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# Effect of repetitive spinal extension exercises in standing versus lying on cardiovascular responses in individuals

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## ABSTRACT

### Background

Repetitive spinal extension exercises have effects on cardiovascular system and it differs when performed in different positions like lying and standing. Rate Pressure Product (RPP) is a valuable marker of cardiac function. Rate Pressure Product (RPP) is the product of mean Heart Rate and mean Systolic Blood Pressure and $10^{-2}$.

### Aim

The aim of the study was to evaluate the effect of repetitive spinal extension exercises in standing versus lying on cardiovascular responses in individuals when these exercises were repeated 10, 15 and 20 times.

### Method

100 subject both males and females were selected between the age group of 20-40 years. Baseline measures of resting heart rate, blood pressure, and rate pressure product were taken before and after each set of exercise i.e. 10, 15 and 20 repetitions with a 15 minute rest between the sets.

### Results

The result of this study showed that Rate Pressure Product increases after 10, 15 and 20 repetitions of spinal extension exercises in both extension in lying and extension in standing.($p<0.0001$)When compared between both the exercises, results of our study showed that cardiovascular changes were more marked in Extension in Lying than Extension in Standing.

### Conclusion

The study concluded that repetitive spinal extension in lying shows more significant effect on cardiovascular response than in standing.

**Keywords:** Extension in standing, Extension in lying, Heart rate, Systolic blood pressure, Rate Pressure Product

## INTRODUCTION

Repetitive spinal extension exercises produce cardiovascular effects after performing them in positions like lying and standing. Cardiovascular demands are directly related to number of repetitions.[1]

Direct measurement of myocardial work as a function of myocardial oxygen demand involves invasive techniques and is not feasible for routine clinical examination. Simple non invasive measures of cardiovascular responses, however, can be obtained with Heart Rate, Systolic Blood Pressure, and the Rate Pressure Product. Rate Pressure Product (RPP) is the product of mean Heart Rate and mean Systolic Blood Pressure and $10^{-2}$.[2]Increase in Rate Pressure Product denotes high cardiac work load.[1]The RPP is considered as an excellent index of myocardial oxygen demand and therefore, work of the heart.[2] RPP is also called the double product.[3]

**RATE PRESSURE PRODUCT (RPP) = MEAN HEART RATE (HR) × MEAN SYSTOLIC BLOOD PRESSURE (SBP) × $10^{-2}$**

RPP reflects the internal myocardial work performed by the beating heart whereas the performance of the external myocardial work is represented by the stages of exercise. Heart, being a muscular organ, its regular functioning needs steady supply of oxygen and nutrients.[4]

Three important mechanical factors determine myocardial oxygen uptake:

1. Tension development within the myocardium.
2. Myocardial contractility
3. Heart rate

When each of these factors increase during exercise, myocardial blood flow adjusts to balance oxygen supply with demand.[3]

RPP is not only an index of oxygen consumption by the heart but also an important indicator of ventricular functional status. Determination of cardiac oxygen consumption becomes important while training an athlete or in monitoring the level of exercise to be done by various groups of persons like obese persons, cardiac patients and diabetic patients. If the cardiac muscle power is over worked beyond 'limit', it may lead to development of angina. That 'limit' can be determined by calculating RPP. Low RPP value suggests the restricted coronary blood supply with inadequate ventricular function[4]

Spinal extension exercise in standing and lying involve muscle co-contraction to stabilize the trunk and arm exercise, both of which are associated with disproportionate cardiovascular demand to a given load compared with leg work.[2]The smaller arm muscle mass and vasculature offer greater resistance to blood flow than the larger and more vascularised lower body regions. This means that blood flow to the arms during exercise requires a much larger systolic head of pressure and accompanying increase in myocardial workload and vascular strain.[3]These exercises are associated with increased cardiovascular stress as manifested by increased work of the heart, which is reflected by increased Heart Rate and Blood Pressure for a given sub-maximal load.[2]

Several researchers have investigated the effect of various types of submaximal work performed by the upper extremities on the RPP versus the lower extremities. The increase in Heart Rate and Systolic Blood Pressure per unit of increase in work is greater during upper extremity exercise than during lower extremity exercise. Isometric muscle contractions are associated with increased cardiovascular stress as manifested by increased work of the heart, which is reflected by increased heart rate and blood pressure for a given sub maximal load. Thus, isometric exercise produces primarily a pressure load. Increase in Heart Rate and Blood Pressure are proportional to the torque produced by the muscles. Lumbar spinal extension involves upper extremity work using both concentric and eccentric contractions. Eccentric muscle contractions are associated with less oxygen demand (and, therefore, less cardiovascular stress) than concentric muscle contractions.[6]

