Salzgeber et al. (2019) *Int J Res Ex Phys*. 14(2):1-10.

International Journal of Research in Exercise Physiology

Original Research Article

Muscle Activation during Several Battle Rope Exercises

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Abstract

Introduction: Training with battle ropes (BR) has become popular in recent years as a modality to increase cardiorespiratory endurance and improve muscular strength and endurance. However, there is limited research on the training responses to BR training, especially in regards to muscle activation. **Purpose:** The purpose of this study was to 1) compare electromyographic (EMG) responses in the vastus medialis (VM), gluteus maximus (GM), erector spinae (ES), external oblique (EO), rectus abdominis (RA), upper trapezius (UT), anterior deltoid (AD), and palmaris longus (PL) during five BR exercises to determine which exercises produced the greatest muscle activation, and 2) determine if the muscles tested were activated to a sufficient degree (greater than 40% MVIC) to increase muscle strength. **Methods:** Twelve males performed the following exercises in a random order: Double Arm Slams, Double Arm Waves, Double Alternating Waves, Single Arm Waves, and Double Outside Circles. Surface EMG was recorded and represented as a percent of the maximal voluntary isometric contraction (MVIC). **Results:** All of the muscles tested were contracting at greater than 40% MVIC for Double Arm Slams and Double Arm Waves. During Double Alternating Waves, all of the muscles were contracting above 40% MVIC except for the VM and the RA. During Double Outside Circles, all the muscles, except for the RA and AD, were contracting above 40% MVIC. For Single Arm Waves, all of the muscles were contracting above 40% MVIC except the VM, GM, and the RA. **Conclusions:** Based on these results, Double Arm Slams and Double Arm Waves would be the best exercises to improve total body muscle strength. However, most of the other exercises could provide strength benefits in select muscles, depending upon the specific motion.

Key Words: Interval Training, Electromyography, HIIT

Introduction

The use of battle ropes (BR) as a training device has increased in popularity in the past several years[1]. Battle ropes are thick ropes that come in a variety of lengths (i.e., 10 to 100 feet) and are generally 1 to 2 inches in diameter[1]. The ropes are anchored at one end and the user performs a wide range of wave type motions, either unilaterally or bilaterally. There are numerous exercises that can be performed with BR and they can purportedly be used for both cardiorespiratory conditioning and muscle strengthening[1-2].

Battle rope training is typically carried out using a high-intensity interval training (HIIT) format. A workout usually consists of alternating bouts of high-intensity exercise followed by either low-intensity exercise or complete rest. The intensity of the workout can be altered by changing rope length, rope thickness, wave velocity, amplitude, anchor position, and the amount of muscle mass used[1].

Fry[3] reported that in order to improve muscle strength, a muscle must be contracting in excess of 40% of one repetition maximum (RM). When performing resistance training, weights are usually assigned based on percentages of 1 RM. However, because BR are not really "lifted," it is difficult to assess how hard the muscles are being taxed. An alternate way to assess how hard the muscles are working is with electromyography (EMG). Electromyography is used to determine the electrical activity within the muscle. As a muscle is signaled to contract by the nervous system, action potentials are created, which are proportional to the force being produced by the muscle[4].

There is limited research on the muscular responses during BR training. Calatayud et al.[5] evaluated muscle activity during unilateral and bilateral BR exercises. With the use of EMG, it was found that both unilateral and bilateral wave movements resulted in moderate-to-high levels of muscle activity in the anterior deltoid, external oblique, and lumbar erector spinae. The study also found that unilateral exercises recruited the external oblique muscles to a greater extent compared to bilateral exercises. Meier et al.[2] found that 5 weeks of HIIT using kettlebells and BR showed small improvements in body composition and grip strength. However, since the training program included both types of training, it was impossible to define the relative contribution of each modality. Finally, Marin, Garcia-Gutierrez, Da Silva-Grigoletto, and Hazell[6] found that whole-body vibration increased muscle activation while using BR, compared to exercising on stable ground.

Because there is limited research on the degree of muscular responses during BR exercise, the purpose of this study was to measure muscle activity during several different BR exercises to determine which exercises may activate select muscles sufficiently to improve muscular strength.

