Rate-pressure product’s behavior in different body positions practicing resistance dynamic exercises

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ABSTRACT: Through the rate-pressure product it is possible to predict, in an indirect way, as oxygen the myocardium can consume. The present study verified the heart rate, the blood pressure and the rate-pressure product, during two exercises against-resistance of inferior parts (squats), which only varied to each other in the performer’s body position (standing or in dorsal decubitus), in order to evaluate the amount of cardiovascular stress that an exercise could generate in relation to the another. Thirty healthy and trained individuals were appraised (30 ± 6 years), which accomplished in each one of the two apparels one set of 10 RM. The data were collected during the rest and the last two repetitions of the set of 10 RM of each apparel. Whole the collected variables were presented according to the descriptive statistics. Already the values of the rate-pressure product obtained during the execution of the exercises, were appraised for the T-test of Student with a significant index of p<0.05 and the found result was very significant (p <0.001). This way it can be said that the standing squats generates a more significant stress in the cardiovascular system than squats accomplished in dorsal decubitus.

Keywords: Rate-pressure product, Resistance dynamic exercises, Body position, Strength training.

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RESUMEN

Comportamento do duplo-produto em diferentes posições corporais nos exercícios contra-resistência

Através do duplo-produto é possível predizer, de forma indireta, quanto oxigênio o miocárdio pode consumir. O presente estudo verificou a frequência cardíaca, a pressão arterial e o duplo-produto, durante dois exercícios contra-resistência de membros inferiores (agachamentos), os quais só variavam entre si na posição corporal do executante (em pé ou em decúbito dorsal), a fim de avaliar a quantidade de estresse cardiovascular que um mesmo exercício, em posições diferentes, poderia gerar em relação ao outro. Foram avaliados trinta indivíduos [30 ± 6 anos] saudáveis e treinados, os quais realizaram em cada um dos dois aparelhos uma série de 10 RM. Os dados foram coletados durante o repouso e as duas últimas repetições da série em cada aparelho. Todas as variáveis coletadas foram apresentadas segundo a estatística descritiva. Já os valores do duplo-produto obtido durante a execução dos exercícios, foram avaliados pelo teste “t” de Student, com um índice de significância de p<0,05. Foram encontradas diferenças significativas e, desta forma, pode-se dizer que o exercício de agachamento realizado em pé gera um estresse mais significativo no sistema cardiovascular do que quando realizado em decúbito dorsal.

Palabras-clave: Duplo-producto, Ejercicios contra-resistencia, Posicion corporal, Entrenamiento de Forza.

INTRODUCTION

It is known that the physical fitness improvement can significantly contribute for the health improvement in the life quality (Paffenbarger, 1998). Within the physical activities which will be able to improve health, the practice of resistance exercises (RE) have been recommended by the main authorities about physical activity, as the American College of Sports Medicine - ACSM (1998, 2000, 2002) and American Heart Association (Pollock et al., 2000), due to the relative safety, even with the so called special populations.

Inasmuch as the RE have gained importance, the number of published studies which has aimed at analyzing the interventive factors (extrinsic and intrinsic) to training tends to increase. As a consequence, the training is personalized so that it meets with major specificity each individual’s needs, such as age (Fiatarone et al., 1990) and cardiovascular diseases (Martel et al., 1999).

Nonetheless, to the RE prescription, some physiological variables should be monitored such as heart rate (HR) and arterial blood pressure (ABP) (McCartney, 1999). The isolated observation of these variables does not assure a significant safety level. However, the association between them can provide sufficient data which are correlated to the myocardial oxygen consumption, in which it was referred as double product (DP). It is calculated from the multiplication of systolic blood pressure (SBP) by the HR. The ACSM (2000) also considers the DP as a better physiological estimate of the RE intensity.

Taking into consideration the existence of extrensical interventive factors to the training and the importance that the DP has over the prediction of the imposition demand to the myocardium, the present study sought to verify the differences in the DP, between the two RE of inferior limbs: half squat on horizontal equipment (SQh) and half squat on vertical equipment (SQv), when done in 10 maximum repetitions (MR).

