original article

Effect of different rest intervals between sets in the growth hormone concentrations in trained older women

Efeito de diferentes intervalos de recuperação entre as séries nas concentrações do hormônio do crescimento em idosas treinadas

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Abstract – The use of shorter rest intervals (RI) between sets of weight exercises has demonstrated to be a strategy to cause elevations of growth hormone concentrations (GH) in young adults. However, is not yet well established whether the magnitude of these elevations is influenced by the aging process. Thus, the aim of this study was to analyze the effect of different RI between sets of weight exercises on GH concentrations. Eighteen trained older women (65.8 ± 4.4 years; 70.2 ± 11.8 kg; 158.2 ± 5.1 cm) were submitted to two experimental exercise sessions in the leg press (separated by intervals between 48 and 72 hours). Both sessions consisted of three sets all performed with absolute loads of 15 maximal repetitions. Participants were instructed to perform maximum repetitions possible in each set until volitional muscle fatigue. In each experimental session, one of the different RI between sets was used: one minute (RI-1) or three minutes (RI-3). A randomized cross-over balanced design was used to determine the order of experimental sessions. Blood samples were collected to determine GH concentrations immediately before and after leg press exercise. Only the session performed with RI-1 showed significant elevations (50.7%; P < 0.05) in GH concentrations after exercise. However, significant differences in post-exercise GH concentrations were not observed between RI (P > 0.05). The results suggest that the use of different RI between sets does not influence the GH concentrations in trained older women.

Key words: Aging; Exercise; Hormones; Muscle strength.

Resumo – A utilização de menores intervalos de recuperação (IR) entre as séries de exercícios com pesos têm-se demonstrado uma estratégia para ocasionar elevações nas concentrações do GH em adultos jovens. No entanto, ainda não está bem estabelecido se a magnitude destas elevações é influenciada pelo processo de envelhecimento. Assim, o objetivo do presente estudo foi analisar o efeito de diferentes IR entre as séries de um exercício com pesos nas concentrações do hormônio do crescimento (GH). Dezoito idosas treinadas (65,8± 4,4 anos; 70,2± 11,8 kg; 158,2± 5,1 cm) foram submetidas a duas sessões experimentais no exercício leg-press, separadas por intervalos entre 48 e 72 horas. Ambas as sessões consistiram de três séries, todas executadas com as cargas absolutas de 15 repetições máximas. As participantes foram instruídas para realizarem o máximo de repetições possíveis em cada série, até a fadiga muscular voluntária. Em cada sessão experimental foi empregado um dos diferentes IR entre as séries: um minuto (IR-1) ou três minutos (IR-3). Um delineamento cross-over balanceado foi utilizado para determinar a ordem das sessões. As coletas sanguíneas para determinar as concentrações do GH foram realizadas imediatamente pré e pós-exercício leg-press. Somente a sessão realizada com IR-1 apresentou elevações significativas (50,7%; P < 0,05) nas concentrações do GH pós-exercício. Entretanto, diferenças significativas nas concentrações do GH pós-exercício não foram observadas entre os dois IR (P > 0,05). Os resultados sugerem que a utilização de diferentes IR entre as séries não influencia nas concentrações do GH pós-exercício, em idosas treinadas.

Palavras-chave: Envelhecimento; Exercício; Força muscular; Hormônios.

INTRODUCTION

Weight exercise is an excellent strategy to increase strength and muscle mass, which has a positive effect on functioning and daily activities and to reduce the incidence of falls in older adults[1-3]. These responses are linked to a number of mechanisms, for example, increased recruitment of muscle fibers, production of reactive oxygen species, changes in local myosin and increased anabolic hormone concentrations[4].

Acute elevation of growth hormone (GH) concentrations changes the dynamic balance between anabolic and catabolic stimuli in muscle, which may increase protein synthesis in muscle cells[5,6]. As described by Kraemer and Ratamess[7], the magnitude of post-exercise GH increases is associated with various acute variables (i.e., intensity, volume, weekly frequency, contraction velocity, order of exercises and rest interval (RI) between sets and exercise).

