CARDIOVASCULAR RESPONSE TO SUSTAINED ISOMETRIC CONTRACTION: AN INTERVENTIONAL STUDY

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ABSTRACT

Background: Cardiovascular diseases are the leading cause of death worldwide. Cardio**-** exercise is one of the preventive measures by which these cardiovascular diseases can be controlled. Exercise using a handgrip dynamometer is a type of isometric exercise where voluntary muscle activity is associated with parasympathetic withdrawal, an increase in sympathetic flow and activation of other central commands.
Method: This study included 300 healthy young adults (150 male and 150 female) of age group 18-25 years. Their height and weight were measured and body mass index (BMI) was calculated. Basal heart rate (HR) and blood pressure (BP) were recorded. They were subjected to hand grip at 30% maximum voluntary contraction for 3 minutes. Post-exercise HR and BP were also recorded. Pre and post exercise HR and BP were compared with paired‘t’ test. ***Result***: All parameters of cardiovascular system increases with isometric contraction but it was found significant in the HR, diastolic blood pressure (DBP) and mean blood pressure (MAP). Another observation was revealed that although DBP was significantly increased with exercise but it was not increased up to normal range. DBP and MAP were significant positively correlated with BMI whereas no significant correlation was observed for systolic blood pressure (SBP) and HR with BMI. ***Conclusion***: Although there are significant changes in all studied cardiovascular parameters (except SBP) but they were found with sympathetic insufficiency.

KEYWORDS: Blood pressure, Body mass index, Heart Rate, Isometric Exercise

INTRODUCTION:

Cardiovascular diseases (CVDs) are the leading cause of death globally (1). Together they resulted in 17.3 million deaths (31.5%) in 2013 up from 12.3 million (25.8%) in 1990 (2). According to global health observatory (GHO) report of the year 2012, cardiovascular diseases were the leading cause of non-communicable disease (NCD) deaths (3). World Health Organisation (WHO) also declared Hypertension as world health theme of the year 2013 on World Health Day (7th April) (4). High blood pressure leads to 13% of CVDs death (1). Hypertension is a major risk factor for hypertensive heart disease, aortic aneurysm, coronary artery disease, peripheral artery disease, blindness, stroke and chronic kidney disease(5).

It is estimated that 90% of CVDs are preventable (6). Prevention of CVD is by impeding atherosclerosis by decreasing risk factors through healthy eating, exercise, avoidance of tobacco, smoke and limiting alcohol intake(1). Dietary and lifestyle changes can improve blood pressure control and decrease the risk of health complications. Hypertension is the most important preventable risk factor for premature death worldwide (7). Thus, the risk factors of these cardiovascular diseases are mainly modifiable. Cardio exercise is one of the preventive measures by which these cardiovascular diseases can be controlled.

Dynamic exercise has been advocated by national and international committees as part of a comprehensive regimen for the treatment of hypertension (8, 9). There has been a paucity of data, however, regarding recommendations for isometric or resistance exercise. A daily activity, such as lifting, holding, carrying a suitcase and in many occupations particularly manufacturing jobs where lifting is common, also involves isometric exercises. Testing of the cardiovascular strain due to static or isometric exercise is important for the prediction and prevention of excessive cardiac load on persons with lowered cardiac reserve in uncontrolled work conditions. The hand grip test is used in testing the cardiac response to increased load.

There is limited knowledge regarding the hemodynamic, circulatory, and BP effects of isometric exercise, particularly in western Rajasthan, so this study was under taken into account to know the cardiovascular response (HR, SBP, DBP and MAP) to increase sympathetic flow by means of sustained isometric contraction with handgrip dynamometer and their correlation with BMI in healthy young adults of Jaipur city.

MATERIALS AND METHODS

This pre and post interventional study was conducted on 300 healthy individuals using 30 cluster techniques covering the whole Jaipur city, in Department of Physiology, SMS Medical College, Jaipur (Rajasthan) in year 2015.

