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original article

Effect of fixed and self-suggested rest intervals between sets of resistance exercise on post-exercise cardiovascular behavior

Efeito do intervalo de recuperação fixo e autossugerido entre séries do exercício resistido sobre o comportamento cardiovascular pós-esforço

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Abstract – This study aimed to compare differences in the number of repetitions after exercises with different rest intervals and to analyze cardiovascular parameters after resistance training. The sample comprised 10 physically active men (23±2 years). The one-repetition maximum (1RM) test was performed in the following order: bench press, guided squat bar, biceps curl and leg curl. After the 1RM test, the individual held three sessions of resistance training, on different days, with rest intervals of 1 minute, 2 minutes, and self-suggested intervals, randomized for each day. We calculated 75% of the load of the 1RM test, with three series of maximum repetitions performed to exhaustion. Cardiovascular variables were measured at rest and during 30 minutes after exercise. In the self-suggested interval, which showed an average time of rest (157±37 seconds) similar to the 2-minute interval, more repetitions were performed compared to the 1-minute interval session, with no difference in relation to the 2 minute-interval session. No difference was found in systolic blood pressure and in the high frequency (HF) component between the intervals, but post-exercise hypotension was observed in diastolic blood pressure after 10 minutes' recovery in all intervals, with a longer duration in the 2-minute interval session. After 30 minutes' recovery, an increase in the low frequency (LF) component was registered for the 2-minute interval session, and an increase in LF/HF was found at 10, 20 and 30 minutes of recovery after sessions with 1- and 2-minute intervals, demonstrating a possible predominance of sympathetic action. The self-suggested interval did not show changes in the components of heart rate variability. These findings suggest that intervals of at least 2 minutes between sets may be interesting to provide more repetitions and reduce the post-exercise sympathetic effect.

Key words: Cardiovascular system; Exercise; Interval.

Resumo – *O objetivo do estudo foi comparar a diferença no número de repetições após exercícios realizados com diferentes intervalos de recuperação e analisar o comportamento cardiovascular pós-esforço. A amostra foi composta de 10 homens (23 ± 2 anos) fisicamente ativos. Foi realizado o teste de uma repetição máxima (1RM) nos exercícios supino horizontal, agachamento na barra guiada, rosca bíceps e mesa flexora, seguido de três sessões de treinamento resistido, com intervalos de recuperação de 1 min, 2 min e autossugerido. Foram realizadas três séries de repetições máximas até exaustão com 75% de 1RM. As variáveis cardiovasculares foram mensuradas em repouso e durante 30 min após o esforço. Observa-se que no intervalo autossugerido, o qual apresentou tempo médio (155±37 segundos) de descanso semelhante ao intervalo de 2 min, foram realizadas mais repetições comparadas ao intervalo de 1 min, porém não se diferenciou do intervalo de 2 min. Não houve diferença para a PAS e para o componente HF entre os intervalos, porém, houve HPE para a PAD após 10 min de recuperação em todos os intervalos, com maior duração no intervalo de 2 min. Após 30 min de recuperação observou-se aumento no componente LF para o intervalo de 2 min e aumento na razão LF/HF após 10, 20 e 30 min de recuperação nos intervalos de 1 e 2 min, demonstrando uma possível predominância da ação simpática. Porém, o intervalo autossugerido não apresentou alterações nos componentes da variabilidade da frequência cardíaca. Dessa forma, o descanso de pelo menos 2 min entre as séries pode ser interessante para proporcionar mais repetições e reduzir o efeito simpático pós-exercício.*

Palavras-chave: *Exercício físico; Intervalo; Sistema cardiovascular.*

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INTRODUCTION

Currently, resistance training has been suggested as part of exercise programs for fitness and health, and should be adjusted according to the individual characteristics of each practitioner[1]. In this regard, variables including number of repetitions and series, load, amount of exercise and rest intervals between series may be differently determined for some groups of individuals, such as elderly[2-4] or hypertensive[5,6] patients. This is because the variables mentioned cause distinct effects on some physiological systems. For instance, blood pressure (BP) is known to increase during exercise according to the load applied[7], leading to major cardiac overload. This cardiac overload increase is important to meet the demands of the exercise, but should be observed and controlled in hypertensive individuals[7].

