THE EFFECT OF BODYBLADE® TRAINING VS STABY PROFESSIONAL DEVICE TRAINING ON ROTATOR CUFF MUSCLE STRENGTH

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Submitted in Partial Fulfillment of the Requirements for Master of Arts Degree in the Steinhardt School of Culture, Education, and Human Development

NEW YORK UNIVERSITY

2015
Special Thanks to:

Maria Isabel Mendieta

My Mother and Father

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Ralph Garcia, PT, MPT, PhD

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All participating research subjects
TABLE OF CONTENTS

ABSTRACT ............................................................................................................................ 4

INTRODUCTION ..................................................................................................................... 5

METHODS ............................................................................................................................. 12

Design ....................................................................................................................................... 12

Participants .............................................................................................................................. 12

Procedures ............................................................................................................................... 13

Randomization ......................................................................................................................... 13

Shoulder Strength Measurements ......................................................................................... 13

Pre-test ...................................................................................................................................... 14

Training Equipment ............................................................................................................... 15

Training Program .................................................................................................................... 15

Post-test .................................................................................................................................... 16

Assumptions ............................................................................................................................. 16

Delimitations ............................................................................................................................ 17

Statistics Analysis ................................................................................................................... 17

RESULTS ................................................................................................................................. 18

Descriptive Statistics ............................................................................................................. 18

Inferential Statistics ............................................................................................................... 19

DISCUSSION ........................................................................................................................... 19

CONCLUSION .......................................................................................................................... 23

REFERENCES .......................................................................................................................... 25

APPENDIXES ........................................................................................................................... 31
ABSTRACT

INTRODUCTION: Several studies have shown that weakness of the external rotator (ER) muscles has been associated with shoulder injuries in professional athletes. Various training programs have been evaluated for strengthening these rotator cuff muscles. Although whole body vibration training (WBV) was developed in the late 20th century for strength training, limited research has been conducted on localized training with upper extremity oscillating poles such as the Bodyblade®. A more recently developed oscillating blade device known as Staby Professional device offers slightly different features to the Bodyblade®. The purpose of the present study was to compare the strength changes in Bodyblade® training vs. Staby Professional device training over a 6-week training program.

METHOD: Twenty-seven young adults (12 male, 15 female) were randomized into two device training groups and completed a 6-week training program. The five shoulder exercises included in the program were forward flexion at 90°, shoulder abduction at 90°, overhead flexion at 180°, scaption at 45° of horizontal abduction, and external rotation at 0° abduction with the elbow flexed to 90°. The average isometric peak force was tested pre-test and post-test using the micro FET2 Hand Held Dynamometer HHD (Hoggan Health industries, Draper, UT, USA).

RESULTS: No significant differences were noted at post-test between Bodyblade® and Staby Professional device for external (p = .171) and internal shoulder muscles isometric strength (p = .308). However the Bodyblade® and Staby Professional device individually produced significant improvements from pre-test to post-test in ER (p = .0002) and IR strength (p = .0002).

CONCLUSIONS: A 6-week Bodyblade® or Staby Professional device training program can significantly improve shoulder IR and ER isometric peak forces.
INTRODUCTION

The incidence of shoulder dislocation and rotator cuff injuries in the US indicates that young males and females are at a high risk of these types of injuries while performing sports activities.\textsuperscript{1-3} The balance between static and dynamic shoulder stabilizers form an important relationship in shoulder stability; these stabilizing structures include the glenohumeral ligaments, capsule, and dynamic stabilizers such as the rotator cuff muscles (supraspinatus, infraspinatus, teres minor and subscapularis).\textsuperscript{4} It is common for the proximal segments of a kinetic chain to be weaker than the distal segments, thus emphasizing the need to strengthen proximal rotator cuff muscles during rehabilitation.\textsuperscript{5} Yanagawa et al tested the contribution of individual muscles of the shoulder to glenohumeral joint loading during abduction (15° to 135° in scapular plane) and found that the line of action of the rotator cuff muscles provided the best position to apply load across the glenohumeral joint therefore contributing significantly to joint stability.\textsuperscript{6} Aackland and Pandy also found that between 0° to 120° of abduction and flexion of the glenohumeral joint, the rotator cuff muscles are better aligned to stabilize the joint.\textsuperscript{7} In addition, Wuelker et al found that a 50% reduction in rotator cuff muscle force produced a 46% greater anterior displacement of the humeral head demonstrating reduced contribution to joint stabilization.\textsuperscript{8} Correspondingly, other studies have shown that weakness of the external rotator (ER) muscles has been associated with shoulder injuries in professional athletes.\textsuperscript{9,10}

