

EFFECT OF AGE ON ACUTE CARDIOVASCULAR RESPONSES TO ISOMETRIC HANDGRIP EXERCISE

Randeep Maan¹, Vidushi Gupta², Hemlata Badyal²

¹ Department of Physiology, Indira Gandhi Medical College & Hospital, Shimla, Himachal Pradesh, India

² Department of Physiology, Dayanand Medical College & Hospital, Ludhiana, Punjab, India

Correspondence to: Randeep Maan (mangat_babbu@yahoo.com)

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ABSTRACT

Background: Many positive physiological adaptations occur in older persons as a result of resistance exercise. Physical changes, such as muscle hypertrophy, decreased adiposity, and enhanced muscular strength, have been reported in several studies. These adaptations have the cumulative effect of increasing quality of life while slowing some age related processes.

Aims & Objective: The purpose of this study was to compare the acute cardiovascular responses of healthy young and older adults to resistance exercise.

Materials and Methods: In the present study eighty healthy normotensive volunteers were recruited and divided into two groups. Group I & II included males in age group of 20-40 years and more than 40-60 years respectively. All the subjects performed IHG exercise. Their HR and BP were recorded prior to and after one minute of 40% maximum voluntary contraction of the forearm. All the recordings were compared within groups and between groups. Results were analyzed using software STATA 10.

Results: At rest & with exercise we found higher level of SBP ($p=0.00$) in older males whereas younger males had higher HR ($p=0.00$). There was no significant difference in DBP. From BP and HR responses, it is clear that greater mean SBP in older age is equally offset by lower heart rates, reflecting no effect of age on workload of heart.

Conclusion: This study indicates that the pressor response is well regulated in both age groups. This supports the inclusion of resistance exercise as part of an overall fitness program designed for healthy older adults.

Key Words: Blood Pressure (BP); Systolic Blood Pressure (SBP); Diastolic Blood Pressure (DBP); Electrocardiograph (ECG); Isometric Handgrip (IHG); Handgrip Dynamometer (HGD); Heart Rate (HR)

Introduction

Many positive physiological adaptations occur in older persons as a result of resistance exercise. Physical changes, such as muscle hypertrophy, decreased adiposity, and enhanced muscular strength, have been reported in several studies. These adaptations have the cumulative effect of increasing quality of life while slowing some age related processes.

Static or resistance exercise involves contraction of skeletal muscle without a change in muscle length, hence also known as isometric exercise (iso = same; meter = length). Static exercise produces a cardiovascular response that differs significantly from that observed during dynamic exercise. There are (at least) two neural systems at work when muscles are exercised. The first is central command located in higher centers in the brain. It monitors the nerve signals sent to the muscles and responds by stimulating areas in the brainstem responsible for HR and strength of contraction. The second is feedback systems that detects work in the muscle by monitoring contraction and build-up of cellular metabolites. It then signals the brainstem to increase CO to compensate for increased muscular activity.^{1,2}

During resistance exercise, a number of physiological changes occur in the heart rate, blood pressure, metabolic rate, hormone secretion, nerve conductivity, muscle activity, and respiration. These distinctive acute responses are influenced by numerous factors, including active muscle mass, relative intensity of the exercise, number of repetitions, type of exercise (isometric, isotonic, or isokinetic), duration of exercise, use of rest periods between exercises, and the intermittent nature of the exercise performance. Cardiac output increases during static contractions owing to an increase in heart rate, with the magnitude of the increase dependent upon the intensity of exercise. Stroke volume remains relatively constant during low-intensity contractions and decreases during high-intensity contractions. The magnitude and the rate of the increase in heart rate depend on the intensity of contraction. Static exercise is characterized by a disproportionate rise in SBP, DBP and mean BP. Thus a significant pressure load is imposed on the heart, presumably to increase perfusion to active muscles.^{1,2}

Until recently, resistance exercise in the older population had been considered risky, in part because of exaggerated responses secondary to the placement of

large demands on the cardiovascular system. However, limited research has been completed that compares the acute cardiovascular responses to resistance exercise of younger and older adults. Although a large number of studies have been conducted using isometric exercise, limited research has been completed that compares the acute cardiovascular responses to resistance exercise of younger and older adults.

