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Original Article

Isometric exercise and its effect on blood pressure and heart rate; a comparative study between healthy, young, and elderly males in and around Raichur city

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Abstract

Introduction: Isometric exercise is a routine part of everyday activities and occupational tasks. Physicians have a responsibility to promote regular physical activity to reduce high blood pressure (BP) and to control weight as physical inactivity is considered as a risk factor for coronary artery disease. Isometric exercises for aging populations have often been discouraged due to harmful effects on the cardiovascular system. However, isometric exercise in older adults and patients of some age group has found to be beneficial for maintaining normal cardiovascular function, but still, controversies are there. The cardiovascular response to isometric exercise has been studied majorly in young adult males. The vascular wall becomes less elastic and stiffer with the advancement of age (Nichols et al., 1985; O'Rourke, 1990; and Cheitlin, 2003). There are very few studies that have compared the isometric exercise response in younger and elderly individuals.

Purpose of the Study: The present study is done to determine the effect of isometric exercise on BP and heart rate (HR) in healthy, young, and elderly males.

Materials and Methods: In the present study, 100 male subjects with age group of 20–30 years and 60–70 years satisfying the inclusion criteria were selected and divided into two groups, namely, young and elderly group, respectively. Resting HR and BP were recorded followed by HR and BP responses to isometric exercise in both the groups. Isometric contraction was held till 60 s using the force transducer at 40% of the maximal voluntary contraction. Pre and post HR and BP were compared.

Results: The elder subjects had a lower HR and a higher BP response than their younger counterparts.

Conclusion: From this study, it is concluded that the increasing age is associated with an altered HR and BP response to isometric exercise.

Key words: Blood pressure response to aging, Heart rate response to aging, Maximum voluntary contraction

INTRODUCTION

The cardiovascular system plays an important role to maintain the homeostasis and to provide nutrients and oxygen to the muscles so that high-energy output can be maintained for a long period of time and the by-products of metabolism are removed rapidly from the site of energy release.

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Isometric exercise produces a significant increase in blood pressure (BP), which is important in maintaining perfusion of muscle during sustained contraction. This response is brought about by the combined efforts of central and peripheral afferent input to medullary cardiovascular centers. In normal individuals, the increase in BP is due to increase in cardiac output with little or no change in systemic vascular resistance.[1]

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With lifestyle changes and modernization, cardiovascular system is more severely affected. The American Heart Association considers ischemic (coronary) heart diseases, hypertensive diseases, rheumatic fever/rheumatic heart diseases, and cerebrovascular diseases (stroke) to be major cardiovascular diseases. The WHO estimates that by 2020 cardiovascular diseases will account for up to 40% of all deaths worldwide.[2] Taking this into consideration, the cardiac rehabilitation has gained its importance.

With aging, there are changes taking place in the cardiovascular system, which result in alterations in cardiovascular physiology. The changes occurring with age differ from person to person with varying rates. The changes associated with aging in the cardiovascular system include a decrease in elasticity and an increase in stiffness of the arterial system. Which leads to increased afterload on the left ventricle, an increase in systolic BP (SBP), left ventricular hypertrophy, and other changes in the left ventricular wall that prolong relaxation of the left ventricle in diastole. There is decrease in intrinsic heart rate (HR) due to dropout of atrial pacemaker cells.[3,4]

In the present study, an effort was made to know effects of isometric contraction in young and elderly normal individuals and also to know whether isometric exercise can be included in elderly normal individual's fitness and cardiac rehabilitation program.

MATERIALS AND METHODS

The study was conducted in the Department of Physiology after taking approval from the Ethical Clearance Committee, Navodaya Medical College.

A total of 100 male subjects from in and around Raichur city were selected and divided into two groups, namely, young and elderly groups with age group of 20–30 years and 60–70 years, respectively.

