Analysis on the cardiac rate, blood pressure and doubled-product in different body positions in resisted exercises

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ABSTRACT

Presently, resisted exercises (RE) have suffered several investigations due to the importance they attained to the development of the cardiorespiratory and neuromuscular fitness. To prescribe the RE, some variables such as cardiac rate (CR), and blood pressure (BP) shall be monitored. The association between the CR and BP supply data to allow the obtainment of the doubled-product (DP). These two variables were used to analyze and compare the hemodynamic responses of the straight seat supine (SRS) and straight slying supine (SRD) and ten repetitions at 65% of a maximum repetition (1 RM) were performed. The sampling was composed by 14 individuals (10 female and 4 male) with mean ages of 23 years (± 4 years), body weight of 61 kg (± 7 kg), and height of 168 cm (± 5 cm). As material to the collection, it was used a *Polar MZ1* frequencymeter (Finland), a *Vasquez-Lubry* sphygmomanometer (Germany), and a *Littman* stethoscope (USA). It was used the coupled *t-Student* test to make a comparison between values found among physiological variables. The statistical analysis had as significance criterion $p < .05$. Every variable presented a mean higher value in the SRS related to the SRD. It was considered the pre- and post-exercise's CR, the BP, SBP and DBP. It is understood that the absolute value of the BP measured by the auscultatory method trends to be lower than the value recorded inside the artery, but in test situations using different intensity exercises, the percentage of the BP variation presents the same trend than the invasive method. Thus, it can be concluded that the SRS and SRD exercises did not present significant differences in none of the physiological parameters studied, but it was noted a small decreased response of that parameter in the SRD exercise. So, it is necessary to accomplish further studies analyzing different body positions to establish a conduct as to these exercises through comparisons.

Keywords: Hemo-dynamic responses. Body position. Strength training.

INTRODUCTION

It is recognized that the improvement of the physical aptitude can contribute in a significant way to the health, raising the quality of life level[1]. Among physical activities that may improve the health, to practice resisted exercises (RE) has been recommended by the major normative agencies of physical activity, such as the American College of Sports Medicine (ACSM)[2,3], and the American Heart Association[4], due to its relative safety, even among the so-called special populations.

As RE acquires importance, the number of published studies aiming to analyze intervenient factors (extrinsic and intrinsic) to the training trend to increase. As consequence, the training is individualized, as to answer more specifically each individual's needs, when it is considered aspects such as age[5], and cardiovascular diseases[6].

Despite of this, it is necessary to be surely surrounded by every precaution in order to increase as much as possible the safety of such practice. The position assumed by the individual to perform the exercise may interfere in some physiological variables. Simão *et al.*[7] showed that for the squat exercise in the lower limbs, the doubled-product was higher when performed in the stand up position in relation to the seat position. The quantification of the cardiovascular overload associated to the exercise is one of the strategies used to assure the safety of such practice[8]. However, some physiological variables shall be monitored to prescribe the RE, such as the cardiac rate (CR), and the blood pressure (BP). The isolated observation of these two variables does not assure a significant level of safety, but the association between them may supply data correlated to the oxygen consumption in the myocardium, and this is usually called the doubled-product (DP), which is calculated by multiplying the systolic blood pressure (SBP) by the CR.

The DP is a variable whose correlation to the oxygen consumption of the myocardium ($M\dot{V}O_2$) makes it to be considered the most reliable indicator of the heart work during continuous physical strength of aerobic nature[10]. This does not impede the DP to have value on the evaluation of the overload imposed to the cardiac muscle[8]. The appropriate occasion to measure the BP by the auscultatory method is fundamental to minimize possible errors contained in such technique[11].

Due to the importance of these physiological parameters (CR, BP, and DP) as to the prescription and controlling of the RE's intensity, having in mind the great scarcity of studies investigating these different body positions, this study has the purpose to analyze and compare the hemodynamic responses of the horizontal aduction of the shoulders with extension of the elbows in the straight supine in two different positions: the straight seat supine (SRS) using the equipment, and the laid down straight supine (SRD), performing ten repetitions at 65% of the workload of one repetition maximum (1 RM).

