

BLOOD PRESSURE AND HEART RATE RESPONSES TO SUSTAINED STATIC (ISOMETRIC) CONTRACTIONS BY HANDGRIP DYNAMOMETRY IN THREE TRIMESTERS OF PREGNANCY

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ABSTRACT

Title: Blood pressure and heart rate responses to sustained static (isometric) contractions by handgrip dynamometry in three trimesters of pregnancy.

Objective: To measure the blood pressure and heart rate responses at various intensities, in three trimesters of pregnancy to the sustained isometric exercises, by handgrip dynamometry and comparing the results with the controls.

Materials and methods: subjects - 20 healthy pregnant women, Controls - 20 non-pregnant healthy women. Subjects were followed for three trimesters. Blood pressure and heart rate were evaluated with handgrip dynamometer at Rest, 20% and 30% intensities of maximum voluntary contraction and Post Exercise. Blood pressure and Heart rate were recorded with the help of Sphygmomanometer, Stethoscope, and ECG machine.

Results: Blood pressure and heart rate increased more during sustained handgrip exercise in Subjects than the Controls. At rest and during static exercise blood pressure reduced in First, Second and increased in Third trimesters, compared to controls. At rest and during static exercise heart rate increased in First, Second trimesters and Third trimester displayed steady levels when compared to the controls. Maximum voluntary contraction in the Controls was higher than the Subjects.

Conclusion: Sustained isometric exercise produces an increase in hemodynamics during different trimesters of pregnancy.

Keywords: Isometric exercise; Pregnancy; Handgrip Dynamometer

1. INTRODUCTION

Exercise has numerous effects on pregnant woman and in turn, pregnancy affects the ability to perform physical activity.¹ Exercise in pregnancy is also a stress to certain degree, causes both pressor and heart rate changes apart from other hemodynamic responses. The dual stresses of pregnancy and exercise may create enhanced physiological demands that could adversely affect pregnancy outcome.²

Static exercise is commonly encountered occupationally and in normal activities of daily living. Also its significance in pregnancy is even more demanding and

this area needs to be addressed. There is sufficient information in the literature about Isotonic (dynamic) exercises to different intensities but literature in isometric exercises during pregnancy is inadequate. Isometric testing offers important clinical information.

The present study aims to measure the changes in blood pressure (BP) and heart rate (HR) responses at various levels of intensities, in all the three trimesters of pregnancy to the isometric exercise using Handgrip Dynamometer (HGD).

2. MATERIALS AND METHODS

Subjects – 20 pregnant healthy women

who were followed up in three trimesters [T1, T2, T3]

Controls – 20 healthy non pregnant women [C]

Instruments used were Handgrip Dynamometer, ECG Machine, Mercury Sphygmomanometer, Stethoscope and Stopwatch. Parameters recorded were: Maximum Voluntary Contraction (MVC), Blood pressure (BP) and Heart Rate (HR).

2.1 Methodology

Informed consent was obtained from all the subjects and controls after receiving full details of the protocol. Study met the approval of the Ethical committee of J.S.S. Medical College, Mysore. BP, HR, MVC at rest and at the end of 20% and 30% MVC and post exercise were recorded for both subjects and controls using Mercury Sphygmomanometer, Stethoscope, ECG machine. Isometric exercise was performed by HGD. The duration of the static exercise is of 3 minutes timed by stopwatch. These tests were performed in 4 sets with proper motivation during sustained hand grip (SHG).

2.1.1 Recording of 1st set of hemodynamics at rest:

BP [both systolic blood pressure (SBP) & diastolic blood pressure (DBP) components] and HR were measured.

ECG 4 Limb leads were connected and chest leads were ignored.

HR is commonly calculated by recording the R-R interval in Limb Lead

$$H. R. = \frac{1500}{R-R \text{ interval}}$$

2.1.2 Recording of MVC: MVC is the maximum force generated by the subject and control during the three attempts or trials using the HGD.