In our study we set to confirm & compare the acute cardiovascular responses to isometric exercise in the subjects of younger and older age group. And find out whether physical activity in form of resistance exercise is positively associated with CVS responses in both the age groups.

Materials and Methods

The present Study was conducted on 80 healthy volunteers (40 younger adults (20-40 years) and 40 older males (>40-60 years). BP and HR was measured in all the subjects before and within one minute of completion of IHG exercise. Blood pressure was recorded with standard mercury sphygmomanometer^[3,4]; measurement of HR was done using lead II of Cardiofax Electrocardiograph (ECG) machine (Medicaid systems).

Selection of Subjects

The subjects were recruited for study purely on voluntary basis from Dayanand Medical College and Hospital, Ludhiana. Each of the subjects was briefed about the study and was asked whether they would participate. Those who agreed signed a written informed consent and their detailed medical and related history along with general examination was undertaken. Those subjects who fulfilled the inclusion criteria were enrolled for the study.

Inclusion Criteria: (i) Age group between 20-60 years; (ii) Heart rate (60—100 beats/min); (iii) Blood pressure (\leq 120/80 mm of Hg)

Exclusion Criteria: (i) Hypertensive; (ii) Diabetic; (iii) Smokers; (iv) Alcoholic; (v) Subjects who had participated in any isometric training within one month from the onset of study

The subjects were screened for inclusion into the study. Two measurements of HR and BP were taken per week for two weeks. The average of four readings was taken as

the resting parameters. The subjects who did not meet the above requirements or had any history of the following were excluded.

After all the requirements were fulfilled, eighty subjects were shortlisted and divided into two groups of forty each: (i) Group I: included males in the age group 20-40 years; (ii) Group II: included males in the age group > 40-60 years.

BP was measured in non-dominant arm in seated position after at least ten minutes of rest, before the start of exercise and within one minute of exercise completion. Subjects were labelled as normotensive, if their resting SBP was \leq 120 mm Hg and resting DBP was \leq 80 mm Hg.^[4] SBP was taken as korotkoff phase I (appearance of sound) and DBP was taken as korotkoff phase V (disappearance of sound).^[5] HR was calculated from RR interval by continuous recording of lead II on ECG machine (Cardiofax Medicaid Ambala). Speed of ECG paper was 25 mm/sec. Heart rate was calculated as follows: Heart rate = $(60 \times 25)/RR = 1500/RR$

Subjects were explained about the use of the handgrip dynamometer (HGD) prior to beginning of isometric exercise. They were also trained to maintain an effort that would enable them to hold a steady tracking on the pointer of the dynamometer at 40% of their maximum voluntary contraction (MVC). MVC was calculated for each subject. To determine the maximum force (MVC) that the subject can exert with their dominant hand, the subject was asked to exert a maximal effort for less than 2 seconds on HGD. After three minutes rest, another effort was made. After three maximal effort recordings, the greater of three was taken as MVC.^[6]

After measuring resting HR and BP the subjects were asked to exert force on the HGD approximately 40% of their MVC (maximum voluntary contraction) with dominant hand and sustain it for a minimum period of 2 minutes till fatigue (not more than 4 minutes if fatigue does not sets in). BP and HR were measured after completion of IHG exercise. The results were compared within and between groups for changes in HR and BP in response to IHG exercise.

Statistical Analysis

Data collected on various variables was analyzed statistically. Mean and standard deviation (SD) was computed. Unpaired 't' test was applied to compare the

means in different groups and paired 't' test to compare the differences between the means within groups before and after exercise. Data was analyzed using Stata 10 (general purpose statistical software package) software.

Results

In the present study, the acute effects of IHG exercise on HR and BP in normotensive healthy volunteers have been studied. With exercise both groups show significant increase in SBP, DBP and HR.