MATERIALS AND METHODS

The sampling was composed by 14 individuals (10 females and 4 males) with mean age of 23 years old (± 4 years), body weight of 61 kg (± 7 kg), and height of 168 (± 5) cm. All of them had six months of minimum experience in RE, and they had already practiced the exercises used to perform the tests. As inclusion criteria, it was considered the use of ergogenic resources, osteo-myo-articular disorders that would totally or partially impede them to per-

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form the exercises, drugs that would affect the BP and the CR, consumption of caffeine or alcohol, and physical activity during the data collection period. All individuals were volunteers, and they were submitted to a PAR-Q[12] questionnaire and signed a consent term according to the Resolution 196/96 of the National Council of Health in Brazil.

Aiming to reduce the possibility of any occurrence of errors during the one tests of maximum repetition (1 RM)[13], the following strategies[14] were adopted: a) instructions related to every test routine were previously supplied to every component of the sampling; b) the individual being evaluated was instructed on the execution's technique; c) the researcher was thoughtful on every moment of the exercises' execution with the purpose to impede that any mistake performed by the individuals could interfere in the data collection; d) tests were previously set, and they were always performed in a same time for each of the individuals.

It was analyzed the SRD and SRS exercises, due to the fact they are composed by the same muscles and technical formats (positioning and adjustment of individuals in the equipments). Having in mind to assure a pattern on the performance of the exercises during the tests, it was set the following steps:

Laid down straight supine:

The individual was in dorsal decubitus on the straight bench with his feet on one step, having his height adjusted in order to have his knees at a 90º angle. The implement where the individual's hands were supported was in the starting position, aligned just below the axillary line. This was the initial and final positions of the movement where the cycle was completed, and from there starting a new repetition.

Seat straight supine:

The bench of the equipment was adjusted as to allow that the implement where the individual was supporting his hands was aligned just below the axillary line when the individual was positioned to perform the movement. Seat on the equipment, the individual's hands were supported on the implement, as to have his elbow at a 90º angle just below his shoulders' line.

His feet were supported on the ground or step, allowing their knees to be at a 90º angle (depending on his height). This was the initial and final positions of the movement where the cycle was completed, and from there starting a new repetition.

In both executions of the concentric phase the articulations performed the simultaneous horizontal flexion of the shoulders in the whole extension of the elbows.

The trial was conducted in three alternate days. In the first day, a test was performed to determine the maximal workload in 1 RM in the SRD. In the second day (48 hours after the first evaluation), the same procedure was performed to the SRS. In the third day (72 hours after the second day), the individuals were submitted to the tests in ten repetitions at 65% of the 1 RM workload in both exercises, in order to measure the DP (BP x CR). After the workload test in the first day, all individuals were instructed to perform no physical activities using their upper limbs during the interval period between sessions, and they should come back to the site of the trial to be submitted to the second and third data collection. Such information was added to the research, in order to allow that the data collected would not suffer any alteration due to muscular stress on the upper limbs. In case the upper limbs would had been worked out during the period between tests, this could compromise the individual when performing the movement due to muscular fatigue.

When reaching the site of the tests, the individual was seat on a chair where he would be for five minutes to rest, and then he had his BP and CR measured. Then, the individual was positioned in the first equipment, which was randomly chosen, and ten repetitions were performed with a workload equivalent to 30% of the 1 RM as warming exercise. After five minutes, 10 repetitions were performed at 65% of the workload.

The CR and BP values were simultaneously measured, just before the beginning of the movement, and between the last but one and the last repetition, having the individual still in the equipment. This procedure was used taking into account that the higher values of the BP and CR responses probably occur during the two last repetitions of all series[15]. To the BP measurement, it was considered the systolic value of the first phase upon hearing the Korotkoff sound, and the fourth phase of the diastolic value. To the CR, it was used the higher value recorded when performing the exercise, or just after its completion, due to the time necessary to the monitor to attain the right measurement. Then, it was allowed a five minutes interval, when the individual repeated the same procedure to the other exercise. The individuals were requested to avoid the Valsalva maneuver when performing the exercises.

The CR measurements were made through a *Polar MZ1* frequencymeter (Finland). The BP measurements were made using a Vasquez-Lubry aneroid sphygmomanometer (Germany) always located on the left arm, and a Littman stethoscope (USA), where it was considered a 2-2 mmHg interval.

It was used the coupled t-Student test to perform a comparison between values found in the physiological variables. The statistical analysis had as significance criterion $p < 0.05$.

RESULTS

Related to the CR of the pre-SRS exercise, the mean value found was of 86 bpm, and to the SRD it was of 81 bpm. In the post-exercise CR, the values to the SRS was of 99 bpm, and to SRD, it was of 96 bpm (figure 1). The significance between exercises related to the CR ($p = 0.285$) did not show any significant difference between values.

