EFFECTS OF 8 WEEKS SINGLE SET VERSUS MULTIPLE-SET RESISTANCE TRAINING ON UPPER AND LOWER BODY MUSCULAR STRENGTH AMONG UNTRAINED MALES IN IRAN

Amir Bahram Kashiani & Kim Geok Soh*

Department of Sport Studies, Faculty of Educational Studies, Universiti Putra Malaysia, 43400, UPM Serdang, Selangor Darul Ehsan, Malaysia

*Email: kims@upm.edu.my

(Received 23 September 2019; accepted 1 January 2019; published online 27 July 2019)

To cite this article: Kashiani, A. B. & Kim, G. S. (2019). Effects of 8 weeks single set versus multiple-set resistance training on upper and lower body muscular strength among untrained males in Iran. Malaysian Journal of Movement, Health & Exercise, 8(2), 153-163.
https://doi.org/10.15282/mohe.v8i1.210
Link to this article: https://doi.org/10.15282/mohe.v8i1.210

Abstract

It is generally accepted that the implementation of high-intensity resistance training can lead to several physiological adaptations such as muscular strength. In recent years, many individuals have been attracted to weight training to increase muscular strength. One of the most important variables affecting muscular strength improvement is the training system. Two common resistance training systems are single set and multiple sets. Which training system is superior remains undetermined. The objective of this study was to examine the effects of 8 weeks single set versus multiple-set resistance training on upper and lower body muscular strength among untrained male adults. Twenty-four apparently healthy untrained males (age: 20.5 ± 1.8 years, body height: 174.9 ± 4.2 cm, body mass: 72.3 ± 3.2 kg, and body fat mass percentage: %18.2 ± 1.3) were selected randomly and assigned into two groups: single set (SS) and multiple sets (MS). Both groups completed 8 weeks of high-intensity resistance training (70-80% of one-repetition maximum) with 8-10 repetitions for 3 times per week which SS and MS groups performed one set and three sets of each exercise, respectively. Dependent variables involving maximal muscular strength using one-repetition maximum were measured before and after the intervention. Significance level was set at $P < 0.05$. No differences existed among both groups at baseline for depended variables. A paired Student's *t*-test and an independent sample *t*-test revealed significant increases in upper and lower body maximal muscular strength in both groups after the intervention ($P < 0.05$), and upper and lower body maximal muscular strength increased significantly more in MS group compared with SS group (%23.43 increase in MS group vs. %12.70 increase in SS group). The results of this study showed that MS resistance training had a significant better effect than SS resistance training to improve upper and lower body muscular strength after 8 weeks of resistance training among untrained male adults.

Keywords: Multiple sets, one-repetition maximum, resistance training, single set

Introduction

Resistance training is one of the most popular and applied forms of physical activity, used to enhance muscular performance and health, alter body composition and improve overall functionality (Kraemer et al., 2009). Several resistance training protocols have been explored to improve different aspects of the neuromuscular system such as maximal muscular strength (Yoon et al., 2015). Resistance training systems affect increasing of muscular strength which single set (SS) and multiple sets (MS) are two commons of resistance training systems (Borg, 1978; Yoon et al., 2015). Usually resistance training programs include 2-3 sets (multiple sets) with 8-10 repetitions to increase muscular strength. However, in the 1990s, several studies found no difference between SS and MS training systems to improve muscular strength (Carpinelli & Otto, 1998; Yoon et al., 2015). Kraemer, Newton, Bush, and Koziris (1995), examined the effects of SS and MS training systems for 9 months and the results reported that MS resistance training are superior to compare with SS resistance training in improving muscular strength. In another study, Paulsen, Myklestad, and Raastad (2003), suggest that MS resistance training is more effective than SS resistance training to improve muscular strength. However, in another study, Hass, Garzarella, de Hoyos, and Pollock (2000), examined the effects of SS and MS training systems on muscular strength and the results showed that SS resistance training is as effective as MS resistance training to improve muscular strength. In another study, Laskowski (2009), reported that a SS resistance training with 12 repetitions can increase muscular strength as much as MS resistance training in the same exercise.