Many studies with young adults have shown that the use of shorter RI between sets provides higher elevations in GH concentrations[8,9]. Bottaro et al.[9] observed in trained women that RI of 30 seconds and one minute provide significantly greater increases in GH levels in comparison to RI of two minutes. In trained men, the same behavior was observed when RI of one (RI-1) and three minutes (RI-3) were compared[8]. Although the results of these studies assist in understanding the effect of different RI on GH concentrations, these findings cannot be extrapolated to older adults due to differences related to the aging process (i.e., GH release throughout the day and immediately after exercise)[10,11].

One way to prescribe loads during weight exercises is the maximum repetitions (RM) zone method, characterized by voluntary muscle fatigue within a given amplitude of repetitions (e.g., 10-12 RM)[12]. When this method is used in multiple sets, RI between sets has great relevance in the magnitude of the restoration of energy sources and intramuscular accumulation of metabolites (e.g., lactate)[8]. When considering that one of the main mechanisms linked to elevations in GH concentrations is the accumulation of metabolites[5,13], the use of lower RI between sets can be an excellent strategy to stimulate GH release. Furthermore, it has been suggested that food consumption before weight exercise sessions influence the balance of metabolites and release of GH concentrations[14]. In this context, it is necessary to evaluate food intake before weight exercise sessions to investigate GH concentrations.

According to the American College of Sports Medicine[12], RI-1 and RI-3 between sets are recommended for increases in strength and muscle mass in older adults. However, the effect of RI on GH concentrations has not been investigated in this population. Thus, the aim of this study was to compare post-exercise GH concentrations using RI-1 and RI-3 between sets in trained older women. It has been hypothesized that 1) both RI between sets promote increases in post-exercise GH concentrations; 2) RI-1 would promote significantly greater elevations in serum GH concentrations after exercise compared to RI-3.

METHODOLOGICAL PROCEDURES

Sample

The sample included 18 older women (65.8 ± 4.4 years; 70.2 ± 11.8 kg; 158.2 ± 5.1 cm) with minimum experience of eight months of supervised weight exercise (2.6 ± 1.4 years). As inclusion criteria, participants' age should be ≥ 60 years, not making use of restrictive or vegetarian diets and conducting the same training protocol in the eight weeks prior to the study. Participants with kidney disease, chronic obstructive pulmonary disease or neurological and cardiovascular contraindications, or muscle, joint and bone limitations of the lower limbs were excluded. Initially, 19 subjects were selected and after careful analysis of the baseline GH concentrations, one participant was excluded for presenting discrepant values (greater than three standard deviations and the third quartile + 1.5 interquartile deviations). This study was approved by the local Ethics Committee (Protocol No. 7090), in accordance with Resolution 196/96 of the National Health Council. After receiving information of the study's objectives and procedures, participants signed the Free and Informed Consent Form.

Experimental Design

During the experimental period, each participant attended the laboratory for five occasions, separated by intervals between 48 and 72 hours. Absolute charges related to 15 RM were determined and retested in the first three visits. In subsequent visits (days 4 and 5), participants underwent two experimental sessions using RI-1 or RI-3. A balanced cross-over design was used to determine the order of sessions. Blood samples were collected to determine the GH concentrations immediately before and after leg-press exercise. In an attempt to minimize circadian variations of GH concentrations, participants performed both experimental sessions at the same time (between 07:00 and 09:00 am). The total volume of sessions and food consumption were obtained to assist in the understanding of acute GH responses. In addition, participants received the following recommendations: a) to avoid physical exercises in the 24 hours prior to the study; b) to refrain from caffeine intake two hours before experimental sessions; c) do not change regular food intake.