Due to the importance of strengthening the rotator cuff muscles, several studies have evaluated effective strength training programs for the rotator cuff muscles. Peak torque ratios have been one of the measures commonly used in testing shoulder strength; given that shoulder strength rotator imbalance appears to be related to the majority of overhead sports injuries.\textsuperscript{11-14} Malliou et al compared 3 training modes in a 6-week exercise program in healthy subjects in order to identify the most effective method to increase shoulder ER/IR
peak torque ratios. The 3 experimental conditions included a group performing multi-joint dynamic exercise (pull-up, overhead press, reverse pull-up, and push-ups), a second group performing isolated exercises for internal and external rotation of the shoulder using a 2 kg dumbbell, and a third group performing isokinetic IR and ER shoulder strength training. The study found that all exercise training modes produced increases in strength values from 70% to 94%, although the isokinetic training program produced more significant increases in shoulder ER/IR peak torque ratios.\(^\text{15}\)

Niederbracht et al analyzed the effect of a shoulder strength training program on the eccentric strength capacity of the external rotator muscles of collegiate women tennis players. The program was conducted for 5 weeks, applying 5 resistance exercises that included shoulder ER exercises at 90°, seated row, scaption, chest press, and external shoulder rotation with TheraBand™ elastic bands. The study showed that ER/IR total work ratios tended to decrease for the control group while it increased for the experimental group. Furthermore, 3 subjects with shoulder rotator muscle imbalances at pre-test in the experimental group had improved ER/IR total work ratios to \(\geq 1.0\) after the intervention, suggesting that the program was successful at restoring the balance between external and internal rotators of the shoulder.\(^\text{16}\)

Wong and Ng found that ER/IR work ratios in healthy individuals maintain a muscle balance closer to or greater than 1, with concentric ER/IR (1.03) and eccentric ER/IR (1.13) work ratios.\(^\text{17}\) These results provided a reference of normal ER/IR work ratios in a healthy population.

Another intervention used to strengthen the rotator cuff muscles has been the use of plyometric exercises, which are commonly used in the advanced stages of rehabilitation.\(^\text{18}\) A study conducted by Carter et al looked at the effects of an 8-week program of high volume upper extremity plyometrics on ER/IR strength ratios and throwing velocity of collegiate
baseball athletes. The results confirmed that the plyometric group had an increased throwing velocity compared to the control group. In addition, a statistically significant increase occurred in peak torque values for eccentric ER in the plyometric group but not for the control group, even though the ER/IR strength ratios did not differ statistically in either plyometric group or control group.\textsuperscript{19}