Methods

Participants

Twelve apparently healthy volunteers between the ages of 20 to 24 years were subjects in this study. Subjects were required to have previous resistance training experience and preferably experience using BR. Before undergoing any training or testing procedures, each subject was informed of the purpose, procedures, potential risks, and benefits of participating in the study and provided written informed consent. The study was approved by the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects.

Procedures

Each subject participated in one practice session and one testing session, both lasting approximately 1 hour. On the practice day, the BR exercises were demonstrated to subjects and they were allowed time to practice each exercise. On a separate day, each subject was tested. Subjects completed an active warm-up, which consisted of riding a stationary bike for 5 minutes and performing 3 minutes of BR exercises. Subjects then performed a maximum voluntary isometric contraction (MVIC) for each muscle of interest using manual muscle techniques.

The eight muscles evaluated in this study were the vastus medialis (VM), gluteus maximus (GM), erector spinae (ES), external oblique (EO), rectus abdominis (RA), upper trapezius (UT), anterior deltoid (AD), and palmaris longus (PL). Prior to MVIC testing, subjects had electrodes placed on the respective muscle bellies, based upon SENIAM guidelines[7]. Electrode sites were shaven and cleaned with alcohol prior to electrode placement. Subjects were advised to not use lotion or oil on the skin prior to testing[8].

Subjects then performed five BR exercises, in random order. The exercises were: Double Arm Slams, Double Arm Waves, Double Arms Alternating Waves, Single Arm Waves, and Double Outside Circles. The BR used was 50 feet in length and 1.5 inches in width. The center of the rope was looped twice around an anchor (a weighted sled) to stabilize the BR. For each exercise, the subject stood with their feet shoulder width apart, with a knees slightly bent. The subject had their back straight with a slight forward lean of the torso, elbows extended so their hands were waist high, and held the BR handles with a handshake grip. The subjects were instructed to do the exercises at a self-selected pace, but were encouraged to do the exercises as vigorously as possible.

EMG analysis

Electrical activity of the VM, GM, ES, EO, RA, UT, AD, and PL was recorded and stored on a personal computer. The EMG signal was preamplified using a differential amplifier (Delsys Trigno Wireless Systems, Boston, MA; bandwidth 20-450 Hz). Raw EMG signals were digitized at 2000 Hz. For each trial, the EMG amplitude (microvolts root mean square [µVrms]) was calculated and represented as a percentage of the maximum RMS value recorded during the MVIC trial. Subjects completed 10 seconds of each exercise with three representative movements averaged for each muscle.

Statistical analyses

For each muscle, normalized EMG activity between exercises was compared using a one-way ANOVA with repeated measures. If there was a significant difference between exercises, pairwise comparisons were made using Fisher's LSD tests. To achieve statistical significance, alpha was set at 0.05. All analyses were conducted using the Statistical Package for the Social Sciences (SPSS, Version 25.0, SPSS, Chicago, IL).

Results

Descriptive characteristics of the subjects are presented in Table 1. Muscle activation for each of the eight muscles, for each exercise, are presented in Figures 1-8, respectively.

Table 1. Descriptive characteristics of subjects (N=12).

	Mean ± SD	Range
Age (yrs)	22.8 ± 1.27	20-24
Height (cm)	177.6 ± 6.4	167.6-190.5
Weight (kg)	80.8 ± 11.1	59.0-95.3

EMG for Double Arm Slams was significantly greater than all of the other exercises for the VM (Figure 1), GM (Figure 2), ES (Figure 3), and RA (Figure 5). For the EO (Figure 4), Double Arm Slams, Double Alternating Waves, and Single Arm Waves were all significantly different than Double Arm Waves and Double Outside Circles. For the AD (Figure 7), Double Arm Slams, Double Arm Waves, Double Alternating Waves, and Single Arm Waves were all significantly different than Double Outside Circles. For the UT (Figure 6) and PL (Figure 8), there were no significant differences between exercises. It should be noted that for the ES, data were only available for nine subjects due to technical difficulties. Another finding from the data was that all eight muscles tested during Double Arm Slams and Double Arm Waves were contracting above 40% MVIC. During Double Alternating Waves, all of the muscles were contracting above 40% MVIC except for the VM (Figure 1) and the RA (Figure 5). During Double Outside Circles, all the muscles, except for the RA (Figure 5) and AD (Figure 7), were contracting above 40% MVIC. For Single Arm Waves, all of the muscles were contracting above 40% MVIC except the VM (Figure 1), GM (Figure 2), and the RA (Figure 5).