Maximum repetitions test (15 RM)

The procedures for determining the loads relating to 15 RM have been previously described[15]. The first two sessions were designed to determine the loads and the third for retesting. During the determination of loads, participants performed three attempts per session with RI of 10 minutes between attempts. At the beginning of each session, a set of 10 repetitions with 50% the load established for 15 RM was performed as warm-up. After 30 seconds, participants were instructed to perform as many repetitions as possible with the load determined by the evaluator. The load selected for the first attempt was determined based on the training loads. After the

first attempt, loads were adjusted according to the maximum number of repetitions (one-kilogram changes were performed every two repetitions outside the target zone). Participants were evaluated in a horizontal leg-press machine (Righetto Fitness Equipment, Campinas, SP, Brazil), with knee angle set to 90º for the beginning of the movement. Legs were positioned in parallel with a small lateral spacing and feet on the platform. Arms were positioned parallel to the trunk and hands on support bar fixed to the seat. The initial position of all participants was recorded and used in the experimental sessions.

During the tests, researchers did not allow pauses between concentric and eccentric phases of the movement. Only repetitions performed with full range of movement were recorded. Additionally, verbal stimuli were given in order to keep participants' motivation.

Experimental sessions

Previously to experimental sessions, subjects performed a warm-up exercise composed of a set of 10 repetitions with 50% 15 RM. After 30 seconds, participants performed three sets with absolute loads of 15 RM. In each series, participants were instructed to perform the maximum possible repetitions until voluntary muscle fatigue. The number of repetitions performed in each set was recorded. The total volume of each experimental session was calculated by the sum of the number of repetitions of the three sets multiplied by the absolute load in kilograms (Σ repetitions x load). Participants were instructed to perform each repetition in about one second in the concentric phase and two seconds in the eccentric phase.

Blood collections and tests

Blood samples (~ 5 ml) were collected immediately before and after leg-press exercise by an experienced nurse. Samples were collected from the antecubital vein into vacutainer tubes without anticoagulant. After collection, blood cells were separated from the serum and stored at 8°C. GH concentrations were analyzed by chemiluminescent immunometric assay method using UniCel™DxI 800 analyzer (BeckmanCoulter; Santana de Parnaíba, SP, Brazil) and the respective Kit (Beckman Coulter, Santana de Parnaíba, SP, Brazil). All analyses were conducted in one day using the same kit. The variation coefficient for duplicate samples was < 5%.

Food intake assessment

Food intake was assessed by a food recall recorded in the 24 h period prior to experimental sessions. Participants were instructed to maintain their eating habits and write down all the food consumption using standard household measures. The total energy and the amount of macronutrients ingested were analyzed in computer software (Virtual Nutri, São Paulo / SP, Brazil). The carbohydrate and protein intake in relation to the body mass was calculated (g.Kg^{-1}). Data were analyzed by trained nutritionist.

