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Summary — This study compared two different rest intervals (RI) between sets of resistance exercise. Ten resistance-trained men (M age = 24.3, SD = 3.5 yr.; M weight = 80.0 kg, SD = 15.3; M height = 1.75 m, SD = 0.04) performed fi ve sets of Smith machine bench presses at 60% of one repetition maximum, either with 1.5 min. or 3 min. RI between sets. Their repetition performance, total training volume, velocity, fatigue, rating of perceived exertion, and muscular power were measured. All of these measures indicated that performance was significantly better and fatigue was significantly lower in the 3 min. RI as compared with the 1.5 min. RI, except the rating of perceived exertion which did not show a significant difference. A longer RI between sets promotes superior performance for the bench press.

Resistance training is a safe and effective method for enhancing muscular strength, hypertrophy, localized endurance, and power (Fleck & Kraemer, 2004 ; American College of Sports Medicine, 2009). Prescription of resistance training is based on individual needs, goals, and physical capacity. In intense resistance training programs, several variables can be manipulated to optimize the continual adaptations to resistance training, including: the exercise mode and order, frequency, volume, load, and rest interval (RI) between sets and exercises (Fleck, & Kraemer, 2004). Furthermore, acute muscle power performance seems to be related to the recovery time between sets (Abdessemed, Duche, Hautier, Poumarat, & Bedu, 1999).

Shorter RI lengths (1 min. vs 3 or 5 min.) between sets and exercises have been shown to elicit significantly greater metabolic (Ratamess, Falvo, Mangine, Hoff man, Faigenbaum, & Kang, 2007 ; Farinatti & Castinheiras Neto, 2011), hormonal (Bottaro, Martins, Gentil, & Wagner, 2009 ; Rahimi, Qaderi, Faraji, & Boroujerdi, 2010), and cardiovascular responses to RT bouts (De Salles, Simão, Ribeiro, Novaes, Lemos, & Willardson, 2009). Tibana, Prestes, Nascimento, Martins, De Santana, and Balsamo (2012) revealed that both adults and adolescents exhibited a higher resistance to fatigue, total training volume, and number of repetitions with longer RI (2 min. > 1 min. > 30 sec.). Different RI lengths between sets can also affect performance over consecutive sets, as a 1 min. RI resulted in lower acute muscular power vs a 3 or 5 min. RI between sets in untrained young students (Abdessemed, et al., 1999). However, few studies have compared different RI lengths between sets on the acute expression of muscular power during dynamic power training (Barnett, Kippers, & Turner, 1995 ; Ratamess, Chiarello, Sacco, Hoff man, Faigenbaum, Ross, et al., 2012).

The American College of Sports Medicine (2009) recommended 2 to 3 min. RI between sets for exercises with novice, intermediate, and advanced individuals undertaking muscular power training. This recommendation requires more scientific basis in that a close examination revealed that the only available findings came from one study conducted with untrained men (Ratamess, et al., 2012). Nevertheless, training status is known to strongly influence fatigue resistance during repetitive maximum exercise (Sargeant, 1994).

Abdessemed, et al. (1999) examined the effect of RI length on muscular power and blood lactate concentration during 10 sets of six Smith machine bench press repetitions performed at 70% of one repetition maximum (1-RM) with 1, 3, or 5 min. rest intervals between sets. No significant difference in mean power occurred between the first and the tenth sets when resting 3 or 5 min. between sets (reductions of 4.9% and 2.1%, respectively); while lactate did not increase significantly from baseline with either of these RI protocols. Conversely, the 1-min. RI protocol resulted in a significant decrease in mean power (27%) and a significant elevation in blood lactate. To note, participants were physical education students not involved in weight or sprint training.

These results suggest that 3 min. to 5 min. rest intervals between sets may allow for maintenance of mean power over consecutive sets performed by untrained men. Considering this, to decrease the overall length of a training session, RI lengths of 1.5 min. and 3 min. were investigated. Moreover, the effect of different RI lengths on muscular power performance in resistance-trained men has not been specifically examined to date. Thus, the purpose of the current study was to examine the acute effects of 1.5 min. and 3 min. RI lengths between Smith machine bench press sets on muscular power, the fatigue index, number of repetitions, volume, velocity, and rating of perceived exertion (RPE) in resistance trained men.