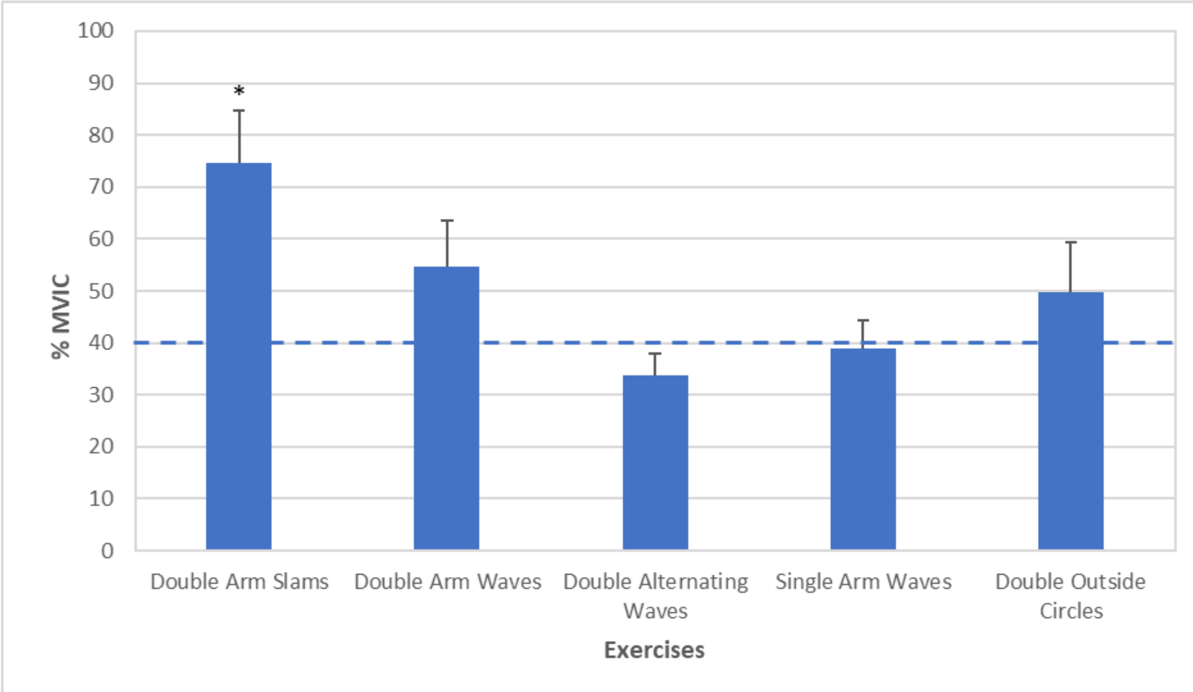

Figure 1. Activation of the vastus medialis for the five battle rope exercises. Dashed line depicts threshold for increasing muscular strength. *Significantly greater than all other exercises (p<.05).