Table-1: Changes in parameters after exercise in subjects in 20-40 years of age

Parameters	Before Exercise		After Exercise		Paired t-value	p-value
	Mean	SD	Mean	SD		
SBP (mmHg)	108.6	7.380	115.60	9.750	5.030	0.000**
DBP (mmHg)	77.45	8.570	80.80	9.540	3.890	0.000**
HR (/min)	80.2	11.510	88.92	10.860	6.780	0.000**
RR (/min)	0.751	0.137	0.68	0.107	4.880	0.000**

p value 0.05 significant (*), highly significant (**). There was statistically significant increase in mean values of SBP (p=0.000), DBP (0.000) and HR (p=0.000) after handgrip exercise in young adults.

Table-2: Changes in parameters after exercise in subjects in > 40-60 years

Parameters	Before Exercise		After Exercise		Paired t-value	p-value
	Mean	SD	Mean	SD		
SBP (mmHg)	117.5	5.430	126.00	7.560	9.030	0.000**
DBP (mmHg)	80.65	8.500	85.70	7.470	6.786	0.000**
HR (/min)	72.95	9.580	78.25	7.880	4.080	0.000**
RR (/min)	0.822	0.114	0.77	0.140	2.380	0.022

p value 0.05 significant (*), highly significant (**). There was statistically significant increase in mean values of SBP (p=0.000), DBP (0.000) and HR (p=0.000) after handgrip exercise in older adults.

Table-3: Comparison of different parameters before exercise among young and older adults

Parameters	Before Exercise				Unpaired t-value	p-value
	20-40 years		40-60 years			
	Mean	SD	Mean	SD		
SBP (mmHg)	108.6	7.380	117.5	5.430	6.130	0.000**
DBP (mmHg)	77.45	8.570	80.65	8.500	1.670	0.097
HR (/min)	80.2	11.510	72.95	9.580	3.060	0.003**
RR (/min)	0.751	0.137	0.822	0.114	2.550	0.013

p value 0.05 significant (*), highly significant (**). Before exercise the resting SBP (0.000) was significantly higher in older adults of 40-60 years age group. The baseline values of DBP (0.097) were insignificant statistically. Baseline HR (0.003) was significantly lower in older adults.

Table-4: Comparison of different parameters after exercise among young and older adults

Parameters	After Exercise				Unpaired t-value	p-value
	20-40 years		40-60 years			
	Mean	SD	Mean	SD		
SBP (mmHg)	115.60	9.750	126.00	7.560	5.320	0.000**
DBP (mmHg)	80.80	9.540	85.70	7.470	2.540	0.012
HR (/min)	88.92	10.860	78.25	7.880	5.070	0.000**
RR (/min)	0.68	0.107	0.77	0.140	3.210	0.002**

p value 0.05 significant (*), highly significant (**). After exercise the SBP (0.000) was significantly higher in older adults of 40-60 years age group. HR (0.000) was found to be significantly lower in older adults.

Comparison between the groups shows that before exercise the resting SBP (p=0.000) was significantly higher in older adults of 40-60 years age group. The

baseline values of DBP (p=0.097) were insignificant statistically. Baseline HR (p=0.003) was significantly lower in older adults (Table 3). After exercise the SBP (p=0.000) was found to be significantly higher and HR (p=0.000) was found to be significantly lower in older adults (Table 4).

With isometric exercise there was rise in SBP in both groups, (Table 4) with older males showing significantly higher SBP values (p=0.000) as compared to younger age group. Resting & post exercise DBP was comparable in subjects of both age groups. Table 3 shows baseline HR response comparison between subjects of younger sex, with younger adults having significantly higher resting HR (p=0.003). As shown in Table 4, there was increase in HR after exercise in subjects of both groups, but younger males had greater response (p=0.000). Hence in present study we found greater BP response in older males and higher HR response in younger males.

