# EFFECTS OF WHOLE-BODY ELECTROMYOSTIMULATION ON STRENGTH AND BATTING VELOCITY AMONG FEMALE COLLEGIATE SOFTBALL PLAYERS

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## Abstract

This study examined the effects of 8 weeks additional dynamic Whole-body Electromyostimulation (WB-EMS) on muscular strength and batting velocity performance in female collegiate softball players. Forty softball players were randomly assigned into 2 groups which are DS (n = 20); DS-EMS (n = 20). Both groups performed 100 normal swing training using a standard bat. However, DS-EMS group performed additional of whole body electromyostimulation after the dry swing training. The training programs were conducted three times a week and all players were tested before (baseline) and at the end of week 8 (wk-8) training. Both groups showed statistically significant increase in predicted 1RM torso rotational strength ($p \leq 0.01$) and batting velocity strength ($p \leq 0.01$) after 8 weeks of training. In addition, WB-EMS group showed significant increase in predicted 1RM bench press, and predicted 1RM squat ($p \leq 0.01$). When comparing between groups, WB-EMS showed statistically greater increases ($p \leq 0.01$) in BV compared to control group. These data indicate that an 8-week of additional dynamic WBEMS training can significantly increase strength (upper-body, lower-body, torso rotational) and batting velocity among female collegiate softball players.

*Keywords:* Dry swing, electromyostimulation, batting, velocity

## Introduction

Batting velocity in softball and baseball sports is an important component of a successful hitting technique (DeRenne, 2007; Szymanski, DeRenne, & Spaniol, 2009; Szymanski, McIntyre, et al., 2007; Wilson et al., 2012). Previous studies mentioned that there were positive correlation between strength and batting velocity (Szymanski, 2007; D. J. Szymanski, J. Albert, et al., 2008). More specifically, past studies indicates that upper and lower body strength (Szymanski, Szymanski, Schade, & Bradford, 2008; J. Szymanski et al., 2008) and torso rotational strength (Szymanski, McIntyre, et al., 2007; J. Szymanski et al., 2008) have a significant relationship with batting velocity. Therefore, it is important to apply training that is able to increase upper and lower body and torso rotational strength.

Over the past 30 years, traditional resistance training had been implemented to increase batting velocity among high school, collegiate, amateur, and professional softball and baseball players (Szymanski, 2007; D. J. Szymanski, J. Albert, et al., 2008; Szymanski et al., 2009) and these studies have reported increment muscular strength and batting velocity. It is well known that traditional resistance training takes up to 60 minutes per session (Nybo et al., 2010). However, coaches nowadays have limited time to train their athletes. Therefore, they usually neglect the conditioning practice and focus more on techniques and tactics of the game. These lead to players having weak strength and only worsen their sports performance.

As the technology improves, short period of electrical stimulation (EMS) training which usually used for rehabilitation purpose has become as a method to increase the physiology and physical characteristics of healthy population. The EMS training was proven able to works as an alternative to the traditional resistance training for developing maximal strength performance in athletes (Filipovic, Kleinöder, Dörmann, & Mester, 2012). Several previous studies reported a significant changes in strength (Babault, Cometti, Bernardin, Pousson, & Chatard, 2007; Billot, Martin, Paizis, Cometti, & Babault, 2010; Girold et al., 2012; Maffiuletti et al., 2000; Maffiuletti, Dugnani, Folz, Di Pierno, & Mauro, 2002; Pichon, Chatard, Martin, & Cometti, 1995) Moreover, EMS has also showed positive effects on sports performance such as swimming (Girold et al., 2012; Pichon et al., 1995), kicking soccer ball (Billot et al., 2010) and rugby (Babault et al., 2007). Previous meta-analysis review on EMS study revealed that past studies applied single electrodes of EMS at specific muscles. This is because at that moment, limited electrodes can be used at one time. Nowadays, EMS technology is improving and WB-EMS had evolved which this equipment able to train several muscle groups simultaneously through vest and electrode belt system (e.g., Miha BodyTec, Augsburg, Germany). This specification becomes handy to all coaches who have limited time for conditioning practice. In comparison with the single electrodes EMS method, there is only few studies that apply WB-EMS methods on athletes (Filipovic et al., 2016). For this reason, the aim of this study is to measure the effects of implementing a WB-EMS training in female collegiate softball training routine on muscular strength and batting velocity.

