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Comparison between Traditional Resistance Training and Whole-Body Electrical Stimulation in Improving Muscular Strength

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Abstract

Greater muscular strength can enhance the ability to perform general sport skills such as jumping, sprinting, and change of direction tasks. Traditional Resistance Training (TRT) is broadly applied by strength and conditioning coaches to increase strength. However, recently, Whole-Body Electromyostimulation (WB-EMS) has been proven to be able to increase muscular strength in high performance athletes. The aim of this study was to examine the effects of two different training modalities on muscular strength. Sixty female collegiate softball players (Age = 23.52 ± 1.89years; Height = 156.20 ± 1.71 cm; Mass = 53.21 ± 3.17 kg) were randomly assigned into 3 groups. Along 8 weeks, all the groups trained like usual, but the first group performed additional of whole-body electrical stimulation (WB-EMS), the second group performed additional of traditional resistance training (TRT), and the third group (CTR) did not perform any additional training after regular softball training. Before and after the 8-week program, muscular strength (upper body and lower body) was evaluated in the 3 groups. The main results showed that after 8-week training, the upper body strength was significantly increased in TRT and WB-EMS groups in comparison with CTR ($p = 0.000$, and $p = 0.000$, respectively). However, t value showed greater improvement of upper body strength in TRT (7.37) group compared to WB-EMS (2.37) group. Similar finding on lower body strength where TRT and WB-EMS groups showed significant increase compared to CTR group ($p = 0.000$, and $p = 0.000$, respectively). Moreover, t value showed greater improvement of lower body strength in TRT (8.40) group compared to WB-EMS (3.97) group. The findings of this study highlighted the efficiency of both training modalities to improve muscular strength but also suggested that the traditional resistance training should be emphasize in improving muscular strength compared to utilizing whole-body electrical stimulation training.

Keywords: electromyostimulation, strength, intensity, repetition maximum

INTRODUCTION

Over the past 30 years, traditional resistance training has been utilised to increase muscular strength among high school, collegiate, amateur, and professional athletes (Szymanski, Albert, Hemperley, Hsu, Moore, Potts & Winstead 2008; Szymanski, DeRenne & Spaniol, 2009). It is typically reported that traditional resistance training takes up to 60 minutes per session (Fisher, Steele, Bruce-Low & Smith, 2011; Nybo, Sundstrup, Jakobsen, Mohr, Hornstrup, Simonsen & Krustrup, 2010). However, in recent times, coaches have limited time to train their athletes. Consequently, they usually neglect the conditioning practice and focus more on techniques and tactics of the game. These leads to players having weak strength base and in turn only worsens their sports performance (Sugimoto, Mattacola, Bush, Thomas, Foss, Myer & Hewett, 2017).

Recently, whole-body electromyostimulation has been used to increase muscular strength in athletes and healthy adults over four to twelve weeks of training (Filipovic, Grau, Kleinöder, Zimmer, Hollmann & Bloch 2016; Filipovic, Kleinöder, Dörmann, & Mester, 2011; Filipovic, Kleinöder, Dörmann, & Mester 2012). Previous meta-analysis of EMS methods revealed that this training method works effectively as an alternative to the traditional resistance training for developing maximal strength performance in athletes (Filipovic et al., 2012). Several studies reported a significant change in strength (Billot, Martin, Paizis, Cometti & Babault 2010; Girold, Jalab, Bernard, Carette, Kemoun & Dugué 2012). Moreover, EMS has also shown positive effects on sports performance such as swimming (Girold et al., 2012), kicking soccer ball (Billot et al., 2010) and rugby (Babault, Cometti, Bernardin, Pousson & Chatard, 2007). All these studies applied single electrodes EMS to specific muscles. However, with the new generation of EMS devices, several muscle groups can be trained simultaneously through electrode belt and vest system.