The inclusion criteria were normotensive males in the above age groups, and exclusion criteria included subjects with chronic history of alcohol, smoking, resting tachycardia (>120 beats per min), hypertension, history of any other cardiovascular disorders, any peripheral vascular disease, those on regular exercise program, and uncooperative subjects.

During the first sitting, the anthropometric parameters and body mass index were recorded. Then, during the second sitting, the subject was asked to relax in supine position for 30 min in the laboratory. Both the groups received isometric exercise for forearm. Pre-exercise evaluation was done for HR and BP and the results were recorded. HR was measured in supine position on a couch using electrocardiography (ECG) leads that were connected using electrodes from the subject to the Bio Amp/Stimulator of PowerLab 8/30 series instrument [Figure 1]. The resting HR was recorded using RR interval in the computerized ECG from lead two of 5 min. BP was measured with digital electronic BP monitor in supine position after a period of rest for 5 min. Isometric contraction was performed by dominant hand by a hand-held force transducer in the seated position, with the arm at approximately 30° of abduction, with the elbow flexed 90° [Figure 2]. The forearm was in neutral pronation/supination. Subjects underwent several preliminary sessions during which they were taught and carefully trained to perform maximum voluntary contraction (MVC) of forearm. MVC was determined as the highest force developed by the subject in previous 5 s maximal contraction trials. Subjects were instructed to breathe normally and avoid holding breath. Each subject gripped force transducer at 40% MVC with the dominant hand for 60 s. Post-exercise HR and BP were taken in supine position and recorded.

Figure 1: Recording of heart rate and blood pressure

Figure 2: Recording of isometric contraction by force transducer

RESULTS

The Statistical software SPSS 11.0 was used and all the data were expressed as mean ± SD, analyzed statistically using paired *t*-test and unpaired *t*-test, and $P < 0.05$ was considered statistically significant and $P < 0.01$ as statistically highly significant.

Results within the group comparison showed a significant increase in HR and BP after 60 s of 40% MVC. Among young subjects, mean pre-SBP was 120.88 ± 9.59, and in post-exercise, it was 125.56 ± 10.39 as shown in Table 1, in elderly subjects, mean pre-SBP was 132.20 ± 4.86, and in post-exercise, it was 142.44 ± 7.03 as shown in Table 2. Further, there was high significant increase in SBP among young and elderly subject as $P < 0.01$ for both the groups. Whereas, mean pre-diastolic BP (DBP) among young subjects was 75.20 ± 7.22, and in post-exercise, it was 77.68 ± 6.80 as shown in Table 3, in elderly subjects, mean pre-DBP was 83.14 ± 4.18, and in post-exercise, it was 88.01 ± 4.95 as shown in Table 4; further, there was highly significant increase in DBP among young and elderly subject as $P < 0.01$ for both the groups. Mean pre-HR among young subjects was 75.04 ± 10.44, and in post-exercise, it was 91.90 ± 10.49 as shown in Table 5, and in elderly subjects, mean pre-HR was 78.66 ± 8.68, and in post-exercise, it was 85.58 ± 8.28 as shown in Table 6; further, there was highly significant increase in HR among young and elderly subject after exercise as $P < 0.01$ for both the groups. However, intergroup comparison indicates mean change in SBP among young was 4.68 and that of elderly was 10.24 (as shown from Graphs 1 and 2), this difference was significantly higher in elderly compare to young subjects as $P < 0.01$. Mean change in DBP among young was 2.48 and that of elderly was 4.98 (as shown from Graphs 3 and 4), this difference was significantly higher in elderly compare to young subjects as $P < 0.01$. Mean change in HR among young was 16.86 and that of elderly was 6.92 (as shown from Graphs 5 and 6), this difference was significantly higher in young compare to elderly subjects as $P < 0.01$. Thus, there is a significant difference in HR and BP response to isometric contraction in young and elderly normal individuals exist. The older subjects had a lower HR and a higher BP response than their younger counterparts.