## Methods

### *Participants*

Forty female collegiate softball players participated in this study. All players were randomly assigned into 2 groups which is the dry swing (DS, n = 20; age 23.40 (1.85) years; height 156 (1.62) cm, weight 54.11 (3.21) kg) group and dry swing with whole-body EMS (DS-EMS, n = 20; age 23.80 (1.85) years; height 156.25 (1.71) cm, weight 52.83 (3.47) kg) group. All players performed normal 100 swings training using standard bat weight (24Oz) during their softball practice (3 times a week). However, DS-EMS performed additional training that involved electrical stimulation after the swing training. All players have no experience/trained with any EMS training before and written informed consent was obtained from them. All players were briefed about the procedures and risks of the study. The experimental procedures performed were been approved by the Ethic Committee of the Research Management Institute (RMI), Universiti Teknologi MARA, Malaysia (600-RMI (5/1/6/01)).

### *Training Protocols*

WB-EMS training was performed three times a week after swing practice for 8 weeks. The WB-EMS training includes of various exercises that usually been used in increasing muscular strength and batting velocity (Szymanski, McIntyre, et al., 2007). This training was programmed according to stepwise periodized (Table 1) method which is similar to previous resistance training used (Stone et al., 2000; Szymanski, Szymanski, Bradford, Schade, & Pascoe, 2007; Szymanski, Szymanski, Molloy, & Pascoe, 2004). The intensity between free weight training and electrical stimulation was being equated in previous study (Hussain et al., 2016). Therefore, this training followed the intensity recommended to increase muscular strength (Baechle, Earle, & Baechle, 2004). A Whole-body EMS system by Miha Bodytec (Augsburg, Germany) was used by the WB-EMS group. This system used electrode vest that stimulate upper body muscles (pectoralis major and minor, latissimus dorsi, and external oblique), used a belt system to the lower body muscles (recus femoris and biceps femoris). Specific ball exercises were include in training program (2 days a week) as it perform similar sequential, ballistic, and rotational movement as batting movement. Biphasic rectangular wave pulsed currents (50 - 90Hz) were used with an impulse width of 350μs and the maximally tolerated intensity were varied between 60 and 100 miliAmpere (mA) depending on the differences among subjects in pain threshold. Every impulse for a single lift in each exercise lasted for 5s followed by another 5s of a rest period.

**Table 1:** Training protocols

| | **Week 1 - 4** | | | **Week 5 - 8** | | |
|---|---|---|---|---|---|---|
| | **Sets** | **Reps** | **%RMM** | **Sets** | **Reps** | **%RMM** |
| Warm-up | 2 | 10 | 50-60 | 2 | 10 | 50-60 |
| Parallel squat | 3 | 6-8 | 65-80 | 3 | 2-4 | 85-90 |
| Stiff leg deadlift | 3 | 6-8 | 65-80 | 3 | 2-4 | 85-90 |
| Bench press | 3 | 6-8 | 65-80 | 3 | 2-4 | 85-90 |
| Triceps kickback | 2 | 10-12 | 50-65 | 2 | 8-10 | 70-75 |
| Biceps curl | 2 | 10-12 | 50-65 | 2 | 8-10 | 70-75 |
| Seated Row | 2 | 10-12 | 50-65 | 2 | 8-10 | 70-75 |
| **Ball exercise** | **Sets** | **Reps** | **%RMM** | **Sets** | **Reps** | **%RMM** |
| Hitters throw | 2 | 6 | 80 | 2 | 8 | 70 |
| Standing figure 8 | 2 | 6 | 80 | 2 | 8 | 70 |
| Speed rotation | 2 | 6 | 80 | 2 | 8 | 70 |
| Standing side throw | 2 | 6 | 80 | 2 | 8 | 70 |
| Squat and throw | 2 | 6 | 80 | 2 | 8 | 70 |

*Experimental Design*

The study was a randomized pre-test post-test study including a dry swing training group (DS) as a control group and a dry swing with an additional of EMS (DS-EMS) as a treatment group. This design helps in measure the effects of the WB-EMS training on strength and bating velocity. The study was conducted during off season and the training interventions were conducted three times per week. Maximal strength and batting velocity was assessed before (baseline) and after 8 weeks (wk8). All tests were conducted on two different days in a standardized order. Strength test were tested on the first day and the batting velocity was tested on the following day.

*Testing procedures*

Before all tests were conducted, the players' demographic data were recorded (Table 2).

