

Acute effects of different rest period between sets on neuromuscular bench press performance

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Abstract

Introduction: Manipulation of resistance training variables allows the maintenance the performance of the proposed exercise. **Objective:** To evaluation the acute effects of different rest intervals on maximum repetition performance, perceived exertion, and fatigue index on bench press. **Methods:** Following ten-repetition maximum testing and retesting, four experimental sessions involved seven bench press sets to concentric failure with the goal of completing the maximum number of repetitions, which included: 1) one-minute rest interval between sets (P1), 2) two-minute rest interval between sets (P2), three-minute rest interval between sets (P3), and five-minute rest interval between sets (P5). **Results:** A main result was observed in maximum repetition performance for all sets ($p < 0.001$). In the fatigue index, only P3 and P5 showed significant differences compared to all other protocols ($p < 0.001$). Besides, the perceived exertion shows a similar trend to fatigue index for longer rest intervals. **Conclusion:** Reducing the maximum repetition performance in shorter intervals is an important tool for reducing the total workout time.

Keywords: Performance; Recovery; Resistance training; Strength training; Strength.

Introduction

Resistance training (RT) have ben gained notable attention since the American College of Sports Medicine,¹ wherein first RT appears, and then suggesting your practice. Different methodological variables may influence the better responses in muscle force, hypertrophy, and muscular endurance. For example, loads intensity, number of repetitions and the rest interval between sets and exercises. Loss performance are expected during session and/or sets by fatigue produced after succession of repetition which avoiding the task continuation.^{2,3}

Furthermore, Willardson⁴ shows that the better RT results depend of the applied tension and ability to maintain the repetitions ranges during the sets progression. Thus, an appropriate variable manipulation is required. Rahimi⁵ observed that longer rest period (5-minutes) has higher total repetition volume in compared to intermediate (2-minutes) and short (1-minute) rest period. De Salles et al.⁶ agreement which found that long intervals resulted in higher total repetition volume for leg press and leg extension. However, Senna et al.⁷ found that longer and short rest period showed similar reductions. Still, Maia et al.² did not observed differences in total training and work volume in bench press and seated row for 2-minutes rest interval period.

Bench press has been the most popular exercise in RT session. Willardson et al.⁸ compared four different loads intensities for maximum repetitions maintenance in the bench press. The authors observed a reduction of approximately 10% in load for maintenance of 10 repetitions maximum in the progression of the series is required. Thus, the aim of this study was to evaluate the effect of different rest intervals on maximum repetitions performance, perceived exertion and fatigue index on bench press.

Methods

Participants

Twenty-five recreationally active men (Table 1) were recruited for the study. An *a priori*

sample size calculation (Effect Size = 1.53; $1-\beta = 0.95$; $\alpha = 0.05$) using G*Power⁹ found that sixteen subjects would be adequate; however, in order to increase statistical power, 25 were recruited.¹⁰ Anthropometric data included body mass (Techline BAL – 150 digital scale, São Paulo, Brazil), height (stadiometer ES 2030 Sanny, São Paulo, Brazil) and adiposity. Subjects were included if they had been involved in resistance training program for at least one year prior to the experiment, average of 50-60 minutes per session, 3-4 sessions per week, using loads with 8-12 repetitions maximum, and rest intervals between 1 and 3 minutes among sets and exercises. Participants were free from any functional limitation or medical condition that could have compromised their health or confounded the results of the study. During the twenty-eighth period of data collection, the subjects were instructed not to engage in any resistance training exercise or other strenuous activity. Prior to the study, all participants were provided verbal explanation of the study and read and signed informed consent and Physical Activity Readiness Questionnaire. All procedures were in accordance with Declaration of Helsinki. The ethics committee of University Hospital Clementino Fraga Filho approved the study (n°09065412.9.0000.5257/12).

Table 1: Subjects characteristics

Age (years)	26.84 ± 4.59
Height (cm)	178.76 ± 6.41
Body Mass (kg)	88.47 ± 21.34
Body Mass Index (m ² /kg)	27.45 ± 5.27
Adiposity (%)	17.71 ± 7.84
Resistance Training Experience (months)	25.64 ± 6.07
Bench Press 10RM (test) (kg)	73.76 ± 9.31
Bench Press 10RM (retest) (kg)	73.68 ± 9.08
Intraclass Correlation Coefficient	0.997

Source: The authors.