Hypothesis 1. A 3 min. rest interval between sets would result in more repetitions and greater training volume compared with a 1.5 min. rest interval.

Hypothesis 2. A 3 min. rest interval between sets would result in greater muscular power (measured as mean, relative or peak) compared with a 1.5 min. rest interval.

Hypothesis 3. A 3 min. rest interval between sets would result in lower fatigue compared with a 1.5 min. rest interval.

Hypothesis 4. A 3 min. rest interval between sets would result in lower RPE compared with a 1.5 min. rest interval.

Hypothesis 5. A 3 min. rest interval between sets would result in greater velocity compared with a 1.5 min. rest interval.

METHOD

Participants

Ten recreationally trained men (M age = 24.3 yr., SD = 3.5; M weight = 80.0 kg, SD = 15.3; M height = 1.75 m, SD = 0.04; M body mass index = 27.6 kg/m2 , SD = 5.2 ; M body fat = 11.2%, SD = 6.9%) participated in this study and completed all experimental sessions. Participants were considered "trained" (approximately six months of consistent resistance training experience) based on the criteria set by the American College of Sports Medicine (2002). In the 12 mo. prior to the study, they had strength trained at least four times per week using three sets of 8–10 RM for the bench press exercise. Each participant underwent a physical examination, which included a medical history, resting and exercise electrocardiogram, blood pressure assessment, and orthopedic evaluation before the resistance training protocols. The exclusion criteria were history of musculoskeletal injuries or any disease that could compromise their health during the study, a negative response on the Physical Activity Readiness Questionnaire (PAR-Q); and taking any medications, anabolic steroids, or nutritional supplements known to affect energy metabolism or resistance exercise performance. All participants signed an informed consent document, and the study was approved by the institutional Research Ethics Committee for Human Subjects (Protocol No. 030/09). Participants were asked to sleep at least eight hours on the night before each experimental session, to maintain their normal hydration status and dietary intake, to avoid any strenuous exercise in the 48 hr. before the experimental sessions, and avoid smoking, alcohol, and caffeine consumption for 24 hours before all tests.

Procedure and Measures

Strength assessments — The Smith machine bench press was used because it is a multi-joint exercise common to most resistance training programs. All participants were familiarized with the testing procedures prior to conducting the experimental protocols. For the determination of the Smith machine bench press 1-RM load, two tests (test-retest) were conducted on two non-consecutive days (minimum of 72 hr. between tests). The intraclass correlation coefficient was $r = .97$, thus confirming the test-retest reliability. Standardized range of motion and performance of the Smith machine bench press was conducted in accordance to Brown and Weir (2001). After 5 min. of light treadmill running, participants performed a specific warm-up of eight repetitions with 50% of an estimated 1-RM (according to the previous loads used by participants in their training routines), followed by three repetitions with 70% of an estimated 1-RM. Consecutive trials were performed for one repetition with progressively heavier loads until the 1-RM was determined within three attempts, using 3 to 5 min. rest intervals between attempts.

Experimental protocols — These were performed at a consistent time of the day (between 7:00 and 8:00 PM) to eliminate potential circadian performance variations and separated by 72 hr. Each protocol consisted of performing the Smith machine bench press exercise with 60% of a predetermined 1-RM for five sets according to the recommendations set for the ACSM (2002) for multi-joint exercises. Participants were instructed to perform the concentric phase of each repetition as quickly as possible. Participants performed each Smith machine bench press protocol using

1.5 min. or 3 min. rest intervals between sets in a randomized counterbalanced order. These rest intervals were chosen because they are commonly used in resistance training protocols. To guarantee a maximal effort, the experimental protocols were individually supervised by an experienced strength and conditioning specialist who provided verbal encouragement for all participants during the sets. The number of repetitions completed in each set, total training volume (total repetitions completed x load), mean power, relative mean power, peak power, mean velocity, fatigue index, and rating of perceived exertion (RPE) were assessed for each Smith machine bench press set and compared between protocols. The RPE was evaluated immediately after the ending of each set. Repetitions not completed to a full range of motion or those repetitions completed with assistance from a spotter were not counted. Subjects were asked to sleep at least eight hours on the day previous to each experimental session and maintain normal hydration status and dietary intake; also to refrain from programmed exercise, avoid smoking, alcohol, and caffeine consumption.