This new technology will be handy to all coaches who have limited time for physical conditioning. In comparison with the single electrode EMS, there are very few studies that apply WB-EMS methods on athletes (Filipovic et al., 2016). Whole Body-EMS has been used in training to improve muscle mass and decrease abdominal fat (Kemmler & von Stengel, 2013), improve energy expenditure (Kemmler, Von Stengel, Schwarz & Mayhew, 2012), improve resting metabolic rate, and body composition (Kemmler Schliffka, Mayhew & von Stengel, 2010) among sedentary and older female adults. However, to date, there is only one applied study measuring the effect of WB-EMS on strength, sprinting, jumping, and kicking capacity in elite soccer players. There is an obvious lack of studies conducted on the effects of WB-EMS on applied sports performance. In light of this knowledge gap, this study aimed to compare between traditional resistance training and WB-EMS program on maximal strength among female collegiate softball players.

METHODOLOGY

Participants

Sixty healthy female collegiate softball players (age: M=23.52, SD=1.89 years old, height: M=156.20, SD=1.71 cm, weight: M=53.21, SD=3.17 kg) were recruited in this study. The characteristics of the participants involved were they must be in the official collegiate softball team roster, have experience in resistance training, and have no self-reported sickness, neurological problems, mental illness, or significant current and past injuries that could place them at risk while performing exercises and trainings.

Experimental Design and Procedures

A randomized pretest-posttest control group design was applied to measure the effects of interventions on muscular strength. The CTR group implemented normal swing training program (100 swings using 24-oz bat) that been adopted from Szymanski et al., (2009) study. This program demonstrated an improvement in batting velocity among baseball players. Furthermore, this program is also being used by the coaches during daily softball training. Even though this training group can be classified as control group, the participants also must go through several sets of swing training. Each exercise session began with a warm-up of swing a standard bat for 2 sets with 10 repetitions. Then, the participants have to swing 20 times for 5 sets. The participants trained using a standard for the whole eight-week period.

The second group was TRT which all the players in this group performed the same swing training as CTR group. However, after finished swing training, this group performed additional of resistance exercised using free weights dumbbells and machines in the gymnasium. This training was programmed according to stepwise periodized method which is similar to previous resistance training used (Stone, Potteiger, Pierce, Proulx, O'bryant, Johnson & Stone, 2000; Szymanski, Szymanski, Szymanski, Molloy & Pascoe, 2007). This training started with low volume of training (high repetition, low intensity) to high volume of training (low repetitions, high intensity). In week one, the intensity was prescribed at 65% of the estimated 1RM obtained during 3RM pretesting. The training intensity was increased by 5% (as tolerated) each week before reaching 80% of estimated 1RM in the fourth week. Then, the 3RM testing was re-conducted at the end of weeks four to determine new predicted 1RM. For the following of week five, the intensity started at 85% of predicted 1RM and increased by 5% at week six to week eight. Along the 8 weeks of training, the intensity was increased incrementally when the participant could complete more than prescribed repetitions. If the individual could not complete repetitions, the resistance was reduced by the smallest amount possible at the next exercise session.

The third group was WB-EMS which all the players in this group performed the same swing training as CTR and TRT group. However, after finished swing training, this group performed additional of electrical stimulation training using whole-body electromyostimulation by Miha Bodytec in the gym's studio. The WB-EMS group exercised for 3 days each week using prescribed electrical stimulation (biphasic rectangular wave pulsed currents - 85Hz; impulse width of 350µs) and the maximally tolerated intensity were varied between 50 to 80 miliAmpere (mA) depending on the week. Every impulse for a single lift in each exercise lasted for 5s followed by another 5s of a rest period. This training was programmed according to stepwise periodized method which is similar to TRT group. This training started with low volume of training (high repetition, low intensity) to high volume of training (low repetitions, high intensity). In week one, the intensity was prescribed at 65% of the 1RM obtained during 1RMMiliampere (1RMM) pretesting. The training intensity was increased by 5% (as tolerated) each week before reaching 80% of 1RMM in the fourth week. Then, the 1RMM testing was re-conducted at the end of weeks four to determine new 1RMM. For the following of week five, the intensity started at 85% of 1RMM and increased by 5% at week six to week eight. Along the 8 weeks of training, the intensity was increased incrementally when the participant could complete more than prescribed repetitions. If the individual could not complete repetitions, the resistance was reduced by the smallest amount possible at the next exercise session.

