Effects of Using Complex Training Method on Muscular Power among Competitive Male Weightlifters

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ABSTRACT

Weightlifting is a sport that requires both dynamic strength and power. Until today, weightlifting coaches are still exploring different training modes in an attempt to enhance both muscular strength and power of the competitive weightlifters. Research has shown that the use of the "right" training method could further provide knowledge on such effect for competitive weightlifters (Storey & Smith, 2012). Thus, the aim of this study was to investigate the effects of using the complex training method (applicable to weightlifting) compared to traditional resistance training on muscular strength among male competitive (state level) weightlifters. Seventeen male competitive weightlifters were randomly assigned into 2 groups: experimental group (Complex Training; n = 9), and control group (Traditional Resistance Training; n = 8). All participants trained for 6 weeks (2 sessions per week) with the total training volume equated between both groups. Participants underwent pre-test and post-test including the anthropometric measurements (height, body weight, and body fat) and lower body strength (CMVJ test) and overall body power (medicine ball throw test) parameters. The results showed that there was a significant increase from pre- to post-test in CMVJ average power t(8) = -4.98; p = .001 and t(7) = -3.99; p = .005), CMVJ height t(8) = -3.17; p = .01 and t(7) = -3.95; p = .006) and medicine ball throw distance t(8) = -12.26; p = .001 and t(7) = -6.13; p = .001) in experimental and control groups respectively. Significant difference (p < .05) was observed in CMVJ average power (5.04 ± 2.61 versus 1.64 ± 1.16), CMVJ height (13.23 ± 7.29 versus 6.70 ± 4.80) and medicine ball throw distance improvements (0.87 ± 0.21 versus 0.46 ± 0.21) between the complex training group and control group respectively at post-test. In conclusion, the use of complex training method showed more superior in enhancing muscular power compared to traditional resistance training after 6 weeks of intervention.

Key words: *complex training, strength, weightlifting.*

Introduction

Weightlifting is a sport that requires both dynamic strength and power (Storey & Smith, 2012). It has been a longstanding part of the modern Olympic Games and has wide and growing international participation. Competitive weightlifting is divided into several body weight categories, which are different for men and women. For men, the body weights include ≤ 56kg, ≤ 62kg, ≤ 69kg, ≤ 77kg, ≤ 85kg, ≤ 94kg, ≤ 105kg, and > 105kg. As for women, the body weights include ≤ 48kg, ≤ 53kg, ≤ 58kg, ≤ 63kg, ≤ 69kg, ≤ 75kg, and > 75kg (Storey & Smith, 2012). Weightlifting is competed at the Olympic Games, Asian Games, SEA Games, Commonwealth Games, as well as International and regional Championships and Opens. The training structure of a competitive weightlifter is characterised by the frequent use of a high intensity resistance exercise movements. A weightlifter typically has two types of training that has been formulated specifically according to their competitive level - junior or senior. The first involves complementary exercises, which include movement patterns similar to the competitive lifts, such as hang snatch, power snatch, hang clean, power clean, snatch pull, clean pull, back squat, and front squat (Stone, Pierce, Sands, & Stone, 2006). The second type of training is the supplementary exercises, which includes overhead presses, back extensions, and abdominal work (Storey & Smith, 2012). Both types of training are known as the resistance training. According to Storey and Smith (2012), many different coaching and training philosophies / methods exist for weightlifters, however many of these training methods had not been researched or scientifically documented, and thus further research is required to substantiate on the best type of training programme for men and women weightlifters of various age groups.

Complex training is a training modality that requires alternating of the body movements biomechanically. It is similar to the combination of high load weight training and plyometric training, set for set, within the same workout (Ebben & Watts, 1998). According to Saeed (2013), complex training involves the completion of a resistance training prior to plyometric training. Combining the bench press with medicine ball power drop is an example of upper body complex training (Chu, 1996). Similarly, for lower body complex training, it requires a combination of back squat and depth jumps (Ebben, 2002). The primary aim of complex training is to improve both strength and power on the same training session (Carter & Greenwood, 2014).