Sample size was calculated 138 subjects at alpha error 0.05 and power 80% assuming correlation of BMI with MAP 0.237 (as per seed article)(10). So for the study 270 subjects were taken with the multiplication of 2 for 30 cluster technique. In total 300 subjects was taken for research purpose.

For this study, healthy young adults aged 18-25 years residing in municipal area of Jaipur were selected. Subjects having any disease interfering with the autonomic nervous system were excluded from this study. Subjects who were either Alcoholics or smokers or tobacco chewers were also excluded from study. Subjects having BMI either below or above the normal rage and or on regular exercise were also excluded from this study. Finally 300 subjects including 150 males and 150 females were included in this study. .

All the subjects included were interrogated and investigated for any disease. BMI was calculated using Quetelet's index (11). Systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured using sphygmomanometer. Mean arterial pressure (MAP) was calculated as,

$$MAP = DBP + 1/3(SBP-DBP)$$

After that each of the subjects was asked to sit comfortably on a chair and was explained about the Sustained Handgrip Test. After recording baseline cardiovascular parameters the subject was asked to grip the Medical scale hand grip dynamometer using maximum force with their dominant hand for a few second. Force value was noted & the procedure was repeated thrice. Maximum value of the three readings was taken as the maximal voluntary contraction (MVC). Then a mark was made on the dynamometer at 30% of MVC of the subject and then the subject was asked to maintain the sustained grip on the dynamometer up to the mark with uniform intensity for the 3 minutes. Just before the release of grip, HR & BP (both systolic and diastolic) were recorded and MAP was calculated.

The change in mean DBP in response to sustained handgrip test was interpreted as (12):

a. ≥ 16 mmHg was taken as normal
b. ≥ 11 -15 mmHg as Borderline
c. ≤ 10 mmHg as Abnormal (12).

This whole procedure is done with each of the subjects

Ethics: Approval from Institutional Ethical committee was obtained prior to conduct study & well-informed written consent of each of the subject was taken.

Statistics: Significance of difference in pre and post exercise (change) in cardiovascular parameters was inferred by paired't-test' (graph pad) and their relation with BMI was inferred by using Karl Pearson's coefficient of correlation by www.alcula.com. For significance p-value less than 0.05 is considered significant.

RESULTS

Mean age of study population was found 20.83± 2.36 years with male- female ratio 1. Mean BMI was 20.63 ± 3.23Kg/m^2 that are within normal range. More than half population belongs to class I socioeconomic status (B. G Prasad criteria) that is 55.33% and in class II 32% population, while class V represents only 0.3% and other class in between this distribution as shown in Table no. 1.

Effect of isometric exercise on cardiovascular response showed a significant increase in HR, DBP and MAP after 3 minutes sustained isometric contraction while there was no significant change in SBP. Mean DBP pre-exercise was 78.24 mmHg and post exercise was 81.69 mm Hg, so there was increase of 3.45 mmHg of DBP after exercise concluding sympathetic insufficiency.

In this study, non-significant correlation was observed of BMI with HR and SBP (fig. 1 &2). While in DBP and MAP had significant positive correlation with BMI (fig. 3 & 4).

DISCUSSION

The present study shows a significant change in HR, DBP and MAP after sustained isometric exercise while a non-significant effect on systolic blood pressure in healthy young adults, the same effects are also observed by many researchers. Goodwin et al (13), Laird et al(14), Jandik et al (15), Hemasanker et al (16) observed that all cardiovascular parameters like HR, SBP, DBP and MAP increased with significant effect after sustained isometric contractions. The similar finding is also observed in the present study, except SBP shows non-significant change.

Girish et al (17) observed the cardiovascular response in trained and untrained females. They found a significant increase in SBP, DBP, MAP and HR response after isometric exercise in untrained control subjects than trained subjects. In the present study also all the subjects are untrained.

