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Does Duration of Rest Interval Affect 1-RM Bench Press Test?

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ABSTRACT

Bench press 1-RM test is a common assessment to measure maximal strength of the upper body musculatures. Most protocols recommend a rest period between the maximum contraction trials to avoid fatigue which may confound the assessment. Factors that influence fatigue are strength level and fatigue recovery rate especially among sedentary population. The objective of this study was to determine the optimal resting period required among sedentary population when assessing upper body strength using the common 1-RM test, and whether gender influenced the findings. In a randomised, cross-over design, thirty (15 males and 15 females) sedentary participants, aged 18 to 24 years underwent 1-RM bench press tests using machine weight and free weight with different rest period between the 1-RM trials (1-min, 3-min, 5-min). The participants lifted a significantly ($p < 0.05$) heavier weight when given 3-min rest for both machine weight test (47.16 ± 26.86 kg) and free weight test (40.73 ± 22.03 kg), as well as when given 5-min rest for both machine weight test (48.11 ± 26.91 kg) and free weight test (42.00 ± 24.67 kg), compared to the 1-min rest group for both machine weight test (41.30 ± 24.31 kg) and free weight test (37.11 ± 22.06 kg), for both gender. There was no significant difference between 3-min and 5-min rest periods for both types of weights. There was also no significant difference between the rest periods needed for both gender in both types of weights. Three-min rest interval is

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enough for sedentary people irrespective of gender for 1-RM strength assessment on either machine weight bench press or free weight.

Keywords: Bench press, free weight, machine weight, rest interval, 1-RM

INTRODUCTION

Strength is described as the ability of muscle to exert force by the American College of Sports Medicine (Garber et al., 2011). Strength is one of the health-related fitness component, and a good strength profile may improve or maintain ability to perform daily activities, bone mass, musculotendinous integrity, fat-free mass (FFM), resting metabolic rate (RMR), and glucose tolerance, among others (Garber et al., 2011). There are various strength measuring tests, and the 1-Repetition Maximum (1-RM) test is one of the most commonly used test to quantify the level of strength, assess strength imbalances, and to evaluate training programmes by trainers, health and fitness professionals and rehabilitation specialists (Braith et al., 1993). Generally, the 1-RM is defined as the greatest resistance that can be moved through the full range of motion in a controlled manner with a good posture and is an indication of one's strength level. Early research on 1-RM testing dates to 1955 and has since been developed to be a reliable assessment of maximal strength (Hoeger et al., 1990). Basically, few maximal trials are carried out and the maximal weight achieved is considered as 1-RM strength. However, there are different rest times between maximal trials recommended by various guidelines. The objective of this study was twofold: to determine which resting interval between the 1-RM trials is the most suitable for the sedentary people for machine and free weights; and to investigate whether there was a difference in optimal recovery time between male and female.

Literature Review

Currently, the guidelines by ACSM (2005) recommends 3-5 minutes of resting interval between trials, while the National Strength & Conditioning Association recommends 2-4 minutes of resting interval, and Adams (2009) Exercise Physiology Lab Protocol recommends 2-7 minutes of resting interval. Different resting intervals may affect the muscle's capability to produce maximum force, as acute neuromuscular fatigue recovery is affected by several factors such as recovery of motoneuronal pool, presynaptic inhibition, changes in neuromodulators hormones, cross-bridge effects, and excitation-contraction coupling failure, which takes different amount of time to recover and is variable within individuals (Carroll et al., 2017). Several researches have been carried out to determine an optimal rest interval between the 1-RM trials, and it has been suggested that 1-minute is enough for those with weight training experience to produce maximal force through 1-RM bench press test, as most of the participants are able to lift 2 consecutive 1-RM load with just a minute rest (Matuszak et al., 2003; Weir et al., 1994). However, similar

data on untrained, inexperienced sedentary population is lacking. It is vital for testers to prescribe the right resting interval in order to get the most accurate 1-RM.

There might be a need to establish different rest interval for sedentary males and females, as several studies found that recovery speed and pattern are different in male and female. Hakkinen (1993) found that acute recovery from fatigue was slower in male compared to female after a maximal relative intensity exercise (1-RM) was performed; and in a later study Hakkinen (1994) found that even in near-maximal, high-intensity, low-repetition exercises, the strength recovery patterns in male was slower than females, and this was not only due to acute fatigue in neuromuscular system caused by higher accumulation of blood lactate concentration in males (15.0 ± 4.0 mmol) compared to female (6.0 mmol ± 1.8 mmol), but also due to the decrease in the voluntary neural activation of the exercised muscles. Other reasons presented include lower muscle fibre cross-section area in female compared to male (60-80 % relative to male), and lower blood androgen level in females which lead to female developing smaller muscles than males (Folland *&* Williams, 2007).