Theoretically, complex training elicits properties of the neurological, muscular, and psychomotor systems to allow the individual to produce more power on the subsequent lighter set (Baker, 2003; Carter & Greenwood, 2014). More specifically, complex training may stimulate motor unit excitability by increasing the motor unit recruitment, synchronisation, and the central input of a motor unit. Complex training may also increase phosphorylation of the myosin light chain in the muscle fibre, which allows the myofilaments to become more sensitive to calcium, which may also decrease the presynaptic inhibition, subsequently increasing the power and strength output (Carter & Greenwood, 2014; Hodgson, Dochery, & Robbins, 2005). This response is referred to as postactivation potentiation (PAP) (Carter & Greenwood, 2014; Hodgson, Dochery, & Robbins, 2005).

According to MacDonald, Lamont, Garner, and Jackson (2013), complex training could promote gains in strength and power if the right recommendations during training were followed. For example, it could enhance the intensity, volume, exercise selection, and training frequency, leading to faster recovery. However, the intensity must be high enough on both resistance and plyometric training, and the volume must be low enough to prevent fatigue. Furthermore, the selection of the exercises must also be biomechanically similar. Typically, a proper complex training may be undertaken 1 to 3 times a week, with 48 to 96 hours of recovery inbetween (Chu, 1996; Ebben & Watts, 1998).

Despite the success of using complex training to enhance body stability and to increase body's power, limited research has been conducted using complex training prescribed specifically for weightlifters. As complex training has been effectively proven in many sports such as volleyball (Saeed, 2013), gymnasts (Mohamed, 2011), rugby (Baker & Newton, 2005), football (Hedrick & Anderson, 1996), and baseball (Dodd & Alvar, 2007), the use of complex training could potentially enhance the power of the lower limb of the competitive weightlifters, and to increase their core stability , leading to the enhancement of weightlifting performance. Obviously, there is still much to be learned in relation to applying different intensity and duration of the complex training method, in particular for the weightlifters.

Weightlifting coaches had been attempting to suggest different training methods in an attempt to enhance muscular power of the competitive weightlifters. Therefore, this study examines the effects of complex training (applicable to weightlifting) compared to traditional weightlifting resistance training on muscular power of the male competitive weightlifters. This research is designed to compare whether a newly developed exercise programme (complex training) is more effective to enhance the power of the weightlifter compared to the traditional resistance training method, which has been practically used in their training regime of most weightlifters. The findings will enhance our knowledge on either beneficial or detrimental effects from the use of complex training. The results of this study can be used by coaches, conditioning trainers, fitness instructors and also athletes in their respective sports in an attempt to use this training method for enhancing muscle power.

Methods

Participants

Seventeen healthy male competitive state level weightlifters volunteered to participate in this study. All participants had at least 2 years of competitive weightlifting experience at the state level. They were invited to participate by using a poster attached to the notice board at the weightlifting training venue. Their age ranged from 15 to 22 years old (mean age 15.7 ± 0.93 years). Participants were randomly selected using computer generated randomised control trial and were assigned to the experimental group (complex training) and the control group (traditional resistance training) randomly. Participants were informed that they were free to withdraw from the study at any time and signed the consent form if they wished to participate in this study. Participants were informed that the results would be confidential. All participants in this study were free from health problems and medical conditions.

Testing Procedures

Participants were tested before and after 6 weeks of intervention. Tests were precluded with a general warm-up and stretching.

Height. Participants' height was measured without shoes with participant stood straight with eyes looking straight forward and participant's feet flat on the portable stadiometer and close together. Height was measured to the nearest 0.1 cm.

Body weight. Participants' body weight was also measured without shoes and with minimal clothing. The participants stood straight and steady on the body composition analyser and the body weight was measured to the nearest 0.1 kg.

Body fat. Body fat was measured without shoes and heavy clothing with the participant standing straight and static on the body composition analyser. The body fat was measured to the nearest 0.1 *%.*

Counter Movement Vertical Jump (CMVJ) test using the Force platform machine. To measure the CMVJ, participants rested their hands on hips to eliminate any influence of the arm swing and stood up for 1 to 2 seconds. Then, the participants had to jump as high as possible and land with normal flexion, followed by standing again in a neutral position for 1 to 2 seconds. The CMVJ average power and CMVJ height values were recorded and used for data analysis.

Medicine ball throw test. To measure the medicine ball throw distance, participants stood on a line with their feet slightly apart and facing the direction of the ball throw. Then, participants grasped the medicine ball with both hands, flexed their knees and lowered the ball to approximately the knee height. From there, the participants extended their legs, followed by extension of their back, elevation of their shoulders and then finally flexion of their shoulders to throw the ball forward, attempting to achieve the maximum horizontal distance.