MATERIALS AND METHODOLOGY

The sample was composed of 30 individuals (20 men and 10 women), aged (30 ± 6 years), minimum experience of 12 months in the RE. All of them have already done exercises which were used for the completion of the tests. None of the participants presented any physical, cardiovascular, breathing impairment which could jeopardize the established movements and workloads. All participants were subject to a PAR-Q questionnaire (Shephard, 1988), but no individual presented positive response to it. It was evidenced that none of the individuals made use of medicine which could change the physiological responses to the exercises, such as beta-blockers or androgenic drugs. Aiming at reducing the probabilities of error occurrence during the tests, the following strategies were used (MONTEIRO, 1997):

1) The instructions concerning the whole routine of tests was previously explained to all participants;
2) The participants were instructed about the completion techniques;
3) The evaluator has been attentive in all moments aiming at avoiding that the participants made mistakes that could interfere the data collection;
4) The tests were scheduled in advance and were always conducted in the same schedule, for each individual.

The analyzed exercises were SQh and SQv due to the fact that they own the same muscular features technical setting (positioning and
used the greatest registered values in the completion of exercises or moments after the end, due to the necessary time for the screen to carry out the proper reading.

The paired test t student was used in order to compare the obtained values in the observed variables. The statistical significance was established at \( p<0.05 \).

RESULTS

In repose, the mean value of the HR was 72 bpm, whereas in the 10 MR of the SQh, the mean value of HR was 144 bpm and in the SQv was 153 bpm. The repose SBP presented a mean value of 125 mmHg. In the completion of SQh and SQv, the SBP presented, respectively, the mean values 173 and 186 mmHg. The mean of diastolic blood pressure (DBP) in repose was 76 mmHg. In the SQh, the DBP presented a mean value of 82 mmHg and

SQh

a) Initial position – The individual was placed in dorsal decubitus in the equipment, with the feet put parellelly and distancing at a distance equivalent to the hip width, and projected forward in the equipment support. The knees were bent at an angle of 80º and in parallel between each other. The elbows were bent in direction to the points of application of workloads on the shoulders, hands supported on themselves and head was positioned to the Frankfurt plain (Gordon, 1988).

b) Concentric phase – It was made up of the full knee and hip extension.

c) Eccentric phase – It is from the end of the concentric phase, the knees and hip return to the initial position.

SQv

a) Initial position – The individual is placed upright, with leg distancing equivalent to the hip width, and knees slightly bent. The hands are supported on the bar which lies in the trapezium region, and with the head is also in the Frankfurt plain (Gordon, 1988).

b) Eccentric phase – It is from the initial position, the hip and knees (up to 80º) are eccentrically bent.

c) Concentric phase – It was made up of the knee and hip extension up to the initial position.

The experiment was conducted on two days for each exercise. On the first day, it was conducted a test for the determination of the workload at 10 MR (Baechle, Earle, 2000). After the test, the individual was recommended that s/he should not do any physical activities with the inferior limbs, during 48 hours, when s/he should return to the experiment place for the second data collection. This information was added to the research so that the collected data did not suffer any alterations due to the muscular stress caused in the inferior limbs. Just in case they had not been worked between the day tests, they could impair the individual in the completion of 10 MR because of muscular fatigue.

On the second day, the data collection was conducted in two moments. Firstly, the HR and the ABP were measured, after the subject remains seated for 10 minutes. After this phase, the individual performed as a warm-up exercise of 10 repetitions with 50% of the load corresponding to a 10 MR. And after 2 minutes, the participants performed the established repetitions for the exercise. Between the 9th and 10th repetition, it was the HR and ABP aiming at trying to verify greater values of these variables. In the gauging of the ABP, it was necessary that the individual relaxed the superior limb which was being monitored, aiming at minimizing the interference provided by the contraction of the brachial biceps tendon.