MATERIAL AND METHODS

Sedentary participants were randomly recruited from the University of Malaya's students. The participants' anthropometric information is shown in Table 1. The definition of sedentary in this study is: not participating in at least 30 min of moderate intensity physical activity on at least three days of the week for at least three months. The participants were selected based on the ACSM Pre-participation Health Screening and Risk Stratifications questionnaire. Each participant signed a written consent form prior to participation. In random order as shown in Table 2, each participant underwent six 1-RM test, 3 each for bench press machine (Nautilus, USA) 1-RM test and free weight (barbell and weight plates, Nautilus, USA) 1-RM test; with resting interval of 1, 3, and 5 minutes between trials.

Table 1

Mean age, body weight, and body mass index of participants (Data are expressed as Mean ± S.D)

Gender	Number	Age	Weight (kg)	Height (m)	Body mass index (kg / m²)
Male	15	20.94 ± 1.44	68.19 ± 12.19*	1.72 ± 0.06*	22.88 ± 4.06*
Female	15	22.53 ± 0.83	57.13 ± 11.08	1.59 ± 0.05	22.20 ± 3.84
All	30	21.65 ± 1.38	62.55 ± 12.84	1.66 ± 0.08	22.42 ± 3.89

The mean BMI of all participants (22.42 ± 3.89 kg/m²) are within the normal range (18.5 - 25.0 kg/m²).
*Significantly higher than female.

Overall Design

The participants were grouped randomly into 3 groups with different testing schedule by simple random sampling:

Table 2

Sequence of rest intervals for each group

	Rest interval between 1-RM trials		
Group 1	1-minute	3-minute	5-minute
Group 2	3-minute	1-minute	5-minute
Group 3	5-minute	3-minute	1-minute

The 1-RM protocol was as follow, after participants did a 10-minute slow jogging as warm-up:

1. As the final preparatory step, the performer loosened up and stretched by lifting one set of 8 repetitions at 50% of perceived 1-RM followed by a 1-minute rest; then performed another set of 5 repetitions with perceived 70% of 1-RM followed by another 1-minute rest.
2. With the participants lying supine on the bench and both feet on the floor, and hands shoulder width apart with palms up against the bar, the participants lifted the resistance with arms fully extended, then lowers the bar to chest and pushed it back up until the arms were locked. One full cycle of these movements is considered as 1 repetition.
3. In the case of free weight test, two testers were placed at each side of the participant or one tester behind the participant's pronated hands spaced about shoulder width apart and at chest level.
4. The participant attempted a single lift at a load that was perceived as close (95%) to the perceived 1-RM. The load was recorded to the scoring sheet.
5. When the participant felt that the previous load was close to actual 1-RM load, 2.5 kg increments was added to the prior load; when the participant felt that the prior estimate of 95% of 1-RM was considerably off from actual 1-RM, then 5 kg increments was added.
6. The participants rested (for 1, 3, and 5 minute, according to group schedule) before the next 1-RM trial.
7. Steps v to vi were repeated until the participant was unable to lift the weight. When this occurred, the participant rested. A 2.5 kg load was subtracted from the load and the participants attempted 1-RM. This weight was recorded as the 1-RM of the participants.

The results were analysed using the IBM SPSS Statistics 21 software (IBM,

USA). Independent *t*-Test was used to calculate the significance of differences among 2 data, where the value of ($p < 0.05$) is considered significant. The One-Way Anova Test was used to calculate the differences among more than 2 data, with the value of ($p < 0.05$) considered significant. The correlation among data was calculated, with the value of ($r > 0.5$) shows that 2 parameters are related to each other while the value of ($r > 0.75$) shows that the 2 parameters are strongly related.

RESULTS

In both free weight and machine weights 1-RM tests, results following 3 minutes rest interval and 5 minutes rest interval were significantly higher ($p < 0.05$) than that obtained after 1-minute rest interval; with no differences between 3 and 5 minutes rest interval (Figures 1 and 2).

Meanwhile, while comparing results between male and females, the male participants produced significantly higher 1-RM values. In both gender, 3 minutes of rest interval produced better results compared to 1 minute rest. There were no differences in 1-RM results following 3 and 5 minutes rest intervals (Figures 3 and Figure 4).

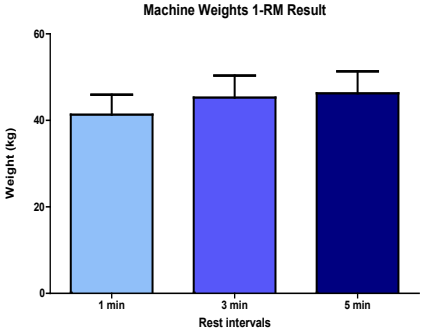

Figure 1. The mean 1-RM results obtained from bench press machine for all participants.
*significantly higher than 1 min.