Procedure

This is a pre-test – intervention – post-test design study to investigate the effects of complex training compared to traditional resistance training on muscular power of the competitive weightlifters. Ethical approval was obtained from the Human Research Ethics Committee of the Universiti Sains Malaysia (USM/JEPeM/1406232), and the study was followed the recommendation by the Declaration of Helsinki and the guidelines of good clinical practice (GCP). Necessary permission was obtained prior to the study using standard consent procedures. After recruiting the participants, the participants were randomly divided into two groups using computerised generated randomised control trial. The experimental group (complex training group) followed the complex training and the control group (traditional resistance training group) followed the traditional resistance training commonly used for weightlifting. The total training volume was equated between complex training and traditional resistance training groups. Duration of intervention was 6 weeks (MacDonald, Lamont, & Garner, 2012). Participants only required to train 2 times per week (3.00 pm – 5.00 pm) on Sunday and Wednesday. Testing for the participants were conducted prior to intervention and after 6 weeks of intervention. Finally, we debriefed all participants and thanked them for their participation.

Data and Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) version 22. All data were examined for normality through the Kolmogrov-Smirnov test. Descriptive statistics (mean and standard deviation) were used to describe the study variables. Preliminary analysis using the independent *t*-test was used to examine any difference between two groups on the baseline. Paired Sample *t*-test was performed to measure significant difference within the groups. Then, Independent *t*-test was used to see the difference between both groups. Statistical significance was accepted at $p < .05$. In the independent *t*-test, the results were checked using the Levene's test to test the equality of variance. Additional analysis using analysis of covariance (ANCOVA) was used to examine whether variables such as gender, and body weight category showed any confounding effect on the main study variables, when a significant differences were found from the independent *t*-test.

Results

Lower Body Power

Preliminary analysis on the baseline tests showed no significant difference in CMVJ average power ($p = .44$) and CMVJ height ($p = .77$) between complex training group and traditional resistance training group. Based on the results at Table 1, there was a significant increase in CMVJ average power $t(8) = -4.98$; $p = .001$) and CMVJ height $t(8) = -3.17$; $p = .013$) from pre-test to post-test for the complex training group. The results at Table 1 showed there was a significant increase in CMVJ average power $t(7) = -3.99$; $p = .005$, and CMVJ height $t(7) = -3.95$; $p = .006$, from pre-test to post-test for the traditional resistance training group.

Table 1: Paired Sample t-test Results for CMVJ

Counter Movement Vertical Jump	Complex Training Group (*n* = 9)	Traditional Resistance Training Group (*n* = 8)
CMVJ Average Power ($W.kg^{-1}$)		
Pre-test	24.78 ± 4.96	26.89 ± 6.04
Post-test	29.51 ± 5.75	28.53 ± 6.82
p value	.001	.005
CMVJ Height (cm)		
Pre-test	40.64 ± 9.44	39.33 ± 8.56
Post-test	51.86 ± 14.21	46.03 ± 11.06
p value	.01	.006

Table 2: Independent Sample t-test Results for CMVJ

	N	Mean	SD	df	*t*	*p*
CMVJ Average Power (W.kg^{-1})						
Complex Training Group	9	5.04	2.61	15	3.40	0.004
Traditional Resistance Training Group	8	1.64	1.16			
CMVJ Height (cm)						
Complex Training Group	9	13.23	7.29	15	2.15	0.04
Traditional Resistance Training Group	8	6.70	4.80			

Table 2 presents the results of CMVJ average power using the Independent sample *t*-test. The mean CMVJ average power increase from pre-test to post-test for the complex training group were 5.04 ± 2.61 W.kg^{-1} compared to traditional resistance training group were 1.64 ± 1.16 W.kg^{-1}. Independent sample *t*-test showed that there was a significant difference in CMVJ average power between the complex training group and traditional resistance training group after the 6 weeks intervention. The computed $t(15) = 3.40$, $p = .004$. Further analyses using ANCOVA found that there was no significant confounding effect on body weight category $F(1, 15) = 1.35$, $p = .26$, on mean CMVJ average power. Table 2 also presents the results of CMVJ height using the Independent sample *t*-test. The mean CMVJ height increase from pre-test to post-test for complex training group were 13.23 ± 7.29 cm compared to traditional resistance training group, 4.80 ± 1.69 cm. Independent sample *t*-test showed that there was a significant difference in CMVJ height between the complex training group and traditional resistance training group after the 6 weeks intervention. The computed $t(15) = 2.15$, $p = .04$. Further analyses using ANCOVA also found that there was no significant confounding effect on body weight category $F(1, 15) = .02$, $p = 0.89$, on mean CMVJ height.