Nevertheless, some resistance-related variables, such as the rest interval between series, still need further investigation. The literature indicates that the number of repetitions performed can be affected by a short rest interval (less than 1 minute), and also that longer intervals (3-5 minutes) promote an increased performance maintenance[8-10]. In addition, increases in BP during exercise have been shown to be inversely associated with rest intervals[11], i.e., the shorter the interval the higher the BP. Additionally, short rest intervals appear to increase after-exercise heart rate for up to 90 minutes[12].

It is important to emphasize the effects of rest intervals, which can vary according to the complexity of a given exercise or set[1]. Thus, the sense of recovery imposed during training can be important to maintain both performance[13] and cardiovascular behavior[11]. In this sense, self-suggested intervals can be an interesting strategy to combine exercise performance with low stress on the cardiovascular system (during and after exercise). However, no study has analyzed the effect of the self-suggested rest intervals during resistance exercises.

Therefore, the present study aimed to assess the effect of different rest intervals on the number of repetitions performed in different resistance exercises and to analyze post-exercise cardiovascular behavior.

METHODOLOGICAL PROCEDURES

Sample

The sample comprised 10 healthy men (23 ± 2 years; 74.4 ± 3.1 kg; 175.2 ± 3.8 cm), practitioners of resistance training for at least six months. The sample was voluntary, and individuals signed a free and informed consent form after approval by the Research Ethics Committee of the State University of Londrina (28/2008). The individuals were instructed not to perform any type of training during the data collection period and to keep their dietary and sleep patterns. The exclusion criteria were: musculoskeletal disorders, smoking, medications that could interfere with the cardiovascular responses, body mass index above 30 $kg.m^{-2}$, systolic (SBP) and/or diastolic blood pressure (DBP) equal to or higher than 140 and 90 mmHg, respectively.

Data Collection Protocol

Initially, one-repetition maximum (1 RM) tests were performed for the exercises bench press, guided squat bar, biceps curl and leg curl. Instructions on test and correct way to perform exercises were standardized. On the day before test, the individuals performed one set of each exercise to standardize the movement execution. On the test day, the individuals were encouraged and instructed to perform two repetitions and allowed up to three attempts with 3- to 5-minute interval to achieve the 1RM in each exercise. Between each exercise, there was a 5-minute minimum interval. A load of 1RM was considered only when a correct repetition of exercise was performed.

As for experimental protocol, the individuals performed three sets of each exercise (bench press, guided squat bar, biceps curl and leg curl) up to exhaustion, with 75% of the load of 1RM. Interval determination between the 1-minute, 2-minute and self-suggested sets was randomized and performed during different days. Before each protocol, a series of warm-ups was performed, with 10 repetitions and 50% of 1RM for each exercise. During the series with 1-minute and 2-minute intervals, an evaluator was responsible for timing. During the series with self-suggested interval, the individuals were instructed to rest sufficient time in order to perform a new set, with no chronometer, watch or evaluator aid.

Cardiovascular measurement

BP was measured using an automatic sphygmomanometer (Omron, HEM 742-E, Bannockburn, EUA). In order to measure the heart rate variability (HRV), an electronic frequency counter was used (Polar RS800cx, Finland) and the recording of RR intervals was performed by a software (Polar Precision Performance 5.00, Kempele, Finland). After that, the software HRV Analysis was employed for quantifying low frequency (LF), high frequency (HF), and ratio between low and high frequency (LF/HF). The LF represents both sympathetic nervous system (SNS), and parasympathetic nervous system (PNS) modulation. The HF is predominantly modulated by PNS; and the LF/HF represents the balance between SNS and PNS.

When arriving at the test place, the individual remained seated and at total rest for 10 minutes for measuring BP and HRV at rest. After training, the individual remained at rest for 30 more minutes for measuring BP and HRV after exercise. After exercise, the BP was taken with 10-minute interval, while the HRV was measured with 5-minute interval up to complete the time set of 30 minutes.

Statistical analysis

Data are described in terms of mean and standard deviation. The Shapiro-Wilk test was applied to check data normality, followed by Mauchly's test for sphericity. A repeated-measures ANOVA was used in order to compare the number of maximum repetitions for each set and interval; and between values of BP and HRV. When required, the Tukey's post-hoc test was used.

For comparing self-suggested interval duration with 1- and 2-minute fixed intervals, a paired Student's t-test was applied. The significance level adopted was 5%, and the data were processed with the statistical software SPSS 17.0.

