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# ANALYSIS OF ACUTE CARDIOVASCULAR RESPONSES ON RESISTANCE EXERCISE IN DIFFERENT RECOVERY INTERVALS

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## ABSTRACT

Introduction: The cardiovascular system is the most submitted to overload during exercise practice. However, there is a lack of knowledge about heart response under different recovery intervals (RI). Objective: The purpose of this study was to analyze the heart overload, using as cardiovascular parameter, the heart rate (HR), systolic blood pressure (SBP) and double product (DP) under different recovery intervals (RI), delimited in 45″ (RI45″), 60″ (RI60″) and 90″ (RI90″) seconds. Methods: The study analyzed 10 volunteers, age 21.5 ± 6.04 years, weight 77.5 ± 10.62 kg and height 179 ± 7 cm, who were submitted to a protocol of three sets of 12 repetitions of 60% 1RM in Leg Press 45º apparatus. The Wilcoxon test was used to compare hemodynamic variables with significance level when $p \leq 0.05$. Results: There were significant differences of all variables when compared to pre-state effort with subsequent sets. The SBP was different between the first and the other sets. Moreover, difference between the second and third sets with RI45″ has been observed, and in the third set, the RI45″ presented greater values when compared to RI90″. Similarly, HR presented difference between the first and all other sets in all RI. The RI45″ and RI60″ showed differences between the second and third sets. However, DP has demonstrated difference between the first and all others sets in all RI, and, the RI45″ and RI60″ showed difference between the second and third sets. Conclusion: According to the results, it is concluded that SBP and HR are sensitive to the number of intrasets, but there was no difference when comparing RI with each other. However, there is greater tendency of RI45″ to cause increased cardiac overload, primarily by increase in SBP.

**Keywords:** *resistance training, heart rate, blood pressure.*

## INTRODUCTION

The elastic resistance training (ERT) or elastic resistance bands may be practiced using practitioner's own weight[1]. This type of exercise may be practiced either by healthy individuals or people with special needs[2-4]. During the physical exercise, there is a higher blood influx to the active muscles because it is necessary to increase oxygen and nutrients and remove metabolic barriers like carbon dioxide, lactate and hydrogen ions. Thus, cardiovascular system receives metabolic and neural stimuli to enhance its performance[5,6].

The method used to analyze the heart overload is double product (DP) which is the product of heart rate (HR) and systolic blood pressure (SBP)[7]. According to Leite and Farinatti[8], this parameter is still little used by health care professionals even though of great significance.

However, hemodynamic responses to ERT are different comparing aerobic exercises to exercising lower limbs. Mechanical vessel constriction surpasses local blood vessel dilation[9]. As consequence of this process, there is a higher resistance to blood flow and increasing in SBP[10].

Besides that, it is known that hemodynamic responses to ERT are directly influenced by the number of repetitions, number of sets, exercising speed, way of exercising and muscles involved in the training[11-15]. According to *American College of Sports Medicine*, intervals of 45 seconds and two minutes interfere in neither the strength nor muscle mass gains. However, studies referring to cardiovascular responses in different recovery intervals (IR) among sets are scarce in scientific literature.

To understand the hemodynamic responses in different IR, this study has the objective of analyzing these responses using SBP, HR and DP parameters in three different IR, delimited in 45″ (IR$45″), 60″ (IR60″) and 90″ (IR90″) using leg press 45° apparatus.

## MATERIALS AND METHODS

In this study, 10 male volunteers, aging 21.5±6.04 years, weighing 77.5±10.62kg and height 179±7cm, having minimum experience of six months in ERT and knowing this specific exercise were selected. The exclusion criteria of the study were: a) use of medicine that may alter HR or SBP; b) presence of any heart diseases; c) use of ergogenic aids at the stage of data collection; and d) presence of osteomioarticular injuries or orthopedic surgery in the last nine months. According to Law no 196/96, all the volunteers have signed a letter of consent in which all study procedures were explained.