DISCUSSION

The peoples over the age of 65 years carry the highest burden of chronic diseases, disability, and health-care

Table 1: Mean of pre- and post-exercise SBP in young individual

One-sample test = young group				
Parameters	**Mean±SD**	***T* value**	***P* value**	**Remark**
Before exercise SBP	120.88±9.59	89.06	0.00	Significant
After exercise SBP	125.56±10.39	85.38	0.00	Significant

SBP: Systolic blood pressure, SD: Standard deviation

Table 2: Mean of pre- and post-exercise SBP in elderly individual

One-sample test = elderly group				
Parameters	**Mean±SD**	***T* value**	***P* value**	**Remark**
Before exercise SBP	132.20±4.86	191.96	0.00	Significant
After exercise SBP	142.44±7.03	143.13	0.00	Significant

SBP: Systolic blood pressure, SD: Standard deviation

Table 3: Mean of pre- and post-exercise DBP in young individual

One-sample test = young group				
Parameters	**Mean±SD**	***T* value**	***P* value**	**Remark**
Before exercise DBP	75.20±7.22	73.56	0.00	Significant
After exercise DBP	77.68±6.80	80.75	0.00	Significant

DBP: Diastolic blood pressure, SD: Standard deviation

Table 4: Mean of pre- and post-exercise DBP in elderly individual

One-sample test = elderly group				
Parameters	**Mean±SD**	***T* value**	***P* value**	**Remark**
Before exercise DBP	83.14±4.18	140.32	0.00	Significant
After exercise DBP	88.12±4.95	125.74	0.00	Significant

DBP: Diastolic blood pressure, SD: Standard deviation

Table 5: Mean of pre- and post-exercise HR in young individual

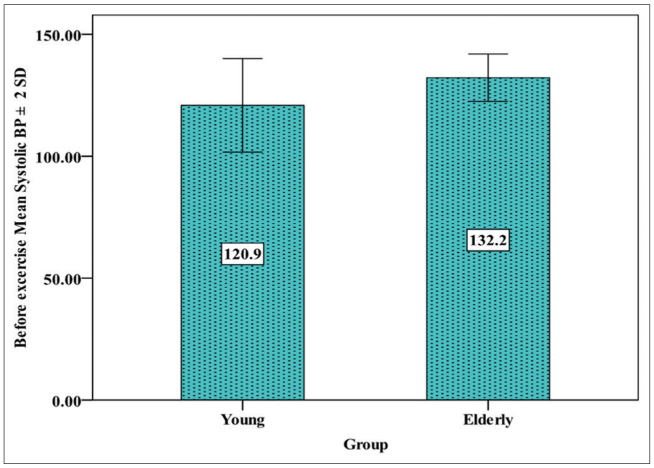
One-sample test = young group				
Parameters	**Mean±SD**	***T* value**	***P* value**	**Remark**
Before exercise HR	75.04±10.44	50.79	0.00	Significant
After exercise HR	91.90±10.49	61.93	0.00	Significant

HR: Heart rate, SD: Standard deviation

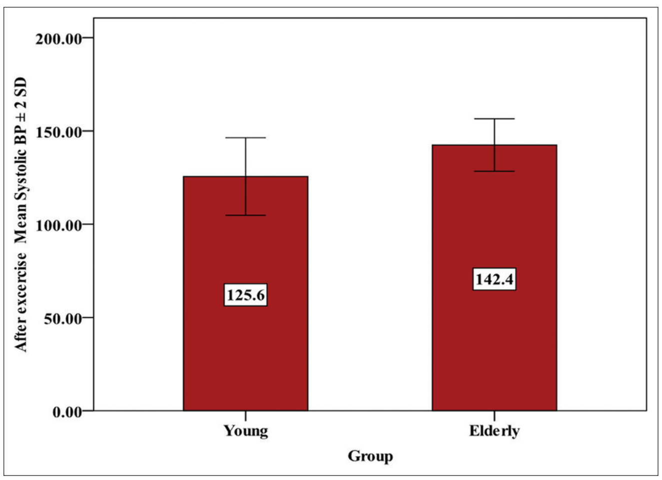
Table 6: Mean of pre- and post-exercise HR in elderly individual