One of the controversial resistance training factors is number of performed training sets to improve muscular strength. Although many studies have examined the effects of SS and MS training systems on muscular strength (Carpinelli & Otto, 1998; Starkey et al., 1996; Yoon et al., 2015), research findings have yet to conclusively determine which training system is more effective to improve muscular strength.

Methodology

Participants and Experimental Overview

This study is a randomised controlled trial with two-arm (2 interventional groups). The Dependent variables were upper and lower body muscular strength. The Dependent variables were measured two times during the intervention, which were at baseline and post-test (after week 8). The participants included twenty-four apparently healthy untrained male volunteers (with no previous experience performing resistance training) with normal BMI (body height: 174.9 ± 4.2 cm, body mass: 72.3 ± 3.2 kg, and body fat mass percentage: %18.2 ± 1.3) between 18 and 24 years of age (age: 20.5 ± 1.8 years) recruited from a fitness gym under supervision of Ministry of Sport in Iran. The sample size was determined using Cohen's interpretation guideline (1988), using a formula to calculate intervention group size as suggested by Chan (2003), on the basis of the results of the maximal muscular strength performance in Shibata, Takizawa, and Mizuno (2015a). All participants completed a health history questionnaire to ensure they were healthy enough and eligible to perform all exercises in the study and they were excluded if they had metabolic, cardiovascular or musculoskeletal diseases, or ingested any medications,

anabolic steroids or nutritional supplements known to affect resistance training performance at least one year before this study. The participants were individually assigned randomly to one of the two groups which were: 1) single set group (SS) (n=12), and 2) multiple set group (MS) (n=12). During the study, participants were not allowed to start any additional exercise programs. The subjects were adequately informed about the risks and benefits involved in the study and provided written informed consent. This study was approved by the research ethics committee, Department of Physical Education and Sports Science, Islamic Azad University, Science and Research Branch, Tehran, Iran.

Anthropometry

The height of all participants was measured with a wall-mounted stadiometer. Also, body mass and fat mass of all participants were measured with a Bioelectrical Impedance Analyser (Tanita- SC-330 MA, USA). The body mass index (BMI) was calculated by dividing body mass (kg) by body height (m) squared (kg/m^2).

Maximal Muscular Strength Measurement

The one-repetition maximum (1-RM) was used for the assessment of the upper and lower body muscular strength. Maximal muscular strength was evaluated using the chest press machine and overhead press machine for upper body and squat machine for lower body. The relative value of muscular strength (kg) was used in all analyses. The pre- and post-training assessments were scheduled at least 72 hours before the first training session and after the final training sessions, respectively. After a light 5 min warm-up, the 1RM test commenced. It was determined by four to six sets with 2-4 minutes rest between sets. The initial pre-maximum set was carried out with the subject executing 8-10 repetitions at 40-60% of estimated 1RM. Following a short rest, the subjects carried out a set of 3-5 repetitions (75% of estimated 1RM). Then, after another two-minute rest, the subjects went through a set of 1-3 repetitions (80-90% of estimated 1RM). On completion of these sets, the participants were rested for four minutes and then proceeded with the first attempt at the 1RM. Should the lift be successfully executed, there was another rest period of four minutes and the weight was increased and another 1RM was attempted. Should this next attempt be unsuccessful, a second attempt at a 1RM with a lowered weight was made after a four-minute rest period (Figure 1). Only successful attempts within the approved range of motion were considered. This procedure continued until the participants failed to complete a lift and the final weight that the participants were able to lift successfully, was noted as the maximal muscular strength score. Pre- and post-assessments were scheduled at the same time of the day in order to limit confounding variables. Verbal encouragement was given on all tests and participants were finished with the light general active cool-down involving stretching for upper and lower body muscle groups and pedalling on a cycle ergometer at a light resistance for five-minute. All test procedures were based on the American College of Sports Medicine (Thompson, Gordon, and Pescatello, 2010), Shiau, Tsao, and Yang (2018), White (2011), Heyward (2014), and Shibata, Takizawa, and Mizuno (2015b).