Volunteers visited the place for testing four times. First visit had the objective of determining the test load and the volunteer was submitted to a repetition maximum test (1RM). For the next three visits, the test protocol was determined in three sets of 12 repetitions at 60% of 1RM and the recovery interval (RI45″, RI60″ or RI90″) was taken randomly.

SBP and HR were measured at 4 distinct moments using sphygmomanometer, BD® stethoscope, and TIMEX® digital heart rate monitor respectively. First, volunteers rested for five minutes right after arriving at the test center and their SBP and HR were measured at the end of the rest. During the training, SBP was measured between the last and the previous repetition of each set because the higher values are found at these moments[16]. HR was measured after five seconds the sets were finished at most because it is the time needed for the monitor update.

Wilcoxon test was performed to verify the existence of significant statistical difference among values of SBP, HR and DP intra and inter sets. $p<0.05$ was found in bilateral tests.

## RESULTS

Table 1 shows values referring to SBP and respective standard deviations with different recovery intervals. Table 1 shows that in all different RIs SBP has increased when comparing to rest of sets. At the interval 45", differences among the first and all the other sets were observed and the lower values were found in the first sets. Similarly, at IR60" there was differences among the first and all the other sets. Besides that, there was difference between second and third sets and the higher value was found in the last sets. IR90" presented significant difference among the first and all the other sets. However, when comparing RI90" and RI45", significant differences are observed among RI sets.

Table 2 shows figures referring to HR at training and respective standard deviations with different RI. Table 2 also presents significant difference among rest and sets during training. At RI45", there is a significant difference among the first and all the other sets. Besides that, there was significant difference between second and third sets and the higher figures were found in the last sets. RI60" showed significant difference among first and all the others sets besides the difference between second and third sets. However, RI90" only showed difference when comparing first sets to all the others.

Table 3 compares the double-product response with respective standard deviations with different RI. According to table 3, we may observe that there was significant difference among rest and subsequent sets. Besides that, significant differences among the first and all the other sets and between second and third sets in 45" were found. RI60" showed significant difference among the first and all the other sets besides the second and third sets. RI90" presented significant difference among the first and all the other sets. When comparing to different RI, no significant difference among them was found.

**Table 1.** Comparison of SBP (mmHg) among different IR.

| RI | Rest | First Sets | Second Sets | Third Sets |
|---|---|---|---|---|
| 45" | 109.8 ± 7.96* | 143 ± 8.01† | 156.6 ± 8.69 | 160 ± 6.79π |
| 60" | 111.4 ± 7.48* | 144.8 ± 8.12β | 153.2 ± 8.85€ | 159.2 ± 8.65 |
| 90" | 110.2 ± 7.96* | 142.8 ± 6.67¥ | 151.6 ± 8.31 | 152.6 ± 7.60 |

* Significant difference among rest and all the other sets. † Significant difference among first and all other sets at 60". € Significant difference between second and third set at 60". ¥ Significant difference among the first set and all the other sets at 90". π Significant difference between 45" and 90" in the third set. Β Significant difference in first set at 60".

**Table 2.** Comparison of HR (bpm) among different IR.

| RI | Rest | First Sets | Second Sets | Third Sets |
|---|---|---|---|---|
| 45" | 67.8 ± 5.73* | 126.9 ± 12.60† | 139.1 ± 13.1β | 145.6 ± 10.33 |
| 60" | 68.5 ± 3.71* | 131.9 ± 16.08¥ | 139.4 ± 14.74£ | 143.1 ± 13.59 |
| 90" | 65.5 ± 5.06* | 127.8 ± 15.27µ | 133.6 ± 14.43 | 136.3 ± 15.04 |

* Significant difference among rest and all the other sets. † Significant difference among first and all the other sets at 45". ¥ Significant difference among first set and all the others sets at 60".
£ Significant difference between second and third set at 60". µSignificant difference among the first set and all the other sets at 90". β Significant difference in second set at 45"