Muscular power output — Average bar velocity and power for the each repetition of the Smith machine bench press was measured with a Cefise Power Output Unit (Peak Power; Cefi se, Sao Paulo, Brazil). The Cefise unit consists of a linear position transducer attached to the end of the barbell which measures linear displacement and time. Power and velocity were averaged for each set (across all completed repetitions), allowing Sets 1, 2, 3, 4, and 5 to be compared.

Fatigue — The number of repetitions, mean power, and mean velocity between the first and fifth set were compared to generate a fatigue index in each protocol as proposed by Tibana, et al. (2012).

Fatigue Index = (5 th set/1 st set) x 10. Higher value (in %) indicates a superior fatigue resistance.

Perceived exertion — During the two familiarization sessions, participants were instructed regarding anchoring procedures and then the OMNI-RES scale was presented to each participant in order to assess the RPE. The OMNI-RES has been validated in young adults to assess the RPE during resistance training (Lagally, Amorose, & Rock, 2009), with intraclass reliability coefficients ranging from 0.69 to 0.95 (Robertson, Goss, Rutkowski, Lenz, Dixon, Timmer, et al., 2003). OMINI scale has both verbal and mode-specific pictorial descriptors (individual performing resistance exercise) distributed along a comparatively narrow numerical response range (0–10), and is presented as a visually discernible exertional intensity gradient. The scale also provides verbal descriptors along with the narrow numerical range and was designed to subjectively evaluate the individual perceived exertion to the resistance training protocol. According to Robertson, et al. (2003), OMNI-RES was validated for use by female and male adults during upper- and lower-body resistance exercise. During each set participants were reminded to “think about your feelings of exertion” and the scale was in clear view during the entire exercise set. A standardized definition of RPE and a set of instructions pertaining to the

OMNI-RES were read before each experimental protocol according to the procedures described by Robertson, et al. (2003). The RPE is defined as the subjective intensity of effort, strain, discomfort, and/or fatigue that is felt during exercise. Thus, the individual set and total session RPE were assessed after the fifth set of the local muscle.

Statistical Analyses

In all statistical comparisons, the alpha level was set at $p \leq .05$. The Shapiro-Wilk normality test and homocedasticity test (Bartlett criterion) confirmed that all variables were normally distributed with homocedasticity. A 2 (1.5, 3 min. RI) x 5 (number of sets) repeated-measures ANOVA was used to analyze the main effects and interactions on the number of repetitions completed per set, volume, RPE, mean power, relative mean power, peak power, and mean velocity. In the case of significant main effects or interactions, subsequent Bonferroni post hoc tests were utilized to assess significant differences. The magnitude of differences was verified by Cohen's *d* effect size with threshold values of 0.2 (small), 0.6 (moderate), 1.2 (large), and 2.0 (very large) considered. Differences between rest interval protocols were compared via paired Student's *t* tests. Considering a power ($1 - \beta$) of 0.80 and an alpha error of .05, the sample size used in this research would allow observation of a moderate effect size. Data were analyzed using the Statistical Package for Social Sciences (SPSS, Version 19, Chicago, IL).

RESULTS

Table 1 summarizes the means and standard deviations of the total number of repetitions completed, total training volume, fatigue index, mean power, relative mean power, peak power, mean velocity, and RPE for the two rest intervals. Overall, performance was better and fatigue was lower in the 3 min. RI, supporting all hypotheses except Hypothesis 4.

Table 2 presents the means and standard deviations of the total number of repetitions completed, total training volume, fatigue index, mean power, relative mean power, peak power, and mean velocity per set for the two rest intervals. When comparing the Set 1 versus Sets 2, 3, 4, and 5 for 1.5 min. and 3 min. RI protocols, fewer repetitions were completed per set, also resulting in a lower training volume. Moreover, mean power, relative power, peak power, and mean velocity decreased as sets progressed for both protocols. RPE increased from the first set vs the second, third, fourth, and fifth sets for the 1.5 min. RI protocol. For the 3 min. RI protocol, RPE increased from Set 1 to Sets 3, 4, and 5 (Table 2).