One-sample test = elderly group				
Parameters	**Mean±SD**	***T* value**	***P* value**	**Remark**
Before exercise HR	78.66±8.68	64.05	0.00	Significant
After exercise HR	85.58±8.28	73.07	0.00	Significant

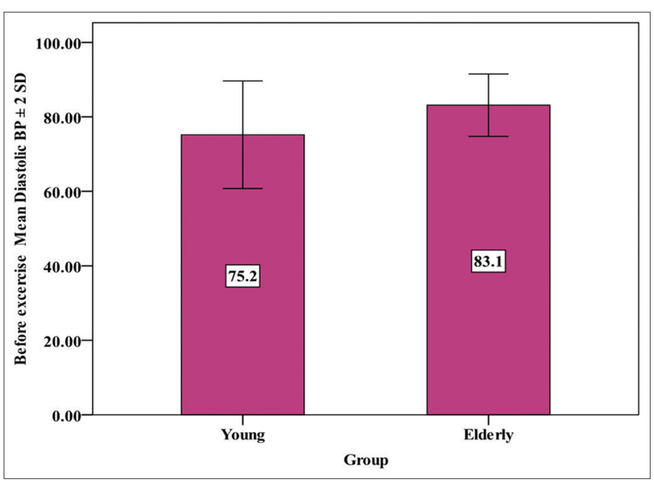
HR: Heart rate, SD: Standard deviation



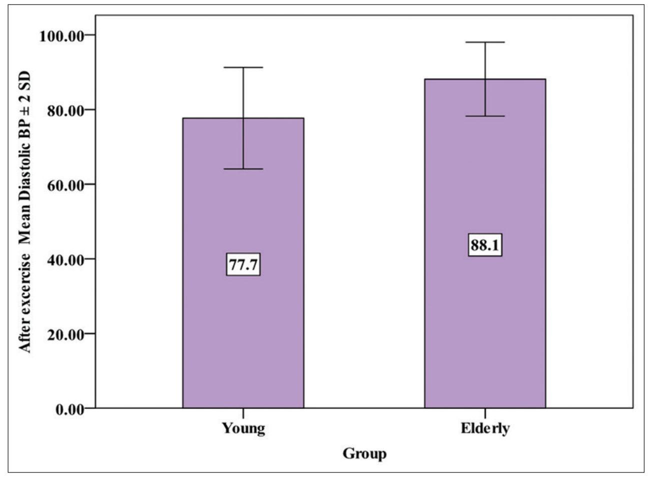
Graph 1: Mean of pre-exercise systolic blood pressure in young and elderly individuals. Highly statistically significant, *P* < 0.01



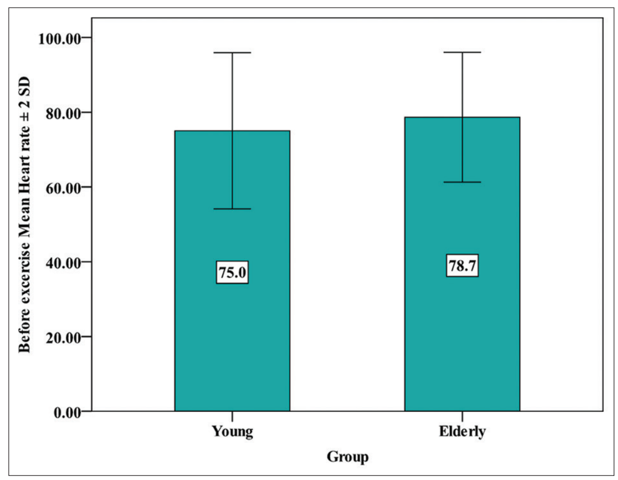
Graph 2: Mean of post-exercise systolic blood pressure in young and elderly individual. Highly statistically significant, *P* < 0.01