Overall Body Power

Preliminary analysis on the baseline showed no significant difference in medicine ball throw distance ($p = .52$) between complex training group and traditional resistance training group. Based on the results at Table 3, there was a significant increase in medicine ball throw distance $t(8) = -12.26$; $p = .001$, from pre-test to post-test for the complex training group. The results at Table 3 also showed there was a significant increase in medicine ball throw distance $t(7) = -6.13$; $p = .001$, from pre-test to post-test for the traditional resistance training group.

Table 3: Paired Sample t-test Results for Medicine Ball Throw Distance (m)

Medicine Ball Throw Distance (m)	Complex Training Group (*n* = 11)	Traditional Resistance Training Group (*n* = 10)
Medicine Ball Throw Distance (m)		
Pre-test	5.57 ± 1.31	5.96 ± 1.14
Post-test	6.43 ± 1.30	6.43 ± 1.11
p Value	.001	.001

Table 4 (p. 14) presented the results of medicine ball throw distance using the Independent sample *t*-test. The mean medicine ball throw distance increase from pre-test to post-test for complex training group was (.87 ± .21 m) compared to traditional resistance training group of (.46 ± .21 m). Independent sample *t*-test showed that there was a significant difference in medicine ball throw distance between the complex training group and traditional resistance training group after the 6 weeks intervention. The computed $t(15) = 3.91$, $p = .001$. Further analyses using ANCOVA found that there was no significant confounding effect on body weight category $F(1, 15) = 0.14$, $p = .71$, on mean medicine ball throw distance.

Table 4: Independent Sample t-test Results for Medicine Ball Throw Distance (m)

Group	N	Mean	SD	df	*t*	*p*
Complex Training Group	9	0.87	0.21	15	3.91	.001
Traditional Resistance Training Group	8	0.46	0.21			

Discussion

The results from the present study showed that there were significant increases in CMVJ average power, CMVJ height, and medicine ball throw distance from pre-test to post-test for both groups (complex training group and traditional resistance training group). Further, the results also showed that there was a significant increase in CMVJ average power, CMVJ height, and medicine ball throw distance by the complex training group, compared to the traditional resistance training group after 6 week of intervention. This is possibly because complex training is superior for targetting specifically muscular power, thus, may be more suitable for improving power as compared to traditional resistance training. Dodd and Alvar (2007) stated that through complex training, the neurological and muscular systems at both ends of the force-velocity continuum are theoretically trained at much higher levels than by traditional modalities. Several researchers have also demonstrated the positive effects of complex training on the enhancement of both upper and lower body power (Baker, 2003; Matthews & Comfort, 2008). Adam et al. (1992) using a training protocol of combining squats and plyometric training showed superior vertical jump characteristics than with the squat only training protocol. Burger, Boyer-Kendrick, and Dolny (2000) observed significantly different muscular power (vertical jump height and medicine ball throw) between complex training and non-complex training among football players. Besides, Santos and Janeir (2008) also found that complex training significantly improve muscular power (squat jump, counter movement jump and medicine ball throw). Mohamed (2011) found that complex training significantly improves muscular power (vertical jump height and seated medicine ball throw distance) among gymnasts. In addition, Saeed (2013) also found that complex training significantly improves muscular power (vertical jump height, standing long jump distance and seated medicine ball throw distance) among volleyball players.

Other reasons on muscular power improvement differences between complex training group and traditional resistance training group may be accounted for complex training incorporates similar high load weight training and plyometric training, set for set, within the same workout, whereas traditional resistance training only have high load applied in weight training exercises alone. Jeffreys (2008) stated that power performance can potentially be enhanced via the application of a pre-conditioning exercise, for example a squat. Similarly, a study conducted by Stone, Sands, Pierce, Ramsey, and Haff (2008) also found a significant increase in power in elite weightlifters using a potentiated sequence of sets, where lower load sets were preceded by heavy sets. Theoretically, complex training elicits properties of the neurological, muscular, and psychomotor systems to allow the individual to produce more power on the subsequent lighter set (Baker, 2003; Carter & Greenwood, 2014). Specifically, complex training may also stimulate motor unit excitability by increasing the motor unit recruitment, synchronisation, and central input to the motor unit. In addition, complex training may also increase phosphorylation of the myosin light chain in the muscle fibre, which allows the myofilaments to become more sensitive to calcium, and it may also decrease presynaptic inhibition, which theoretically will allow subsequent power output to be augmented (Carter & Greenwood, 2014; Jeffreys, 2008; Hodgson, Dochery, & Robbins, 2005). This response is referred to as postactivation potentiation (PAP), which occurs in individuals with greater maximal strength (Baker, 2012).