Whole body vibration training (WBV) was developed in the late 20\textsuperscript{th} century for strength training and as a means of preventing bone density loss in astronauts experiencing weightlessness.\textsuperscript{20,21} WBV is applied using a mechanical device that continuously oscillates with a set frequency and amplitude transmitting vibration waves on a platform while the individual stands or exercises on it.\textsuperscript{22} Hand et al compared WBV and resistance training on isokinetic output of the rotator cuff muscles. The study involved a 10-week training program with female varsity athletes. One group received WBV training prior to resistance training sessions involving multijoint dynamic resistance exercises, while the second group only completed the resistance training sessions. Participants in the WBV group adopted a modified push up position on the vibration platform, a position that was maintained for 2 sets of 60 seconds, at 4-mm amplitude and 50 Hz frequency with a 30 second rest period between sets. The results found no significant difference in work output between WBV and resistance training groups, although both groups improved similarly from the baseline test. The findings suggested that adding WBV training to a resistance program did not provide significantly better results in rotator cuff strength than carrying out the resistance program by itself.\textsuperscript{22} However, the study did not have a group that only performed WBV training; instead they had a group that included resistance training and WBV training at the same time. Thus, there was a potential for confounding to have occurred, thus failing to show the individual effect of WBV training.
Another oscillatory device that has been included in shoulder rehabilitation programs for rotator cuff muscle strengthening is the Bodyblade® (Hymanson, Inc, Playa Del Rey, CA).²³,²⁴ It was created by Hymanson in 1991 and is comprised of a flexible blade measuring between 3.3 to 5 feet (1 to 1.52m) in length and weighing 1.25 to 2.5 pounds (0.57 to 1.13 kg) depending on the particular model (Bodyblade® Pro, Classic and CxT).²⁵ The center of the blade has a handgrip that allows for a 1-hand or 2-hand grip of the device that can be placed in the sagittal, frontal, and transverse planes of movement. The two ends of the blade can oscillate with a natural frequency of 4.5 Hz, and the vibration can challenge muscles to maintain the stability of the joint as well as controlling the movement of the device.²⁵ As the blade oscillates with greater intensity, it requires greater resistance to control the movement of the blade.²⁵ The blade can oscillate 270 times per minute and produce forces up to 151N.²⁵ Several studies have analyzed the effects of the Bodyblade®.²⁶-³³ While the majority of studies focused on measuring muscle activation through surface EMG,²⁶,²⁹-³² several have quantified strength changes during a training program²⁷,²⁸,³³. Studies that compared muscle activation between the Bodyblade® and other training conditions generally found significantly greater muscle activation for the Bodyblade®. For instance Arora et al using a sample of 12 healthy males found significantly greater anterior deltoid (TheraBand™ Flexbar 49.3% to Bodyblade® 76.9%), transverse abdominis/internal obliques (TheraBand™ Flexbar 47.0% to Bodyblade® 79.4%), and lumbosacral erector spinae (TheraBand™ Flexbar 19.4% to Bodyblade® 40.6%) MVC activation when compared to a single oscillating foam bar.²⁶ Moreside et al also found that trunk muscle activation levels could be greater when using the Bodyblade® than when using other spine stabilization exercises.³⁰ Similarly Parry et al showed significantly greater MVIC activity when using the Bodyblade® Pro than when using lightweight dumbbells for deltoid strengthening (dumbbells 33.08% to Bodyblade®
Pro 61.32%), serratus anterior (dumbbells 34.95% to Bodyblade® Pro 71.89%), pectoralis major (dumbbells 43.57% to Bodyblade® Pro 71.41%), infraspinatus (dumbbells 44.24% to Bodyblade® Pro 189.10%), and erector spinae (dumbbells 45.10% to Bodyblade® Pro 62.40%).

On the other hand, other studies failed to find strength changes using the Bodyblade®. Sugimoto and Blanpied compared the effect of an 8-week program on shoulder IR and ER strength in 40 healthy subjects using Bodyblade® versus TheraBand™. Maximal isometric torque was measured at 10° of shoulder IR and 65° of shoulder ER, as well as peak concentric and eccentric torque (between a range of 10° IR to 65° ER) at 60°.s⁻¹ and 120°.s⁻¹ speeds. The results indicated no significant improvement in shoulder IR and ER strength in the Bodyblade® group over TheraBand™ training or control group. An important limitation in the study was that the control group had disproportionately more males (6 males of 14) with greater height (174.7 cm), weight (76.4 kg), and strength values than found in the Bodyblade® (4 males of 10, 169.2 cm and 71.3 kg) and TheraBand™ groups (3 males of 9, 168.4 cm and 70.8 kg). In addition, the study used a limited number of Bodyblade® exercises to improve shoulder ER/IR strength.

Lake examined the effects of a 10-week Bodyblade® training program on shoulder rotation strength and throwing velocity in 26 collegiate athletes. IR and ER strength were measured through a modified cable tensiometer while throwing velocity was tested with a radar gun. No significant differences in shoulder rotation strength were found between the control group and the Bodyblade® group at pre-test or post-test. However, significant increases in throwing velocity were found in the Bodyblade® group compared to the control.

One case study evaluated the outcome of the Bodyblade® training over a period of 4-6 weeks as a conservative treatment of glenohumeral instability. The patient in this study
was an 18-year old male with right hand dominance, who was diagnosed with left shoulder dislocation. A handheld dynamometer was used to measure strength in both the involved and uninvolved sides, with measures taken at initial evaluation and at discharge. The progression of exercises using the Bodyblade® increased in difficulty from bilateral grip to unilateral, from partial range of motion to full range of motion, and to repeated proprioceptive neuromuscular facilitation (PNF) patterns. Subsequently, distal support was challenged by standing on 1 leg while performing the above exercises and finally carrying out these exercises with bilateral and unilateral grip extensions in a prone position while over a Swiss ball. The results confirmed a marked strength improvement in shoulder flexion (21 to 42 pounds of force), internal rotation (16 to 26 lbs.), scapular retraction (17 to 22 lbs.), and depression (12 to 23 lbs.) at discharge.