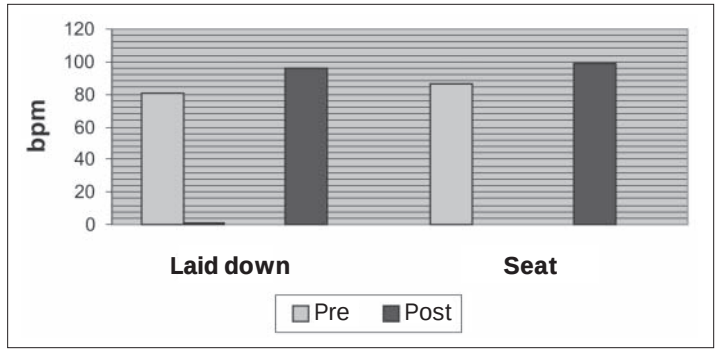

***Fig. 1** – CR responses to the laid down and seat supine exercises*

Taking into account that the auscultatory method can cause underestimated values for the SBP during the RE[16], the DP will not correspond to the real value as well. However, regardless the way used to perform the measurement, the BP variation can inform the demand's magnitude imposed by the exercise. The pre-exercise SBP presented a mean value of 116 mmHg for the SRS, and 113 mmHg for the SRD. The post-exercise SBP presented mean values of 128 and 127 mmHg for SRS and SRD, respectively. The pre-exercise diastolic blood pressure (DBP) was of 76 mmHg in the SRS, and 69 mmHg in the SRD. The post-exercise DBP was of 72 mmHg in the SRS, and 65 mmHg in the SRD. The significant SBP between exercises was of $p = 0.692$, and for the DBP it was of $p = 0.511$, thus not showing any significant difference for both values in the two variables (figure 2).

The pre-exercise DP was of 9,931 in the SRS, and 9,125 in the SRD. The post-exercise values were 12,554 in the SRS, and 12,151 in the SRD (figure 3). The significance between exercises was of $p = 0.112$.

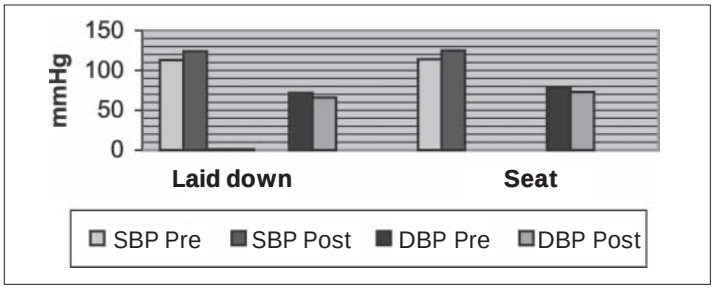

***Fig. 2** – BP responses to the laid down and seat supine exercises*

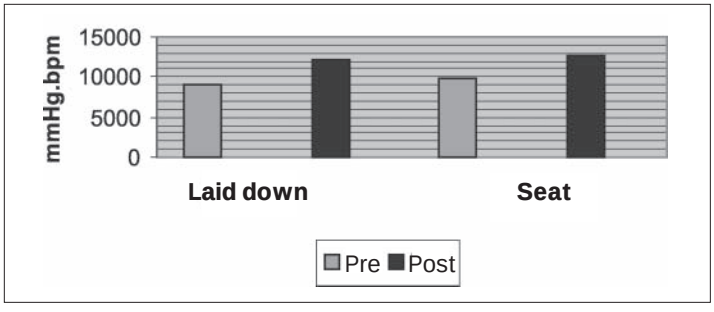

***Fig. 3** – DP responses to the laid down and seat supine exercises*

DISCUSSION

There is scarcity of information concerning to cardiovascular responses and the adaptation to the RE[7]. It can be identified in the literature a predominance of studies searching the correlation of the cardiovascular safety to the type of contraction involved in the exercise (static or dynamic), mainly on individuals pertaining to the risk groups or athletes[17].

Before starting the discussion on the data obtained, some comments related to the materials and methods shall be clarified. The first observation is related to the BP measurement through the auscultatory method.