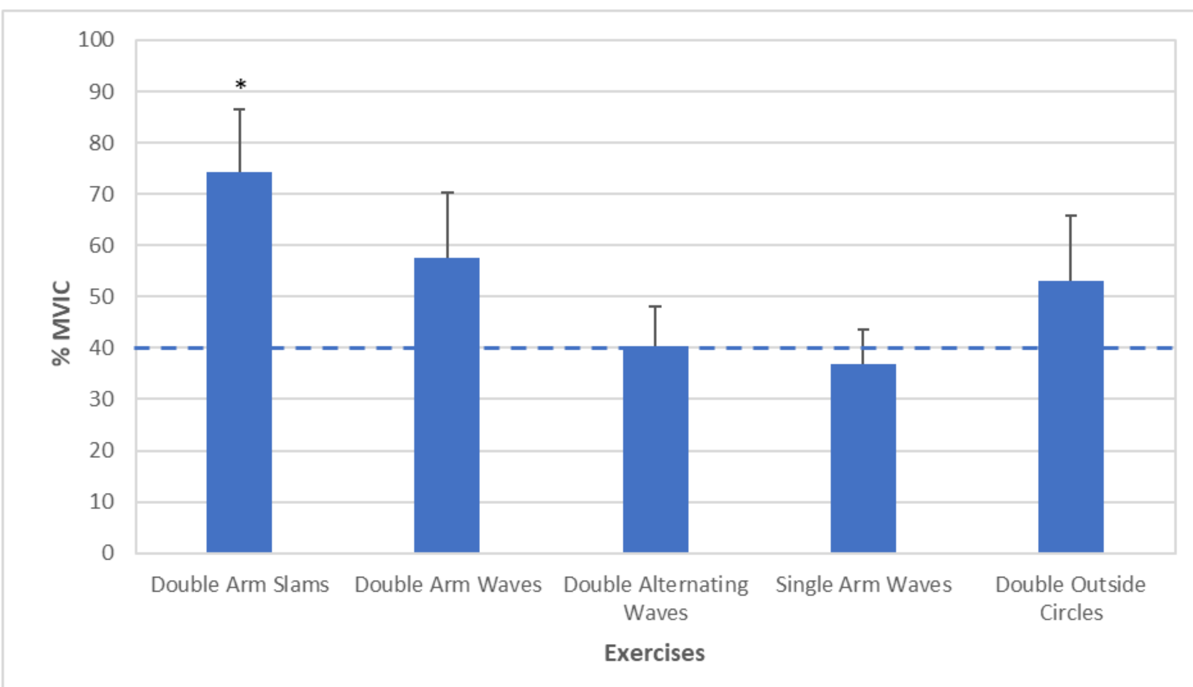

Figure 2. Activation of the gluteus maximus for the five battle rope exercises. Dashed line depicts threshold for increasing muscular strength. *Significantly greater than all other exercises (p<.05).

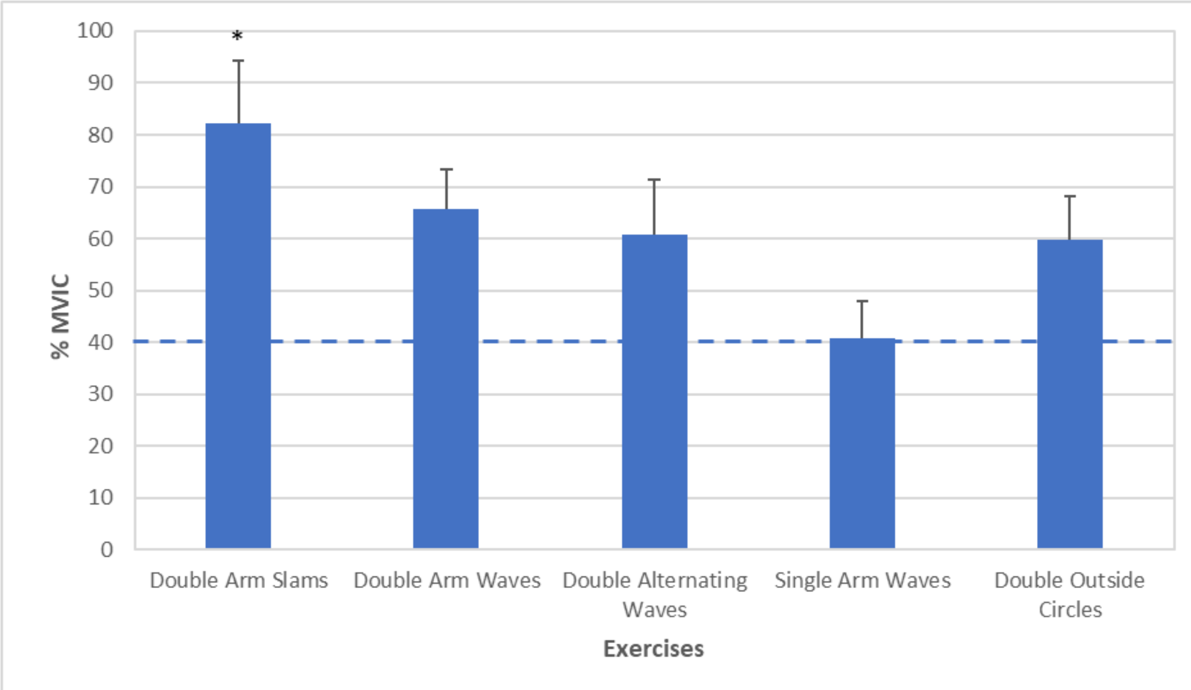

Figure 3. Activation of the erector spinae for the five battle rope exercises. Dashed line depicts threshold for increasing muscular strength. *Significantly greater than all other exercises ($p<.05$).