**Table 3.** Comparison of DP (mmHg.bpm) among different IR.

| RI | Rest | First Sets | Second Sets | Third Sets |
|---|---|---|---|---|
| 45" | 7,429.4 ± 654,1* | 18,171.4 ± 2.299† | 21,856.4 ± 3,078.4β | 23,328.6 ± 2,332.2 |
| 60" | 7,618.6 ± 470.4* | 19,179 ± 3,259.9# | 21.449.4 ± 3,454.8¥ | 22,868.2 ± 3,358.3 |
| 90" | 7,203.8 ± 572,9* | 18,240 ± 2,247.1£ | 20,273.8 ± 2,630.9 | 20,806 ± 2,563.6 |

* Significant difference among rest and the others sets. † Significant difference among first and all the other sets at 45". # Significant difference among first and all the other sets at 60"
¥ Significant difference between second and third sets at 60". £ Significant difference among first and all the other sets at 90". β Significant difference in second and third sets at 45".

## DISCUSSION

The direct methodology to measure SBP is performed through an intra-arterial catheter[17]. As this method is invasive, high costly and uncomfortable for the volunteer because of the pain it may cause, we decided to use a different method to measure SBP. So, auscultatory method, even underestimating SBP values, is accepted and used in the scientific field[16]. However, this measuring method is used in a daily basis in health care services. Besides, it is known that SBP decreases after around three seconds in submaximal exercises and until 10 seconds in maximum exercise[11]. Hence, this study followed regulations on measuring SBI in ERT avoiding post-exercise hypotension.

Table 1 shows the figures referred to SBP. The increasing of this variable during the training when compared to rest named positive inotropic effect is explained by the arterial vasoconstriction and arterioles in inactive tissues. That improves the venous return and myocardial contraction along with increasing systolic volume which is an essential factor[10,18].

During training, we observed differences among the first and all the other sets in all different RI. Similar study, Polito[19] when studying the effect of two different recovery intervals in the workbench, observed that SBP is influenced directly by the sets numbers as well as RI among sets. He also found that the higher values of RI were related to shorter times. According to Pollock[20], SBP is influenced in a way that it increases the response when submitted to high intensity of effort and all the muscles involved in the training. However, when comparing different RI in third sets, there was difference between RI45" and RI90". So, lower RI caused a significant increase when compared to higher RI. The most probable explanation is the fact that RI90" enhanced rest among the sets which kept pressure levels lower contrasting with RI45". Although, resting time *versus* training is a factor that may alter SBP responses. Table 2 demonstrates the HR response during training. It is known that HR is directly related to training level[5,7]. Thus, this variable is related to the number of repetitions, load and phenomenon called positive chronotropic effect, that is, increasing HR when comparing to resting. That fact is explained by decreasing parasympathetic tone triggered by the motor cortex and afferent neurons (mechanical receptors and chemoreceptors) which transmit information to cardiovascular center. That will increase the cardiac sympathetic tone releasing higher quantity of norepinephrine and generating higher activity on the sinoatrial node and increasing heart rate[5,7,10].

Based on the findings, HR presented differences among the first and all the other sets showing an accumulative effect of sets, that is, the higher the sets, the higher responses of HR were observed[21,22]. So, HR values are altered by RI.

Table 3 demonstrates the results found concerning DP. This variable shows a rate of cardiac overload and it related to oxygen inhaled by the myocardium[5,23]. According to our study, lesser overload was found in the first sets comparing to second and third sets. Thus, the increasing of sets as well as repetitions supports that finding[8,13,14,16]. Besides, changes in SBP and mainly HR values trigger the increasing DP[24]. However, this study shows that RI, mainly inter-sets are influenced by increasing SBP as shown by RI90" and RI45".

## CONCLUSION

According to the methodology applied and the results found, we may conclude that SBP and HR when compared inter-sets may change because of number of sets. However, when comparing hemodynamic responses among RI, there is a higher tendency that the lower interval (RI45") may cause cardiac overload mainly because of increasing SBP.

All authors have declared there is no potential conflict of interests concerning this article.

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