2.1.3 Recording of 2nd set of hemodynamic parameters: BP & HR at 20% MVC: The subjects were instructed to sustain the handgrip with dominant hand at 20% of the predetermined MVC for 3 minutes or as long as possible, whichever occurs or sets early. During this period BP and HR were measured as done

during 1set of recordings. Rest was given for 5minutes.

2.1.4 Recording of 3rd set of hemodynamic parameters: BP & HR at 30% MVC: The subjects performed the sustained isometric contraction at 30% MVC for 3 minutes. The subjects were implored to continue the handgrip exertion until failure or fatigue sets in. During this period BP and HR were measured as done during 1set of recordings. Rest was given for 5minutes.

2.2.1.5 Recording the 4th set - Post Exercise (PE) hemodynamic parameters: BP & HR are recorded in the same way as set 1.

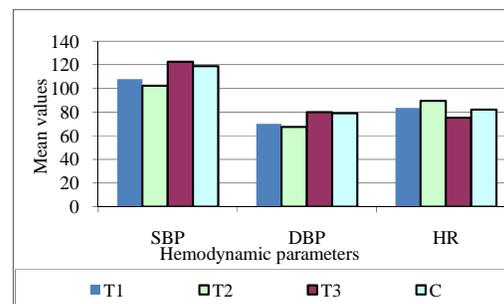
All the data was tabulated, comparison was done between the three trimesters in subjects and with the controls.

3. RESULTS

Statistical methods like Independent samples 't' test, Paired samples 't' test, Analysis of variance (ANOVA-One way), Tukey's HSD Test, Repeated measure ANOVA were applied.

At rest SBP response was higher in the order T3>C>T1>T2. DBP was also higher in the same order as SBP. While HR was higher in the order T2>T1>C>T3 as in **Figure 1**.

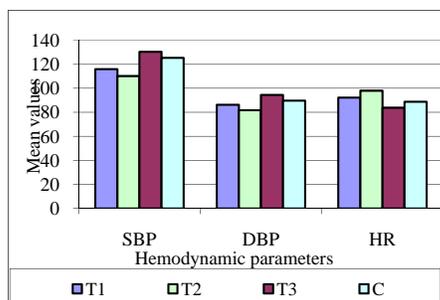
Figure 1:



All the three parameters at 20% MVC intensity have shown significance in P value. In all the trimesters and in Controls the rise of SBP was in the same order as seen above T3>C>T1>T2. DBP showed

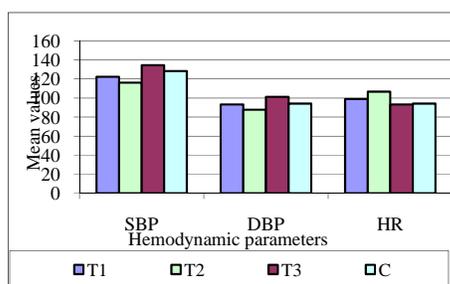
same kind of change as SBP. HR displayed the rise in the order of $T2 > T1 > C > T3$ as in **Figure 2**.

Figure 2:



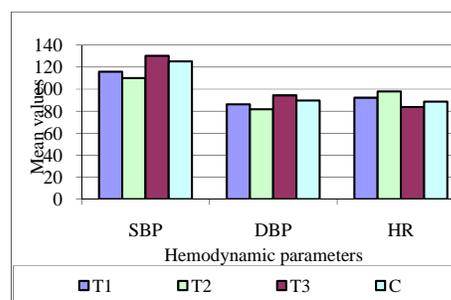
Hemodynamic parameters at 30% MVC displayed the same kind of proportional change as in 20% MVC but showed more rise in SBP in the order $T3 > C > T1 > T2$. DBP also stuck to the same order as SBP and HR also found the same order as in the 20% MVC but more proportional rise during sustained handgrip as in **Figure 3**.

Figure 3



During the PE, all the 3 hemodynamic parameters exhibited significance. PE parameters displayed almost the same responses observed during the Rest phase, indicating PE cardiovascular responses were nearly equal to the rest readings. Hence recoveries from the sustained isometric contractions have produced the resting or basal levels. The rest of 5 min between the isometric exercises produced the required time to bring back the hemodynamic parameters to normal or near normal values as in **Figure 4**.