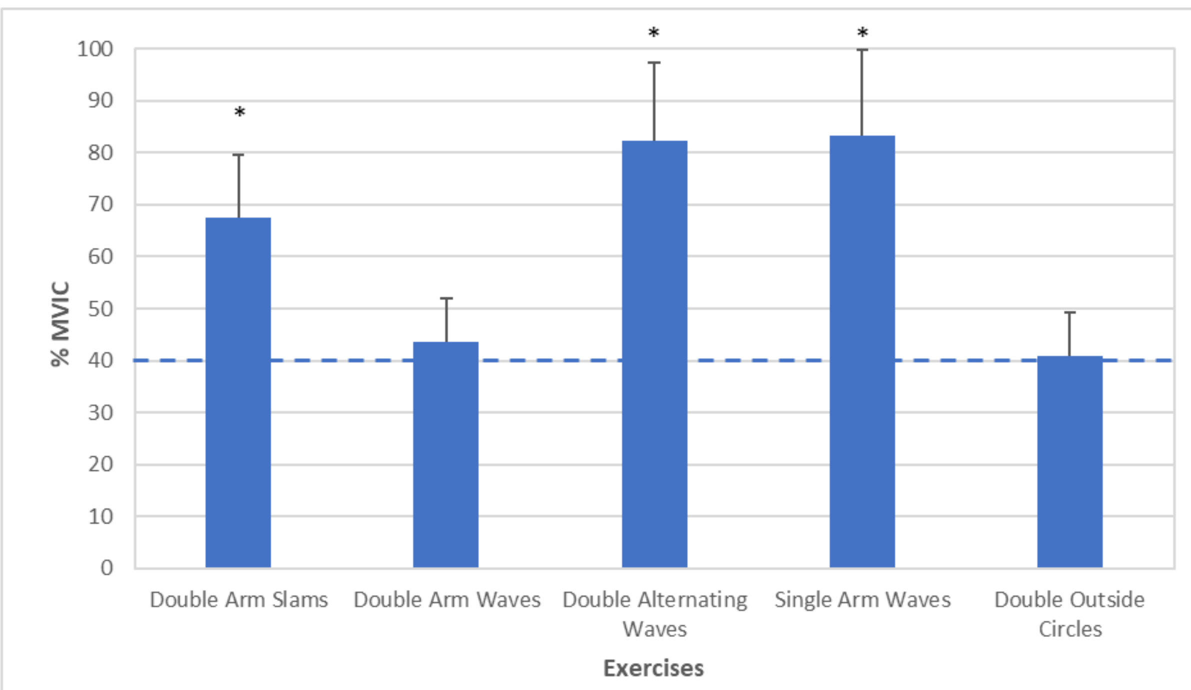

Figure 4. Activation of the external oblique for the five battle rope exercises. Dashed line depicts threshold for increasing muscular strength. *Significantly different than Double Arm Waves and Double Outside Circles ($p<.05$).