## METHODOLOGY

- **Type of study -** Crossover Study
- **Sampling method** - Convenient Sampling
- **Sample size** - 100
- **Study setting** – 1. Dr. Vasantrao Pawar Medical College, Hospital and Research Centre, Nashik

2. Subjects in and around Nashik

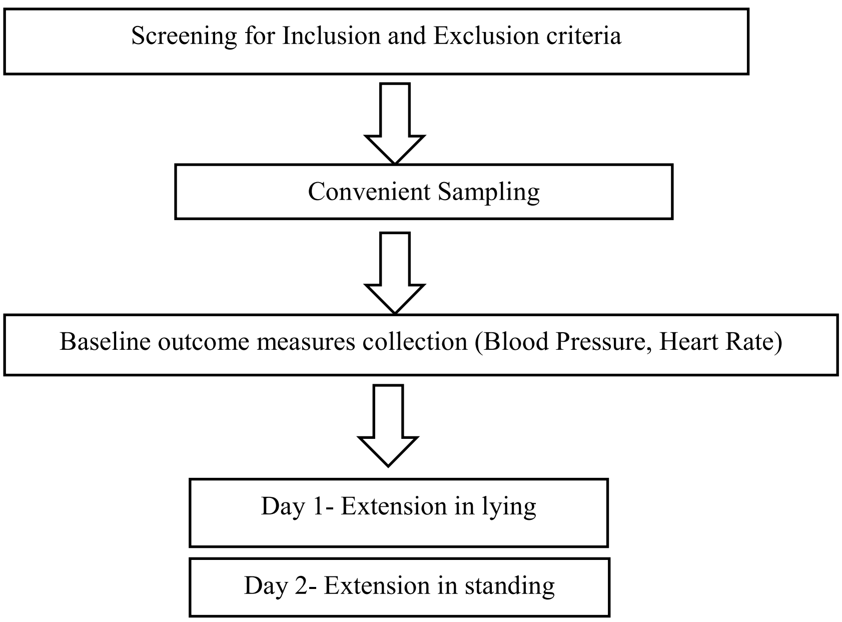
- **Study duration** - 6 months

100 subjects were evaluated and screened based on the inclusion and exclusion criteria. The inclusion criteria used was age group 20-40 years and both males and females. The exclusion criteria used was any subject suffering from anaemia, cardiovascular disease, pulmonary disease, recent musculoskeletal trauma, spinal pathology, low back pain, metabolic disorder.

### Instruments and tools used

- Consent form
- Pen
- Paper
- Digital Sphygmomanometer (OMRON HEM-7124)
- Yoga mat
- Chair

### Procedure



Data Analysis and Results

3 sets of exercises with post outcome measures

10 repetitions with post outcome measures

15 repetitions with post outcome measures

20 repetitions with post outcome measures

3 sets of exercises with post outcome measures

10 repetitions with post outcome measures

15 repetitions with post outcome measures

20 repetitions with post outcome measures

The same subject performed both exercises i.e. Extension in Lying on Day 1 and Extension in Standing on Day 2.

## Day 1- Extension in lying

The subject was made to sit in a relaxed position in a chair for 5minutes. Baseline Systolic BP, Diastolic BP, Heart Rate was taken before the exercise. Heart Rate and Blood Pressure was recorded twice to obtain mean values. The subject was asked to lie in prone. Then, they were instructed to lift up their upper body off the floor with their hand supporting the body. Their hips should remain in contact with the floor. Each subject performed 3 sets of exercises with 10, 15 and 20 repetitions. Subjects were given a rest period of 15 minutes following each set to make sure their Heart Rate and Blood Pressure comes to baseline before they perform the next level of repetitions. They were instructed to complete each exercise to their maximum possible end range and hold for 1-2 second. They were asked not to hold their breath during the exercise. After the subject completed 1 set of exercise, Heart rate and Blood Pressure was taken using digital sphygmomanometer.

## Day 2- Extension in standing

The same subject was made to sit in a relaxed position in a chair for 5minutes. Baseline Systolic BP, Diastolic BP, Heart Rate was taken before the exercise. Heart Rate and Blood Pressure was recorded twice to obtain mean values. The subject was instructed to bend backwards in standing position with hands at the waist. Each subject performed 3 sets of exercises with 10, 15 and 20 repetitions. Subjects were given a rest period of 15 minutes following each set to make sure their Heart Rate and Blood Pressure comes to baseline before they perform the next level of repetitions. They were instructed to complete each exercise to their maximum possible end range and hold for 1-2 second. They were asked not to hold their breath during the exercise. After the subject completed 1 set of exercise, Heart rate and Blood Pressure was taken using digital sphygmomanometer.