The HR was gauged by means of Polar Protrainer NV (Kempele, Finland) screen and the ABP measured by an aneroid sphygmomanometer using the auscultatory method. For the measure of the ABP, it was considered as the systolic value the first Korotkoff sounds and diastolic values, the fourth phase. For the HR, it was
in the SQv of 84mmHg. The DP presented, in repose, a mean value of 9.001. In the SQh, this variable changed for 25.010, whereas in the SQv, the mean value was 28.489 (cf. Chart 1):

Taking into account that the auscultatory method could result underestimated values for the SBP during the RE (Wiececk et al., 1990), the DP will not either correspond to the real value real. However, irrespective of measured manner, the variation of the ABP might inform the magnitude of the imposed demand for the exercise. This way, we considered some alterations in the ABP e DP in percentual terms. In relation to the repose, the SBP presented alteration of 38.6% (p<0.05) for SQh and of 48.6% (p<0.05) for SQv, whereas the DBP changed a little, showing 7.8% and 9.9% of increase for the SQh and SQv, respectively (cf. Figure 1). While the DP increased at 177.8% (p<0.05) during the SQh and 216.5% (p<0.05) in the SQv (cf. Figure 2). Comparing the exercises, the alteration of the SBP and DBP was, respectively, 7.2% and 1.9%, whereas the DP was 13.9% (p<0.05) (cf. Figure 3).

DISCUSSION

It lacks a wealth of information concerning the cardiovascular responses and adaptations to the RE. Conclusions embracing these cardiovascular responses are more complicated for several reasons, as the most important: which effects of volume and intensity which the training has over physiological responses and adaptation along the time at the RE (Simão, 2003). In the literature, it is identified the prevalence of studies which seek to relate the cardiovascular safety to the type of contraction involved during the exercise (static or dynamic), mainly, individuals belonging to risk group or athletes (Farinatti, Assis, 2000).

The major difficulty in studying the ABP pattern of behavior during the RE is the way of measure. Although the gold standard is an invasive method by means of an intra-arterial catheter (A-line), this practice is of high risk, because this may provoke hemorrhage, spasm, pain and arterial occlusion (Gosthall et al., 1999). In this manner, non-invasive procedures are safer; however, they might underestimate mainly the systolic value the auscultatory method. Nevertheless, although the SBP may be underestimated, the difference percentual, when compared different intensities, tends to remain constant (Polito, Farinatti, 2003). Consequently, the absolute value of the ABP, measured by auscultatory method, tends to be inferior to that one registered in the artery, but, in situations of tests in exercises with different intensities, the percentual variation of the SBP presents the same tendency as the invasive method.

The DP (HR x SBP) is the myocardial work estimate and is proportionate to the myocardial oxygen consumption. Some parameters are used in order to control the intensity and the risk associated with an activity. Within these, the ABP and HR proved to be useful, but, considered isolatedly cannot guarantee safety. In group, however, they define the third parameter, and it is not widely used in the environment of exercise prescription (DP) (Farinatti, Assis, 2000). The DP presents a strong correlation to myocardial oxygen consumption, as its best indirect predictor. In this manner, it would be interesting to use it as a safety parameter in order to observe in which types of activities the cardiovascular system is exposed to a greater work, and thus, higher risks (Araújo, 1984).

The literature demonstrates that the DP tends to increase during physical activities, but its behavior is dependent on the demand nature (Simão, 2003). The proximate values in proximate load of the maximum individual aerobic power may be up to five times greater than in repose. On the other hand, the DP during exercises with weights is usually lower at up to 75% of the maximum load in inferior limbs (Simão, 2003). Farinatti and Assis (2000) observed the HR, SBP, DBP and DP, during the RE and the moderate aerobic intensity, with 18 apparently healthy individuals. It was conducted strength test with 1RM, 6RM and 20RM (knee extensor muscles) and submaximum aerobic speeds (cycle ergometer, 20 minutes at 75-80% of HR of reserve). The conclusion of the study demonstrates the following: strength exercises, independently of intensity, imposed lower heart demand than the aerobic activity; the DP in force exercises is associated more to the repetitions than the workloads, whereas in the aerobic exercises the intensity proved to be more important that the during of activity. According to Fleck (1988), the decrease of myocardial oxygen consumption in repose seems to be deriving from the adaptation to the training of strength.

The studies, which monitored HR, SBP and DP during the RE, mainly, when maximum repetitions were involved, verified a significant increase of these variables in relation to the repose (MacDougall et al., 1985; Fleck, Dean, 1987; Benn et al., 1996; Gosthall et al., 1999; Farinatti, Assis, 2000). However, it was not observed the influence of body position as a probable intervening variable.