Because of weaknesses in study designs and generalizability issues in the aforementioned studies, it remains unclear whether the Bodyblade® is an effective tool in strengthening the rotator cuff muscles of the shoulder.

A more recent oscillating blade device known as the Staby Professional was developed in Germany by Burkhardt in 2001. The Staby Professional device has distinctive features compared to the Bodyblade®. The oscillating pole in the Staby Professional device is made of modern fiberglass material. Additionally it has 2 semi-ball caps at both ends of the pole that can adjust the intensity of vibration in the pole. The pole has a length of 1.5 m (28 cm longer than the Bodyblade®) and weighs 0.8 kg (0.12 kg heavier than the Bodyblade®). The Staby Professional device also has a natural frequency of 4.77 Hz (0.27 Hz higher than the Bodyblade®) and can oscillate 286 times per minute compared to 277 in the Bodyblade®.

No studies were found in the published English literature that examined the effects of the Staby Professional device, however 3 studies were conducted on a similar device called
the FLEXIBAR™ (Flexi-Sports, Bisley, Stroud, UK). The FLEXIBAR™ is also an oscillatory pole made of fiberglass material and developed by German physiotherapists with very similar characteristics to the Staby Professional device. The FLEXIBAR™ has a length of 1.52 m, weighs 0.72 kg, and has a natural frequency of 5 Hz. The only major difference that distinguishes the Staby Professional device from the FLEXIBAR™ is the 2 adjustable semi-ball caps at both ends of the pole. Mileva et al found that in 9 healthy men the FLEXIBAR™ produced greater muscle activation in the muscles involved during a 1 leg squat position compared to the control sham bar, thus creating a stronger training stimulus. Similarly, Kim et al observed that in 20 healthy subjects the FLEXIBAR™ induced greater muscle activation in the erector spinae muscles when compared to bridging-only exercises. Hallal et al also found that in 12 healthy females the FLEXIBAR™ significantly increased the activation of upper trapezius, lower trapezius, and middle deltoid muscles in comparison to a sham non-oscillatory pole.

No study was found that compared the strength training effects of the Bodyblade® and the Staby Professional device on the rotator cuff muscles of the shoulder. Considering that the Staby Professional device has a higher natural frequency and higher number of oscillations per minute than the Bodyblade®, it could have a greater potential to increase strength than the Bodyblade® due to increased resistance derived from the higher number of oscillations per minute. Likewise the Staby Professional device has a greater length and weight than the Bodyblade®, thus requiring greater torque to control the oscillations produced by the device.

The purpose of the present study was to compare the strength changes in Bodyblade® and Staby Professional device training over a 6-week program. It was hypothesized that training with the Staby Professional device would produce significantly greater strengthening in shoulder IR and ER as compared to training with the Bodyblade® (Hypothesis 1). It was
further hypothesized that there would be a significant increase in shoulder IR and ER strength from pre-test to post-test in both groups (Hypothesis 2).

METHODS

Design

This study used an experimental, randomized two group pre-test post-test design. The dependent variables in the study were average isometric peak force in shoulder IR and ER; and the independent variable was the training device (Staby Professional device and Bodyblade®).

Participants

Thirty participants (12 male and 18 female) from New York University were recruited as a sample of convenience to participate in this study by posting flyers in New York University’s Physical Therapy Department and major buildings around campus. Three participants dropped out during the training program, therefore resulting in a total sample of 27 participants (12 male and 15 female). Fourteen participants were in the Bodyblade® group, and thirteen participants were in the Staby Professional device group; this number is consistent with the sample size used in previous studies that tested strength changes in IR and ER of the shoulder after training with an oscillation device.28,33 Interested individuals contacted the investigator and were informed about the study and criteria for inclusion (Table 1).