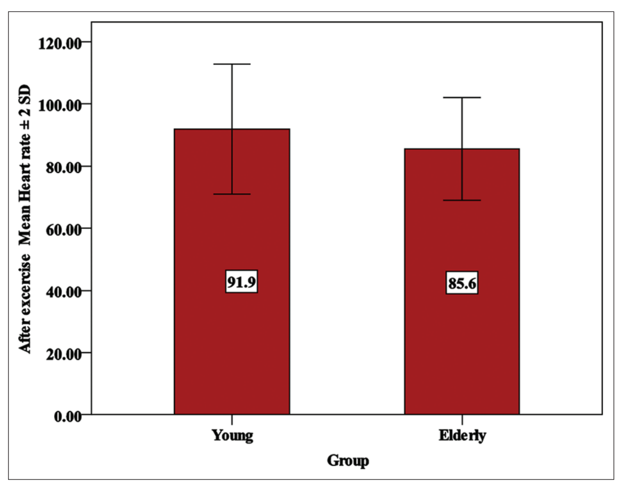
Graph 3: Mean of pre-exercise diastolic blood pressure in young and elderly individual. Highly statistically significant, *P*<0.01



Graph 4: Mean of post-exercise diastolic blood pressure in young and elderly individual. Highly statistically significant, *P* < 0.01



Graph 5: Mean of pre-exercise heart rate in young and elderly individual. Not significant



Graph 6: Mean of post-exercise heart rate in young and elderly individual. Highly statistically significant, *P* < 0.01

utilization.[5] Although many of these problems can be prevented, most of the physicians fail to provide an appropriate exercise recommendation to their patients that includes an individualized motivational message, a safe exercise program, and a tailored exercise prescription.[6]

The present study examined the HR and BP responses to 40% MVC in two age groups of healthy males. The findings showed an age-related difference in cardiovascular responses to isometric contraction. These results are consistent with studies done by Petrofsky and Lind, 1975,[7] Taylor *et al*., 1991; 1995.[8,9]

Sympathetic stimulation seems to be a secondary mechanism for increasing the HR; however, it becomes functional only after the first mechanism of vagal withdrawal has been utilized. The pressor response to handgrip was accompanied by increased cardiac output, and there was no change in calculated systemic vascular resistance. After intravenous propranolol, handgrip exercises resulted in increased peripheral resistance and an equivalent rise in arterial pressure but no increase in cardiac output. It was concluded that the increase in resistance was due to sympathetically induced vasoconstriction. The left ventricular ejection time (corrected for HR) was prolonged by handgrip. The increased afterload imposed on the left ventricle by SHG (sustained handgrip) may explain the prolongation of ejection time index. The study has defined the role of the sympathetic nervous system in the HR and pressor responses to SHG.[10]

It has been established that compared to dynamic exercise the isometric contractions causes marked increases in both SBP and DBP, while the rise in HR is less marked.[11] When comparing young and older individuals, some studies have found similar responses in HR to isometric exercise,[12,13] whereas others have noticed a lower HR in the aged persons.[7-9] In contradistinction, it has been shown that the older persons exhibit either a similar[8,12,13] or a greater[7] BP response to isometric contractions. These variations in readings may be due to variation in subject population, in experimental protocol (fatiguing vs. non-fatiguing contractions), or in the muscle group tested. The age-related changes in physical activity, reductions in skeletal muscle mass and muscle strength may also have been confounded the comparisons of younger and older age groups.[14]

CONCLUSION

From this study, it is concluded that the increasing age is associated with an altered HR and BP response to isometric exercise. There was an increase in HR and BP with isometric exercise in both young individuals and elderly individuals, but the elderly subjects had a lower HR and a higher BP response than their younger counterparts. The magnitude of the BP response depends on the degree of effort or central command and not the actual force production, and finally, isometric exercise should not be included as an overall fitness program for healthy elderly individuals due to potentially harmful effects on the cardiovascular system.

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