Heart Frequency Patterns Due to 30% and 50% Maximal Isometric Contraction (MIC) in Adolescents

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Abstract. We often do isometric contractions. Isometric contractions cause cardiovascular responses, including changes in heart rate. The aim of this study was to examine the effect of isometric contraction intensity equivalent to 30% MIC and 50% MIC with handgrip and backlift on increased heart rate. This research is a quasi-experimental, pretest, and post-test design. The subjects were 60 men aged 17-24 years who met the inclusion criteria and were divided into 2 groups, the group with a handgrip dynamometer and the treatment group with a backlift dynamometer. Heart rate frequency measurements were carried out before, during, and after isometric contraction with handgrip and backlift dynamometers, which were equivalent to 30% and 50% MIC. The results showed that there was a significant difference (p <0.05) between heart rate frequencies, before, during, and after isometric contractions. Increasing the intensity of isometric contraction from 30% to 50% MIC, both with handgrip and backlift dynamometers, increased heart rate significantly (p <0.05). There was a significant increase (p <0.05) in the pulse frequency between isometric contraction and handgrip dynamometer with backlift. The conclusion of this study is that the magnitude of the increase in heart rate due to isometric contraction is 50% MIC equivalent to 30% MIC.

1 Introduction

Isometric contractions we often do in everyday life. These contractions will cause a response in the body's organ systems, including the cardiovascular system. Cardiovascular responses include changes in heart rate. Isometric contractions can be used to assess left ventricular function. Occasionally a left ventricle that appears to be functioning normally at rest will respond abnormally to isometric exercise. Preoperative evaluation of left ventricular function in aortic valve disease during isometric contraction with a handgrip dynamometer was found to be useful for assessing prognosis. Isometric contractions are also important for assessing autonomic function. There is a positive relationship between autonomic dysfunction and mortality from cardiovascular disease, including sudden death [1-3].

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Isometric contractions cause an increase in heart rate. The heart rate per minute describes the activity of the heart in pumping blood out of the heart [4, 5]. The muscles require an enormous increase in blood flow during strenuous work. Strenuous physical work causes an increase of about 30 to 40% in arterial blood pressure, this leads to an approximately twofold increase in blood flow [6-8].

The effect of isometric contraction intensity and the magnitude of muscle mass contracting on heart rate is not yet clear. Handgrip and backlift dynamometers can be used to measure the strength of isometric contractions. Moderate-intensity isometric contractions are equivalent to 30% MIC, whereas severe ones are equivalent to 50% MIC [9,10]. The problem that will be studied in this study is to examine the pattern of heart rate on the increase in the intensity of isometric contractions (moderate intensity isometric contractions equivalent to 30% MIC and heavy intensity equivalent to 50% MIC and the amount of muscle mass contracted. The purpose of this study was to examine the effect of the intensity of isometric contractions is equivalent to 30% MIC (moderate-intensity isometric contractions) and 50% MIC (severe intensity isometric contractions) in the heart rate pattern in the early adult group. In addition, to study the effect of isometric contractions with a handgrip dynamometer and backlift on the pattern of heart rate.

2 Methods

This research is quasi-experimental research, with pre-test, and post-test design. The research subjects were 60 teenage boys aged between 17-24 years, with blood pressure 110/70-139/89 mmHg, and heart rate of 60-80 beats/minute. The exclusion criteria were students with a Body Mass Index (BMI) of more than 25. BMI of more than 25 was not included as research subjects because research subjects had to have a normal BMI.

Isometric contractions are contractions without a change in muscle length. Isometric contractions in this study were measured using a handgrip and a backlift. A handgrip is a tool for hand contraction that can be used to assess the strength of hand contraction. A backlift is used to measure the strength of contraction of the isometric arm and back muscles [9,10].