All participants met the following criteria: 1) male or female volunteers between the ages of 18 and 45 years of age; and 2) individuals, who are able to read and speak English (8th grade level). Participants were excluded from the study if they had: 1) a history of shoulder instability; 2) limited shoulder or elbow motion on the dominant side; 3) an existing or a previous shoulder injury in the last 3 months on the dominant side (ie, tendonitis, bursitis, sprain, strain, dislocation, or subluxation); 4) surgery or physical therapy on their
dominant upper extremity in the past 12 months; 5) a history of cardiovascular disease (heart attack, heart surgery, heart valve disease, heart transplantation, hypertension, or congenital heart disease); 6) currently undergoing a strength training program on their dominant upper extremity; 7) currently practicing overhead sports (tennis, baseball, volleyball, climbing and throwing activities); and 8) females volunteers, who were pregnant.

**Procedures**

This study secured approval by the University Committee on Activities Involving Human Subjects (IRB#:15-10481). All participants reported to the Arthur J Nelson Human Performance Laboratory in the Department of Physical Therapy of New York University. Participants were provided with an informed consent, and they completed a questionnaire to collect demographic data (age and gender), medical history, and arm dominance information.

**Randomization**

Participants were randomly assigned in 1 of 2 groups: Bodyblade® training (BT) group or Staby Professional device training (ST) group using a table of random numbers.

**Shoulder Strength Measurements**

The Micro FET2 Hand Held Dynamometer HHD (Hoggan Health industries, Draper, UT, USA) was used to measure average isometric peak force. The dynamometer is a battery-operated, load cell system with a digital reading of peak force allowing for data to be recorded at low or high threshold. The low threshold setting was used in this study as it allowed for sensitive strength recording in the range of 0.8-100 pounds. The device was calibrated according to the manufacturer’s guidelines and the energy level of the batteries was monitored throughout testing.

Cools et al had shown that the intra-rater and inter-rater reliability of the HHD in shoulder ER and IR can be high (ICC’s between 0.93 and 0.99); and their testing was performed with a sample of 30 asymptomatic adults with the following mean and standard
deviation () demographics; 22.1(1.4) years, 76.8(17.8) kg and 1.72 (1.9) meters.\textsuperscript{39} Testing was conducted by 2 experienced examiners, a male examiner 1.73 meters high and weighing 75 kg and a female examiner 1.63 meters high and weighing 59.5 kg.\textsuperscript{39} The validity of the HHD in shoulder ER was tested by Roy et al in 38 participants (21 men and 17 women) with a mean age of 29.7 for men and 24.9 for women. The study included 2 physical therapists as testers, (tester 1: height = 1.73 m, weight = 75 kg; tester 2: height = 1.80 m, weight = 79.5 kg). Pearson product correlation coefficient showed high correlation (r = 0.85) between the HHD and the LIDO static dynamometer.\textsuperscript{40} The seated testing position has been recommended in the literature as it provides reliable measures.\textsuperscript{39,41}

**Pre-test**

Pre-testing was conducted 1 week before the commencement of the training program. Participants were given instructions about the 2 testing positions in shoulder IR and ER. A warm up period of 5 minutes consisted of shoulder IR/ER TheraBand™ exercises with light resistance (yellow/red band) and a pendulum exercise for the dominant shoulder. Participants were then placed in the seated position with their shoulder in 0° adduction, upper arm at 0° rotation, elbow at a 90° flexion, and the wrist in neutral rotation as suggested by Reimann et al.\textsuperscript{41} The non-tested arm rested in the participant’s lap. The contact surface of the HHD was placed on the distal aspect of the radial/ulnar region, on the posterior side of the hand for ER and anterior side for IR.

Once in position, the participant performed 1 isometric contraction of IR and ER against the tester’s hand to ensure the correct action was carried out. Then a “make” test was performed by gradually increasing resistance up to maximum voluntary effort over a 2-second period and holding the maximum voluntary effort for 5 seconds without breaking the participant’s strength.\textsuperscript{41} If the participant “broke” the resistance (ie, did not maintain muscle contraction), then data were not recorded, and the test was repeated. The commands “When I
say go! Take 2 seconds to come to your maximal effort, then push as hard as you can against me, Harder, Harder and Relax” was given to carry out maximal IR and ER efforts for each test. The intensity of the commands was controlled by playing a recording for all participants.

Isometric strength measurements were recorded for 3 test repetitions in shoulder IR and ER, then an average was taken from the 3 recordings for data collection. Participants rested for 30 seconds between measurements and for 1 minute between tests positions (ER/IR). Testing sequence in IR/ER was alternated between participants to avoid any order effects in the data.