In our study, once there is a significant different between the values of DP in the completion of exercises, it is necessary to evidence the reason that propitiates the raising of this variable. The explanation that might answer this is the fact that the SQv possesses a venous return of inferior limbs made difficult in relation to the squat performed in dorsal decubitus. In addition, the necessary body mass for the stabilization and movement control, when contracted, will favor the increase of the SBP.

Some evidences have shown that the RE can be used safely, even for individuals with cardiovascular impairments (Pollock et al., 2000). Normally, it is believed that the DP of 30.000 or more as a cut-off point on the angina (Fardy, Yanowitz, 1995). Based on these data, our studies corroborate the fact that in

| Chart 1 – Average values for the observed variables (n=30) |
|---------------------------------|---------------|---------------|
|                                | Repose        | Horizontal Squat | Vertical Squat |
| Cardiac frequency (bpm)        | 71.6 ± 8.2    | 143.8 ± 10.6    | 152.7 ± 11.9   |
| Systolic blood pressure (mmHg) | 125 ± 9       | 173.3 ± 11.5    | 185.8 ± 12.4   |
| Diastolic blood pressure (mmHg)| 76.5 ± 6.5    | 82.5 ± 9.6      | 84.1 ± 11.6    |
| Rate-pressure product (mmHg.bpm)| 9001.6 ± 1561.9| 25010.8 ± 3253.5| 28489.1 ± 3934.1|
case the individual cannot have an excessive increase of the DP, it is advisable to complete exercises in dorsal decubitus, since in our data, the SQh presented a mean of DP 25.010 and the SQv 28.489, demonstrating that exercises in this position might be a safety factor for bearer individuals of some cardiovascular disease.

As a matter of fact, some studies have verified that the RE is relatively safe as for the response of the DP, as for the elderly (Bermon et al., 1996; McCartney et al., 1993; Mazzeo et al., 1999) as for young people (Sai et al., 2000; Farinatti, Assis, 2000; Leite, Farinatti, 2001). The cardiovascular demand deriving from the RE is generally lower than that one observed during the aerobic work. This premise could be evidenced on observing the tables of some studies that inquired the DP response in aerobic works (Gould et al., 1985; Rasmussen et al., 1985), in strength exercises (Fleck, Dean, 1987; McCartey et al., 1993) and in experiments which compared both types of training (Benn et al., 1996; Farinatti, Assis, 2000).

The reduced DP observed is probably the combined effect of low HR and ABP to a certain activity, as previously discussed. The reduced ABP in repose and during the submaximum exercise might be considered a positive adaptation, mainly in individuals who have ischemic cardiovascular disease. Therefore, a higher workload might be demanded in order to achieve the same DP, as a consequence of training. The result of this adaptation might reduce the probability of a heart ischemic event during the physical activity.

The DP results follow a very similar pattern of behavior of HR. The practical performance of resisted exercises, generally performed intermittently, possess mean values of FC influenced by the duration of repose periods between the exercise sessions and by the time of stimulation applied to the acting musculature. It is important to observe that the SQh possesses a mean of lower HR than the SQv, also due to the body position. This fact makes us infer that in the moment of prescription of strength exercises, aiming at a lower increase in the HR, the performed exercises in that position might be essential due to the individual’s physical fitness.

Nevertheless, as it lacks studies related to it, it cannot be affirmed that there will always be a significant difference between the inferior limbs using different body positions, once several factors are involved, such as the degree of body angulation, and even the size and quantity of muscle groups. And thus, the verified results in this study might not have occurred if one of squat movements were performed in slant equipment, or if the muscle groupings involved were smaller. For instance, in a recent study (Guimarães et al., 2002), it was compared the hemodynamic responses in the knee flexion movements performed seated and lied down, however, the results did not indicate any significant influence of position over the variables.

Furthermore, it can be observed that the squat exercise performed in dorsal decubitus offers some relative safety in comparison to the upright squat. However, it urges that other studies be carried out in order to compare these data, verifying the behavior of DP using other types of repetitions and exercises.

REFERENCES