Testing

Estimations of One Repetition Maximum (1RM) for upper body and lower body strength were made by performing 3RM tests (the most amount of weight lifted 3 times) on the bench press and squat test. Multiple RM prediction models are considered valid ($r = 0.84 – 0.92$), safe, and reliable methods to predict 1RM (Ruivo, Carita & Pezarat-Correia, 2016). The procedure of conducting multiple RM test for bench press and squat were as per suggested by Baechle, Earle and Baechle (2004). The estimated 1RM was subsequently predicted by using Bryzcki's equation (Ruivo et al., 2016). The predicted 1RM measured at baseline (week-0) and after week - 4 (to ensure that appropriate % were used during training), and after week-8 of training.

Data Analysis

The Kolmogorov-Smirnov test of normality was conducted before the analysis and all parameters were found to be normally distributed. Baseline and after week-8 differences of predicted 1RM and batting velocity between groups were investigated using the independent t-test. Assumption of homogenous variances was tested using Levene's test. To determine the effect of the training interventions, a paired sample t-test was conducted. For all inferential statistical analyses, significance was defined as p-value less than 0.05. All descriptive and inferential statistical analyses were conducted using SPSS 23 (IBM®, Armonk, NY, USA).

RESULTS

After eight weeks of training, all three groups showed improvement in pre and post for upper and lower body strength with significance value is 0.000, which is below 0.05 for both bench press and squat tests (Table 1). Therefore, there is a statistically significant difference in the mean of upper body strength and lower body strength between TRT, WB-EMS, and CTR groups. Further analysis was conducted to determine which group show greater improvement in both upper and lower body strength. Table 2 showed that TRT group demonstrated greater improvement in both upper and lower body strength compared to WB-EMS and CTR groups.

There was a statistically significant difference between groups in bench press as determined by one-way ANOVA ($F(2,57) = 120.038$, $p = .000$). A Tukey post hoc test revealed that the upper body strength was statistically significantly improved in TRT (7.37 ± 1.63 kg, $p = .000$) and WB-EMS (2.37 ± 1.72 kg, $p = .000$) groups compared to the CTR group (-0.68 ± 1.62 kg). Furthermore, there was a statistically significant difference between the TRT and WB-EMS ($p = .000$).

In lower body strength, there was a statistically significant difference between groups in bench press as determined by one-way ANOVA ($F(2,57) = 61.81$, $p = .000$). A Tukey post hoc test revealed that the upper body strength was statistically significantly improved in TRT (8.40 ± 1.29 kg, $p = .000$) and WB-EMS (3.97 ± 2.74 kg, $p = .000$) groups compared to the CTR group (0.45 ± 2.49 kg). Furthermore, there was a statistically significant difference between the TRT and WB-EMS ($p = .000$).

Table 1. Analysis of variance for Strength

		Sum of Squares	df	Mean Square	F	Sig.
Bench Press	Between Groups	660.789	2	330.395	120.038	.000
	Within Groups	156.888	57	2.752		
	Total	817.677	59			
Squat	Between Groups	635.256	2	317.628	61.810	.000
	Within Groups	292.910	57	5.139		
	Total	928.166	59			

Table 2. Multiple Comparison

Variables	(I) Group	(J) Group	Mean Difference	Standard Error	Sig.
Bench Press	TRT	WB-EMS	4.99*	.525	.000
		CTR	8.05*	.525	.000
Squat	TRT	WB-EMS	4.43*	.717	.000
		CTR	7.95*	.717	.000

*The mean difference is significant at the 0.05 level

DISCUSSION

The main findings of this study were that three TRT and WB-EMS sessions in addition to 100 normal swing training sessions per week over eight weeks (for a total of 24 sessions) was sufficient to enhance strength in collegiate level female softball players. For predicted maximal strength, the TRT and WB-EMS groups showed significant increases in mean predicted 1RM bench press and squat after eight weeks of training.