The high intensity and enough rest within the exercise pair maybe also the reason for power improvements using the complex training method compared to the traditional resistance training only.

Several researchers concluded that complex training must be conducted in high intensity level for both weight training and plyometric training, which is approximately 80-90% of 1 RM and 30-50% of 1 RM, respectively (Ebben, 2002; Ebben & Watts, 1998; Carter & Greenwood, 2014; Chu, 1996; Comyns, Hennessy, & Jensen, 2007; Docherty, Robbins, & Hodgson, 2004). The recommendations for rest within pair in complex training was 0.5-1.5 minutes for beginners and intermediate athlete and 1-3 minutes for advanced and elite athletes (Carter & Greenwood, 2014; Chu, 1996; Ebben, 2002; Ebben & Watts, 1998;). Jeffreys (2008) stated that intense activities, whilst evoking greater PAP, will evoke greater fatigue. Similarly, the greater the time difference between the conditioning activity and subsequent performance, the greater the recovery from fatigue, but also the greater the decrement in PAP.

Chiu, Fry, Weiss, Schilling, Brown, and Smith (2003) in establishing the effects of PAP on jump squats, utilised 5 sets of 1 repetition to stimulate PAP and demonstrated significant increase in peak power for strength trained athletes but not in the recreational trained athletes. This is in agreement with the research from Gargoulis et al. (2003) who compared advanced maximal strength athletes versus naive maximal strength athletes, as well as Young, Jenner, and Griffiths (1998), and Duthie, Young, and Aitken (2002) who had noted the greatest PAP enhancement among the strongest participants in their respective studies. In this study, the participants were state level (elite) competitive weightlifters, thus, it is possible that the participants had the strength that could trigger higher PAP by using the complex training, but such "effect" perhaps couldn't be replicated if the participants were novice weightlifters.

Conclusion

The findings of this study showed significant increase in CMVJ average power, CMVJ height, and medicine ball throw distance from pre-test to post test for both intervention groups. In addition, significant differences in CMVJ average power, CMVJ height, and medicine ball throw distance were found in complex training group compared to traditional training group after 6 weeks' intervention. This indicated that complex training group experienced superior improvements in CMVJ average power, CMVJ height, and medicine ball throw distance compared to traditional resistance training group. In conclusion, complex training has proved superior in increasing muscular power as compared to the traditional resistance training.

Practical Implications for Coaches

Complex training must be a part of a periodized training plan. First, coaches must ensure athletes already have a good base strength before starting complex training. Recommendations for intensity and volume of exercise are consistent: complex training must be conducted in high intensity level for both weight training and plyometric training, which is approximately 80-90% of 1 RM, and 30-50% of 1 RM, respectively. The volume of complex training should be low enough to guard against fatigue so the athlete can focus on quality of work performed. Two to five sets of any complex pair are recommended. For repetitions, 2-8 reps during the weight training and 5-15 reps during the plyometric part are recommended. For exercise choice, pairing logic in complex training must follow the principles of biomechanics and velocity specificity required in power sports. Complex pairs should include a multijoint weight training exercise followed by a biomechanically similar plyometric exercise. Recommendations for frequency and recovery between training sessions are consistent as well. Complex training may be undertaken 1-3 times a week with 48-96 hours recovery between sessions in which exercise affects the same muscle group. The rest within pairs and rest between pairs (intra sets) also play an important role in complex training to make the training more effective and get the best result in power. Recommendations for rest within the pair are 0.5-1.5 minutes for the beginners and intermediate athletes; and 1-3 minutes for advanced and elite athletes. For the rest between pairs, the recommendations are 1-3 minutes for beginners and intermediate athletes; and 3-5 minutes for advanced and elite athletes.

Acknowledgement
This research is supported by the USM Short Term Grant (304/PPSP/61313041).

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