Interactions revealed that the number of repetitions completed per set, training volume per set, mean power, relative mean power, peak power, and mean velocity per set were higher for the 3 min. RI protocol vs 1.5 min. RI. Moreover, the number of repetitions and training volume per set were higher for 3 min. vs 1.5 min. RI on Sets 2, 3, 4, and 5. The peak power per set was higher for the 3 min. RI protocol on

Sets 2 and 3 as compared with the 1.5 min. RI protocol. Also, the mean velocity per set was significantly different between RI protocols on Sets 2 and 5 (3 min. > 1.5 min.). No significant differences were found for RPE between the RI protocols. However, significant main effects were evident between Set 1 and Sets 2, 3, 4, and 5 for the 1.5 min. RI protocol; while for the 3 min. RI protocol significant differences were evident between Set 1 and Sets 3, 4, and 5 (Table 2).

DISCUSSION

The main purpose of the present study was to examine the acute effects of 1.5 min. and 3 min. rest intervals between Smith machine bench press sets on muscular power, the Fatigue Index, number of repetitions, volume, mean velocity, and RPE in resistance trained men. The results reinforce previous suggestions (Abdessemed, et al., 1999 ; American College of Sports Medicine, 2009) about the importance of instituting longer RI between sets to allow for greater power production and maintenance of volume/repetition performance as well as velocity over consecutive sets in a resistance training session.

TABLE 1

TOTAL NUMBER OF REPETITIONS, TOTAL TRAINING VOLUME, FATIGUE INDEX, MEAN POWER, RELATIVE MEAN POWER, MEAN VELOCITY, AND RATING OF PERCEIVED EXERTION FOR EACH PROTOCOL

Measure	1.5 Min.		3 Min.		Δ (%)	95%CI	ES
	M	*SD*	*M*	*SD*			
Total repetitions	35.9	10.3	46.4	11.2	29.3‡	7.6, 13.3	1.02
Total training volume, kg	1346.1	624.1	1744.1	789.2	29.6‡	232.6, 563.2	0.63
Fatigue Index, %	20.9	7.6	33.2	6.3	58.5†	5.9, 18.5	1.60
Mean power, W	130.1	35.0	142.3	37.9	9.4†	4.5, 19.9	0.34
Relative mean power, W/kg	1.66	0.50	1.82	0.55	9.7†	0.05, 0.26	0.32
Peak power, W	226.1	57.4	244.7	57.0	8.2*	−0.46, 37.6	0.32
Mean velocity, m/sec.	0.35	0.09	0.39	0.10	1.7*	0.001, 0.067	0.31
Rating of Perceived Exertion	8.9	0.4	8.7	0.4	9.6	−0.18, 0.48	0.35

Note.—CI = confidence interval; ES = effect size, Cohen's *d*. *$p < .05$. †$p < .01$. ‡$p < .001$.