Design

A randomized within-subject design was used. Subjects visited the laboratory on ten occasions during a twenty-eight period with for-

ty-eight hours between visits (Figure 1). During the first six visits, the subjects underwent three familiarization visits, anthropometric assessment and a ten-repetition maximum (RM) testing and retesting, respectively. Following 10RM testing, four experimental sessions followed in a randomized order, which included: 1) one-minute rest interval between sets (P1), 2) two-minute rest interval between sets (P2), three-minute rest interval between sets (P3), and five-minute rest interval between sets (P5). Each experimental session consisted of seven sets of bench press with 10RM load to concentric failure with the goal of completing the maximum number of repetitions.

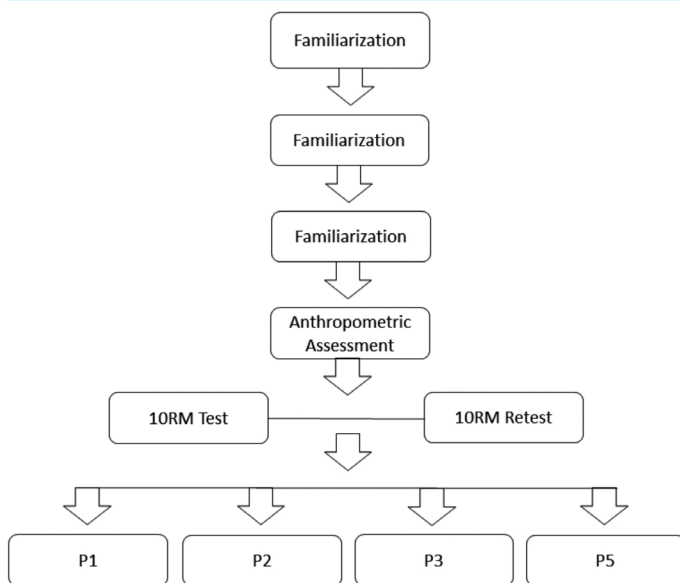


Figure 1: Study design

RM = repetition maximum. P1 = one-minute rest interval between sets, P2 = two-minute rest interval between sets, P3 = three-minute rest interval between sets, and P5 = five-minute rest interval between sets.

Source: The authors.

Procedures

Ten RM Test

Ten repetitions maximum was determined similar to Simão et al.¹¹ Participants initially performed a standardized warm up consisting of two sets of fifteen repetitions of bench press with approximately 50% of normal training

load. After the warm up, ten-repetition maximum testing was performed. For the first trial, subjects increased their warm up load by 100% and adjusted the load as needed in the subsequent trials. Execution of the bench press was standardized insofar as no pauses were allowed between concentric and eccentric portions of the lift. A maximum of three trials were allowed per testing session, separated by three minutes of passive rest. Testing was then repeated on another day at least 48 hours later (retest). The higher load between the two testing days was considered as the 10RM load. The 10RM load was confirmed by calculating the intraclass correlation coefficient. In an effort to

minimize the margin of error, the following strategies were adopted:¹¹ a) all subjects received standardized instructions about the exercise technique and data collection, b) subjects received feedback as to their technique and were corrected if and when appropriate, and c) all subjects were always verbally encouraged. The knee extension apparatus used for 10RM testing and during the experimental sessions was the same (Pure Strength – Olympic Flat Bench, Technogym, Cesena, Italy).

Perceived Exertion

The perceived exertion¹² have been used for intensity evaluation. This scale allows the intensity view after sets and/or session completed and has a visual characteristic which ranges between 0 (extremely easy) and 10 (extremely hard). The reports value was noted at the ending of each sets.