RESULTS

Table 1 presents the mean time in seconds for self-suggested interval protocol. No significant difference was detected between sets of this protocol, as well as for 2-minute interval. Conversely, all self-suggested intervals were significantly higher (P<0.01) than 1-minute interval.

Table 1. Mean time in seconds of self-suggested interval for each set.

	Bench press	Guided squat bar	Biceps curl	Leg curl
1st Set	129.0 ± 35.53	152.7 ± 32.74	138.1 ± 34.94	128.1 ± 36.33
2nd Set	134.0 ± 31.80	148.0 ± 52.98	143.6 ± 35.87	138.2 ± 42.17
3rd Set *	140.9 ± 41.42	146.7 ± 53.08	154.0 ± 36.8	155.3 ± 37.83

*On the 3rd set the interval refers to the rest to perform the next exercise.

Figure 1 presents the repetition number of each exercise interval and set. It was observed for the self-suggested interval, in the first and second sets of bench press that, the repetition mean was higher in comparison with 1-minute interval. Regardless of the bench press interval time, more repetitions were performed in the first set when compared with the second and third sets; and more repetitions in the second set when compared with the third set.

In the guided squat bar exercise, a significant difference was found only between the first and the second set with 2 minute-interval, with more repetitions executed in the first set when compared with the second set.

In relation to biceps curl, the comparison between different intervals within the same set indicated a significant difference only for the first set, in which with 2 minute-interval, the individuals completed more repetitions than with 1 minute-interval. When comparing the same interval of different sets, the 1 minute-interval presented a higher repetition number for the first set in relation to the third set, and the 2 minute-interval presented a higher repetition number for the first set in relation to the second and third sets.

As for leg curl, the comparison within the same interval of different sets pointed that both 1 minute-interval and 2 minute-interval had more repetitions performed for the first set in relation to the third set.

The Table 2 presents the values of the total number of repetitions for each interval. The 2-minute and self-suggested intervals had more repetitions performed in relation to the 1 minute-interval (P=0.01). No significant difference was observed when comparing both 2 minute-interval and self-suggested interval.