**Training Equipment**

As mentioned above, the 2 devices used were, the Bodyblade® Classic (Hymanson, Inc, Playa Del Rey, CA) and the Staby Professional device (S.W.H.C GmbH Schlingenerstr. Germany). The devices were examined before and after interventions to ensure proper device operation.

**Training Program**

Both groups performed the same exercise program over a period of 6 weeks, as described in Table 2. The first session began with instructions on the use of the oscillating device. Each participant received instructions in how to perform each exercise with the correct technique. The grip emphasized a neutral wrist position, maintaining the center ridge in the blade between the thumb and the index finger. As vibration was produced, the hand holding the device would only move about 1 inch to sustain a continuous vibration through the exercise. Posture and alignment were maintained throughout the exercise, keeping shoulders and neck relaxed. While vibrating the oscillating device the trunk remained stable and the head looked forward. The intensity of oscillation performed by each participant was visually monitored to ensure it remained consistent throughout all sessions. Once the participant indicated sufficiency in maintaining continuous speed and tempo with the
oscillating device, as well as performing the exercise with correct technique, an exercise session would follow.

Five exercises were included in the program involving shoulder movements (flexion/extension, abduction/adduction, IR/ER, and horizontal abduction/adduction) in 3 axis (X, Y and Z). Exercises were performed on the dominant shoulder, defined as the shoulder used for throwing a ball. During week 1 through 4, the participants completed 4 exercises in the standing position, involving forward flexion at 90°, shoulder abduction at 90°, scaption at 45° of horizontal abduction, and external rotation at 0° abduction with 90° of elbow flexion and neutral wrist. An additional exercise of overhead flexion at 180° was introduced in week 5 and 6. These progressions were used by Buteau et al, who showed significant strength gains after training with the Bodyblade®. Training sessions were conducted 3 times per week and each session lasted between 10-12 minutes. Each exercise set was 30 seconds, which was applied in accordance with the manufacturer’s recommendations for both devices.25,34

Post-test

Post-testing was completed at least 1 day but no more than 7 days after the last training session of the program. The procedures were similar to those used during the pre-testing session; the sequence of IR and ER testing was the same as used during pre-test.

Assumptions

The following assumptions were made; all testing and training equipment would remain in optimal conditions for its use. Participants were honest about their medical history.
Participants taking part in the exercise program would offer their true effort while training with the oscillating device and during testing. The motivation levels of participants would remain stable throughout the program.

**Delimitations**

This study did not conduct EMG activity of the IR and ER muscles as there have been previous studies that examined this variable during training with an oscillation device.\textsuperscript{31,32} Average isometric peak force only measured IR and ER as these muscles have been shown to contribute clinically to shoulder joint stability.\textsuperscript{6-8}

**Statistics Analysis**

This study collected descriptive data on the 2 group’s characteristics including: age, gender, shoulder dominance (right or left), and attendance rate. These data are presented as a summary table in the results section of the study. Average isometric peak force data were examined for normal distribution, and statistical assumptions were checked.

To determine group equivalence prior to the training program, an independent t-test was used on pre-test scores for shoulder internal and external rotator muscles. To determine differences between groups following the intervention, an independent t-test was carried out on post-test scores on these 2 muscle groups. Additionally a paired t-test was used to examine differences within-subjects (pre-test and post-test scores) for each group (Bodyblade® and Staby Professional device). The level of significance for the study was set at alpha = .05, however as multiple t-tests were used, this was adjusted to P< .006 (Bonferroni correction = 0.05/8). The statistical package SPSS (IBM, version 22.0) was used for analysis.

The study included supplementary analysis reporting shoulder ER/IR average peak isometric force ratios for each group at pre-test and post-test. A paired t-test was used to examine differences from pre-test to post-test ratio scores for each group (Bodyblade® and Staby Professional device).
RESULTS

In total, 27 participants completed the study and 3 discontinued the training program. In the Bodyblade® group, 1 participant failed to complete the training program due to time constraints. In the Staby Professional device group, 1 participant left the program due to lack of interest while yet another participant stopped the training program due to an illness unrelated to exercise.