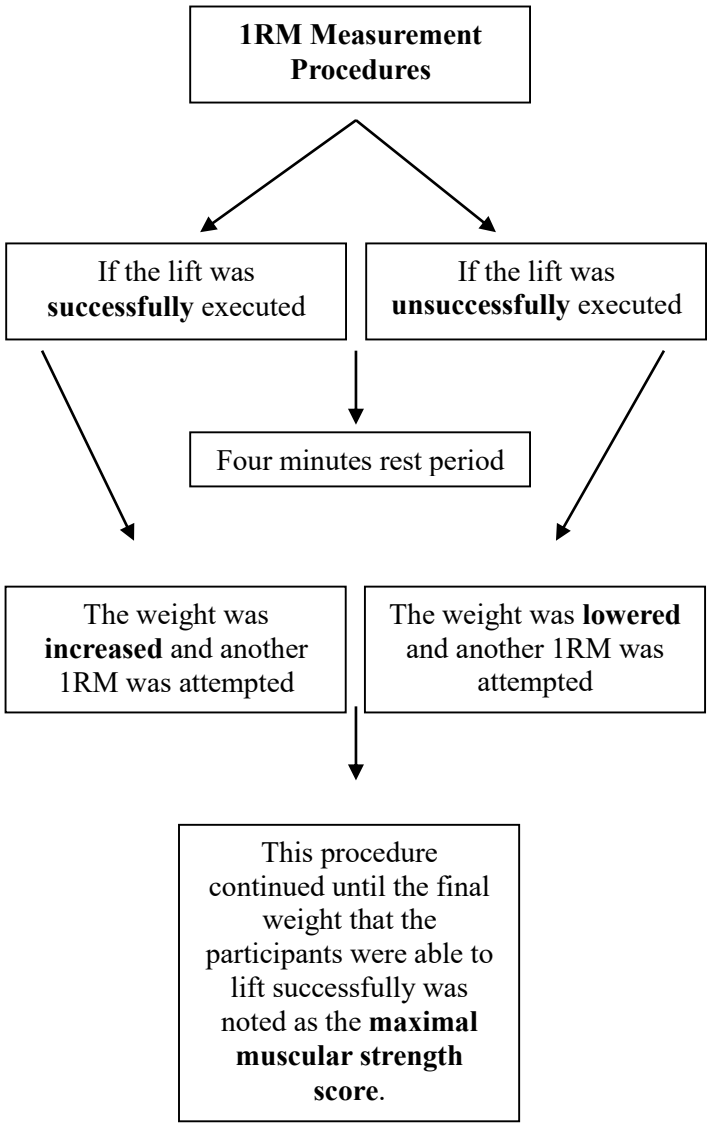

Figure 1: Maximal muscular strength measurement procedures

Resistance Training Intervention

The training protocol included single set and multiple sets, and participants performed their special training program assigned to them for 8 weeks. The SS and MS groups performed one set and three sets of each exercise, respectively. Training programs were the following exercises: squat, chest press, pullover, overhead press and dumbbell triceps extension. All training programs were based on Shoepe, Ramirez, Rovetti, and Kohler (2011) and White (2011). Until the end of week 8, the participants trained at 70%-80% of their estimated 1RM with 8–10 repetitions for three days per week. Participants had two minutes rest periods between sets. The training routines are presented in Table 1. Prior to and following

the training sessions, the participants had a five-minute warm-up and another five minutes to cool down, which involved pedalling on a cycle ergometer and stretching of all the major muscle groups. At the end of week 8, the post-test was processed during a separate session for the purpose of measuring upper and lower body muscular strength.

