INFLUENCE OF THE MUSCLE GROUP IN HEART RATE RECOVERY AFTER RESISTANCE EXERCISE

EXERCISE AND SPORTS SCIENCES

ORIGINAL ARTICLE

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ABSTRACT

Introduction: Resistance exercise (RE) is a widely practiced type of exercise and is recommended for strength and muscle mass maintenance or improvement, being used for esthetic and health purposes. Despite this, little is known about the impact of this type of exercise on cardiac autonomic control, nor the influence of muscle group in this response. Objective: The objective of this study was to investigate the influence of muscle group used during RE, on post-resistance exercise heart rate recovery (HRR). Methods: The study included 14 males (27.4 ± 6.1 years, 79.4 ± 10.4 kg, 1.77 ± 0.1 m) experienced in ER practice. The experimental protocol consisted in performing the 1-RM test and re-test on bench press and half squat to determine the maximum dynamic force; and execution of maximum number of repetitions at 80% 1RM with assessment of HRR for 1 minute post-exercise. Results: The results indicate lower HRR at 10, 20, 30 and 40 seconds after half squat compared to horizontal bench press ($p < 0.05$). Conclusion: The findings confirm the influence of muscle group on post-resistance exercise cardiac autonomic response.

Keywords: exercise, weight lifting, heart rate.

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INTRODUCTION

Resistance exercise (RE) is characterized for voluntary muscular contraction by a body segment against a force which is opposite to the movement[1]. Many studies have shown the benefic effects of regular practice of this kind of exercise in strength[2] and muscle mass increase[3], improvement in aerobic fitness[4], osteoporosis prevention and treatment[5] as well as other chronic musculoskeletal diseases[6], among others. These factors stimulate th RE practice by many individuals, either for esthetical or health promotion aims.

Despite the benefits of RE practice, the acute metabolic and mechanical stimulus which occurs during a RE session promotes cardiovascular stress and alteration in the cardiac autonomic balance; that is, decrease of vagal activity and increase of cardiac sympathetic activity[7-9]. These responses increase heart rate (HR) with the aim to meet the increased blood demand in the active musculature. Immediately after the end of the RE, the HR rapidly decreases and this decrease has been widely used for evaluation of the autonomic impact produced by the physical exercise[10]. It is known that in the first recovery moments post-exercise, the main mechanism aassociated with HR recovery (REC-HR) is the reactivation of the vagal tonus[11]. Evidence indicates that reduced levels of REC-HR are associated with higher mortality risks[12]. Therefore, it is necessary that factors which may influence on this variable are investigated in order to aid in the safe RE prescription.

Many studies have assessed the REC-HR after aerobic exercise and observed that exercise intensity[13], aerobic fitness[14], physical training[15], among other factors, influence on the behavior of this variable. On the other hand, despite the high number of practitioners, few studies have been carried out in the attempt to evaluate the REC-HR after the RE[7,8]. It is known that after this kind of exercise, the sympathetic activity is increased and the vagal activity decreased in levels higher than in the aerobic exercise, which significantly delays the REC-HR[7] and that the RE intensity influences on these responses[8]. Due to the clinical importance of the study of the REC-HR and the possibility to use this instrument for RE prescription and follow-up, it is necessary to verify if other factors have also influenced the variable in question. Therefore, the influence of the used muscle group in the REC-HR is not known yet. Evidence with aerobic exercise indicates that the exercise performed with lower limbs produces lower REC-HR in comparison with the exercise performed with upper limbs [16]. Thus, the aim of the present study was to test the hypothesis that the REC-HR is slower after RE of lower limb in comparison with RE of upper limb. Therefore, we compared the behavior of this variable after the bench press and half squat exercises.

METHODS

Individuals

14 male individuals (26.6 ± 4.9 years; 25.3 ± 2.9 kg/m^2), practitioners of resistance training for at least one year, with training weekly frequency equal or higher than three sessions, participated in this study. Individuals who used medication which could influence on the exercise response were not included in the sample. The individuals were forbidden to perform any physical exercise and ingest alcoholic or caffeinated drinks in the 24 hours preceding the tests. The volunteers received information about the study's procedures and signed a free consent form before their participation. The experimental protocol was approved by the Ethics Committee in Research of the University of Trás-os-Montes and Alto Douro and respected the resolution 196/96 from the National Health Board concerning research with humans.