## DATA ANALYSIS

The collected data is analysed using GraphPad Instat. Repeated measures ANOVA was used to compare the values of RPP obtained at rest and after 10, 15, and 20 repetitions after performing the two types of exercises i.e. spinal extension in lying and spinal extension in standing. Paired-t test was used to determine the statistical differences in the values of RPP within two types of exercises i.e. spinal extension in lying and spinal extension in standing at rest and for 10, 15 and 20 repetitions. Multiple comparisons were done to analyze the significance within each group by Tukey-Kramer's Multiple Comparison post-hoc analysis.

**Table no. 1 Comparison of rate pressure product during spinal extension in lying**

| | MEAN±SD | TEST | P-VALUE | F-VALUE | SIGNIFICANCE |
|---|---|---|---|---|---|
| **REST** | 89.29±12.67 | REPEATED MEASURES ANOVA | <0.0001 | 1203.5 | SIGNIFICANT |
| **10 REPS** | 99.74±14.07 | | | | |
| **15 REPS** | 111.7±13.42 | | | | |

| | |
|---|---|
| **20 REPS** | 126.6±13.83 |

**Table no.2 Multiple comparison of rate pressure product within the group of spinal extension in lying**

| | TEST | P-VALUE | T-VALUE | SIGNIFICANCE |
|---|---|---|---|---|
| **REST V/S 10 REPS** | TUKEY-KRAMER'S MULTIPLE COMPARISON | <0.0001 | 21.643 | SIGNIFICANT |
| **REST V/S 15 REPS** | | <0.0001 | 47.614 | SIGNIFICANT |
| **REST V/S 20 REPS** | | <0.0001 | 80.079 | SIGNIFICANT |
| **10 REPS V/S 15 REPS** | | <0.0001 | 23.807 | SIGNIFICANT |
| **10 REPS V/S 20 REPS** | | <0.0001 | 56.271 | SIGNIFICANT |
| **15 REPS V/S 20 REPS** | | <0.0001 | 30.300 | SIGNIFICANT |

**Table no.3 Comparison of rate pressure product during spinal extension in standing**

| | MEAN±SD | TEST | P-VALUE | F-VALUE | SIGNIFICANCE |
|---|---|---|---|---|---|
| **REST** | 83.62±12.45 | REPEATED MEASURES ANOVA | <0.0001 | 917.73 | SIGNIFICANT |
| **10 REPS** | 89.01±12.46 | | | | |
| **15 REPS** | 94.85±13.48 | | | | |
| **20 REPS** | 101.5±14.22 | | | | |

**Table no. 4 Multiple comparison of rate pressure product within the group of spinal extension in standing**

| | TEST | P-VALUE | T-VALUE | SIGNIFICANCE |
|---|---|---|---|---|
| **REST V/S 10 REPS** | TUKEY-KRAMER'S MULTIPLE COMPARISON | <0.0001 | 19.696 | SIGNIFICANT |
| **REST V/S 15 REPS** | | <0.0001 | 43.332 | SIGNIFICANT |
| **REST V/S 20 REPS** | | <0.0001 | 66.967 | SIGNIFICANT |
| **10 REPS V/S 15 REPS** | | <0.0001 | 19.696 | SIGNIFICANT |
| **10 REPS V/S 20 REPS** | | <0.0001 | 47.271 | SIGNIFICANT |
| **15 REPS V/S 20 REPS** | | <0.0001 | 23.636 | SIGNIFICANT |

**Table no. 5 Comparison of rate pressure product between spinal extension exercise in lying and standing**

| | LYING | STANDING | TEST | P-VALUE | T-VALUE | SIGNIFICANCE |
|---|---|---|---|---|---|---|
| **REST** | 89.29±12.67 | 83.62±12.45 | PAIRED T-TEST | <0.0001 | 5.361 | SIGNIFICANT |
| **10 REPS** | 99.74±14.07 | 89.01±12.46 | | <0.0001 | 8.951 | SIGNIFICANT |
| **15 REPS** | 111.7±13.42 | 94.85±13.48 | | <0.0001 | 12.984 | SIGNIFICANT |
| **20 REPS** | 126.6±13.83 | 101.5±14.22 | | <0.0001 | 18.487 | SIGNIFICANT |

## DISCUSSION

The purpose of this study was to determine the effect of repetitive spinal extension exercises in standing versus lying on cardiovascular responses in individuals when these exercises were repeated 10,15 and 20 times.

In this study, 100 subjects were selected. 2 consecutive days exercise was performed i.e. Day 1 extension in lying and Day 2 extension in standing. Systolic blood pressure, diastolic blood pressure and heart rate were measured at rest and after 10, 15 and 20 repetitions.