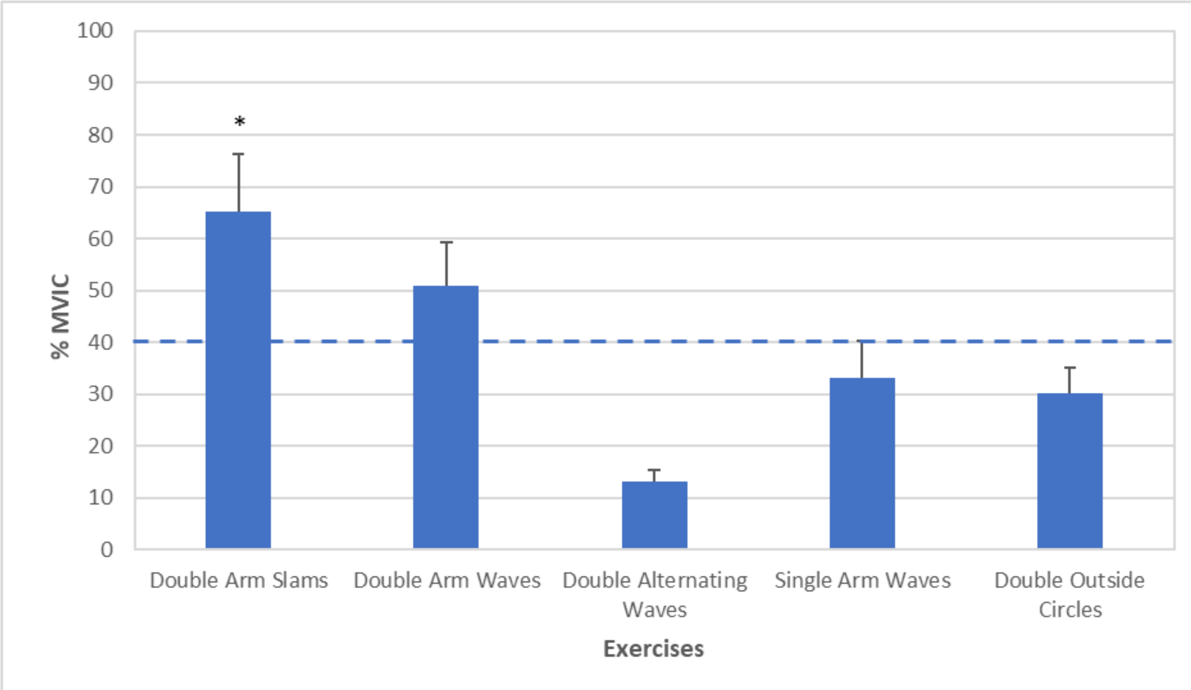

Figure 5. Activation of the rectus abdominis for the five battle rope exercises. Dashed line depicts threshold for increasing muscular strength. *Significantly greater than all other exercises ($p<.05$).

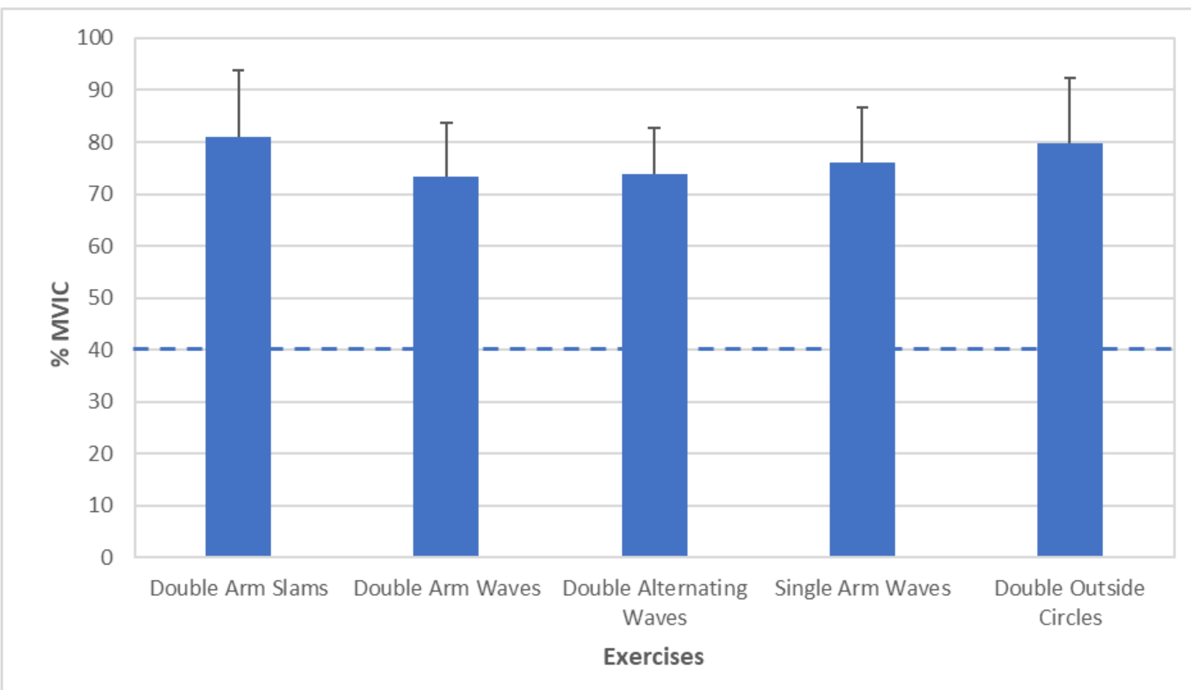

Figure 6. Activation of the upper trapezius for the five battle rope exercises. Dashed line depicts threshold for increasing muscular strength.