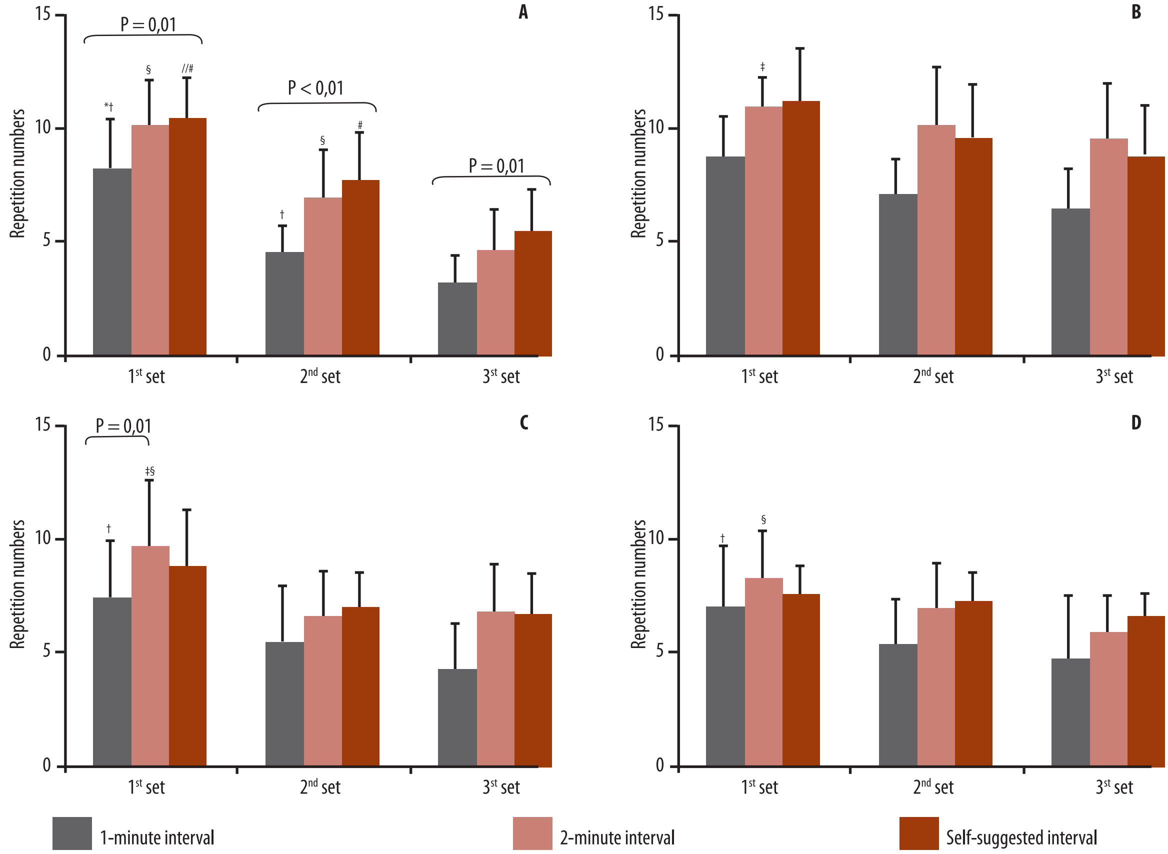

Figure 1. Comparison between repetition numbers performed for each of the 3 sets, between 1-minute, 2-minute and self-suggested rest intervals. A: bench press; B: guided squat bar; C: biceps curl; D: leg curl; * P<0.05 vs. 2nd set (1 min.); † P<0.05 vs. 3rd set (1 min.); ‡ P<0.05 vs. 2nd set (2 min.); P<0.05 vs. 3rd set (2 min.); // P<0.05 vs. 2nd set (self-suggested); #P<0.05 vs. 3rd set (self-suggested); § P<0.05 vs. 3rd set (2 min.).

Table 2. Comparison between mean values of repetition number of each interval between the three sets.

	Bench press	Guided squat bar	Biceps curl	Leg curl
1 min	$5.3\pm2.6^{*\dagger}$	$7.4\pm1.8^{*\dagger}$	$5.8\pm2.6^{*\dagger}$	$5.6\pm2.6^{*\dagger}$
2 min	7.2±3	10.1±2.1	7.8±2.8	7.0±2.1
Self-suggested	7.8±2.7	9.7±2.4	7.6±2.2	7.0±1.3

*p<0.05 vs 2 min; †P<0.05 vs self-suggested

Table 3 lists the values of the cardiovascular behavior after exercise. No significant difference was found in SBP and in the HF, with different intervals, between rest and recovery. Conversely, DBP analysis revealed post-exercise hypotension (PEH) after 10-minute' recovery in all intervals. Additionally, after 20-minutes' recovery the reduction only remained in the intervals 1- and 2-minute and after 30-minutes' recovery the PEH was maintained only in the 2-minute interval. The LF component increased after 30-minutes' recovery in the 2-minute interval, representing the only difference registered for this variable. The LF/HF ratio increased during the 10th, 20th and 30th minute after exercise in the 1- and 2-minute intervals, with no significant difference for the self-suggested interval.

Table 3. Cardiovascular behavior at rest and after exercises performed with different rest intervals.

		Rest	Post-10	Post-20	Post-30
SBP	1 min.	120.8±9.4	121.2±9.3	119.3±15.7	121.7±6.6
	2 min.	125.2±9.1	121.6±8.8	121.4±9.5	119.4±8.1
	Self-sug	124.6±7.6	122.2±8.5	122.6±10.2	122.1±8.6
DBP	1 min.	65.4±7.4	55.4±5.6*	56.5±4.0*	62.0±13.9
	2 min.	66.3±7.9	59.3±4.9*	58.3±6.1*	59.9±7.4*
	Self-sug.	68.0±5.3	60.4±6.0*	64.3±8.6	63.5±10.5
LF	1 min.	55.0 ± 16.3	55.6 ± 15.17	70.3 ± 9.1	61.6 ± 19.8
	2 min.	47.7 ± 19.1	60.3 ± 12.73	61.3 ± 16.4	61.0 ± 12.7*
	Self-sug.	57.1 ± 19.3	65.8 ± 12.86	70.8 ± 12.6	69.2 ± 6.3
HF	1 min.	22.3 ± 20.7	8.4 ± 6.1	8.4 ± 3.7	9.94 ± 2.9
	2 min.	27.3 ± 23.9	11.0 ± 7.9	11.4 ± 13.9	9.93 ± 6.2
	Self-sug.	15.1 ± 9.6	10.6 ± 4.5	9.9 ± 5.6	9.16 ± 2.9
LF/HF	1 min.	3.8 ± 2.2	9.9 ± 7.8*	9.5 ± 3.7*	6.3 ± 2.0*
	2 min.	3.4 ± 2.1	9.4 ± 7.8*	11.3 ± 6.7*	8.2 ± 4.1*
	Self-sug.	5.8 ± 4.9	7.3 ± 2.7	8.7 ± 3.5	8.3 ± 3.0

SBP: systolic blood pressure; DBP: diastolic blood pressure; LF: low frequency component; HF: high frequency component; LF/HF: ratio between low and high frequency; * P<0.05 related to the respective value at rest.

