ABSTRACT

The purpose of this study was to document the cardiovascular responses of subjects to different isometric hand grip exercises. The subjects were asked to maintain a sustained hand grip pressure at 20% of MVC with his dominant hand, after 15 min rest, the subject was asked to do at 50% of MVC. Heart rate (HR), corrected QT interval (QTc) and PR interval (PR) were obtained from systolic blood pressure (SBP), and diastolic blood pressure (DBP) was obtained by sphygmomanometer. HR, SBP, DBP was high after 50% of MVC compare to baseline and 20% MVC (p<0.000). QTc and PR was shortened after 50% of MVC compare to baseline and 20% MVC (p<0.000). From this study it can be concluded that, as the intensity of isometric exercise increases, the heart rate, systolic blood pressure, diastolic blood pressure also increases. Cardiac conduction rate also increases in response to intensity of isometric contraction.

KEY WORDS : Isometric exercise, Cardiac response, Hand grip test, Maximum voluntary contraction

Introduction

Cardiovascular diseases (CVDs) are the number one cause of death globally, more people die annually from CVDs than from any other cause [1]. An estimated 17.3 million people died from CVDs in 2008, representing 30% of all global deaths. Of these deaths, an estimated 7.3 million were due to coronary heart disease and 6.2 million were due to stroke[2]. Low and middle-income countries are disproportionately affected: over 80% of CVD deaths take place in low- and middle-income countries and occur almost equally in men and women[1]. The number of people who die from CVDs, mainly from heart disease and stroke, will increase to reach 23.3 million by 2030[1,3]. CVDs are projected to remain the single leading cause of death. Most cardiovascular diseases can be prevented by addressing risk factors such as tobacco use, unhealthy diet and obesity, physical inactivity, high blood pressure, diabetes and raised lipids. 9.4 million deaths each year, or 16.5% of all deaths can be attributed to high blood pressure[4]. This includes 51% of deaths due to strokes and 45% of deaths due to coronary heart disease[5].

Exercise is a common physical stress that can elicit cardiovascular abnormalities that are not
present at rest, and it can be used to determine the adequacy of cardiac function. Human physical activity involves a combination of dynamic and static exercises. Static exercise can be characterized by increase in muscle tension with little or no change in the length of the muscle[6].

Dynamic exercise can be characterized by a rhythmic contraction and relaxation. Static effort, in contrast to dynamic exercise, can be characterized by a prolonged state of muscle contraction, which usually implies a postural stance. No external work is performed. Muscle length does not increase, but remains in a state of heightened tension, with force exerted over an extended period. This type of isometric exercise is performed as a part of activities such as weight lifting, pushing an object etc., During static effort; the blood vessels are compressed by the internal pressure of muscle, so that blood flow to the working muscle is restricted. The restriction of the blood flow to the working muscle is directly related to the relative intensity of static effort expressed as a percentage of maximum voluntary contraction force (MVC) [6]. Studies have shown that the magnitude of hemodynamic changes occurring during static exercise seems to depend upon the relative strength of contraction i.e. the proportion of maximal effort employed[7].

Isometric exercises may be used to evoke or accentuate indirect physical evidence of cardiac dysfunction due to left ventricular myocardial diseases[8].

Therefore, the purpose of this study was to document the cardiovascular responses of subjects to different isometric handgrip exercises and hopefully to provide guidelines for safe evaluation and prescription of isometric exercises for patients suffering from cardiovascular diseases.

### Materials and Methods

Subjects and laboratory setting: Following the Institute ethics clearance, thirty healthy male subjects were recruited from the students and residents of Narayana Medical College, Nellore, Andhra Pradesh, India, based on the following inclusion and exclusion criteria. Inclusion criteria consisted of age: 25–35 years, no history of hypertension, diabetes, smoking, or any other chronic diseases. Subjects hospitalized within last 3 months, those who had myocardial infarction or recurrent anginas within last 6 months were excluded from the study.

All experiments were performed at the cardiac autonomic function research laboratory in Department of Physiology, Narayana Medical College (NMC), Nellore, Andhrapradesh. The subjects were asked to refrain from heavy physical activity for 24 hours and from consumption of alcohol and caffeinated beverages for 12 hours prior to the measurements. The temperature of the laboratory was kept between 25°C - 28°C and lights subdued. The patients were asked to void urine before testing and made to sit in the lab comfortably get to accustom used to the new environment. First the heart rate and auscultatory blood pressure was measured after subject had been sitting quietly for 10mins. The mean of three consecutive measurements with a maximum variation of 4mm Hg of both systolic and diastolic blood pressures was accepted[9]. The recording of heart rate was done from the ECG recordings on the ECG machine (Cardioinwin system, PC based 12 channel simultaneous digital ECG, Genesis Media System Pvt. Ltd, India).

Each subject was asked to sit comfortably till they attained basal heart rate and blood pressure, the subject was then asked to perform the maximum hand grip. Then 20% and 50% of MVC was calculated.
Isometric exercise at 20% and 50% of MVC:
The subjects were asked to maintain a sustained hand grip pressure at 20% of MVC with his dominant hand. After 15 min rest, the subject was asked to do at 50% of MVC. Heart rate (HR), corrected QT interval (QTc) and PR interval (PR) were obtained systolic blood pressure (SBP), and diastolic blood pressure (DBP) was obtained by sphygmomanometer.