Priyadarshini et al (10) found a significant increase in all cardiovascular parameters after hand grip exercise in healthy young adults. The similar effect is also observed in this study, except SBP. They found a non-significant correlation of HR, SBP, DBP and MAP with BMI. Although in the present study a significant positive correlation of BMI with DBP and MAP is observed but a non-significant correlation with SBP, while with HR a negative non-significant correlation is observed.

Isometric exercises like stretches, extensions and presses will cause the heart rate to increase.

When we perform isometric exercises, our muscles contract and blood vessels constrict, preventing new, oxygen-laden blood from reaching the affected muscle tissue. When muscle tissues are deprived of enough oxygen, both our systolic and diastolic blood pressure readings will rise. As long as we maintain the muscle contraction, both our heart rate and blood pressure will steadily rise. Even after we have finished the exercise, it may be a few minutes before blood pressure returns to normal (18). The isometric contraction is a resistance exercise and its cardiovascular response is different from that of dynamic exercises.

Since both systolic and diastolic pressures increase in static exercise, there is a marked increase in mean arterial pressure (19, 20, and 21). In the present study, however, a non-significant rise in SBP after exercise was observed; this less increase in SBP may be due to fluctuations in SBP in daily activities.

Moreover, as in any muscular work, static exercise increases metabolic demands of the active muscle. The high intramuscular tension in static work results in mechanical constriction of the blood vessels, which impedes blood flow to the muscle. The reduction in muscle blood flows during static exercise results in a build-up of local by-products of metabolism. These chemical by-products [H_, adenosine diphosphate (ADP), and others] stimulate sensory nerve endings, which leads to a pressure reflex, causing a rise in diastolic pressure and mean arterial pressure (pressure response).

Further, in the present study, there is a significant change in DBP and the mean difference of DBP between pre and post exercise is only 3.45 mmHg which is <10 mmHg (12), that indicates sympathetic insufficiency in healthy subjects. The sympathetic insufficiency may cause less contraction of vascular smooth muscle resulting in the lesser amount of rise in peripheral resistance that may be the probable reason of smaller rise in diastolic blood pressure after isometric sustained exercise.

Limitations: In present study sympathetic insufficiency is tested only by sustained isometric contraction apart from other tests like sympathetic skin response, cold pressure response, blood pressure response to standing, heart rate variability etc.

CONCLUSIONS

Thus the present study concluded that there was a significant change in HR, DBP and MAP except for SBP due to sustained isometric contraction and a positive significant correlation of BMI with DBP and MAP. Moreover, the young healthy adults of Jaipur city shows a sympathetic nervous system insufficiency that was measured by change in DBP, though they had normal BMI.

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TABLES

Table 1: Study population distribution

S. No.	(n=300)	Observation Data
1	Mean age (years) Mean ± SD	20.83 ± 2.36
2	Male/Female ratio	150/150=1
3	BMI (kg/m^2) Mean ± SD	20.63± 3.23
4	Socioeconomic status	
	Class I	55.33 %
	Class II	31.67%
	Class III	10.67%
	Class IV	2.00%
	Class V	0.33%

n: number of subjects

"Table 2: Effect of isometric contractions on cardiovascular response"

S. No.	Parameters (n=300)	Pre	post	t	P	Significance
1	HR (beats/min.)	86± 12.04	89.94± 12.89	7.55	<0.0001	HS
2	SBP (mmHg)	119.46± 15.34	125.94± 60.08	1.935	0.0539	NS
3	DBP (mmHg)	78.24± 10.90	81.69± 12.07	5.9907	<0.0001	HS
4	MAP (mmHg)	92.05± 11.62	95.30± 13.18	6.4620	<0.0001	HS

