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Myocardial load at 30% and 50% of Maximal Voluntary Isometric Contraction in healthy individuals with Active and Sedentary Lifestyle

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Abstract

Background: Activities of daily living consists of isometric & isotonic contraction. Isometric contraction is a static contraction that exerts pressure overload on the heart. Studies have been carried out demonstrating hemodynamic effects of isotonic exercises however limited studies are available on myocardial load with isometric exercises. **Aims and Objectives:** To study the myocardial load at 30% and 50% of maximal voluntary isometric contraction (MVIC) in individuals with active and sedentary lifestyle**. Study design and setting:** Observational cross-sectional study was carried out in a tertiary care hospital. **Materials and Methods:** 140 healthy subjects (70 each in active & sedentary group) were recruited for the study. Baseline demographics of both groups were comparable. Hemodynamic parameters were taken at rest. Subject performed 30% and 50% MVIC and hemodynamic parameters were recorded during and post contraction. **Statistical Analysis:** Paired t test was used to compare the myocardial load between 30% and 50% MVIC in both groups. Repeated measures ANOVA was used to compare the myocardial load between active & sedentary groups at 30% and 50% MVIC. **Result:** There was a statistically significant difference in heart rate, systolic blood pressure &rate pressure product between 30% and 50% in active as well as sedentary groups. There was statistically no significant difference in heart rate, systolic blood pressure & rate pressure product between active & sedentary groups at 30% and 50% MVIC. **Conclusion:** The myocardial load during activities at submaximal intensities (<50%) is within the physiological limits and can be performed safely in individuals with active and sedentary lifestyle.

Abbreviations:

- Blood pressure- BP
- Diastolic blood pressure- DBP
- Heart rate- HR
- Maximal Voluntary isometric Contraction-MVIC
- Rate Pressure Product- RPP
- Systolic blood pressure- SBP

Keywords: Social Motives, Affiliation, Recognition, Motivations of Marathoners Scales, Masters Athletes.

INTRODUCTION

Activities of daily living (ADL) is a combination of isometric and isotonic muscle contraction.[1] The proportion of haemodynamic load corresponds to the amount of maximal voluntary contraction and the duration for which it is carried out.[1] One of the commonly used sympatho-excitatory stress like isometric muscle contraction can be done using sustained handgrip test.[2] This form of exercise increases the heart rate and blood pressure and thereby myocardial oxygen requirements.[3]

Individuals having an active or sedentary lifestyle have variability in their resting heart rate and blood pressure. Active group have conditioning effect on their heart i.e. they have increased vagal tone and also their response to exercise (dynamic) is variable.[4] Studies have been carried out in heart failure & hypertensive patients which have shown increased haemodynamic load during higher intensity of contraction and thus it is recommended to allow up to 50% of maximal voluntary isometric contraction in these patients.[5,6] Although the haemodynamic effects of dynamic exercise have been well studied,

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there is limited knowledge of haemodynamic effects of isometrics in people with active and sedentary lifestyle.

Thus, the current study was undertaken to observe the myocardial load to isometric exercise test in healthy individuals with active and sedentary lifestyle.

MATERIALS AND METHODS

Participants

140 healthy individuals in the age group of 20-40 were recruited in the study. They were evaluated for their lifestyle using ACSM's criteria and divided into active & sedentary groups.[7] Active lifestyle was defined as performing light intensity exercise – 30mins brisk walking/day or moderate intensity exercise - 5times/week or high intensity exercise - 3 times/week for last 6 months. Sedentary lifestyle was defined as sitting – 8-10 hrs/ day or walking – less than 30mins/day for last 6 months. Individuals having hypertension, diabetes mellitus, ischemic heart disease or any other significant medical disease affecting the haemodynamic response were excluded from the study. An observational cross-sectional study was carried out after obtaining ethical clearance from the Institutional Ethics Committee of a tertiary care hospital. All the subjects were seated comfortably on a chair with arm rest at room temperature.

Study procedure

Heart rate & blood pressure were taken at rest with the subject sitting comfortably in a chair with back support & arm rest. Subject was asked to perform 100% of his MVIC on hand dynamometer (JAMAR) for 30 seconds. 30% and 50% of his MVIC were calculated. Further, subject performed 30% and 50% MVIC for 2 mins with 10 mins of rest pause in between the two contractions for the parameters to return to rest. Heart rate and blood pressure were recorded during and immediately after the contraction. Rate pressure product was derived using systolic blood pressure & heart rate.

