necessary to obtain a sub-maximal absolute force or workload.[21]

The reduction in rate pressure product may be due in part to training induced reduction in total peripheral resistance and hence reduced after load [22]. Reduction in myocardial wall tension is another reason for decline in rate pressure product.[22] Resistance training induced significant increase in left ventricular posterior wall thickness with non-significant changes in left ventricular chamber size, end-diastolic diameter and volume. According to Laplace's law, represented by the formula T= P x R/Wt, where T is myocardial wall tension, P is pressure, R is chamber radius or diameter/2 and Wt is wall thickness, increase in left ventricular left ventricular posterior wall thickness will lead to reduction in myocardial wall tension.[23]

IHG exercise training of 5 weeks resulted in statistically very highly significant decrease in SBP at 2$^{nd}$ min of exercise, DBP at 2$^{nd}$ min of exercise, heart rate at 2$^{nd}$ min of exercise, RPP at 2$^{nd}$ min of exercise and heart rate after 1 min of exercise. There was very highly significant increase in heart rate recovery (Table 4). The attenuated response in heart rate, systolic blood pressure, diastolic blood pressure, MAP to isometric hand grip strength exercise in trained normotensive individuals was also reported by Girish Babu M and Manjunath ML.[24] Others studies also reported decrease in heart rate for a given submaximal workload in strength trained normotensive individuals.[25] The acute blood pressure response to exercise and rate pressure product were reported to have been decreased after training among normotensives.[23] Many studies also reported increase in HRR after resistance training, indicating an enhanced ability for faster cardiovascular recovery.[26]

The reduction in heart rate and blood pressure response during IHG exercise as a result of the 5 weeks IHG exercise training is a positive adaptation, indicating low stress on cardiovascular system.[27] The decreased blood pressure response to IHG exercise with training may also suggest decrease in sympathetic activity, as BP response to handgrip exercise is an important sympathetic function test.[28] The significantly higher HRR after IHG exercise training also indicates reduction in sympathetic activity or an increase in vagal activity.[29]

IHG exercise training of 5 weeks resulted in statistically significant increase in interventricular septum thickness, highly significant increase in left ventricular posterior wall thickness and very highly significant increase in left ventricular ejection fraction. There was statistically very highly significant decrease in left ventricular end systolic diameter and highly significant decrease in left ventricular end systolic volume. However, statistically insignificant increase was observed in case of left atrial size, left ventricular end diastolic diameter and left ventricular end diastolic volume (Table 5). The increase in interventricular septum and left ventricular posterior wall thickness has been reported earlier after isometric or static exercise training or in static exercise trained individuals.[30] Toufan M et al reported that isometric exercise training reduced left ventricular end-systolic diameter.[31] The training induced improvement in left ventricular ejection fraction, and hence left ventricular systolic function has also been reported earlier.[22,32]

The significant increase in interventricular septum and very highly significant increase in left ventricular posterior wall thickness after the training might indicate increase in cardiac mass.[22] The overloading and stretching of myocardium due to exercise leads to higher rates of protein synthesis leading to hypertrophy.[33] Pressure overload resulting from the intermittent rise in blood pressure and intrathoracic pressure occurring primarily during resistance training leads to an increase in number of sarcomeres (working in parallel) resulting in concentric hypertrophy.[34]

It is to be noted that the increase in left ventricular thickness and hence possibly mass was not associated with decrease in end-diastolic diameters or volumes (Table 5), unlike in cases of pathological pressure overload conditions caused by hypertension or cardiac hypertrophy in various forms of cardiomyopathy.[35]

The improvement in left ventricular systolic function as a result of the IHG exercise training might be due to increase in left ventricular contractility. This improvement in cardiac contractility was indicated by the very highly significant decrease in left ventricular end-systolic diameter and volume with insignificant increase in end-diastolic diameter and volume (Table 5), as reported earlier.[36] The enhanced cardiac contractility may in turn be due to the improvement of intrinsic contractile properties of cardiac muscles and increased response to inotropic stimulation, which may be partly due to increase sensitivity of cardiac myocytes to calcium when stretched.[33] Future studies with larger sample size and longer duration are warranted to examine the long-term safety and efficacy of isometric hand grip exercise training on cardiovascular functions.