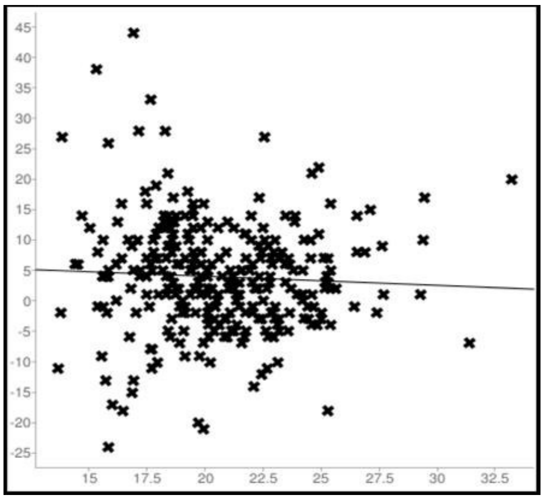
HS: Highly significant; NS: Non-significant

FIGURES

Figures 1-4

"Correlation and Regression of BMI with various cardiovascular parameters"

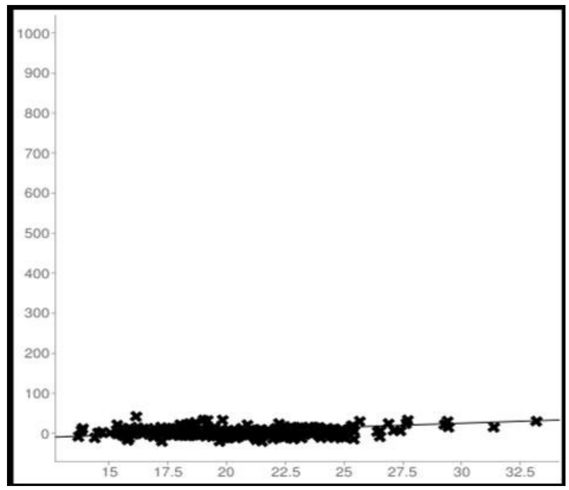
Figure: 1



Correlation of BMI with HR=-0.053 (p>0.05)

Regression equation (y = 7.011 – 0.148x)

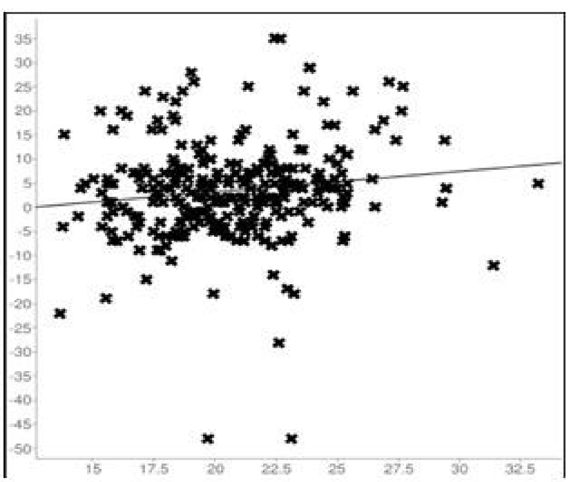
Figure: 2



Correlation of BMI with SBP=0.11(p>0.05)

Regression equation (y = 1.976x – 34.283)

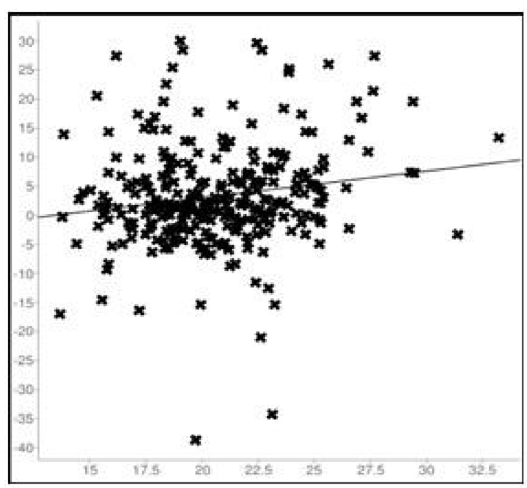
Figure no. 3



Correlation of BMI with DBP= 0.1379(p<0.05)

Regression equation (y = 0.425x – 5.33)

Figure no. 4



Correlation of BMI with MAP=0.1698 (p<0.05)

Regression equation (y = 0.458x – 6.178)