TABLE 2

Repetitions, Training Volume, and Rating of Perceived Exertion For Each Set

Variable	Set 1		Set 2		Set 3		Set 4		Set 5	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Repetitions										
1.5 min.	16.3	4.1	7.4	2.1	4.3	1.5	4.4	1.5	3.5	1.7
3 min.	17.5	3.7	9.7	2.3	6.6	2.2	6.8	2.2	5.8	1.6
p	.16		.0002		7.34 E-05		.0003		.0002	
95% CI	−2.5, 0.14		−3.6, −0.95		−3.2, −0.55		−3.7, −1.0		−3.6, −0.95	
Effect size	0.29		0.95		1.53		1.59		1.34	
Δ, %	7.4		31.1		53.5		54.7		65.7	
Training volume, kg										
1.5 min.	624.8	303.1	288.9	150.5	168.9	98.7	172.2	99.5	142.8	101.5
3 min.	677.4	321.9	376.2	184.7	256.1	145.6	272.6	166.9	228.9	123.8
p	.19		.001		.0007		.003		.002	
95% of CI	−111.1, 5.9		−145.8, −28.7		−145.7, −28.6		−159.0, −41.9		−144.7, −27.6	
Effect size	0.17		0.58		0.88		1.00		0.84	
Δ (%)	8.4		30.2		51.6		58.3		60.3	
Rating of Perceived Exertion										
1.5 min.	7.7	0.6	8.5	0.7	9.3	0.7	9.4	0.7	9.8	0.4
3 min.	7.8	0.4	8.3	0.5	9.0	0.8	9.3	0.7	9.5	0.7
p	.67		.49		.34		.67		.19	
95% of CI	−0.67, 0.47		−0.42, 0.72		−0.27, 0.87		−0.47, 0.67		−0.27, 0.87	
Effect size	0.15		0.21		0.44		0.14		0.71	
Δ (%)	1.3		1.8		3.2		1.1		3.1	
Peak Power, W										
1.5 min.	293.5	65.7	215.7	54.2	199.3	55.2	200.8	54.8	189.0	42.1
3 min.	305.4	67.1	239.2	53.7	230.0	56.9	216.0	49.2	195.4	36.5
p	.29		.001		.03		.13		.69	
95% of CI	−33.0, 9.1		−45.1, −2.9		−51.8, −9.6		−41.3, 0.83		−28.6, 13.5	
Effect size	0.18		0.43		0.55		0.27		0.15	
Δ (%)	4.1		10.9		15.4		7.6		3.4	
Mean power, W										
1.5 min.	170.9	37.6	124.3	35.4	117.7	39.6	120.0	35.3	103.5	34.2
3 min.	180.7	47.3	142.5	34.9	131.2	39.0	132.1	40.6	114.7	29.9
p	.16		.0001		.03		.01		.12	
95% of CI	−28.0, −0.84		−31.3, −4.09		−25.7, 1.51		−26.6, 0.55		−19.2, 7.98	
Effect size	0.26		0.51		0.34		0.34		0.32	
Δ (%)	5.7		14.6		11.5		10.0		10.8	

TABLE 2 (CONT'D)

REPETITIONS, TRAINING VOLUME, AND RATING OF PERCEIVED EXERTION FOR EACH SET

Variable	Set 1		Set 2		Set 3		Set 4		Set 5	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Relative mean power, W/kg										
1.5 min.	2.18	0.60	1.62	0.49	1.51	0.52	1.55	0.49	1.31	0.46
3 min.	2.31	0.71	1.84	0.49	1.69	0.51	1.72	0.59	1.47	0.48
p	.17		.0006		.04		.01		.08	
95% of CI	−0.25, 0.006		−0.34, −0.07		−0.29, −0.03		−0.26, 0.007		−0.33, −0.07	
Effect size	0.20		0.44		0.33		0.34		0.35	
Δ (%)	5.7		13.7		11.6		10.8		12.2	
Mean velocity, m/sec.										
1.5 min.	0.47	0.11	0.34	0.09	0.32	0.09	0.32	0.08	0.30	0.11
3 min.	0.49	0.12	0.39	0.09	0.35	0.10	0.35	0.10	0.34	0.10
p	.23		.01		.14		.16		.05	
95% of CI	−0.05, 0.002		−0.07, −0.01		−0.05, −0.005		−0.05, 0.004		−0.06, −0.01	
Effect size	0.24		0.52		0.32		0.29		0.31	
Δ (%)	5.6		14.4		9.1		6.8		11.7	

Note.—CI = confidence interval.

Although the ACSM position stand (2009) recommended 2 to 3 min. rest intervals between sets for exercises with novice, intermediate, and advanced individuals undertaking muscular power training, this evidence was based in one study conducted with untrained men. Moreover, the recommendation for power training is to use loads ranging from 30 to 60% of 1-RM, while heavy resistance training may actually decrease power output unless accompanied by explosive movements. It has been shown that during traditional weight training the load is decelerated for a considerable proportion (24–40%) of the concentric movement (Elliott, Wilson, & Kerr, 1989 ; Newton, Kraemer, Hakkinen, Humphries, & Murphy 1996). This percentage increases to 52% when performing the lift with a lower percentage of 1-RM lifted or when attempting to move the bar rapidly in an effort to train more specifically near the movement speed of the target activity (Newton, et al., 1996). For this reason, the load of 60% of 1-RM was chosen for the present study as recommended by the ACSM position stand (2002).