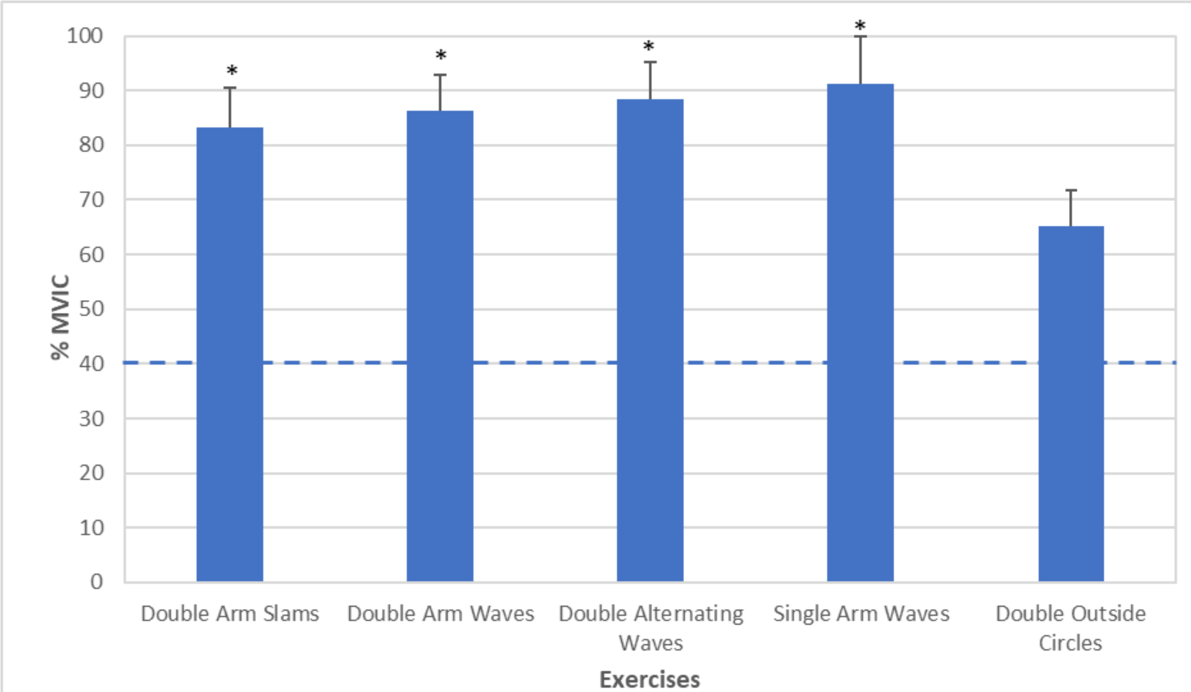

Figure 7. Activation of the anterior deltoid for the five battle rope exercises. Dashed line depicts threshold for increasing muscular strength. *Significantly greater than Double Outside Circles ($p<.05$).