Statistical Analyses

Data are presented as means \pm standard deviations. Initially, the neuromuscular fatigue index (FI) was calculated in each protocol using equation proposed by Dipla *et al.*¹³, where a higher percentage value (%) indicates a superior fatigue resistance: $FI = (\text{lastset} / \text{firstset}) \times 100$. Normality and sphericity were ensured

using Shapiro-Wilks test. A repeated measures ANOVA was used to means analysis and make inferences in the inter-protocol comparisons. Thereafter, a Tukey post-hoc was used to identify significant differences. Additionally, Cohen's d effect size was calculated using the formula 1

$$d = \frac{M_d}{s_d} \quad (1)$$

where M_d is the mean difference and s_d is the standard deviation of differences. Cohen's d effect-sizes were defined as small, medium, and large for 0.2, 0.5, and 0.8, respectively.¹⁴ Finally, the Kruskal-Wallis nonparametric test was used for analysis de perception exertion data. All analyses were performed using SPSS version 21 (SPSS Inc., Chicago, IL, USA) and an alpha level of 0.05 was accepted.

Results

On average, the number of repetitions completed in the P5 ($d=-2.57$) was 45.8%, 37.1% and 26.9% greater than in the P1 ($d=-14.55$), P2 ($d=-10.86$), and P3 ($d=-8.66$), respectively (Figure 2). In figure 2, was observed a main result in P1 and P3, which has a statistically significant decrease pattern in maximum repetition performance until fifth sets ($p<0.001$). A main effect was also found in P2 until sixth sets ($p<0.001$) and P5 until third sets ($p<0.001$). Additionally, there was no significant difference in the first set between the different recovery ($p>0.05$). Still, P5 showed a higher number of repetitions in comparison with other protocols for

all sets, except for second set which P3 and P5 showed no significant difference between them ($p>0.05$). Finally, P1 shows fewer repetition performance for all sets, except for second set, which observed no difference for P2 ($p>0.05$).

In the fatigue index, P3 and P5 was significant higher in comparison to all other protocols ($p<0.001$), whereas P1 and P2 showed no significant differences ($p>0.05$) (Figure 3). Besides, the perceived exertion shows a similar trend to fatigue index for longer rest intervals ($P5>P3>P2>P1$) (Figure 4).

Discussion

The purpose of this study was to evaluate the influence of different rest intervals on the maximum repetitions performance, perceived exertion and fatigue index in bench press multiple sets. The main effects confirm the initial hypothesis which higher rest interval provide better repetitions performance and fatigue index but lower perceived exertion. The results of this study according to previous literature findings.^{2,5,8}

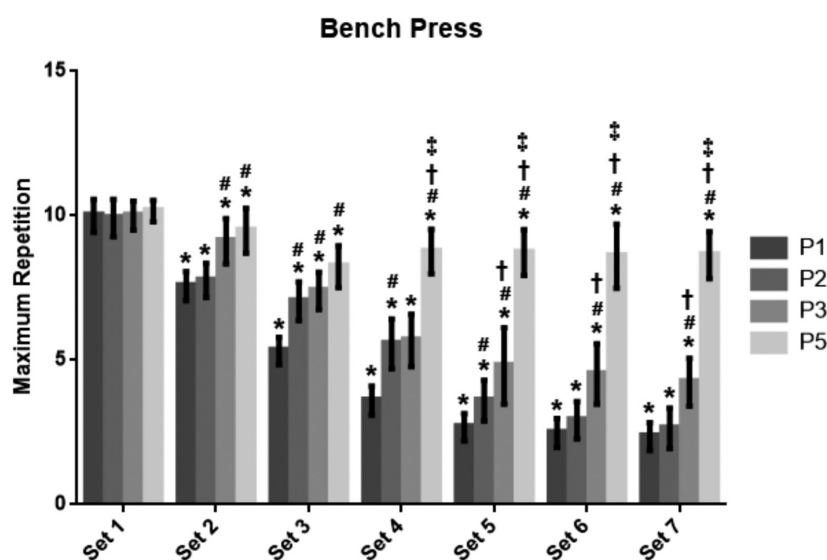


Figure 2: Maximum repetition performance across each set P1 = one-minute rest interval between sets, P2 = two-minute rest interval between sets, P3 = three-minute rest interval between sets, and P5 = five-minute rest interval between sets.

Source: The authors.