Experimental protocol

The experimental protocol occurred in four days. On the first day, the individuals performed body weight and height evaluation and skinfolds were verified. On the second and third days, they performed the 1RM test and retest in the bench press and half squat exercises. The highest loads obtained were chosen for determination of the 1RM value. When maximal load values differed in more than 5% between the 1RM tests, a third test was performed. On the fourth day, the volunteers performed the maximal number of repetitions in the bench press and on free bar and half squat on free bar at 80% of 1RM. After the exercises, the individuals remained seated during one minute for evaluation of the HR recovery.

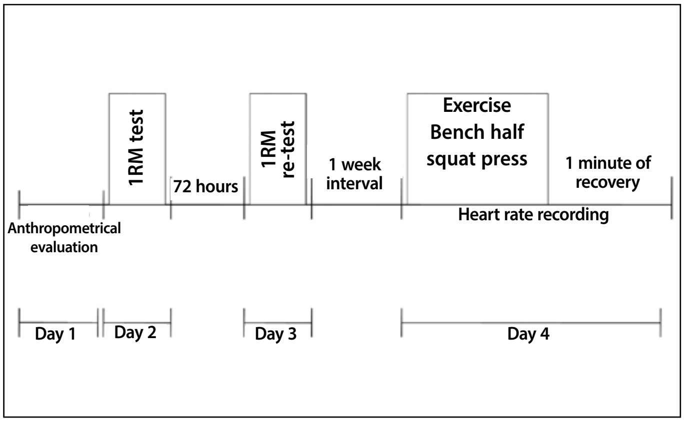


Figure 1. Experimental protocol.

Anthropometrical evaluation

In order to have the anthropometrical parameters measured, the volunteers were told to wear light clothes. Initially, they were placed in the center of the plataform of the Tanita electronic scale, Corporation, BC-531, Tokyo, Japan, remaining steady until the reading shown on the device was stabilized and the body weight determined, which was expressed in kilograms (kg). Height was measured with a measuring tape previously attached to a wall, vertically to the ground. In order to have height determined, the volunteers were placed with feet united and heels, coccyx, scapular waist and occipital region touching the wall. Height was defined as the distance in a straight line between the vertex (cranium) and the flooring on which the feet rested; the individuals were at erect position, according to the Frankfurt plane. The body mass index (BMI) and body surface area were calculated from the body weight and height values17.

Estimation of fat percentage was performed through the evaluation of the chest, midaxillary, triceps, subscapular, abdominal, suprailiac and thigh skinfolds, which were measured by an experienced evaluator. Lange® caliper (Cambridge Scientific Industries, Cambridge, MD). The formulas used to obtain body density were proposed by Jackson and Pollock18 and the density conversion in fat mass by the SIRI equation.

1RM test

The 1RM load was determined through the protocol described by Kraemer ***et al.***[19], which is composed of the following steps: general activation with five to 10 repetitions with load between 40 and 60% of perceived maximum; after one-minute rest, performance of stretching and three to five repetitions, with load of 60 to 80% of perceived maximum; after two-minute recovery, implementation of load close to the perceived maximum and attempt to perform one repetition maximum; after this load be or not be surpassed, resting time of five minutes was allowed, increasing or decreasing the load value. The maximal value was that at which the individuals of the sample were able to perform a single repetition.

Heart rate evaluation

HR was recorded during the exercise and in the recovery period through a Polar cardio frequency meter, RS800cx (Polar Electro, Kempele, Finland; sampling frequency = 1,000 Hz). Immediately after the end of the exercise, the volunteers moved to a chair, and remained seated there during one minute for recovery. Post-exercise recovery posture was standardized so that it did not influence on the REC-HR behavior. The HR peak of the exercise and the HR were calculated in 10-second windows for the analysis of the REC-HR during the entire post-exercise period. The data were presented in absolute values (bpm) na relative values (% of HR peak).