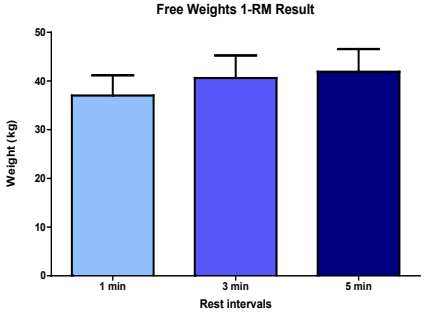

Figure 2. The mean 1-RM results obtained from free weight bench press for all participants.
*significantly higher than 1 min.

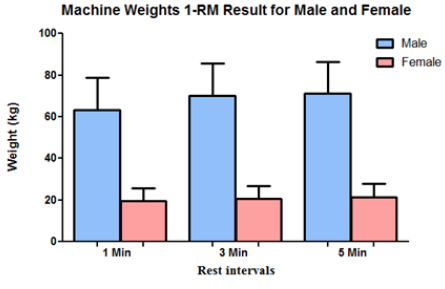

Figure 3. The mean machine weight 1-RM results for male and female participants.

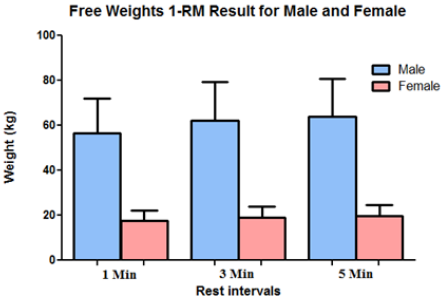

Figure 4. The mean free weight 1-RM results for male and female participants.

DISCUSSION

The results show that 3 minutes rest interval is optimal for both free weight and machine weights 1-RM tests. This is consistent with past studies that state that longer (2 to 3 minutes) rest interval allows for significantly greater strength production than shorter (30 to 90 seconds) rest interval (Willardson & Burkett, 2008; De Salles et al., 2009). In contrast to how 1 minute rest interval is enough for weight trained and experienced populations to produce maximal force during 1-RM attempt (Weir et al., 1994; Matuszak et al., 2003), present study found that the sedentary population would need more than 1-minute rest interval, with 3 minutes rest allowing for best results.

The main reason cited for the need of longer rest-interval needed to produce maximum strength include, but not limited to, is to provide enough time to replenish phosphocreatine (PC) in worked muscles, as the ATP-PC system is the main energy system providing energy during an 1-RM attempt which typically last less than 5-second (De Salles et al., 2009). Another reason cited is that the participants may feel psychologically safer and have more confidence to produce maximal force with longer rest interval, stimulating the neuromuscular system to produce full effort and vice-versa, as short resting interval may lead to the participants feeling psychologically unsafe and as a result the neuromuscular system is not stimulated to exert maximum effort (Matuszak et al., 2003). There are, however, studies which asserted that 3 minutes rest interval between maximum force production efforts could impair maximal force production capability, resulting in a reduced 1-RM (Matuszak et al., 2003; Willardson & Burkett, 2008). One reason cited for the reduction in maximal force is the accumulation of lactic acid in muscles after long period (5-minute) of inactivity, as well as the muscle switching to resting mode (Matuszak et al., 2003). Participants for both said study was, however, recreationally weight-trained people, and the lactic acid profile may differ from the participants of present study who are all sedentary. Future study may include analysing changes in blood lactic acid level to investigate this phenomenon.

Another finding from the present study is that both gender produced the highest 1-RM results with 3 minutes rest interval between 1-RM attempts, with no significant differences in results obtained between the 3-minute and 5-minute rest intervals protocol. This result contradicts with past study which found that females had faster acute muscular recovery allowing them to produce maximal strength with less rest interval compared to males (Hakkinen, 1993). Even in sub-maximal force production, males recover slower than females (Hakkinen, 1994); males also have slower HR recovery following sub-maximal bench press exercise to exhaustion compared to females (Vieira et al., 2010). However, none of those studies showed the difference in studies time needed to fully recover maximal strength producing capability in males and females. In our study, the rest interval between 1-RM trials

chosen was 1 minute, 3 minutes, and 5 minutes. A 3-minutes rest interval is sufficient for our participants of both gender to recover their maximum force production capability. Perhaps future study should include neurophysiological measures which will provide information on the adaptations that take place during the contraction during the 1-RM trials.

CONCLUSION

In conclusion, 3 and 5-minute rest intervals allow greater maximum force production for a 1-RM test protocol either using a machine weight or free weight. The results suggest that a rest period of 3-minute in between 1-RM attempt is recommended as the optimal rest period for both sedentary male and female to test their maximum strength, without the need to spend extra rest time that does not benefit to test results.

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