DISCUSSION

The rest interval is a resistance-related variable that can directly affect the performance of subsequent sets and muscle strength, directly influencing efficiency and the ultimate effectiveness of resistance training programs[11]. The main results demonstrate that the individuals had 2-minute average rest during the self-suggested interval, and these results are in accordance with the recommended time interval of the American College of Sports Medicine[1]. Moreover, a higher number of repetitions was observed in all exercises in relation to the 1-minute interval. These data seem to corroborate other information in the literature, indicating that shorter intervals may not be enough for muscle recovery and may compromise performance of the subsequent sets[10,13].

Regardless of performance in relation to rest interval, the goal of this study was to analyze the cardiovascular behavior after resistance exercises. Our results did not evidence significant differences in SBP after three rest intervals. Notwithstanding, the duration of DBP reduction was longer for the 2-minute interval, although a reduction was also observed after 10 minutes for the 1-minute and self-suggested intervals, and after 20 minutes for the 1-minute interval. As in the present study, Veloso et al.[10] did not report reduction in the SBP after resistance training with different rest intervals (1, 2 and 3 minutes), although the authors observed reduction in DBP after 1-minute interval. An explanation for these conflicting findings may reside in the DBP behavior itself after resistance exercise. Several studies even presenting significant reductions in SBP did not necessarily point out falls in DBP[14,15]. In other words, the reduction in DBP after exercise seems to be less susceptible to the exercise stimulus itself and, therefore, its behavior is not predictable[14-19].

In addition to the rest interval effect, other variables may also influence the post-exercise cardiovascular response, such as the training volume[14]. In this sense, when the load is maintained, a larger volume seems to indicate post-exercise hypotensive effect [20]. In the present study, there was higher number of repetitions in each exercise when performed the self-suggested and 2-minute interval. However, no differences were observed between intervals in relation to the BP response after exercise, indicating that the effect of volume on PEH may depend on the muscle mass or the number of sets[21].

Considering the HRV, an increase in the sympathetic component (LF) was observed after 30-minute' recovery related to rest only for the 2-minute interval. The sympathetic / parasympathetic balance (LF/HF) increased in relation to rest for the 1- and 2-minute intervals throughout the monitoring period after exercise. In studies using aerobic exercise, we observed that, just after the exercise completion, a rapid vagal reactivation occurs and the autonomic control becomes slower after exercises with higher metabolic demand[22]. Regarding the resistance exercise, few studies observed changes in the HRV[16,23,24]. Ruiz et al.[23], for example, reported lower vagal reactivation 30 seconds after an aerobic exercise session, when comparing with a resistance training session and a combined session (aerobic+resistance). The sympathetic predominance during the recovery period, observed in our study, was also found in a previous study consisted of a resistance training program for 12 weeks with elderly people[24]. Nevertheless, the mechanisms that induce greater sympathetic modulation are poorly understood.

In view of the gaps in the literature as well as the possible mechanisms involved in the PEH and HRV, Rezk et al.[16] assessed the influence of the resistance exercise intensity on these variables and observed that the high and low intensity (80% and 40% 1RM) reduced the SBP. Conversely, only lower intensities reduced the DBP, and this drop occurred as a result of lower cardiac output. There was an increase in the HR in order to compensate this BP reduction, provided by a high sympathetic modulation to the heart[16]. No study was found aiming at relating the possible interferences of rest interval between sets on HRV. Thus, based on our results, it is suggested that the longer the rest interval, the lower is the effect of the exercise on the autonomic balance (sympathetic / parasympathetic).

CONCLUSION

The results of the present study suggest that 2-minute and self-suggested intervals are equivalent in terms of recovery for the forthcoming set. In the method here employed, resting for at least 2 minutes in-between sets can be interesting to promote the performance of a higher number of repetitions and to reduce post-exercise sympathetic effects.

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