From data analysis of this study, it was found that repetitive spinal extension in lying and standing both had significant effect in increasing Rate Pressure Product with more marked change observed in Extension in Lying than Extension in Standing.

EIL and EIS increase the work of the heart in people with no spinal impairments and no cardiovascular or cardiopulmonary insufficiencies. The cardiovascular demand increased as the number of repetitions for a given type of exercise increased.[14] HR, SBP, DBP and RPP increases after 15 and 20 repetitions of spinal extension exercises in both EIL and EIS. [1] 10 repetitions of spinal loading exercises in lying or standing positions are associated with the least cardiovascular stress.[2]

Using Repeated measures ANOVA test for analysis on data of Rate Pressure Product during Repetitive Spinal Extension in Lying, the p value obtained was <0.0001 which implies that it is statistically significant. This suggests that Repetitive Spinal Extension in Lying has significant effect in increasing Rate Pressure Product.

The plausible explanation can be extension in lying, a modified push-up exercise, involves upper extremity muscles to raise the upper trunk weight against gravity. [2] The smaller arm muscle mass and vasculature offer greater resistance to blood flow than the larger and more vascularised lower body regions. This means that blood flow to the arms during exercise requires a much larger systolic head of pressure and accompanying increase in myocardial workload and vascular strain.[3] During lying, cephalad fluid shifts occur which increase venous return and central blood volume, thus, the demand on the heart is greater.[2]

Using Repeated measures ANOVA test for analysis on data of Rate Pressure Product during Repetitive Spinal Extension in Standing, the p value obtained was <0.0001 which implies that it is statistically significant. This suggests that Repetitive Spinal Extension in Standing has significant effect in increasing Rate Pressure Product.

The plausible explanation can be that standing position is associated with less cardiac work. [2]The cardiac demand in standing position is lesser than in lying position due to cephalad fluid shifts in lying. Cardiac output and arterial pressure fall in standing position due to distension of venous system below the heart resulting in decreased venous return with rapid accumulation of blood in the legs.[1]

Using paired t-test for analysis on data of Rate Pressure Product between Repetitive Spinal Extension in Lying and Standing, the p value obtained at baseline was <0.0001, after 10 repetitions was <0.0001, after 15 repetitions was <0.0001 and after 20 repetitions was <0.0001 which implies that it is statistically significant. This suggests that cardiovascular changes were more marked in Extension in Lying than Extension in Standing.

The plausible explanation can be arm exercise in comparison with leg exercise is accompanied by a large rise in heart rate, blood pressure, pulmonary ventilation, and arterial lactate concentration and this difference is attributed to more dominating sympathetic vasoconstriction tone during arm exercise.[14]

During exercise, cardiovascular parameters change to supply oxygen to working muscles and to preserve perfusion of vital organs. The vascular resistance and HR are controlled differently during exercise. At the onset of exercise, HR elevation is mediated mostly by central command signals via vagal withdrawl.[8]As the work rate increases, heart rate continues to rise above this level due to continued parasympathetic withdrawal and due to added effect of sympathetic stimulation from cardiac accelerator nerves. The increase in arterial pressure during exercise is believed to result mainly from the activation of motor areas of the nervous system to cause exercise and from the activation of reticular activating system of brain stem which includes greatly increased stimulation of the vasoconstrictor and cardio acceleratory areas of the vasomotor centre. These increase the arterial pressure instantaneously to keep pace with the increase in muscle activity. During exercise coronary blood flow increases four to six times above resting level. This is achieved because the increase in myocardial metabolism in exercise has a direct effect on the coronary vessels, causing them to dilate.[18]

Blood flow is also affected by the magnitude and frequency of active muscular contractions. The muscle metabolism increases in response to voluntary contractions and therefore, blood flow increases to active musculature.[1]

The results support that these exercises performed represent a risk for a patient with underlying cardiovascular dysfunction. [14]RPP is an indicator of increased myocardial oxygen demand and the product of SBP and HR is well correlated to myocardial oxygen consumption.[8]The degree to which an increase in RPP is an index of cardiovascular stress, represents cardiovascular strain depends on the underlying path physiology. [14]If SBP alone increases without altering the HR, it favours the myocardial oxygenation than an increase in HR along with SBP.[4] Lesser RPP is an indicator of more PSN activity and increased parasympathetic tone which is believed to be cardioprotective.[4]Thus, monitoring the cardiovascular status of patients with spinal problems for which the exercises are indicated and hemodynamic responses also should be considered when they are prescribed for home exercise program.[8]

## CONCLUSION

Spinal extension in lying and standing when done repetitively shows significant changes in cardiovascular response in individuals but extension in lying has greater cardiovascular effect than extension in standing.

Thus, it can be concluded that repetitive spinal extension in lying shows more significant effect on cardiovascular response than in standing.

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