Results
Baseline characteristics of the study participants are presented in Table No. 1. As shown in Table No. 2, HR, SBP, DBP was high after 50% of MVC compared to baseline and 20% MVC (p<0.000). QTc and PR was shortened after 50% of MVC compared to baseline and 20% MVC (p<0.000).

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Parameter</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age</td>
<td>29 ± 2</td>
</tr>
<tr>
<td>2</td>
<td>Height</td>
<td>180.45 ± 24.34</td>
</tr>
<tr>
<td>3</td>
<td>Weight</td>
<td>68.54 ± 9.34</td>
</tr>
<tr>
<td>4</td>
<td>SBP</td>
<td>111.4 ± 9.7</td>
</tr>
<tr>
<td>5</td>
<td>DBP</td>
<td>73.4 ± 4.82</td>
</tr>
</tbody>
</table>

Values are Mean ± SD. SBP; systolic blood pressure, DBP; diastolic blood pressure.

Table No. 1: Baseline characteristics.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Parameter</th>
<th>Baseline (Mean ± SD)</th>
<th>20% of MVC (Mean ± SD)</th>
<th>50% of MVC (Mean ± SD)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HR</td>
<td>71.6 ± 7.34</td>
<td>79.6 ± 7.2</td>
<td>89.2 ± 12.4</td>
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<tr>
<td>2</td>
<td>SBP</td>
<td>111.4 ± 9.7</td>
<td>121.9 ± 8.3</td>
<td>129.8 ± 8.9</td>
<td>0.000</td>
</tr>
<tr>
<td>3</td>
<td>DBP</td>
<td>73.4 ± 4.2</td>
<td>84.9 ± 6</td>
<td>93.1 ± 7.4</td>
<td>0.000</td>
</tr>
<tr>
<td>4</td>
<td>QTc</td>
<td>418.7 ± 41.69</td>
<td>390.9 ± 47.56</td>
<td>362.6 ± 57.4</td>
<td>0.005</td>
</tr>
<tr>
<td>5</td>
<td>PR</td>
<td>182 ± 51.6</td>
<td>147 ± 28.6</td>
<td>133 ± 33.3</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Values are Mean ± SD. HR; heart rate, SBP; systolic blood pressure, DBP; diastolic blood pressure, QTc; corrected QT interval, PR; PR interval.

Table No. 2: Results of cardiovascular parameters following two different intensities of isometric hand grip exercise.

Discussion
The world health organization expert committee on rehabilitation states that “the primary purpose of an exercise test is to determine the response of the individual effort at given level and from this information to estimate probable performance in specific life and occupational situations”[10].

This study shown increase in heart rate. This may be explained by central command theory and exercise pressor reflex theory[8]. The central command theory involves activation of higher brain centers on the violation and initiation of muscular contraction. Presumably, signals are irradiated to cardiovascular control centre in brain stem and this information contributes to the cardiovascular changes[8]. The exercise pressor reflex theory suggests that there is a reflex stimulation originating in nerve endings in the contracting muscle activated either by chemical substances presumably formed during the contraction or by physical deformation. Thus during sustained isometric contraction the greater the number of motor units activated, the greater the activation of the afferent fibers[8].

In an extensive study conducted by Williams J.P Alonos, the increase in heart rate was produced by isometric contraction and the increase in heart rate depended on increase in force generated by muscle and muscle mass involved. Our study corroborates with this[8] and other similar studies.
The next finding of this study was the increase in systolic blood pressure as the strength of contraction increases. This may be explained as isometric exercise impulses from proprioceptors in the working muscle, limbic cortex, motor cortex activates the vasomotor centre. This in turn increases the sympathetic discharge causing an increase in the heart rate and venous return, leads to an increase in cardiac output and systolic blood pressure. Diastolic pressure was increased as the strength of contraction increases. This can be explained as isometric contraction causes increase in sympathetic flow and increases the level of circulating catecholamine and thus leads to constriction of arterioles and increase in total peripheral resistance. These in turn increases diastolic blood pressure.

Another finding of this study was the decreased PR interval. This may be due to both withdrawal of the vagal influences and activation of the sympathetic influences to the atrioventricular conducting system. In a study conducted by Alberto Ferrari et.al., atrioventricular conduction time was shortened considerably during isometric contraction. This study showed marked shortening of PR interval during isometric handgrip exercise[11] our study corroborates with this and similar studies.

The decreased QTc may be due to withdrawal of vagal influences and activation of sympathetic influences to the atrioventricular conducting system.

**Conclusion**

From this study it can be concluded that, as the intensity of isometric exercise increases, the heart rate, systolic blood pressure, diastolic blood pressure also increases. Cardiac conduction rate also increases in response to intensity of isometric contraction. During isometric handgrip exercises PR interval and QTc was shortened. It has been proposed that autonomic nervous system play an important role in cardiovascular changes during isometric hand grip exercise. Both increased sympathetic flow and vagal withdrawal are responsible for cardiovascular changes during isometric exercise. Baroreceptor and chemoreceptor reflexes, higher centers, vasomotor centre play main role in cardiovascular response during exercise.

Routine activities in everyday life either in house or work place like lifting of pushing may suddenly increase the cardiac workload. So patients with cardiovascular diseases must take care while doing such activities.

**References**