This result was aligned with previous study that showed an increment in muscular strength after following resistance training and single muscle attachment of electrical stimulation (Colson, Martin & Van Hoecke, 2000; Enoka, 1988; Martin, Cometti, Pousson & Morlon 1993). Previous studies stated that the improvement of neural adaptation was the reason of how muscular strength in resistance training (Moritani & Devries, 1980) and whole-body electromyostimulation (Guette, Ballay & Martin, 2006; Maffiuletti, Cometti, Amiridis, Martin, Pousson & Chatard, 2000) increased.

Strength improvement was usually associated with changes occurring in the central nervous system (e.g.; increased in neural drive) and/or at the muscle level (e.g.; hypertrophy). Although no EMG or cross-sectional area were measured in this study as to confirm on the strength improvement, it was assumed that whole-body electromyostimulation training had produced neural adaptation compared to muscular adaptation. This is because, it was commonly accepted that during the first few weeks (three to five) of resistance training and electrical stimulation training, there was no modifications at the muscle level (Aldayel, 2010). Furthermore, electrical stimulation mechanism resulted in excitation of intramuscular branches of the nerve and not directly the muscle fibers (Aldayel, 2010).

It has been said that muscle contraction that is stimulated by electrical stimulation occur when the depolarization of motor axons directly evoked through a peripheral mechanism to the electrodes that placed on the skin. As fast twitch muscle fibers are located near the skin where the electrodes are placed, this probably leads to greater fast twitch muscle fibers recruitment compared to slow twitch muscle fibers (Aldayel, 2010).

In addition, the training program given to both training groups involved with progressive overload. Progressive overload is one of the most important factors in increasing sports performance. It has also been shown that altering the training load does affects acute metabolic (Ratamess, Alvar, Evetoch, Housh, Kibler & Kraemer, 2009; Ratamess, Falvo, Mangine, Hoffman, Faigenbaum & Kang, 2007) and neural (Ratamess et al., 2009), hormonal (Kraemer and Ratamess, 2005; Kraemer, Spiering, Volek, Ratamess, Sharman, Rubin &Van Heest, 2006), and cardiovascular (Ratamess et al., 2009) responses towards exercise. The training load (intensity) was started at low intensity and was increased weekly up to 90% of 1RMM at the end of the training period.

Increasing the load imposed on skeletal muscle elicits adaptations that result in increased muscle size and changes in contractile characteristics (Bird, Tarpenning & Marino, 2005). It can be concluded that the principle of overload leads to muscular strength adaptation and this adaptation leads to the increment of dynamic strength. This statement supports the significant improvement in dynamic strength shown in previous studies which applied the principle of progressive overload in their resistance training program (Szymanski et al., 2009; Szymanski, McIntyre, et al., 2007; Szymanski, Szymanski, et al., 2007).

This study has also provided support for the use of WB-EMS as an alternative or supplementary training method in improving batting velocity. As a practical recommendation for softball players, it is suggested that additional WB-EMS be used by coaches in enhancing their players' batting velocities across eight weeks of training.

CONCLUSION

In conclusion, this current study showed that both Traditional Resistance Training and Whole-body Electromyostimulation were able to increase muscular strength among softball players. Furthermore, this current study revealed that among the 2 training modes conducted in this study, TRT demonstrated greater improvement in both upper and lower body strength compared toWB-EMS. Although this study was able to reach some conclusions about the effectiveness of both TRT and WB-EMS training, however, the underlying mechanism of the training was not fully explored. Therefore, further investigation related to electromyography (EMG) analysis and study at cell level is needed to clarify the possible underlying mechanisms effect of WB-EMS training. These studies could help in justify the changes occur in human body after following WB-EMS.

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