After signing the informed consent, the subjects were divided into handgrip and backlift dynamometer groups. Control is each subject alone without treatment. Measurement of heart rate (with ECG in lead II) was performed in the second, third, and fifth minutes before isometric contraction, three times each. Both groups of subjects performed maximal contractions for 3 minutes, then rested for 20 minutes. Subjects performed one isometric contraction with a handgrip dynamometer and a backlift equivalent to 30% MIC for 3 minutes and the heart rate was measured in the first, second, and third minutes during isometric contractions. Subjects measured heart rate in the second, third and fifth minutes after completing isometric contractions with a handgrip dynamometer and a backlift equivalent to 30% MIC. After resting for 10 minutes, the subjects performed isometric contractions with a handgrip dynamometer and a backlift equivalent to 50% MIC for 3 minutes and the heart rate was measured in the first, second, and third minutes when performing isometric contractions. Subjects were measured heart rate and blood pressure in the second, third and fifth minutes after completing isometric contractions with a handgrip dynamometer and a backlift equivalent to 50% MIC. After the prerequisite test was performed to assess the normality and homogeneity of the study samples, differences in heart rate response before, during, and after isometric contractions were analyzed by ANOVA.
3 Results

The age of research respondents is between 17-24 years, this age is included in the adolescent age group. BMI ranges from 19-25. BMI research respondents within normal limits. Subjects at the beginning of the study had a heart rate between 64-80 beats/minute. The research subjects' heart rate was within normal limits. Systolic blood pressure was between 110-117 mmHg, diastolic blood pressure was between 70-75 mmHg, and mean arterial blood pressure was between 83-86 mmHg. The blood pressure of the research subjects was within normal limits. Each research subject has data that varies slightly, but after testing the prerequisites for assessing normality and homogeneity, it turns out that the data are normally distributed and homogeneous. The average heart rate before, during, and after treatment can be seen in Table 1.

Table 1. Average Heart Rate Before, During, and After Isometric Contractions Equivalent to 30% and 50% MIC

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Before</th>
<th>During</th>
<th>After</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handgrip 30% MIC</td>
<td>75.57 ± 3.95</td>
<td>89.93 ± 8.51</td>
<td>78.03 ± 4.98</td>
<td>0.001</td>
</tr>
<tr>
<td>Handgrip 50% MIC</td>
<td>75.57 ± 3.95</td>
<td>98.57 ± 8.51</td>
<td>81.93 ± 4.93</td>
<td>0.001</td>
</tr>
<tr>
<td>Backlift 30% MIC</td>
<td>76.73 ± 3.02</td>
<td>104.23 ± 3.06</td>
<td>83.30 ± 2.89</td>
<td>0.001</td>
</tr>
<tr>
<td>Backlift 50% MIC</td>
<td>76.73 ± 3.02</td>
<td>110.67 ± 7.01</td>
<td>90.97 ± 3.97</td>
<td>0.001</td>
</tr>
</tbody>
</table>

The results of ANOVA analysis showed that there was a statistically significant difference (p<0.05) between the mean heart rate before and during, during, and after isometric contractions equivalent to 30% and 50% MIC with handgrip and backlift dynamometers, statistically significant (p<0.05). The difference in mean heart rate before and after the isometric contraction was equivalent to 30% and 50% MIC with a backlift dynamometer and 50% MIC for isometric contraction with a handgrip dynamometer was significant (p<0.05). The difference in mean heart rate before and after isometric contractions equivalent to 30% MIC with a handgrip dynamometer had no statistically significant increase (p>0.05). The results of the Paired t-test analysis showed a significant difference (p<0.05) in the increase in heart rate between isometric contractions equivalent to 30% and 50% MIC with handgrip and backlift dynamometers (Figure 1).

Fig. 1. The mean heart rate during contraction is the equivalent of 30% and 50% MIC with a handgrip and backlift dynamometer
4 Discussion