**CONCLUSION:** Isometric Hand Grip exercise training of 5 weeks resulted in improvement of the cardiovascular parameters, including rate pressure product during exercise and at rest, indicating a decrease in cardiovascular stress.
The post training echocardiographic analysis also revealed positive cardiac morphological and functional adaptation. There was increase in both systolic and diastolic cardiac function.

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| Sl. No. | Parameters | Mean±SD |
|---|---|---|
| 1 | Age (years) | 23.57±1.83 |
| 2 | Height (cm) | 170.93±5.45 |
| 3 | Weight (Kg) | 70.00±4.92 |
| 4 | BMI (Kg/m$^2$) | 23.97±0.39 |
| 5 | Resting SBP (mmHg) | 108.97±7.29 |
| 6 | Resting DBP (mmHg) | 69.03±5.99 |
| 7 | Resting MAP (mmHg) | 82.34±6.01 |
| 8 | Resting Pulse Pressure (mmHg) | 39.93±5.03 |
| 9 | Resting Heart rate (beats per min) | 73.00±2.99 |
| 10 | Resting Rate Pressure Product (mmHg per min) | 7950.43± 569.89 |

***Table 1: Baseline anthropometric and cardiovascular parameters of the subjects (n=30)***

| Sl. No. | Parameters | Mean±SD |
|---|---|---|
| 1 | Left atrial size (cm) | 3.05±0.34 |
| 2 | Interventricular septum Thickness (cm) | 0.79±0.06 |
| 3 | Left ventricular post.wall thickness (cm) | 0.82±0.08 |
| 4 | Left ventricular end diastolic diameter (cm) | 4.50±0.37 |
| 5 | Left ventricular end diastolic volume (ml) | 106.97±7.55 |
| 6 | Left ventricular end systolic diameter (cm) | 2.86±0.18 |
| 7 | Left ventricular end systolic volume (ml) | 40.82±3.31 |
| 8 | Left ventricular ejection fraction (%) | 61.79±2.51 |

***Table 2: Echocardiographic parameters of the subjects at day 0 (n=30)***

| Sl. No. | Parameters | 0$^{th}$ Day (Mean±SD) | 8$^{th}$ Day (Mean± SD) | 22$^{nd}$ Day (Mean±SD) | 36$^{th}$ Day (Mean±SD) | p-value |
|---|---|---|---|---|---|---|
| 1 | Resting SBP (mmHg) | 108.97± 7.29 (98-122) | 107.43±6.86 (98-120)** | 106.40±7.36 (97-118)***# | 105.73±6.83 (96-118)***###^ | 0.001 |
| 2 | Resting DBP (mmHg) | 69.03±5.99 (58-82) | 67.43±6.19 (56-80)*** | 66.20±6.49 (53-78)***### | 65.00±6.74 (50-78) ***###^^^ | 0.001 |
| 3 | Resting MAP (mmHg) | 82.34 ± 6.01 (74-95) | 80.77±6.02 (71-93)*** | 79.59±6.26 (70-91)***### | 78.38±6.48 (67-91)***###^^ | 0.001 |
| 4 | Resting Pulse Pressure (mmHg) | 39.93±5.02 (31-52) | 40.03±4.90 (32-50) | 40.20±5.61 (32-51) | 40.67±5.79 (33-55) | 0.220 |
| 5 | Resting Heart Rate (beats per min) | 73.00±2.99 (68-79) | 72.07±3.31 (66-78)*** | 71.50±2.98 (66-78)*** | 70.77±3.16 (66-77) ***###^^ | 0.001 |
| 6 | Resting Rate Pressure Product (mmHg per min) | 7950.43±569.89 (7100-9360) | 7740.47±584.14 (6860-8968)*** | 7605.30±581.13 (6600-8658)***## | 7481.00±566.86 (6566-8468) ***###^^ | 0.001 |

***Table 3: Effect of duration of isometric exercise training on resting blood pressure, heart rate and rate pressure product among the subjects (n=30)***