Statistical analyses

The Shapiro-Wilk and Levene tests were used to check for normal distribution and data homogeneity, respectively. Results are expressed as mean ± standard deviation. The two-way analysis of variance for repeated measures on the second factor was used for comparisons between the different conditions (RI-1 and RI-3) and moments (GH concentrations before and after exercise). The effect size (h_p^2) and the power of the analyses were calculated. A 95% confidence interval was adopted to make inferences based on magnitude[16]. For the classification of magnitudes, a three-level scale was adopted: positive, negative or trivial effect. The Student t test for dependent samples was used to compare the number of repetitions of test-retest sessions, total volume and food consumption between experimental sessions. The intra-class correlation (ICC) was used to evaluate the reliability of test-retest at 15 RM. The significance level for all analyses was P < 0.05. Statistical procedures were performed using the Statistica ™ software, version 7.0.
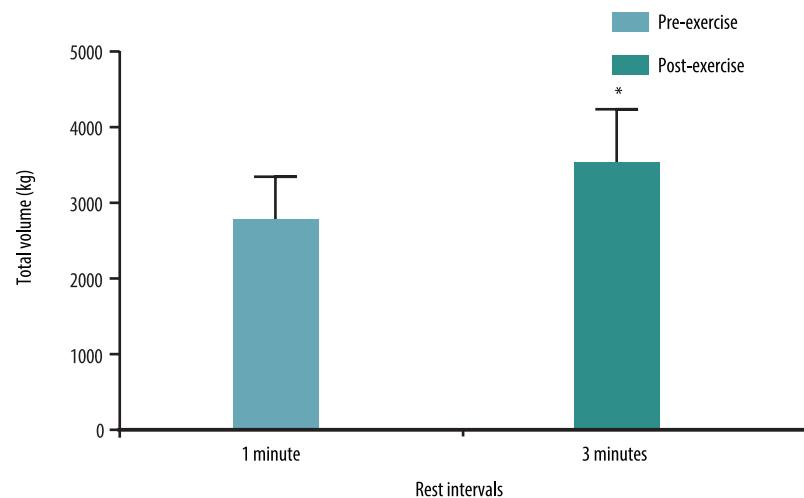
RESULTS

The ICC for the 15 RM test was 0.94 (CI 95% 0.86 - 0.97). No significant differences were observed for the number of repetitions performed in test-retest sessions (P > 0.5). The typical error measure of our laboratory is of 0.97 repetitions [17]. The GH concentration values of each experimental session are shown in Figure 1. Significant main moment effect was observed ($F_{(1,17)}$ = 7.02; P < 0.05; h_p^2 = 0.18; *power* = 0.73). Significant increases in post-exercise GH concentrations were observed only for RI-1 (P < 0.05). The inference based on magnitudes was deemed inconclusive because negative values exceed 10%. However, the main effect of Condition ($F_{(1,17)}$ = 0.20; P > 0.05; h_p^2 = 0.01; *power* = 0.07) and Condition x Moment interaction ($F_{(1,17)}$ = 0.32; P > 0.05; h_p^2 = 0.01; *power* = 0.09) was not verified.
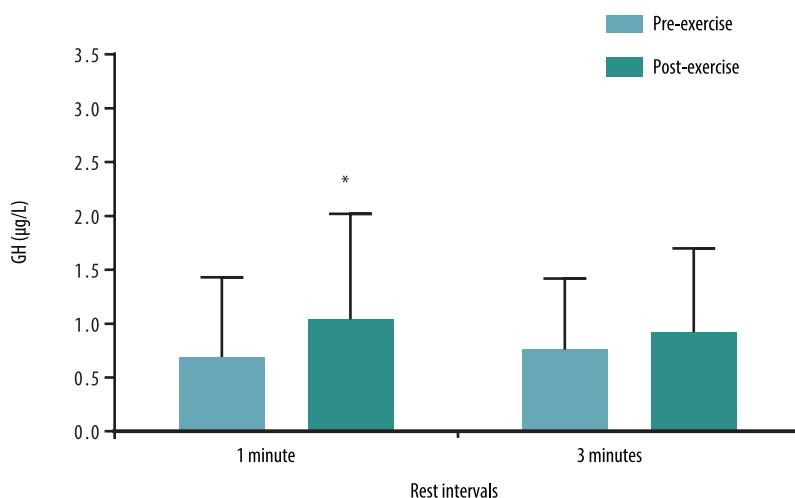
Figure 1. Growth hormone (GH) concentration values of weight exercise sessions performed with different rest intervals between sets in trained older women (n = 18). *Significant differences (P < 0.05) compared to pre-exercise. Values expressed as mean ± standard deviation.

The total volume of the exercise session with RI-3 was statistically higher (27.1%; P < 0.05) when compared to IR-1 (Figure 2).

Figure 2. Total volume (load x repetitions) of weight exercise sessions performed with different rest intervals between sets in trained older women (n = 18). * Significant differences (P < 0.05) compared to RI-1. Values are presented as mean ± standard deviation.