Statistical analysis

The data were presented in mean ± standard deviation. The analysis of the data distribution curve by the Shapiro-Wilk test confirmed their normality. Two-way (exercise x time) analysis of variance was performed to compare the HR values in the exercise peak and at every 10 seconds of recovery. When the interaction between the factors of the analysis of variance was observed, the Student's *t* test for paired samples was performed for identification of the points in which the differences occurred. The significance level of the tests was of 5%. The software used for the analyses was the STATISTCA, v. 8.0.

RESULTS

Individuals

Thirteen individuals successfully completed the experimental protocol of the study. In one individual, the HR record in the bench press presented high levels of interference, which made the use of this information impossible. The sample characterization is presented in detail in table 1. The 1RM values of the half squat exercise were significantly higher than in the bench press exercise.

Table 1. Sample characterization (n = 14).

	Mean ± standard deviation
Age (years)	27.4 ± 6.1
Body weight (kg)	79.4 ± 10.4
Height (m)	1.77 ± 0.1
BMI (kg/m2)	25.0 ± 2.6
Fat percentage	10.5 ± 4.6
Body surfacce area (m^2)	1.9 ± 0.1
1 RM bench press (kg)	96.7 ± 21.7
1 RM ½ squat (kg)	126.8 ± 32.3*

* Statistically significant difference in comparison with the bench press ($p < 0.05$).

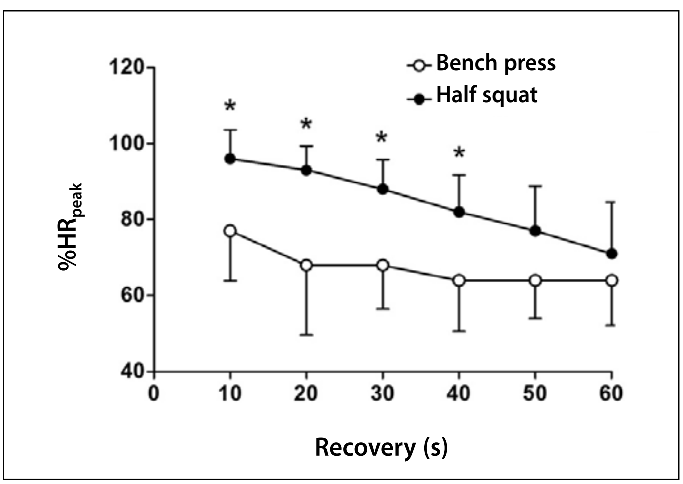
Heart rate recovery after the bench press and half squat exercises

Table 2 presents the HR values in the exercise peak and at every 10 seconds of recovery, after the bench press and half squat exercises. Lower HR values were observed in the 10, 20, 30 and 40 second-windows after the first exercise in comparison with the second. Figure 2 presents the recovery HR values normalized in percentage by the HR peak. This procedure was adopted in an attempt to remove the influence the HR peak values could have in the results. However, even with this procedure, lower HR values after the bench press were observed in comparison with the half squat, corroborating the findings presented in table 2.

Table 2. Mean HR peak and recovery values, in the bench press (n = 13) and ½ squat exercises (n = 14).

	Bench press	½ squat	P
HR peak	162.1 ± 28.6	149.8 ± 13.3	0.154
HR10s	122.6 ± 18.3*	143.5 ± 12.0	0.001
HR20s	106.9 ± 26.1*	138.2 ± 11.5	< 0.001
HR30s	109.1 ± 20.2*	131.1 ±12.6	0.002
HR40s	104.7 ± 24.9*	123.2 ± 15.7	0.003
HR50s	103.3 ± 20.0	114.7 ±17.3	0.117
HR60s	101.0 ± 16.0	105.6 ± 19.3	0.500

* Statistically significant difference between the exercises ($p < 0.05$)



* Statistically significant difference between the exercises ($p < 0.05$).

Figure 2. HRpot-exercise decrease, normalized by HR peak.

Individual responses of heart rate after bench press and half squat exercises

Figure 3 presents the individual HR values after the bench press and half squat exercises. The individual analysis made it possible to observe that in five individuals who performed the half squat, the post-exercise HR values in the first recovery moments were higher than the HR peak value, indicating hence that the REC-HR after this kind of exercise may present a delay which could have influenced on the results (figure 4). This delay in the REC-HR did not occur after the bench press.