Discussion

Regular physical activity and high fitness level are associated with reduced risk of premature death from any cause and from cardiovascular disease in particular among asymptomatic men and women, with the benefits extending to even patients with established cardiovascular disease.^[7] Earlier exercise programs emphasized on dynamic exercise, but research increasingly suggests that static exercise when appropriately prescribed has favourable effects not only on muscular strength and endurance but also on cardiovascular function, metabolism, coronary risk factors, psychosocial well-being and bone mineral density especially important in elderly for maintaining functional independence.^[8]

In the present study, the acute effects of IHG exercise on HR and BP in normotensive healthy volunteers have been studied. Eighty healthy normotensive volunteers were recruited and divided into two groups. Subjects in group I and group II included males in age group of 20-40 years and more than 40-60 years respectively. All the subjects performed IHG exercise. Their HR and BP were recorded prior to exercise and within one minute of cessation of exercise. All the recordings were compared within groups and between groups before and after exercise, with age.

Age and Blood Pressure Response

In the present study, the resting SBP was found to be

significantly higher in older adults ($p=0.000$) as compared to younger subjects as shown in Table 3. The higher resting SBP in old age is attributed to increased stiffness and decreased elasticity of arterial tree.^[8] After exercise the BP response showed greater increase in SBP in older adults ($p=0.000$) as compared to younger subjects (Table 4). But if expressed as percentage above baseline, this difference between the groups disappeared. So the elevation in older subjects may be attributed to differences in resting SBP and not to changes induced by resistance exercise. A greater SBP response to IHG exercise was seen in older individuals as compared to younger individuals in studies conducted by Petrofsky JS, Van Loan MD and Smolander J et al.^[9] However, most recent studies show that the SBP response to exercise is not affected by age as found in our study as well.^[10]

The resting DBP was significantly higher ($p=0.000$) in older adults (Tables 1 & 2). After exercise there was increase in DBP in young as well as old subjects with higher rise in older age groups. The higher rise in BP in older age group could be due to greater increase in peripheral vascular resistance as compared to younger individuals.^[11] There is disagreement about the DBP response to resistance exercise; some authors report an increase and others report no change.^[12] These discrepancies may reflect differences in measurement techniques like auscultation, intra-arterial assessment and timing of the measurement.

Age and Heart Rate Response

In the present study, younger adults had significantly higher ($p=0.003$) baseline HR than older adults (Table 3). Table 4 shows HR response after exercise. Both the groups responded with increase in HR, with significantly higher response in younger adults ($p=0.000$) as compared to older age group.

The resting values of HR were lower in older adults due to decrease in atrial pacemaker cells with age leading to reduced intrinsic HR.^[13] Although HR increased with isometric exercise in individuals of all decades, greatest increase was found in youngest decade. The resting cardiac vagal tone declines with age^[14] and cardiac vagal withdrawal is the key autonomic mechanism for the exercise-induced tachycardia, thus the HR response to isometric exercise in older humans is restricted by an inability to reduce vagal outflow below already reduced levels (blunted tachycardia response seen in older

adults). As in our study many studies observed smaller increase in HR response to exercise with age.^[15] From BP and HR responses, it is clear that greater mean SBP in older age is equally offset by lower heart rates, reflecting no effect of age on workload of heart.

Hence in the present study we found that resistance exercise elicits similar responses in healthy young and older populations. There was no exaggerated response seen in older population otherwise which could have placed large demands on cardiovascular system. Along with favourable effects on cardiovascular system resistance exercise prevents loss of bone mineral density enhancing musculoskeletal fitness. Since the fastest growing segment of the population consists of those over 65 years of age^[14], it can be prescribed to older adults, promoting independence and helping in prevention of falls. Resistance exercise is an effective method to improve muscle strength and endurance, modify coronary risk factors, and enhance psychosocial well-being in people of all ages.

Conclusion

In the present study the effect of age and sex on cardiovascular response to isometric handgrip exercise was studied. The effect of exercise with age showed increase in SBP, DBP and HR in all the groups, with significantly higher HR response in younger age group and higher BP response in older adults. The less increase in HR in older adults was due to lesser vagal withdrawal as compared to younger subjects. Greater pressor response in older adults is attributed to age related changes in vessel wall and increased peripheral resistance response in response to exercise.

Since cardiovascular response to exercise is major criterion in exercise prescription, resistance exercise can be added as a part of regular physical activity program. This can help to decrease the risk of chronic diseases and improve the quality of life of people of all age groups, especially helping older adults to improve and maintain their health and independent lifestyle.

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