Table 1: The training routines

Weeks 1-8	Single set group	Multiple sets group
Weeks 1-2 Repetitions	8	8
Weeks 3-4 Repetitions	8	8
Weeks 5-6 Repetitions	10	10
Weeks 7-8 Repetitions	10	10
Frequency	3 Days/Week	3 Days/Week
Weeks 1-2 Intensity	70% of 1RM	70% of 1RM
Weeks 3-4 Intensity	70% of 1RM	70% of 1RM
Weeks 5-6 Intensity	80% of 1RM	80% of 1RM
Weeks 7-8 Intensity	80% of 1RM	80% of 1RM
Sets	1	3

Research Finding

All data were expressed as means ± standard deviation (SD). Data were tested for normal distribution with Kolmogorov-Smirnov method and for homogeneity of variances with Levene's test (Byrne, 2016; Garson, 2012; Meyers, Gamst, & Guarino, 2016). The variables were analyzed using a paired Student's *t* test to compare baseline versus post-test values and an independent sample *t*-test analysis was used to compare the values of Dependent variables in baseline and post-test between SS and MS groups. The statistical significance was set at $P < .05$. The statistical procedures were conducted using Statistical Package for Social Sciences software (SPSS) Version 24 (IBM Company, United States).

Maximal muscular strength measurement

No significant differences were evident between both groups in terms of upper and lower body muscular strength before the training program began ($P > 0.05$). The increase in rates, means and standard deviations of baseline and post-test values for upper and lower body muscular strength in both groups are presented in Table 2. The analysis of data demonstrated that there were significant increases in post-test values of upper and lower body muscular strength in both groups ($P < 0.05$). On completion of the training program, there was a significant improvement in upper and lower body muscular strength for MS group to compare with SS group in post-test values ($P < 0.05$). In this study, the results showed that upper and lower body muscular strength increased significantly more in the MS group as compared with SS group after 8 weeks of resistance training. Figure 2 also shows the upper and lower body muscular strength differences in both groups post-test values.

Table2: Increase rate, means and standard deviations of Dependent variables in SS and MS groups (M ± SD)

Variables	Single set group			Multiple sets group		
	Baseline	Post test	Increase rate	Baseline	Post test	Increase rate
Chest press strength (kg)	36.25 ± 2.95	40.50 ± 3.55	% 11.72	36.08 ± 3.50	44.25 ± 4.37	% 22.64
Overhead press strength (kg)	31.08 ± 2.60	35.75 ± 2.66	% 15.02	31.25 ± 2.45	39.41 ± 2.42	% 26.11
Squat strength (kg)	55 ± 4.76	61.25 ± 6.07	% 11.36	54.16 ± 4.17	65.83 ± 5.57	% 21.54