Statistical Analysis

Data was analysed using SPSS version 23. Repeated Measures ANOVA was used to compare rate pressure product at 30% and 50% between active and sedentary groups with level of significance set at $p < 0.05$ and confidence interval of 95%.Paired t-test was used to compare rate pressure product between 30% and 50% in active as well as sedentary groups with level of significance set at $p < 0.05$ and confidence interval of 95%.

RESULTS

Group characteristics

There were 34 males & 36 females in active group and 35 males & 35 females in sedentary group. Mean age group in active group was 28± 6 yrs & sedentary was 29± 5 yrs. Mean 100% MVIC in active group was 13± 6 kgF and 9 ± 3 kgF in sedentary group. Basal heart rate was 77± 8 bpm & 80± 10 bpm in active & sedentary group respectively. Basal systolic blood pressure was 115± 12 mmHg & 118± 8 mmHg in active & sedentary group respectively. Basal rate pressure product (mmHg*beats/min) was 8989 ±1397 in active group & 9541±1600 in sedentary group.

Myocardial load at 30% and 50% MVIC in active and sedentary groups

There was a statistically significant difference in heart rate, systolic BP & rate pressure product($p=0.00$) between 30% and 50% in active group and similarly in sedentary group. There was statistically no significant difference in heart rate, systolic BP & rate pressure product between active and sedentary groups at 30% as well as 50% MVIC.

DISCUSSION

Isotonic(dynamic) and isometric(static) exercises are known to impose different type of hemodynamic load on the heart. Haemodynamic response to exercise is primarily mediated by alterations in parasympathetic and sympathetic neural activity.[8] Static exercise imposes pressure load on the myocardium in response to the relative tension (% of MVIC) in the muscle group. The stroke volume remains largely unchanged. The rise in the cardiac output is mainly attributed to the rise in the heart rate. The increased cardiac output and the reflex vasoconstriction results in rise in the systolic and diastolic blood pressure.[9]

Haemodynamic changes between 30% & 50% MVIC in Active group & Sedentary group.

The hemodynamic response to isometric contraction depends upon the intensity of contraction.[8] Thus, the hemodynamic load was studied at two different percentages of submaximal intensities i.e. 30% MVIC to 50% MVIC. On studying the change obtained in hemodynamic response between 30% and 50% MVIC in active group, the difference in HR was from a minimum of 0.88bpm to maximum of 3.23bpm with a mean difference of 2.05 (±4.93) bpm. Similarly, the difference in systolic blood pressure was from a minimum of 1.79 mmHg and maximum of 5.37mmHg with a mean difference of 3.58(±7.5) mmHg. The difference in rate pressure product was from a minimum of of 333mmHg*bpm and maximum of 854 mmHg*bpm with a mean difference of 594 mmHg*bpm as shown in table 1.

Similarly, on studying the change obtained in hemodynamic response between 30% and 50% MVIC in sedentary group, the difference in HR was from a minimum of 3.22 bpm and maximum difference of 4.52 bpm with a mean difference of 3.87(±2.7) bpm. Similarly, the difference in systolic blood pressure was from a minimum of 3.11 mmHg and maximum difference of 5.14mmHg with a mean difference of 4.12(±4.26) mmHg. The difference in rate pressure product was from a minimum of minimum difference of 686 and maximum difference of 1015 mmHg*bpm with a mean difference of 850 mmHg*bpm as shown in table 2. It could be explained by the mechanism that with increase in the strength of contraction there is increased recruitment of motor units thus increased sympathetic stimulation thus increased hemodynamic response. [10,11]

K Balu [10] found statistically significant rise in HR by 8 bpm, SBP by 10mmHg and DBP by 11mmHg at 20% MVIC and statistically significant rise in HR by 18 bpm, SBP by 18mmHg and DBP by 20mmHg at 50% MVIC in healthy individuals in the age group of 25-35. In a study, Priyadarshini *et al* [12] found a significant increase in HR by 36bpm, SBP by 25mmHg, DBP by 13 after hand grip exercise (30%MVIC for 3 mins) in healthy young adults in the age group of 17-25 years. Ewing *et al*. [13] carried out in untreated systemic hypertension showed no significant difference in the hemodynamic load at 30% MVIC for 4mins as compared to the normal individuals and hence concluded that isometric exercise at submaximal intensity can be prescribed for hypertensives. However, a study by Elkayam *et al*. [1] in the patients with chronic advanced heart failure that evaluated the hemodynamic effects of isometric exercise in 53 patients with congestive heart failure (CHF) and compared them with those found in 10 normal subjects. In both groups, isometric exercise (30% of MVC for 5-7 minutes) increased heart rate and blood pressure. This study was carried out for a longer duration(5-7mins) in contrast to our study which was carried for shorter duration (2 mins).