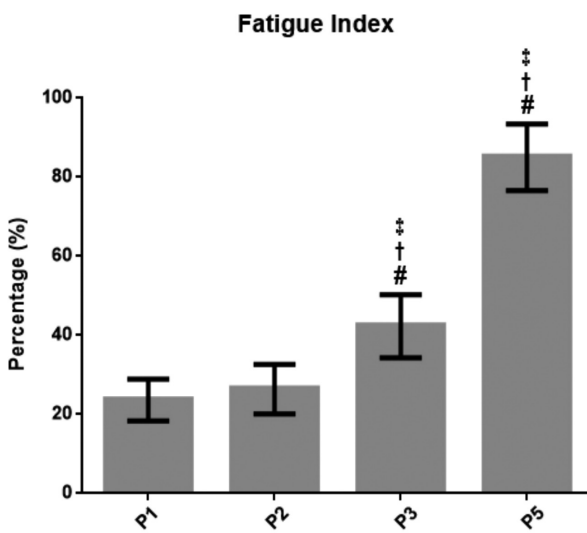


Figure 3: Fatigue index across each set P1 = one-minute rest interval between sets, P2 = two-minute rest interval between sets, P3 = three-minute rest interval between sets, and P5 = five-minute rest interval between sets.

Source: The authors.

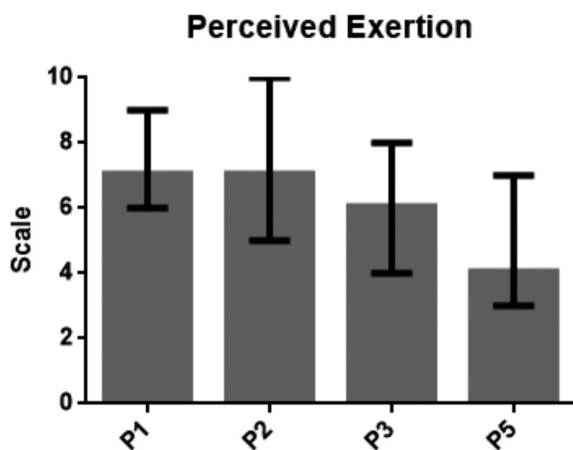


Figure 4: Perceived exertion across each set. P1 = one-minute rest interval between sets, P2 = two-minute rest interval between sets, P3 = three-minute rest interval between sets, and P5 = five-minute rest interval between sets.

Source: The authors.

The American College of Sports Medicine in last position stand recommended 1-2 minutes for multi-joint exercises rest interval. Studies^{15,16} indicate that this interval range may not be efficient for performance maintenance. Senna et al.¹⁵ compare two and five-minutes rest inter-

val on the number of repetitions in three sets with 10RM load in lower and upper body exercises. The results show that the training session performance is reduced by shorter intervals in compare to longer intervals (5>2-minute) and the last in compare to initial exercises as upper as lower body exercises. Additionally, Senna et al.¹⁶ compare one, three and five-minutes on repetition performance and perceived exertion. The authors observed a decline by shorter intervals and increases in perceived exertion (1>3>5-minute). Literature is still unclear regarding the optimal interval length for muscle recovery in different exercises, however recent evidences disagree with the ACSM position stand and show a trend for longer intervals are better for maximum repetition performance maintenance.

Recently, the self-suggest of rest interval has been gaining importance in the literature. First, Goessler and Polito¹⁷ observed similar exercises dose-response with different rest intervals. For example, the self-suggest shows as average duration (155 ± 37 seconds) statistical similar to two-minutes. Still, De Salles et al.¹⁸ compare two-minutes and self-suggested rest intervals in exercise performance. The results did not demonstrated differences in the number of repetitions between two-minutes and self-suggested, which both reduces similarly the performance. These findings disagree with the ACSM, but has an interesting practical application, allowing a good performance with a lower volume in the training session (time-effective strategy).