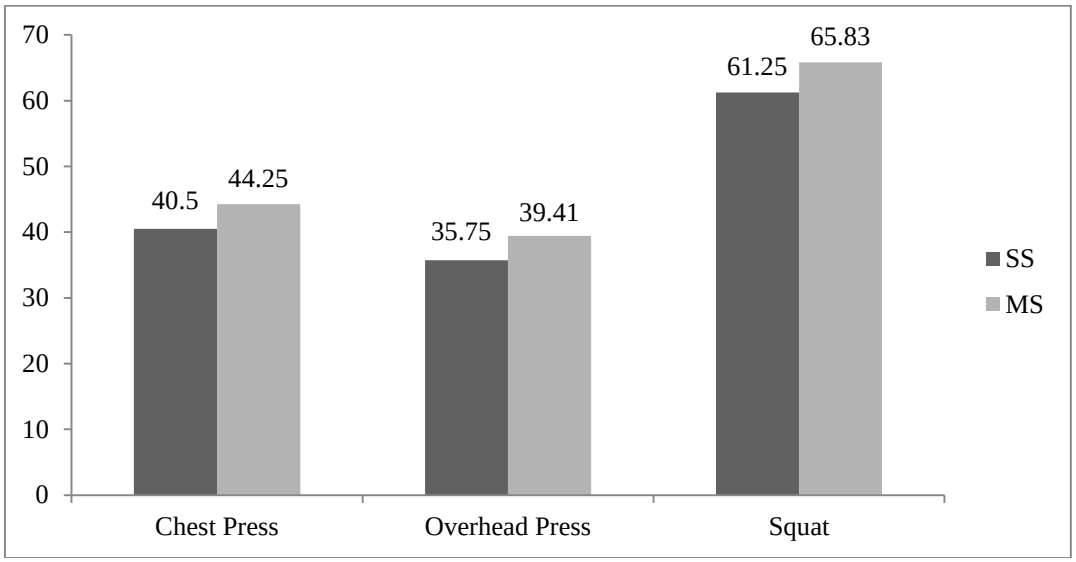

Figure 2: Upper and lower body muscular strength differences in both groups post-test values

Discussion

This segment examines the essential finding from the present study with those cited in the literature, as well the limitations of the present study and conclusion.

Resistance training on upper and lower body muscular strength

Kraemer (1997) examined the effects of a single set resistance training versus multiple-set resistance training for 9 months and reported that multiple set resistance training is more effective than single set resistance training in improving muscular strength. In another study, de Hoyos et al. (1998), examined the effects of a single set resistance training versus multiple-set resistance training for 6 months and reported that multiple set resistance training is more effective than single set resistance training in improving muscular strength. Kelly et al. (2007), examined the effects of a single set resistance training versus multiple-set resistance training on muscular strength and reported that multiple-set resistance training are more effective than a single set resistance training in improving muscular strength. Also Bottaro et al. (2009), examined the effects of a single set resistance

training versus multiple-set resistance training on upper and lower body muscular strength in untrained individuals and reported that multiple-set resistance training are more effective than a single set resistance training in improving muscular strength.

But findings of this study are not in line with some researches. Feigenbaum and Pollock (1997), reported that single set resistance training is as effective as multiple-set resistance training in improving muscular strength. In another study, Hass et al. (2000), reported that a single set resistance training is as effective as multiple-set resistance training in improving muscular strength. One reason for the contradictory results of muscular strength changes in comparing single set and multiple sets resistance trainings is different training periods, protocols and subjects (Fleck & Kraemer, 2014).

The results of several research works showed that single set resistance training performed continuously in a longer period of time may also provide the same results on muscular strength as multiple-set resistance training provides within the short period of time (Carpinelli & Otto, 1998; Hass et al., 2000; Kraemer et al., 2000; Reid, Yeater, & Ullrich, 1987), and also single set resistance training is appropriate for untrained individuals who are willing to reach their primary goals as improving maximal muscular strength (Fleck & Kraemer, 2014).

The number of sets is an important part of the exercise volume and the volume of exercise is crucial in producing the required stimulus to elicit specific physiological adaptations. Multiple-set resistance training include more sets than a single set resistance training and it causes to generate required stimulus which are effective in improving muscular strength (Carpinelli & Otto, 1998; Galvao & Taaffe, 2004). On the other hand, single set resistance training is appropriate for untrained individuals who are not able to do multiple-set resistance training for some reasons such as deficient time and/or injuries (Hass, Feigenbaum, & Franklin, 2001; Kraemer et al., 1995). The results of this study showed that both single set and multiple-set resistance training systems are significantly effective in improving upper and lower body muscular strength. In particular, multiple-set resistance training is significantly superior to compare with single set resistance training in improving upper and lower body muscular strength after 8 weeks resistance training among untrained male adults.

Limitations

Certain variables outside of the gym control could affect the results (i.e. genetics, motivation levels, and muscular soreness and overall fatigue). Genetic factors apparently have a strong influence on how people respond to the exact resistance training protocol. Also, some untrained individuals may perceive a sub-maximal effort instead of perceiving a maximal effort during training because of different motivation levels and/or muscular soreness and overall fatigue with resistance training (Naimo, 2011; Otto & Carpinelli, 2006). But motivation levels of untrained individuals will be increased with exact and complete explanations about advantageous effects of particular physical activity in the beginning of the study (Otto & Carpinelli, 2006). Muscular soreness occurs when a muscle is stretched and microfilaments of the muscle are damaged temporarily due to performing resistance training, but muscular soreness usually disappears within a few sessions of

resistance training (Wilmore, Costill, & Kenney, 2008). In order to control the effects of limitations in this study, before starting the intervention, the participants were given a briefing which explained the advantages of the exercise training programme.