Food intake of 24 hours before blood sample collections is presented in Table 1. No statistically significant difference was observed in food intake between the two experimental sessions (P > 0.05).

Table 1. Values of total calories, macronutrients, and relationship between carbohydrate and protein intake and body mass (BM) of experimental sessions performed with rest intervals of one (RI-1) and three minutes (RI-3) in trained older women (n = 18).

	RI-1	RI-3
Total calories (Kcal)	1625.7 ± 539.4	1558.5 ± 607.2
Carbohydrates (%)	67.5 ± 9.5	63.7 ± 8.1
Proteins (%)	18.4 ± 5.7	21.4 ± 6.7
Lipids (%)	14.1 ± 4.9	14.9 ± 3.3
Carbohydrate intake/BM (g.Kg^{-1})	3.3 ± 1.2	3.2 ± 1.3
Protein intake/BM (g.Kg^{-1})	0.9 ± 0.4	1.1 ± 0.5

Values expressed as mean ± standard deviation.

DISCUSSION

The aim of this study was to analyze the effect of RI-1 and RI-3 between sets on post-exercise GH concentrations. Contrary to our hypotheses, only RI-1 caused significant increases in post-exercise GH concentrations. In addition, significant differences were observed between post-exercise RI-1 and RI-3 (Figure 1). Exercise session performed with RI-3 showed significantly higher total volume when compared to RI-1 (Figure 2). Food intake of 24 hours before the experimental sessions showed no significant differences (Table 1).

GH is a potent anabolic hormone synthesized and released in a pulsatile way by somatotropic cells located within the anterior pituitary gland[18].

Numerous benefits might be associated with GH release, for example, potentiation of IGF-1 release, mobilization of fatty acids, modulation of the activity of satellite cells, increases in the absorption of amino acids and protein synthesis in muscle cells [5,6,19].

One way to stimulate GH release is to perform exercises with weights, and the magnitude of this behavior is extremely sensitive to the protocol selected[20]. Studies comparing the effect of different RI between sets have indicated that shorter RI provides higher elevations in post-exercise GH concentrations[8,9]. Boroujerdi and Rahimi[8], for example, compared the effect of RI-1 and RI-3 on GH concentrations in trained young men. Participants performed five sets with loads 15% above 10 RM in bench press and squat exercises. Significant increases in post-exercise GH concentrations were observed for both RIs. However, significantly higher increase was observed for exercise set performed with RI-1 (2604.1%) compared with RI-3 (2060.4%). In trained young women, Bottaro et al[9] compared the effect of using RI of 30 seconds, one and two minutes on GH concentrations. Three 10 RM sets were performed in leg extension, squat, leg curl and leg press exercises. Elevations in post-exercise serum GH concentrations were significantly higher in sets with RI of 30 seconds (168.4%) and one minute (151.8%) compared with sets performed with RI of two minutes (65.2%). Unlike these studies, in the present study, no significant differences were observed in the post-exercise GH concentrations between different RIs. In addition, lower percentage increases were observed for RI-1 and RI-3 (50.7% and 21.5%, respectively). Different factors may be associated with these discrepancies, for example, age of participants, number of repetitions and exercise intensity.

It has been shown that increases in post-exercise GH concentrations are mitigated with the aging process[10]. Hakkinen and Pakarinen[10] compared the effect of a set of weight exercises on the GH concentrations in men and women of different age groups (30, 50 and 70). Participants of the three age groups performed five sets with maximum load for 10 repetitions in bench press, abdominal and leg press exercises. RI-3 was adopted between sets. Significant increases in serum GH concentrations were observed only for individuals aged 30 and 50 years, indicating that older adults (aged 70 years) may be less sensitive to GH releases associated with the performance of weight exercises. However, a study carried out in the same laboratory using leg press exercise with shorter RI (two minutes) observed increases in post-exercise GH concentrations in older adults[21], indicating that weight exercises may influence GH release.