Figure 4:



4. DISCUSSION

Muscular activity is associated with a rise in blood pressure and an increased heart rate reflecting a circulatory adaptation to the muscular work performed. Regulation of the cardiovascular functions during static muscle contraction is of central or peripheral origin (“central command”) descending from the higher motor centers to the heart and the vasomotor system.³ On the other hand, reflexes from contracting muscles are also known to affect the cardiovascular system during exercise.⁴

In this study two levels of static (20% and 30%) contractions were recorded for 3 min because (a) contractions greater than 15% maximal voluntary contraction are known to cause progressive hemodynamic changes to the point of fatigue (b) the duration approximates the point of fatigue⁵. Especially we chose this level of 30% intensity, judging it to be tolerable to most subjects, when held sustained contraction for 3 minutes. Our study results also indicated a significant change when the magnitude of the hemodynamic changes occurring during the static exercise seems to depend upon the relative strength of contraction and on the duration of contraction similar to the Lind and McNicol studies.⁶ The contraction used in our study was of greater intensity (30% MVC), and utilized a smaller skeletal muscle mass as in Davies and Starkie study. It is possible that a smaller skeletal muscle mass and greater intensity results

in a greater degree of effort, which may contribute to the rise in HR.⁷

Subjects in first and second trimesters have shown a rise in heart rate than the Controls and a profound rise was seen in the second trimester as the first haemodynamic change during pregnancy seems to be a rise in heart rate. This is in accordance with other studies done by Hunter and Moll. Starting between two and five weeks this continues well into the second and third trimesters.^{8,9} During sustained isometric exercise (20% & 30% MVC) the heart rate was raised due to decreased vagal tone. Withdrawal of the vagal tone is the autonomic effector mechanism to which the development of tachycardia during SHG is generally attributed.¹⁰ Another potential mechanism for a positive chronotropic response is the reflex described by Blinks in his study, coincided with ours and it is due to increased venous return.¹¹

In our study, blood pressure in first and second trimesters showed a fall compared to Controls. The fall in BP was significant in the second trimester than the first indicating that BP decreases in early pregnancy, reaching a minimum in mid pregnancy.¹² Our findings were supported by Duvekot study. The first trimester of pregnancy also showed a lower sympathetic modulation. Whereas in the third trimester, there was an increase in the BP stating that an increase in sympathetic modulation was responsible for the raise in BP, this is again in accordance with kuo's study.¹³ SBP and DBP rose significantly with a greater increase in DBP due to the increase in peripheral resistance. The marked rise in arterial pressure during SHG may also be viewed as an obligatory response designed to improve flow to exercising muscle.

It is reported that due to longer latency period (3-6sec) between sympathetic stimulation and cardiac acceleration, withdrawal of vagal tone was the first mechanism to be utilized in the heart rate

response to SHG and the sympathetic response occurred after the first mechanism had been utilized, so it is unlikely that sympathetic stimulation initiates the heart response. The results we obtained were similar to other studies carried out by three other authors; Kozlowski, Petro and Nutter.^{14,15,10} Hence our study showed a certain rise in HR during sustained static exercise in both first and second trimesters and then return to steady state in the third trimester, whereas, the BP also showed elevated levels with sustained static exercise though at rest in the first trimester there was fall in BP and in second it was even less. Thus demonstrating a Bi-phasic hemodynamic response during pregnancy in accordance with Kuo's study.¹³

CONCLUSION

Isometric handgrip exercise was performed in a reproducible, graded manner in the supine position while permitting the continuous recording of electrocardiographic and hemodynamic data. As Static efforts can provoke cardiac arrhythmias and load the left ventricle, certain precautions must be taken. The electrocardiogram should be continuously monitored and isometric handgrip exercises terminated if angina pectoris or rhythm disturbances develop.

With cautious monitoring under the supervision of a physician stress testing can be undertaken without risks in pregnant women. Our goal is to catalogue events in a setting similar to "*real world exercises*" like lifting weights. A future experimental goal would be to construct a model of isometric exercise that would allow simultaneous maternal and fetal hemodynamic measurements.

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