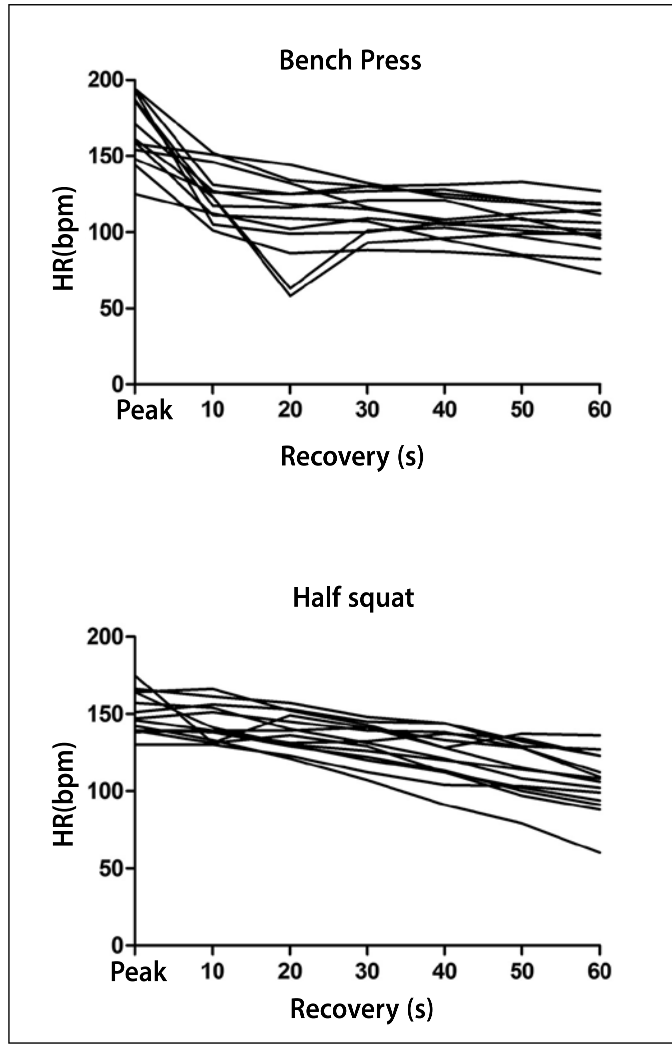


Figure 3. Individual behavior of HR after the bench press (n = 13) and half squat exercises (n = 14).

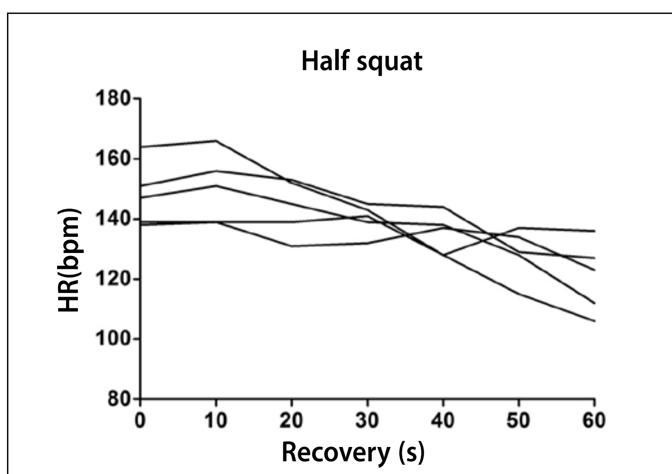


Figure 4. HR behavior after half squat exercise in the individuals who presented delay in the beginning of the REC-HR (n = 5).

DISCUSSION

The present study observed lower REC-HR after the half squat in comparison with the bench press, an indication of lower vagal reactivation in the first exercise than in the second[11]. The HR peak was similar between exercises, which discards the possible influence this variable could have on the findings. It is also worth mentioning that even if there was influence of the HR peak in the REC-HR, it would be eliminated by the percentage normalization of the post-exercise HR values, by the HR peak (figure 2), a fact which did not occur in the present study.