Haemodynamic changes between Active and Sedentary groups at 30% and 50% MVIC.

It is known that the active group of individuals have a conditioning effect on their cardiovascular system due to the predominance of vagal

tone at rest and thus show lesser variability in the hemodynamic parameters following exercise as compared to that in the sedentary or physically inactive group.[4] However, with isometric exercise at 30% & 50%MVIC, this study did not find any statistically significant difference between the 2 groups thus this form of exercise poses similar haemodynamic load at submaximal intensities of isometric contraction on both the groups. The difference in heart rate at 30% MVIC between active and sedentary group was 3 bpm similarly at 50% MVIC was by 4 bpm. The difference in systolic blood pressure at 30% MVIC between the two groups was 1mmHg and at 50% MVIC was 4 mmHg. The difference in rate pressure product between the two groups is depicted in the fig 1 & 2.

As myocardial load corresponds to the rate pressure product which a product of systolic blood pressure and heart rate, the myocardial load increases with increase in any of the two or both the parameters. In this study, there was rise in heart rate as well as systolic BP which thereby caused increased myocardial load. However, the myocardial load which is imposed at 30% and 50% MVIC was observed to be within the physiological limits as per the standard guidelines for hemodynamic response to the exercise testing.[14] The activities of daily living require isometric activity which corresponds roughly to 30% MVIC [5] and also these activities are carried out for a short duration, the myocardial load is within normal limits and thus these activities can be performed by the healthy individuals of both the active and sedentary groups safely. This form of exercise can also be used as a part of exercise prescription in healthy individuals.

Table 1: Comparison between 30% & 50% MVIC in Active group.

30%-50% MVIC Active	Mean	Standard deviation	95% Confidence Interval Lower Bound	Upper Bound	Significance
HR (beats/min)	-2.0587	4.93402	-3.23362	-0.88067	0.00*
SBP (mmHg)	-3.5857	7.5229	-5.37949	-1.79194	0.00*
RPP (mmHg*bpm)	-594.2	1,092.137	-854.6825	-333.8603	0.00*

Level of significance p<0.05*

Table 2: Comparison between 30% & 50% MVIC in Sedentary group

30%-50% MVIC Sedentary	**Mean**	**Standard deviation**	**95% Confidence Interval Lower Bound**	**Upper Bound**	**Significance**
HR (beats/min)	-3.87143	2.72360	-4.52085	-3.22201	0.00*
SBP (mmHg)	-4.1285	4.26622	-5.14582	-3.11133	0.00*
RPP (mmHg*bpm)	-850.9	691.49477	-1,015.80	-686.047	0.00*

Level of significance p<0.05*

Table 3: Comparison between Active and Sedentary groups at 30% and 50% MVIC.

Parameter	**Significance (p value)**	**Significance**
	30% active vs 30% Sedentary	50% active vs 50% Sedentary
HR (beats/min)	0.47	0.85
SBP (mmHg)	0.54	0.50
RPP (mmHg*bpm)	0.47	0.56