Abdessemed, et al. (1999) revealed that 1 min. RI protocol resulted in a decrease in mean power and a significant elevation in blood lactate in physical education students during 10 sets of six Smith machine bench press repetitions performed at 70% of 1-RM with 1, 3, or 5 min. rest interval between sets. However, no significant decreases in mean power occurred with rest intervals of 3 or 5 min. between sets, suggesting these intervals between sets might be sufficient to maintain mean power over consecutive sets in untrained physical education students. Interestingly, the current study in trained recreational lifters was consistent in demonstrating greater maintenance of muscular power when utilizing 3 min. vs 1.5 min. rest intervals between sets.

Previous studies have consistently demonstrated reductions in repetition performance when rest intervals were less than 2 min. between sets (Willardson & Burkett, 2005, 2006), especially when sets are performed to failure, even in recreationally resistance trained men (Miranda, Fleck, Simão, Barreto, Dantas, & Novaes, 2007). Tibana, et al. (2012) reported that the number of repetitions performed, volume, and fatigue resistance for the bench press exercise were compromised by a progressively shorter rest intervals between sets (30 < 60 < 120 sec.) in adolescents and adults. Ratamess, et al. (2007) demonstrated that irrespective of the intensity, the volume per set was significantly decreased in each set over five sets when 30 sec. and 1 min. rest intervals were used. However, the volume per set was maintained over two consecutive sets with 2 min. RI between sets; three consecutive sets with 3 min. RI between sets; and four consecutive sets with 5 min. RI between sets.

Villanueva, Villanueva, Lane, and Schroeder (2012) investigated six men with several years of experience in resistance training and proposed that, given sufficient training experience (e.g., 2 yr.), maintenance of repetition performance over repeated sets of higher intensity resistance training (eight sets of three repetitions at 85% of 1-RM) is attainable, when using 1 min. or 1.5 min. rest intervals. However, the authors state that a notable limitation to their study is that the general suggestion to rest 3– 5 min. between training sets to maximize and/or maintain repetition performance over repeated sets is derived exclusively from hypertrophic and muscular endurance protocols, none of which are prescribed as 8-RM. This study provides evidence to suggest that repetition performance can be maintained throughout a high intensity protocol, even when employing rest intervals typically prescribed for hypertrophic resistance training. Moreover, the effect sizes (Cohen's d) between many of the conditions were moderate to large: control vs strength 1.5 min. ($d = 0.6$); hypertrophy 1.5 min. vs hypertrophy 1 min. ($d = 0.7$), strength 1 min. ($d = 0.9$), and strength 1.5 min. ($d = 0.6$), respectively. Conversely, results from the present study revealed that the 1.5 min. rest interval was not sufficient to maintain the number of repetitions completed, with a moderate effect size of 1.02 between 3 min. vs 1.5 min., and also between Sets 2 to 5 (moderate to large − 0.95 to 1.34). This reinforces that the difference between studies might be associated with the difference in protocols; only the Smith machine bench press was used with five sets at 60% of 1-RM with repetitions leading to failure, while Villanueva, et al. , used a whole body session designed for hypertrophy (three sets of 10 repetitions at 70% of 1-RM) or maximal strength (eight sets of three repetitions at 85% of 1-RM).

The results of the current study are partly explained by the dependency of power performance on the function of the phosphagen system. The RI between sets when training for muscular power should closely match the time required for replenishment of phosphocreatine (PCr), which requires a minimum of 4 min. recovery (Harris, Edwards, Hultman, Nordesjö, Nylind, & Sahlin, 1976). If the rest interval is not sufficient to allow for replenishment of PCr, energy production shifts to emphasize the glycolytic system. This results in the accumulation of H^+ ions and disturbances in the concentration gradients of other ions (i.e., Na^+, K^+, Ca^{2+}, Mg^{2+}, and Cl^-), resulting in a lowered intracellular pH. At low pH values, both the peak isometric force and the maximal velocity of shortening are substantially depressed.