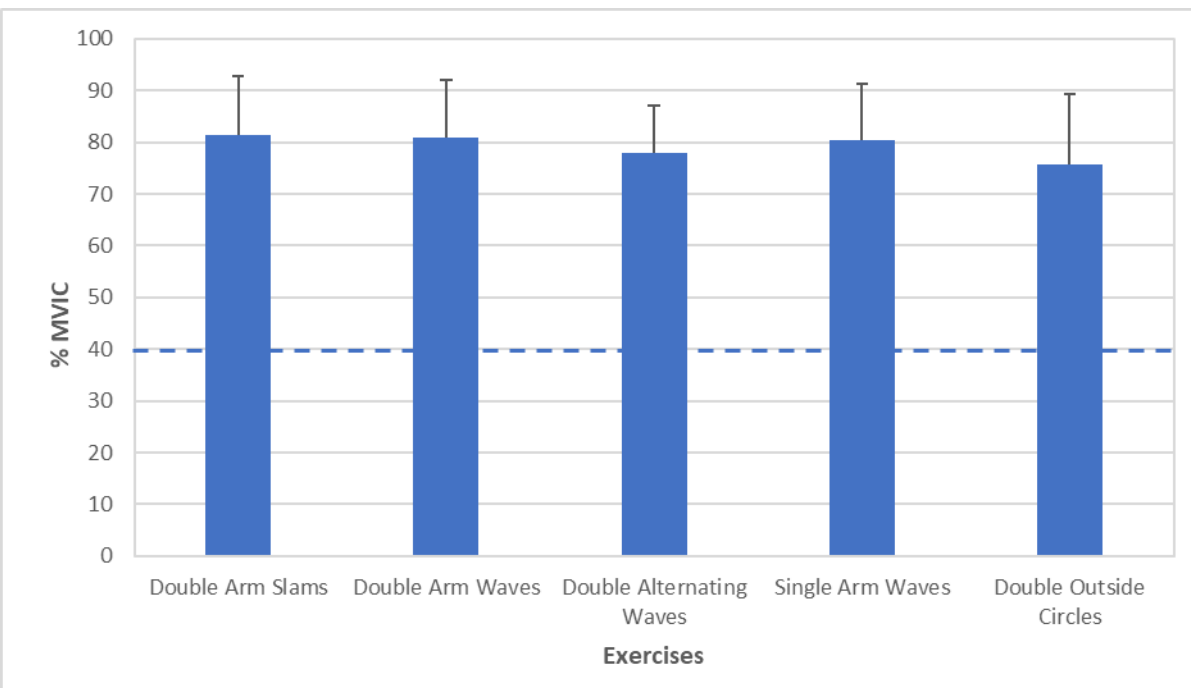

Figure 8. Activation of the palmaris longus for the five battle rope exercises. Dashed line depicts threshold for increasing muscular strength.

Discussion

The main purpose of this study was to determine if BR exercises can overload the muscles sufficiently enough to improve muscular strength. In order to improve muscle strength, it is generally accepted that a muscle must be contracting above 40% MVIC[3]. Double Arm Slams and Double Arm Waves were above 40% MVIC for all of the muscles evaluated, signifying that these two exercises should improve muscle strength throughout the body. With a few exceptions, most of the muscles were contracting at or above this minimal threshold for the majority of the exercises. For instance, during Single Arm Waves, all of the muscles were contracting above 40% MVIC except for the VM, GM, and RA. When looking at that exercise, there is not as much movement in the lower body or the abdominal region. The VM, GM, and RA are used primarily as stabilizing muscles rather than primary muscles during those motions. It was particularly interesting to note that during Double Alternating Waves the RA was only contracting at 12% MVIC. Because there is so little up-and-down body motion during this exercise, the RA was relatively inactive.

Another important finding of this study was that Double Arm Slams was the best exercise for activating the majority of the muscles tested. EMG levels in all of the muscles were significantly greater than or equal to all of the other exercises. The main reason for this finding is that there was more vertical motion of the entire body as the subject brought the BR above their head and then forcefully slammed the rope into the ground.

Calatayud et al.[5] compared unilateral and bilateral BR exercises and found that both movements can be used to provide moderate-to-high muscle activity in the AD, ES, and EO. The current study found similar results, as all three muscles were contracting above 40% MVIC for all five exercises. Consistent with both studies, there was higher activation in the AD and EO for Single Arm Waves compared to Double Arm Waves. It was felt that during Single Arm Waves the EO must work harder in order to maintain proper balance and trunk stability.

Muscle activation in the PL was tested since it has a significant role in grip strength. A study by Meier et al.[2] found that 5 weeks of training with kettlebells and battle ropes resulted in an increase in grip strength. It should be noted that subjects trained with both BR and kettlebells in that study. However, since we found that the PL was contracting in excess of 75% MVIC for all of the BR exercises, it is reasonable to assume that BR training alone will increase grip strength.

Conclusions

Based on the results of this study, it can be concluded that BR can be an effective modality to increase muscular strength. If one had to choose a single exercise, Double Arm Slams activated the majority of muscles evaluated to the greatest degree.

Disclosures

This study was funded by the American Council on Exercise (ACE). However, ACE was not involved in the design of this study, collection or analysis of the data, or the preparation of this manuscript.

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