According to Kraemer and Ratamess[7], protocols with high volumes, moderate to high intensity and short RI tend to produce higher acute elevations in GH concentrations. Although the mechanisms linked to these responses have not yet been fully cleared, it is believed that metabolic stress (e.g., pH reduction, hypoxia effects, lactate accumulation and inorganic phosphate) is the major causative factor of this response[5]. In the present study, the three sets of experimental sessions were held until voluntary

muscle fatigue. Accordingly, the significant increase in post-exercise GH concentrations observed only in exercise session with RI-1 (Figure 1) may likely be associated with higher metabolic stress. On the other hand, the greater total volume obtained in session with RI-3 (Figure 2) may have aided in absolute increases in GH concentrations and therefore decreased differences in GH release compared to RI-1.

An important consideration to be highlighted is the individual variability of GH release after weight exercises[22]. Raastad et al.[22] compared the effect of moderate (70% of 3 RM and 76% of 6 RM) and high intensity exercise (3 RM and 6 RM) on GH concentrations in nine trained men. The RIs adopted were four and six minutes. Although both protocols have not shown significant increases in GH concentrations, great individual variability in GH responses was observed. Among participants, three subjects showed no elevation of GH concentrations in any of sessions, five showed moderate responses in both protocols and one participant showed an increase of two times the GH concentration in both sessions. In the current study, when investigating the behavior of GH responses of participants, eleven showed absolute elevation of GH concentration in both sessions, six only in session with RI-1 and one only in session with RI-3. One possible explanation for these differences may be the variability of the training history of participants (2.6 ± 1.4 years). Thus, adopting more stringent inclusion criteria, establishing minimum and maximum experience with weight exercises can be a strategy to achieve more consistent results.

Based on the individual variability, the isolated analysis of participants who showed absolute increases of GH concentration in both sessions (responders) may be an additional strategy. When checking the data of 11 participants in the present study, the largest absolute increases were observed for RI-1 and RI-3 (76.6% and 85.7%, respectively) compared to values of the total sample. In addition, statistically significant increase in post-exercise GH concentrations was observed in both sessions; however, no differences between RIs were observed.

Food consumption prior to weight exercise sessions substantially influenced the release of GH concentrations [14]. In this study, the amount of total calories, macronutrients and the relationship of carbohydrate and protein intake and body mass in 24 hours before the experimental sessions were not significantly different (Table 1). Although this measure suggests that food intake did not influence differently the GH release between experimental sessions, these results should be treated with caution, as this measure does not distinguish the amount of amino acids, fiber and saturated and unsaturated fats ingested.

In order to meet the principle of progression, RI variations between sets can be a strategy to increase muscle mass and strength, reflecting in improvements in daily living activities (e.g., getting up from a chair and climbing stairs), thus reducing the number of falls in trained older adults. However, this study has some significant limitations. The use of a single exercise may not be enough to cause a suitable stimulus for acute GH re-

lease. However, evaluating exercises in isolation can be a strategy to avoid the effect of multiple exercises order. An important point that should also be highlighted was the lack of assessment of the possible mechanisms associated with changes in post-exercise GH concentrations using different RI. As previously mentioned, it is suggested that shorter RI between sets should provide higher metabolic stress, which appears to be important to stimulate GH release[5]. Konet al.[13] verified by restricting blood flow that elevations in serum GH concentrations are associated with the accumulation of metabolites.

CONCLUSION

The results of this study suggest that the use of different RI between sets does not significantly influence serum GH concentrations in trained older women. Although RI-1 significantly elevated post-exercise GH concentrations, no differences were observed in the different RI between sets. Future studies should be conducted using a greater number of exercises and different intensities. Furthermore, additional studies are needed to determine the mechanisms for the increase of post-exercise GH concentrations in older women.

Acknowledgments

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