Interestingly, in a different study, a continuous loading resistance training protocol consisting of four sets of six repetitions with a 5 min. rest interval was compared with an intraset rest loading protocol consisting of eight sets of three repetitions separated by 2.2 min. rest intervals, and an intraset rest loading protocol consisting of eight sets (Sets 1, 3, 5, and 7 consisted of 3 repetitions, and Sets 2, 4, 6, and 8 were performed to failure separated by 2.2 min. rest intervals). The continuous and third intraset rest protocols resulted in higher blood lactate levels as compared with the second intraset rest protocol without concentric failure in 10 resistance-trained young men (Denton & Cronin, 2006). Although lactate was higher for the third intraset protocol, mean power levels were higher as compared to the other protocols. This implies that other mechanisms, rather than lactate levels, may be involved with power decrease during subsequent sets.

The RPE results indicated that both the 1.5 min. and 3 min. RI protocols induced a progressive increase in the RPE progressively over the five sets. This is consistent with previous studies (Pincivero, Gear, Moyna, & Robertson, 1999 ; Woods, Bridge, Nelson, Risse, & Pincivero, 2004) that also reported no significant difference in the RPE during resistance protocols conducted with different rest intervals. Farah, Lima, Lins-Filho, Souza, Silva, Robertson et al . (2012), found that during a resistance training session, the RPE was higher when the RI between sets was 30 sec. vs 1.5 min. Additionally, effect sizes indicated that the differences in RPE between RI lengths were higher for Set 3 in 19 resistance-trained young students. The authors proposed that resistance training leading to failure would represent the maximal perceived exertion independent of the rest interval employed. The current study confirmed that sets leading to failure result in an elevated RPE along sets, independent of the RI length. It is notable, although not statistically significant, that the 3 min. protocol was associated with slightly lower RPE values over consecutive sets. However, in the present study only the Smith machine bench press was used and resistance training was designed for power, while Farah, et al. (2012) used fi ve exercises with three consecutive sets of 12, 9, and 6 repetitions at 50% of 1-RM.

The current study had some limitations that should be considered, such as the small number of participants and the lack of metabolic and muscle activation measures. It should be noted that when the objective is muscular hypertrophy or localized muscular endurance, inducing a higher level of fatigue via shorter RI between sets might be a good stimulus in the long term due to the associated hormonal responses

(Villanueva, et al., 2012 ; Schoenfeld, 2013). However, in untrained college subjects submitted to 12 weeks of resistance training with two sets of 8 to 12 repetitions, maximal strength increased by the same amount with short or long RI (2 min. vs 4 min.) (Gentil, Bottaro, Oliveira, Veloso, Amorim, Saiuri, et al., 2010). To note, these results should be considered only for untrained individuals in the early beginning of a training program. Similarly, Buresh, Berg, and French (2009) found that 10 weeks of resistance training resulted in increases in squat and bench press strength, arm and thigh hypertrophy, and lean mass in untrained young males, with no difference between 1 min. vs 2.5 min. RI. Greater post-exercise hormonal response following 1 min. RI protocol vs 2.5 min. was evident only in the first week of resistance training. A limitation of these conclusions was the underpowered sample, only six participants in each group. However, although not statistically significant, the effect sizes (Cohen's d) between many of the conditions were moderate to large. The authors state that in the early stages of resistance training, gains in lean tissue and strength may be mediated more strongly by factors other than the magnitude of hormonal responses. Possibly, resistance training periodization and manipulation of training variables may contribute to maximizing results by eliciting greater hormonal responses and muscular adaptations. Future studies investigating the effects of different rest interval on muscle power may focus on other exercises during a training session, such as leg presses, squats, and a complete session for whole body.

In summary, the current study demonstrated that the use of a 3 min. RI between multiple Smith machine bench press sets allowed for a higher mean, relative and peak power, as well as higher average velocity, volume and number of repetitions, and resistance to fatigue. Professionals involved with resistance training prescription for trained men should consider the use of 3 min. versus a shorter rest interval between sets to achieve higher muscular power and better performance. Similarly, athletes that must demonstrate consistently high power output with increasing fatigue during competition (e.g., soccer, basketball) might benefit from a protocol in which 3 min. rest intervals are instituted between repetition maximum sets.

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