Level of significance p<0.05*

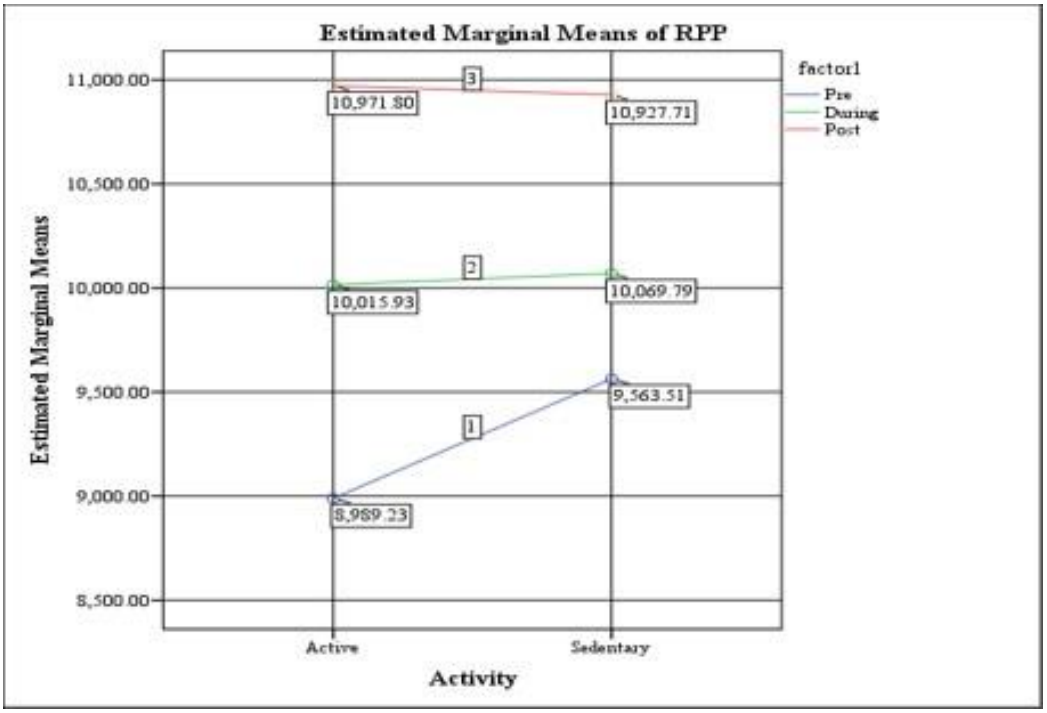

Figure 1: RPP at 30%(mmHg*beats/min) at pre-during-post level in Active & Sedentary groups.

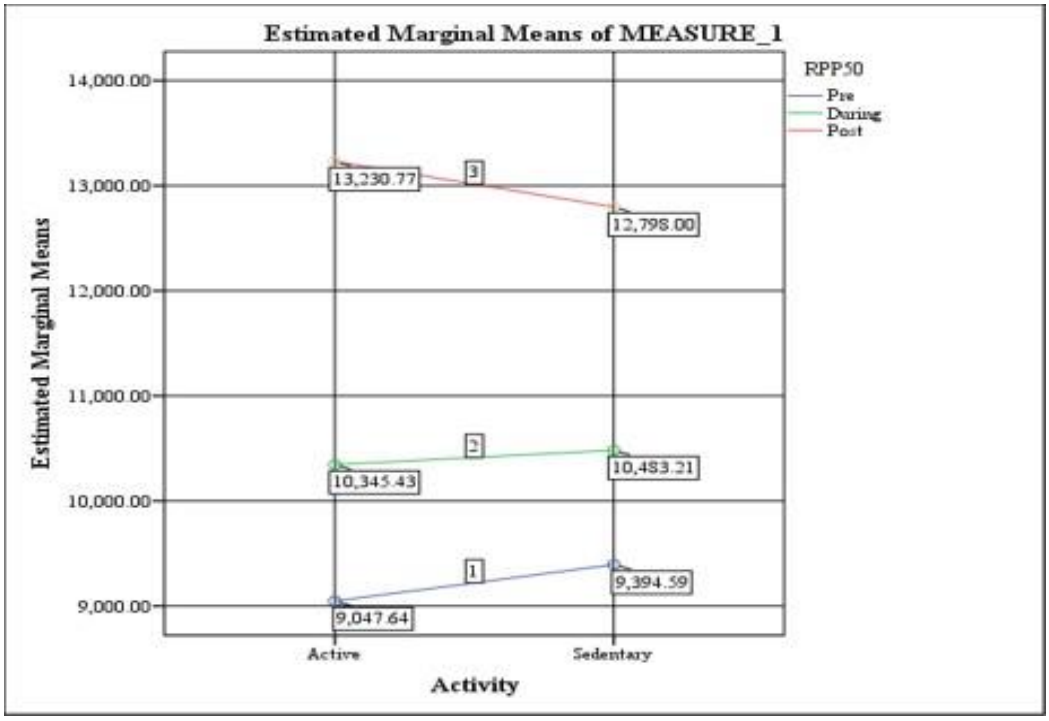

Figure 2: RPP at 50%(mmHg*beats/min) at pre-during-post level in Active & Sedentary groups

CONCLUSION

The study found a statistically significant difference in the haemodynamic load between 30% and 50% MVIC in active as well sedentary groups. There was no statistically significant difference in rate pressure between active and sedentary groups at both the intensities of contraction. However, these differences were within the physiological limits. The vitals i.e. heart rate, blood pressure and rate pressure product returned to the resting levels within 1-3 mins after terminating the contraction. Thus, activities of submaximal intensities can be performed safely by healthy individuals with active or sedentary lifestyle.

Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Authors' contributions

SS and MJ conceived and designed research, performed the study, analysed and wrote the manuscript. All authors read and approved the manuscript. All the authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

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