**Table 2:** Mean (SD) baseline descriptive data for groups

| Group | Age (years) | Height (cm) | Weight (kg) |
|---|---|---|---|
| DS (n = 20) | 23.40 (1.85) | 156 (1.62) | 54.11 (3.21) |
| DS-EMS (n = 20) | 23.80 (1.85) | 156.25 (1.71) | 52.83 (3.47) |

All of the participant in this study have been involved in resistance training less than 1 year. According to Baechle et al. (2004), these participants can be classified as beginner to intermediate lifters and due to that, 3RM test (most amount of weight lifted 3 times) of bench press, squat, and torso rotational were performed to determine the predicted 1 repetition maximum (most amount of weight lifted at 1 time – 1RM). Previous study stated that multiple RM test is valid (r = 0.84 – 0.92) and reliable to determine the prediction of 1RM (Ruivo, Carita, & Pezarat-Correia, 2016). Before 3RM bench press were conducted, full body dynamic warm-up was performed by all participants. The procedure of conducting multiple RM test for bench press and squat were followed Baechle et al. (2004). For torso rotational strength test, procedure from previous study by Szymanski, Szymanski, et al. (2007) were followed. The 1RM bench press, squat and torso rotational subsequently predicted using Bryzcki equation (Ruivo et al., 2016). To ensure the appropriate intensity (%RM) was used during training, the predicted 1RM bench press, squat, and torso rotational tests was assessed at week 0 and end of week 4.

Batting velocity was being tested on the following day after strength tests. Before the bat swing was measured, a 5-minute full-body warm-up exercise was performed. Players have to perform 5 dry swings using the same bat they used for testing. An aluminium softball bat, measuring 84 cm long and weighing 680 g, was used. The bat swing velocity was measured by a portable swing analyzer device (ZEPP., USA) with the reliability showed r = 0.822-0.988 (Bailey, McInnis, & Batcher, 2016). The batting velocity test begins as the participant stands on the starting position where she can swing with her maximum batting velocity. Each participants performed 5 swings with a break time of 30-s between swings. While encouragement to focus on the external environment was given, each player was instructed to swing as fast as possible and keep maintaining the same stance and same swing mechanics. Encouragement was given to elicit optimal performance (Gray, 2009). The velocity of the five swings were manually recorded for analysis.

*Statistical analysis*

Normality of distribution was conducted before the other analysis. Independent t-test at week 0 and week 8 was conducted to measure the differences occur between groups in predicted 1RM strength test and batting velocity. Paired sample t-test was conducted to measure the effect of training along 8 weeks period of time. Further analysis using Pearson product-moment correlation was conducted to detect correlation among strength variables and batting velocity.significance value was set as the p-value less than 0.05 and all statistical analyses were conducted using IBM statistic Version 20 (Armonk, NY).

## Results

*Group comparison*

After 8 weeks, the DS-EMS showed a significant ($p \leq .01$) higher in predicted 1RM bench press, squat, and torso rotational strength as well as batting velocity compared to DS group (Table 3). DS group showed no significant improvement in predicted 1RM bench press and squat ($p > .05$).

**Table 3:** Mean (SD) DS and DS-EMS for pre-test, post-test and percent (%) change

| Variable | Pre-test | Post-test | % change |
|---|---|---|---|
| Bench Press | | | |
| DS | 25.10 (3.02) | 25.33 (2.88) | 0.92 |
| DS-EMS | 24.08 (3.50) | 26.46 (3.07) | 9.88†‡ |
| Squat | | | |
| DS | 42.71 (2.15) | 42.83 (1.93) | 0.28 |
| DS-EMS | 42.04 (2.53) | 46.01 (2.36) | 9.44†‡ |
| Torso Rotational | | | |
| DS | 28.29 (5.16) | 30.95 (5.03) | 9.40† |
| DS-EMS | 27.70 (5.57) | 33.31 (4.06) | 20.25†‡ |
| Batting Velocity | | | |
| DS | 54.20 (3.65) | 55.00 (3.48) | 1.48† |
| DS-EMS | 54.30 (3.64) | 56.25 (3.21) | 3.59†‡ |

* DS = Dry Swing, DS-EMS = Dry Swing and EMS
† Significant difference within groups at $p \leq 0.05$.
‡ Significant difference between groups at $p \leq 0.05$

*Correlation*

At baseline, this study documented a significant correlation between predicted 1RM bench press (r = 0.876, $p \leq .001$), squat (r =.897, $p \leq .001$) and torso rotation (r = .847, $p \leq .001$) with batting velocity. After 8 weeks of training, the analysis showed significant correlations between improvement in predicted 1RM torso rotational and batting velocity for DS (r = .832, $p \leq .001$) and DS-EMS (r = .873, $p \leq .001$). While DS group showed no significant ($p > .05$) correlation between gain in predicted 1RM bench press and squat and batting velocity, DS-EMS group demonstrated significant ($p \leq .05$) correlation between gain in predicted 1RM bench press (r = 545, $p = .013$) and predicted 1RM squat (r = 450, $p = .047$) and batting velocity.