Isometric contractions cause an increase in heart rate [11-13]. Contraction isometric intensity can increase heart rate. Several studies have shown a relationship between increased heart rate and isometric contractions. Contraction isometric intensity can increase heart rate [11, 14]. The heart rate during the isometric contraction was greater than before the isometric contraction (Table 1). These results are consistent with research conducted by Gálvez et al. (2000) and Silva et al. (2018) which showed that an increase in heart rate occurs immediately during contraction isometrics. The average heart rate between 107-115 beats per minute is included in the moderate workload [12]. The results of this study (Figure 1), isometric contractions with a handgrip dynamometer in the first, second and third minutes and with a backlift dynamometer in the first and second minutes, the heart rate is still classified as a moderate heart rate. The working heart rate with a backlift dynamometer in the third minute is quite heavy. The frequency of the heartbeat describes the balance of the body at that time. Isometric contractions with great intensity and sustained for a long time, the large anaerobic metabolism cannot be matched by aerobic aerobics. This happens because at the time of isometric contraction the blood vessels in the muscle are pinched so that the blood is disturbed and the oxygen supply is not sufficient for the needs of the active muscle cells [2, 15].

Central and peripheral mechanisms influence heart rate response due to isometric contraction. The increase in heart rate during isometric contraction is more controlled by the central mechanism of increased sympathetic nerve activity than by peripheral receptor feedback. Isometric contractions in the first minute cause an increase in sympathetic nerve activity. Increased sympathetic nerve activity causes an increase in heart rate, and the myocardium contracts more strongly [2, 4]. Heart rate decreased after performing isometric contractions equivalent to 30% and 50% MIC in the isometric treatment with handgrip and backlift (Table 1). The recovery heart rate is essential, among other things, to determine the workload performed. The heart rate of recovery in the fifth minute still means the workload is heavy. The recovery heart rate can also be used to calculate the total cardiac cost [2, 16, 17]. The results of this study indicate that the heart rate before isometric contraction is equivalent to 50% MIC with a backlift dynamometer above 90 beats per minute (Table 1). The work done causes a heavy burden on the heart [13, 18]. Decreased heart rate after isometric contraction occurs due to relaxation so that the blood vessels are not squeezed anymore, also due to reduced sympathetic nerves so that the heart rate also decreases. [19, 20]. The mean heart rate before and after isometric contraction equivalent to 30% MIC with a handgrip dynamometer was not significantly different (p>0.05) (Table 1). It is probably because the research subjects have reached recovery time.

The results of this study indicate that the increase in heart rate during isometric contractions with a backlift is greater than that of a handgrip (Table 1). The results of research conducted by Galves et al. (2000), Gladwell and Coote (2002) [21] showed that the increase in heart rate is influenced by the intensity of isometric contractions and the amount of muscle mass involved. The greater the intensity of the isometric contraction and the mass of the muscles engaged during the isometric contraction, the greater the increase in heart rate. It occurs because the greater the intensity of the isometric contraction and the muscle mass, the more motor units work [22, 23]. The mean heart rate before and after isometric contraction equivalent to 30% MIC with a handgrip dynamometer was not significantly different (p>0.05) (Table 1). It is probably because the research subjects have reached recovery time [24-26].

The results of this study showed a statistically significant increase in heart rate due to isometric contractions in the 17-24 year age group so in the following age period or the elderly group, caution should be exercised in performing isometric contractions with
moderate and heavy loads so, as not to adversely affect health. Heavy or light work intensity affects pulse rate, length of work, rest time, and work rhythm that is in accordance with the optimal human capacity will also affect the pulse frequency so that it does not exceed the maximum limit. The clinical significance of this study, among others, is that isometric contractions affect the heart rate and must consider the maximum heart rate limit. The results obtained in this study are expected to provide additional information about the effect of isometric contractions on heart rate. Practically, the results of this study are expected to be used as a consideration for people with cardiovascular disorders, such as hypertension and tachycardia, to be careful in carrying out load-bearing work.

5 Conclusion

The increase in heart rate due to isometric contraction is equivalent to 50% MIC, higher than 30% MIC with handgrip and backlift dynamometers. The increase in heart rate due to isometric contraction with a backlift dynamometer is greater than that of a handgrip. The pattern of heart rate response to moderate and severe isometric contractions (30% and 50% MIC) with handgrip and backlift dynamometer in the first, second and third minutes was still linear.

References


14. G. O. Silva et al., Acute blood pressure responses after different isometric handgrip protocols in hypertensive patients, Clinics (Sao Paulo), 73, e373 (2018)