According to Leite and Farinatti[8], one of the obvious critiques which arises is the possibility to underestimate the pressure, considering the accuracy of the invasive methods, such as the intra-arterial catheterism. It is obvious that the absolute values of the BP supplied by the invasive techniques have major validity and reliability. However, such evaluation was performed in healthy individuals – and since catheterism is an invasive method, it implies considerable risks (such as pain, arterial spasm, thrombosis, stenosis, vasovagal syncope, hemorrhage, etc.). Due to its invasive nature, considered a gold standard, to promote risks through the use of such application would surpass ethical limits having in mind the scientific investigation[19]. Some authors[8,11,20-24], argue on the applicability of invasive methods to quantify the systemic pressure, once they are extremely sensitive to the pulse pressure while performing the activity, and less to the flow detection[18]. It is recognized that the measurement made through the auscultatory method trends to underestimate the absolute values of the BP during the exercises. However, in more intense exercises, compared to those values obtained through auscultatory methods, the relationship between both of them trends to be kept, as it was described in some studies[7,8,20-22]. Considering the bias that the BP's underestimation happens in a systemic way, the association of an activity with the highest or lowest BP values can be detected. Therefore, due to the nature of the demand proposed in this study, this seems to be sufficient.

In the literature, there are several studies on the acute cardiovascular responses during physical exercises. They show that REs present a lower DP than the aerobic exercises[17]. Farinatti and Assis[17] evaluated 18 individuals in counter-resistance exercises in 1, 6, and 20 maximum repetitions (RM), and a continuous aerobic training in the cycloergometer for 20 minutes at 75-80% of the reserve CR. In the RE, the highest DP was recorded in 20 RM, followed by the 6 RM, and finally, the 1 RM, recording the lower value for DP.

Thus, in the RE, the increase in the DP was more associated to the number of repetitions than to the workload, and in the aerobic workload it was recorded a highest DP compared to the RE. It can be concluded that regardless their intensity, the RE imposes a lower cardiac demand than the aerobic activity. These findings confirm other studies analyzing the DP in aerobic works[23,24].

In our study, the CR did not present significant differences between the two positions, despite it had shown highest values in the seat straight supine. The systolic and diastolic blood pressures did not present significant difference between them as well, but in both exercises the SBP raised during the exercise, while the DBP reached lowest values in both. Several studies[7,8,11,17,18,25,26] confirm our findings, once they show a higher CR, BP and DP during the RE, as it occurred in our study. But there is a major lack of works investigating such physiological parameter concerning different body positions. In a recent study, the influence of the body position in the hemodynamic responses was verified through the comparison of the squat exercise to different positions (dorsal decubitus in the equipment or stand up) presented the highest DP value when performed in the stand up position[7]. It is not evidenced the same occurrence in the knees' flexion, and therefore, it was found no significant differences compared to the flexor table (dorsal decubitus), and the flexor chair (in the seat position) in 10 RM[26].

Evidences has shown that the RE may be safely applied even in those cases of individuals bearers of cardiovascular onsets[4]. Our study confirms the fact that when the individual is not allowed to have an excessive raise in the DP, it is preferable to perform the exercise in dorsal decubitus, since in our study the SRD presented a mean DP of 12,151, and SRS of 12,554, showing that the exercises in dorsal decubitus would be a safety factor for individuals bearers of any cardiovascular disease.

The reduced resting BP and during the sub-maximal exercise would be considered a positive adaptation, particularly in individuals with ischemic disease. Therefore, it would be required a higher workload to attain the same DP as a consequence of the training. The result of such adaptation would be that it probably would reduce the probability for an occurrence of an event of cardiac ischemia during the physical activity.

As it was previously seen in other studies[7,8,26], it also can be evidenced that the lower the muscular mass demanded, the lowest will be the DP in its absolute form. However, as there is scarcity of studies related to the DP, it can not be asserted that there will always be a significant difference between exercises of the lower limbs under different body positions, once several factors are involved, such as the body angle grade, and even the size and quantity of the muscular groups. Thus, the results attained in this study could not be attained if one of the supines would be performed in an inclined equipment, or if the muscular groups involved in the movement were lower.

It can be concluded that the straight supine exercises, laid down or seat did not present significant difference in none of the physiological parameters studied. But in the straight laid down supine it was observed that every physiological response (CR, SBP, DBP and DP) were a little more lower than in the straight seat supine. Thus, it is necessary to accomplish further studies analyzing different body positions in other exercises to set through comparisons the adequate conduct as to the prescription of such exercises.

All the authors declared there is not any potential conflict of interests regarding this article.

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