RE is a kind of exercise practiced by individuals of different ages and with different aims. Resistance training presents many benefits to health[4-6], being recommended for maintenance and development of muscular fitness[1]. However, despite being widely practiced, little is known about the behavior of the REC-HR in RE. Due to the clinical importance and the possible use of this information for the exercise prescription, it is necessary to investigate which RE variables influence on the REC-HR. It is already known that the autonomic imbalance caused by the RE is higher than the one caused by the aerobic exercise, which promotes a slower REC-HR after the first exercise in comparison with the second [7]. The exercise intensity is one of the most investigated variables and which mostly influences on the cardiovascular responses during the RE[8,20]. The intensity used in the present study (80% of 1RM), despite being recommended for muscle strength improvement in weight lifters and individuals experienced in resistance training[1], it promotes higher alteration in the autonomic balance[8], leading to slower REC-HR[9]. However, even in the high intensity, other factors may alter the autonomic responses and, in the present study, it was observed that the muscle group also influences on these responses.

The REC-HR evaluated in the first moments post-exercise, such as the one in the present study, enables the study of the vagal reactivation post-exercise[11]. Therefore, it can be said that vagal reactivation was slower after exercises for lower limbs in comparison with exercises for upper limbs. There are not many articles available in the literature which evaluated the REC-HR after resistance exercise, making it difficult to speculate about our findings. Nevertheless, an important datum presented here can partially explain our findings. As previously mentioned and demonstrated in figure 4, some individuals who performed the half squat presented higher post-exercise HR values than the HR peak values, especially in the first recovery windows. Such fact indicates delay in REC-HR, since only from this peak on, the supported decrease of HR occurs. The half squat involves the recruitment of a bigger muscle group, promoting compression of great part of the vascular tree of lower limbs[21]. The muscle relaxation which occurs immediately after the end of this exercise produces heart rate reduction[20], promoting deactivation of the cardiopulmonary reflex[22] and of the arterial baroreflex control[23]. In order to compensate this hypotensor stimulus, increase of sympathetic activity takes place[20] and, consequently, of HR, as demonstrated in some individuals in the present study. This factor probably does not occur in the same magnitude in the bench press, since this exercise involves the activation of lower muscle mass, which causes lower vascular compression and lower transient decrease of blood pressure post-exercise.

Another possible explanation for our results lies in the energetic issues of the two exercises. The half squat presents higher energetic expenditure than the bench press[24,25] and the accumulated oxygen debt and the contribution of the anaerobic ways are also higher in that exercise[24,25]. Due to the inverse relation between metabolic stress of the anaerobic activity and REC-HR[13], the results of the present study become coherent.

The similar HR peak values in the exercises call our attention. Since there is higher physiological demand of the half squat in comparison with the bench press, one could expect that the HR values in the first exercise would be higher than in the second one. Although some studies indicate that the higher number of motor units recruited in the exercise involving higher muscle groups promotes higher cardiovascular response during exercise[26], there is still controversy in the literature concerning this idea[27]. The involvement of a smaller muscle group and reduced vascular tree of the bench press exercise promotes higher accumulation of metabolites, stimulating hence III and IV muscular afferents, causing HR increase through the activity of the muscle mechano and metaboreflex systems[28]. This factor would compensate the greater muscle group used by the half squat and the higher participation of accessory and synergic muscles, which cause HR increase through higher excitement of the motor cortex[29]. However, the methods used by the present study do not let us confirm such theories.

CONCLUSION

Our findings indicate delay in the vagal reactivation after the half squat in comparison with the bench press, confirming the presented hypothesis. Due to the association between cardiovascular risks and the magnitude of the post-exercise vagal reactivation[30], and the relation between size of the muscle group and cardiovascular stress caused by physical exercise demonstrated, it is recommended to suppose that the bench press exercise is preferable than the half squat in individuals with high cardiovascular risks. However, the sample characteristic of the present study, does not let us make such extrapolation. Therefore, similar studies with risk groups are necessary. Moreover, it is important to verify whether other exercises for lower limbs which recruit similar musculature to the half squat, such as the leg press and the extension on Roman chair, produce lower autonomic impact, so that the substitution can be made. Finally, further studies which investigate the mechanisms which are behind the RE autonomic behavior, become necessary so that the presented speculations can be corroborated or discarded.

All authors have declared there is not any potential conflict of interests concerning this article.

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