Conclusion

In summary, both single set and multiple set resistance training systems were significantly effective in improving upper and lower body muscular strength, but multiple-set resistance training is significantly more effective in improving upper and lower body muscular strength to compare with single set resistance training after 8 weeks resistance training.

The results of this study may be beneficial for untrained individuals who are willing to find a better method of resistance training to reach their primary goals as increasing maximal muscular strength for being healthy and to combat muscular weakness. In addition, this information also can increase the choices of available resistance training systems and encourage participation in workouts that are known to have health benefits. Furthermore, multiple-set resistance training also provides more options in exercise prescription for the strength and conditioning practitioners. Also, multiple set resistance training can be introduced to Ministry of Sport and Ministry of Health, health centres and fitness institutes and also using in physical education classes at schools and universities for health promotion.

References

Borg, G. (1978). Subjective effort in relation to physical performance and working capacity. *Psychology: From Research to Practice*, 331-361.

Bottaro, M., Veloso, J., Salles, B. F. d., Simao, R., Celes, R., & Brown, L. E. (2009). Early phase adaptations of single vs. multiple sets of strength training on upper and lower body strength gains. *Journal of Isokinetics and Exercise Science, 17*(4), 207-2012.

Byrne, B. M. (2016). *Structural equation modeling with AMOS: Basic concepts, applications, and programming* (Third Ed.). New York: Taylor & Francis Group.

Carpinelli, R. N., & Otto, R. M. (1998). Strength training: Single versus multiple sets. *Sports Medicine, 26*(2), 73-84.

Chan, Y. H. (2003). Randomised controlled trials (RCTs)-sample size: The Magic Number? *Singapore medical journal, 44*(4), 172-174.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (Second ed.). United States: Lawrence Erlbaum Associates.

Feigenbaum, M. S., & Pollock, M. L. (1997). Strength training: rationale for current guidelines for adult fitness programs. *The Physician and Sports Medicine, 25*(2), 44-63.

Fleck, S. J., & Kraemer, W. (2014). *Designing resistance training programs* (Forth ed.). United States: Human Kinetics.

Galvao, D. A., & Taaffe, D. R. (2004). Single- vs. multiple-set resistance training: recent developments in the controversy. *Journal of Strength and Conditioning Research, 18*(3), 660-667.

Garson, G. D. (2012). *Testing statistical assumptions* (Sixth ed.). United States: Statistical Associates Publishing.

Hass, C. J., Feigenbaum, M. S., & Franklin, B. A. (2001). Prescription of resistance training for healthy populations. *Journal of Sports Medicine, 31*(14), 953-964.

Hass, C. J., Garzarella, L., Hoyos, D. d., & Pollock, M. L. (2000). ingle versus multiple sets in long-term recreational weightlifters. *Medicine and Science in Sports and Exercise, 32*(1), 235-242.

Heyward, V. H., & Gibson, A. L. (2014). *advanced fitness assessment and exercise prescription* (Seventh ed.). New Mexico: Human Kinetics.

Hoyos, D. V. D., Herring, D., Abe, T., Garzarella, L., Hass, C., Nordman, M., & Pollock, M. L. (1998). Effect of 6 months of high or low volume resistance training on muscular strength and endurance. *Medicine and Science in Sports and Exercise, 30*, 165.

Kelly, S. B., Brown, L. E., Coburn, J. W., Zinder, S. M., Gardner, L. M., & Nguyen, D. (2007). The effects of single versus multiple sets on strength. *Journal of Strength and Conditioning Research, 21*(4), 1003-1006.

Kraemer, W. J. (1997). A Series of Studies: The Physiological Basis for Strength Training in American Football: Fact Over Philosophy. *Journal of Strength and Conditioning Research, 11*(3), 131-142.