## Discussion

The primary finding of this study was additional of WB-EMS (three times a week) after swing training over 8 weeks demonstrated increase in muscular strength (bench press, squat, and torso rotational) and sports skill performance (batting velocity) in collegiate female softball players.

In regards to predicted maximal strength (predicted 1RM) the DS-EMS group showed significant increases in mean predicted 1RM bench press, squat, and torso rotational after 8 weeks of training. Gain in predicted 1RM bench press and torso rotational have not been discovered by any study using WB-EMS yet. Nonetheless, gain in predicted 1RM for lower body strength have been shown by one study using WB-EMS (Filipovic et al., 2016). In Filipovic's study, he demonstrated a significant increase in 1RM leg strength of +13.06% after 7 weeks of dynamic WB-EMS. Considering predicted 1RM strength test of squat results are in line with the findings of studies using 12-28 sessions local EMS training (Babault et al., 2007; Filipovic et al., 2012; Maffiuletti et al., 2000; Maffiuletti et al., 2002; Willoughby & Simpson, 1998) and findings using resistance training (Szymanski et al., 2009; Szymanski, McIntyre, et al., 2007; Szymanski, Szymanski, et al., 2007; D. J. Szymanski, J. M. Szymanski, et al., 2008) on the upper body, lower body, and torso rotational muscles in trained athletes.

The studies using isometric and dynamic EMS on quadriceps femoris muscles showed significant increase in Fmax isometric knee extensor up to +14.5% (Maffiuletti et al., 2002). Further EMS study also showed significant gain of isokinetic torque in eccentric condition (+29% at -120 $^{\circ}\cdot s^{-1}$; +17.9% at -60 $^{\circ}\cdot s^{-1}$; $p \leq .01$), and concentric condition (+37.6% at 60 $^{\circ}\cdot s^{-1}$ and +48.9% at 300 $^{\circ}\cdot s^{-1}$; $p \leq .05$) (Brocherie, Babault, Cometti, Maffiuletti, & Chatard, 2005).

Previous study using resistance training demonstrated gains in bench press, squat, torso rotational and batting velocity. Study by Szymanski, Szymanski, et al. (2007) indicate greater improvement in predicted 1RM bench press (+15.06%), predicted 1RM squat (+40.23%) and 3RM torso rotational (+17.1%) after following resistance training and medicine ball training for 8 weeks. The results of improvement in strength and batting velocity were correlated in this study for WB-EMS group. This was supported by previous study that also indicated significant relationships between improvement scores of bench press, squat, and torso rotational strength to improvement scores of batting velocity (Szymanski, Szymanski, et al., 2007).

The changes occurred in this study supports the kinetic link theory (Putnam, 1993). Putnam in his study mentioned that if each of the muscles involved were improved in strength and velocity, it would be justifiable that the greater momentum that generated from the large base segments (legs and hips) were then transferred through the stronger torso muscles to the stronger, smaller adjacent segments such as shoulders and arms when performing softball swing.

In additional, the interaction of three body segments which are hips, torso, and upper body were the segments that a softball/baseball player depends on when they wanted to utilize their body as a kinetic link when performing batting (rotational) movements. Shaffer, Jobe, Pink, and Perry (1993) in their study mentioned that during the pre-swing and swing phase of hitting, the quadriceps, buttocks, and hamstring have a high level of activity, which contributes to the legs' stabilizing role needed to initiate power as the torso rotates during a softball/baseball swing.

## Conclusion

Three dynamic WB-EMS sessions in combination with normal 100 swings per week are sufficient for effectively enhancing maximal strength and batting velocity in female collegiate softball players. This study found that stimulation using WB-EMS training able to enhance softball players' performance and also able to complement or modify the common training structure. Further study is needed to investigate the use of WB-EMS concurrently with swing training. This probably will be more time saving for the coaches in training their players on the field.

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