$p<0.05$ - significant, $p<0.01$- highly significant, $p<0.001$ very highly significant.
Repeated measure ANOVA with Bonferroni post hoc test. *Comparison with 0$^{th}$ day, # with 8$^{th}$ day and ^ with 22$^{nd}$ day.
1 to 3 symbols indicate 'significant to very highly significant' difference.

| Sl. No. | Parameters | 0th Day (Mean±SD) | 8th Day (Mean±SD) | 22nd Day (Mean±SD) | 36th Day (Mean±SD) | p-value |
|---|---|---|---|---|---|---|
| 1 | SBP at 2nd min of exercise (mmHg) | 132.60±7.51 (110-158) | 130.20±8.27 (108-157)*** | 129.30±7.65 (106-150)*** | 127.93±7.31 (104-146) ***###^^^ | 0.001 |
| 2 | DBP at 2nd min of exercise (mmHg) | 89.60±7.55 (70-116) | 86.83±7.92 (67-113)*** | 84.53±7.18 (65-100)***### | 82.80±6.80 (65-96) ***###^^^ | 0.001 |
| 3 | Heart rate at 2nd min of exercise (beats per min) | 100.70±3.43 (90-106) | 98.47±3.79 (88-104)*** | 96.37±4.25 (87-102)***## | 95.27±3.86 (87-101) ***###^^ | 0.001 |
| 4 | RPP at 2nd min of exercise (mmHg per min) | 13356.13±919.66 (10780-15800) | 12828.37±1043.09 (10384-15543)*** | 12464.37±969.74 (10176-14400) ***## | 12193.90±931.97 (9880-14016) ***###^^^ | 0.001 |
| 5 | Heart rate after 1 min of exercise (beats per min) | 90.07±3.53 (80-96) | 86.73±3.79 (76-93)*** | 83.56±4.08 (74-89)***### | 81.37±3.77 (74-87) ***###^^^ | 0.001 |
| 6 | Heart Rate Recovery (beats per min) | 10.57±2.27 (8-20) | 11.73±1.93 (10-20)*** | 12.80±1.29 (11-18)***### | 13.90±1.71 (12-22) ***###^^^ | 0.001 |

***Table 4: Effect of duration of isometric exercise training on blood pressure at 2nd min. of exercise, heart rate at 2nd min. of exercise, rate pressure product at 2nd min. of exercise; and heart rate recovery among the subjects (n=30)***

$p<0.05$ - significant, $p<0.01$- highly significant, $p<0.001$ very highly significant. Repeated measure ANOVA with Bonferroni post hoc test. *Comparison with 0th day, # with 8th day and ^with 22nd day. 1to3symbols indicate 'significant to very highly significant' difference.

| Sl. No. | Parameters | 0 Day (Mean±SD) | 36 Day (Mean±SD) | p-value |
|---|---|---|---|---|
| 1 | Left atrial size (cm) | 3.047±0.340 | 3.053±0.339 | 0.161 |
| 2 | Interventricular septum thickness (cm) | 0.79±0.06 | 0.80±0.06 | 0.023 |
| 3 | Left ventricular post. wall thickness (cm) | 0.82±0.08 | 0.86±0.09 | 0.001 |
| 4 | Left ventricular end diastolic diameter (cm) | 4.50±0.37 | 4.51±0.37 | 0.083 |
| 5 | Left ventricular end diastolic volume (ml) | 106.98±7.55 | 107.14±7.74 | 0.169 |
| 6 | Left ventricular end systolic diameter (cm) | 2.96±0.18 | 2.81±0.19 | 0.01 |
| 7 | Left ventricular end systolic volume (ml) | 42.82±3.31 | 40.56±3.39 | 0.001 |
| 8 | Left ventricular ejection fraction (%) | 62.79±2.51 | 65.10±2.54 | 0.001 |

***Table 5: Effect of isometric exercise training on cardiac functions assessed by echocardiography among the subjects (n=30)***

$p>0.05$ -non significant, $p<0.05$ – significant, $p<0.01$- highly significant, $p<0.001$- very highly significant. Paired t test.

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