Similar results have been observed in the fatigue index. Previous studies indicate that rest interval between sets,^{2,19} exercise order,²⁰ and the exercise intensity¹⁹ have dose-response proportional to the fatigue. Tibana et al.¹⁹ observed that lower rest intervals may potentiate the fatigue effects. Furthermore, Maia et al.² confirm this remark, which found that the rest intervals is inversely proportional to fatigue. Finally, Spinetti et al.²⁰ observed that the exercise order may increase the fatigue effects on the training session continuation. Besides, the perceived exertion following the rest intervals and fatigue index

trends, which appears that smaller rest intervals have increased efforts.

Previously, many neurophysiological mechanisms are perturbed until the body feels the fatigue effects (i.e. energy reserves, ion concentration and arrangement of contractile proteins). Accordingly, a number of underlining mechanisms can help explain the findings of the present study. First, decreases in muscle voluntary activation (i.e. number and discharge rates of the motor units). This modulation in muscle activation results decrease in afferent feedback from agonist muscles, following by a drastic decrease in power output as a result of greater fatigue.^{3,21} Second, the motor units are either not recruited or may not fire often enough for the muscle fibres to generate maximal force.²² Finally, the fatigue is inverse correlated with the rest interval and metabolic response.²³ A rest interval suiting has an important metabolic function, since the recharge of ATP-CP, the buffering of glycolytic metabolism of H⁺ and lactate removal occur during this recovery.²³

There are limitations and delimitations to be considered when interpreting the results of this present study. First, 10RM test was purposely chosen for its practical applicability and cardiovascular safety.²⁴ Seconds, inter-individual differences in repetition duration were not tightly controlled. This can be considered as both a limitation and strength of this design. Specifically, the lack of control reduces the internal validity of the results, as the movement velocity could possibly influence the outcome. Velocity loss during RT has been shown to be an indicator of neuromuscular fatigue, and indeed changes in repetition duration occur over the course of a set performed to momentary concentric failure as was performed in the present study. Conversely, the freedom to choose the pace duration enhances the ecological validity of the findings, as it better represents real-life training scenarios. The results of this study may only apply to the exercises examined which were all compound multi-joint exercises. Whether the same between-day rest interval optimizes reliability of 10RM testing for

single joint exercises is less clear. Finally, only male's subjects were utilized, so these results cannot be extrapolated to females, who have been shown to be less fatigable than males, when it comes to dynamic contraction^{25,26} and have higher relative muscle force.²⁷

Conclusions

Although maximum repetition performance was reduced for shorter rest intervals, there is an important tool that allows more efficient training for subjects have not seek performance, by reducing the total workout time.

References

1. American College of Sports Medicine. ACSM Fitness Book (2nd Ed.). Champaign: Human Kinetics, 1998.
2. Maia MdeF, Paz GA, Miranda H, Lima V, Bentes CM, Novaes JS, Vigário DS, Willardson JM. Maximal repetitions performance, rating of perceived exertion, and muscle fatigue during paired set training performance with different rest intervals. *J Exerc Sci Fitness* 2015;13(1):104-110.
3. Boyas S, Guével A. Neuromuscular fatigue in healthy muscle: Underlying factors and adaptation mechanisms. *Ann Phys Rehabil Med* 2011;54(2):88-108.
4. Willardson JM. A brief review: factors affecting the length of the rest interval between resistance Exercise sets. *J Strength Cond Res* 2006;20(4):978-984.
5. Rahimi R. Effect of different rest intervals on the exercise volume completed during squat bouts. *J Sports Sci Med* 2005;4(4):361-366.
6. De Salles BF, Simão R, Ribeiro FM, Novaes JS, Lemos A, Willardson JM. Rest interval between sets in strength training. *Sports Medicine* 2009;39(28):765-777.
7. Senna GW, Willardson JM, Scudese E, Simão R, Queiroz C, Avelar R, Martin Dantas EH. Effect of different interset rest intervals on performance of single and multijoint exercises with near-maximal loads. *J Strength Cond Res* 2016;30(3):710-716.
8. Willardson JM, Simão R, Fontana FE. The effect of load reductions on repetitions performance for commonly performed multijoint resistance exercises. *J Strength Cond Res* 2012;26(11):2939-2945.

9. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods* 2007;39(2): 175-191.
10. Beck TW. The importance of a priori sample size estimation in strength and conditioning research. *J Strength Cond Res* 2013;27(8):2323-2337.
11. Simão R, Farinatti PTV, Polito MD, Maior AS, Fleck SJ. Influence of Exercise order on the number of repetitions performed and perceived exertion during resistance exercises. *J Strength Cond Res* 2005;19(1):152-156.
12. Robertson RJ, Goss FL, Turkowski J, Lens B, Dizon C, Timmer J, Frazee K, Dube J, Andreacci J. Concurrent validation of the OMNI perceived exertion scale for resistance exercise. *Med Sci Sports Exerc* 2003;35(2):333-341.
13. Dipla K, Tzirini T, Zafeiridis A, Manou V, Dalamitros A, Kellis E, Kellis S. Fatigue resistance during high-intensity intermittent exercise from childhood in males and females. *Eur J Appl Physiol* 2009;106(5):645-653.
14. Cohen J. Statistical power analysis for behavioral sciences. Routledge; 1988.
15. Senna G, Salles BF, Prestes J, Mello RA, Simão R. Influence of two different rest interval lengths in resistance training session for upper and lower body. *J Sports Sci Med* 2009;8(2): 197-202.
16. Senna G, Willardson JM, de Salles BF, Scudese E, Carneiro F, Palma A, Simão R. The Effect of the rest interval length on multi and single-joint Exercise performance and perceived exertion. *J Strength Cond Res* 2011;25(11): 3157-3162.
17. Goessler KF, Polito MD. Efeito do intervalo de recuperação fixo e autossugerido entre séries do exercício resistido sobre o comportamento cardiovascular pós-esforço. *Revista Brasileira de Cineantropometria e Desempenho Humano* 2013;15(4): 467-475.
18. De Salles BF, Polito MD, Goessler KF, Mannarino P, Matta TT, Simão R. Effects of fixed vs. self-suggested rest between sets in upper and lower body exercises performance. *Eur J Sport Sci* 2016;16(8):927-931.
19. Tibana RA, Prestes J, da Cunha Nascimento D, Martins OV, de Santana FS, Balsamo S. Higher muscle performance in adolescents compared with adults after a resistance training session with different rest intervals. *J Strength Cond Res* 2012;26(4):1027-1032.
20. Spinetti J, De Salles BF, Rhea MR, Lavigne D, Matta T, Miranda F, Fernandes L, Simão R. Influence of exercise order on maximum strength and muscle volume in nonlinear periodized resistance training. *J Strength Cond Res* 2010;24(11):2962-2969.
21. Gandevia SC. Spinal and Supraspinal factors in human muscle fatigue. *Physiol Rev* 2001;81(4):1725-1789.
22. Taylor JL, Todd G, Gandevia SC. Evidence for a supraspinal contribution to human muscle fatigue. *Clin Exp Pharmacol Physiol* 2006;33(4): 400-405.
23. Ratamess NA, Falvo MJ, Mangine GT, Hoffman JR, Faigenbaum AD, Kang J. The effect of rest interval length on metabolic responses to the bench press exercise. *Eur J Appl Physiol* 2007;100(1):1-17.
24. Monteiro ER, Novaes JS, Fiuza AG, Portugal E, Triani FS, Bigio L, Santos R, Palma A, Corrêa Neto VG. Behavior of heart rate variability after 10 repetitions maximum load test for lower limbs. *Int J Exerc Sci* 2018;11(6):834-843
25. Hunter SK. Sex differences and mechanisms of task-specific muscle fatigue. *Exerc Sport Rev* 2009;37(3):113-122.
26. Monteiro ER, Brown AF, Bigio L, Palma A, Dos Santos LG, Cavanaugh MT, Behm DG, Corrêa Neto VG. Male relative muscle strength exceeds females for BP and back squat. *JEPOnline* 2016;19(5):79-85.
27. Monteiro ER, Steele J, Novaes JS, Brown AF, Cavanaugh MT, Vingren JL, Behm DG. Men exhibit greater fatigue resistance than women in alternated bench press and leg press exercises. *J Sports Med Phys Fitness* 2019; 59(2):238-245.