Kraemer, W. J., Adams, K., Cafarelli, E., Dudley, G. A., Dooly, C., Feigenbaum, M. S., . . . Triplett-McBride, T. (2009). American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Medicine and Science in Sports and Exercise, 41*(3), 687-708.

Kraemer, W. J., Newton, R. U., Bush, J., & Koziris, L. (1995). Varied multiple-set resistance training programs produce greater gains than single set programs. *Medicine and Science in Sports and Exercise, 27*(5), 195-200.

Kraemer, W. J., Ratamess, N., Fry, A. C., Triplett-McBride, T., Koziris, L. P., Bauer, J. A., . . . Fleck, S. J. (2000). Influence of resistance training volume and periodization on physiological and performance adaptations in collegiate women tennis players. *The American Journal of Sports Medicine, 28*(5), 626-633.

Laskowski, E. R. (2009). Strength training sets: How many for best results? *Journal of Physical Medicine and Rehabilitation*, 1-4.

Meyers, L. S., Gamst, G., & Guarino, A. J. (2016). *Applied multivariate research: Design and interpretation* (Third ed.). United Kingdom: Sage.

Naimo, M. (2011). *The effects of blocked versus random practice on the acquisition of skill and strength of the free weight bench press.* (Master of Science), The Florida State University.

Otto, R. M., & Carpinelli, R. N. (2006). A critical analysis of the single versus multiple set debate. *Journal of Exercise Physiology, 9*(1), 32-57.

Paulsen, G., Myklestad, D., & Raastad, T. (2003). The influence of volume of exercise on early adaptations to strength training. *Journal of Strength and Conditioning Research, 17*(1), 115-120.

Reid, C. M., Yeater, R. A., & Ullrich, I. H. (1987). Weight training and strength, cardiorespiratory functioning and body composition of men. *British Journal of Sports Medicine, 21*(1), 40-44.

Shiau, K., Tsao, T. H., & Yang, C. B. (2018). Effects of single versus multiple bouts of resistance training on maximal strength and anaerobic performance. *Journal of Human Kinetics, 62*, 231-240.

Shibata, K., Takizawa, K., & Mizuno, M. (2015a). Comparison between twelve and six sets of high load leg extension on muscle strength. *Malaysian Journal of Movement, Health & Exercise, 4*(1), 51-59.

Shibata, K., Takizawa, K., & Mizuno, M. (2015b). Does power output vary accordingly with high load resistance training? A comparative study between bulk-up and strength-up resistance training. *Malaysian Journal of Movement, Health & Exercise, 4*(2), 7-14.

Shoepe, Ramirez, Rovetti, & Kohler. (2011). The Effects of 24 weeks of Resistance Training with Simultaneous Elastic and Free Weight Loading on Muscular Performance of Novice Lifters. *Journal of Human Kinetics, 29*, 93–106.

Starkey, D. B., Pollock, M. L., Ishida, Y., Welsch, M. A., Brechue, W. F., Graves, J. E., & Feigenbaum, M. S. (1996). Effect of resistance training volume on strength and muscle thickness. *Medicine and Science in Sports and Exercise, 28*(10), 1311-1320.

Thompson, W. R., Gordon, N. F., & Pescatello, L. S. (2010). *ACSM's guidelines for exercise testing and prescription* (Eighth ed.). Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins.

White, J. B. (2011). *Effects of Supersets Versus Traditional Strength Training Methods on Muscle Adaptations, Recovery, and Selected Anthropometric Measures.* (Doctor of Philosophy), Ohio University.

Wilmore, J. H., Costill, D. L., & Kenney, W. A. (2008). *Physiology of Sport and Exercise* (Forth ed.). United States: Human Kinetics.

Yoon, A., Hong, J. Y., Choi, S. M., Hahn, D. W., Kim, K. J., & Lee, S. H. (2015). Comparison of multiple sets and progressive single set of resistance training on muscle mass and strength in rat. *Journal of Exercise Science, 24*(3), 267-274.