Descriptive Statistics

The group characteristics in Table 3 show a balanced distributed sample of participants in the Bodyblade® (14) and Staby Professional device (13) groups with mean ages of 28.6 and 27.1 years respectively. Age was not statistically significant (p = .354), between the 2 groups. Shoulder dominance was predominantly greater for the right side (n = 26), compared to the left side (n = 1). The attendance rate for the Bodyblade® and Staby Professional device group was 92% and 94% respectively.

The boxplots in Figures 1 and 2 show the distribution of the scores in each group with an increase in peak force from pre-test to post-test for shoulder ER and IR isometric strength. The boxplots in Figure 1 reveal one outlier for the Bodyblade® group at post-test for ER isometric strength. In addition, the pre-test median ER strength score for the Staby Professional device group was lower and its post-test scores contained more variability as compared to the Bodyblade® group.

The boxplots in Figure 2 show symmetric distributions for the Bodyblade® and Staby Professional device group for IR force distributions at pre-test and post-test. The Bodyblade® group had two outliers at pre-test IR and one outlier at post-test IR.

Data met the assumptions for use of parametric statistics, as the Lavene’s test for equality of variance was not significant between the Bodyblade® and Staby Professional
device groups at pre-test IR (p = .947) and ER (p = .159) nor at post-test IR (p = .887) and ER (p = .990).

**Inferential Statistics**

Group equivalence at baseline was compared at pre-test between Bodyblade® and Staby Professional device groups, showing no significant difference in ER peak isometric forces (p = .157) or IR peak isometric forces (p = .403) (Table 4).

Differences were compared at post-test between Bodyblade® and Staby Professional device groups, showing no statistical significance, ER (p = .171) or IR (p = .308), thus rejecting hypothesis 1 that stated that the Staby Professional device training would produce significantly greater strengthening in shoulder IR and ER (Table 5).

However, research hypothesis 2 was accepted as the Bodyblade® and Staby Professional device individually yielded significant improvements from pre-test to post-test in ER (p = .0002) and IR peak isometric force (p = .0002) respectively as shown in Tables 6 and 7 and Figures 3 and 4.

Supplemental analyses revealed small increases in average peak isometric ER/IR force ratios from pre-test to post-test for both the Bodyblade® (4% increase) and Staby Professional device (5.7% increase), although these changes were not statistically significant for either the Bodyblade® (p = .416) or Staby Professional device (p = .308) groups, (Table 8).

**DISCUSSION**

This study found no significantly greater strengthening effect in shoulder IR and ER with the Staby Professional device training compared to the Bodyblade® training (Hypothesis 1). However, the study did find a significant increase in ER and IR strength from pre-test to post-test for both the Bodyblade® and Staby Professional device groups
(Hypothesis 2). Furthermore, ER/IR strength ratios were maintained throughout the study suggesting strengthening of both agonist and antagonist muscles occurred during both Staby Professional device and Bodyblade® training.

The first hypothesis was not supported in this study; after 6 weeks of training, the Staby Professional device did not produce significantly greater strengthening in shoulder IR and ER than the Bodyblade®, suggesting that both devices produced a similar effect. Therefore, the features of the Staby Professional device - greater length (28cm longer than the Bodyblade®), weight (0.12 kg heavier than the Bodyblade®), and oscillation frequency of 286 times per minute compared to 277 in the Bodyblade® - did not significantly improve strength over the Bodyblade®. The Staby Professional device may not have produced a physiologic response greater than that of the Bodyblade® in this study. For instance, the effect of vibration on a muscle can stimulate the muscle spindle, which in turn excites α-motor neurons, producing contractions of homonymous motor units - a response known as the tonic vibration reflex. The Staby Professional device’s vibration may not have excited greater numbers of motor neurons through the action of the tonic vibration reflex than those of the Bodyblade®, as their overall designs are not that different.

For hypothesis 2, the present study did show a significant increase in ER and IR strength from pre-test to post-test for both the Bodyblade® and Staby Professional device group. This finding can be of importance as it showed that a 6-week training program with either Bodyblade® or Staby Professional device can increase shoulder ER (Bodyblade® 40% increase and Staby 39% increase) and IR average peak isometric forces (Bodyblade® 32% and Staby 28% increase) in healthy young adults.

The case study conducted by Buteau et al supported an increase in IR strength after 6 weeks of training using the Bodyblade® in an 18-year old male patient with a shoulder dislocation. However, as there are few studies that can be found on rotator cuff muscle
strengthening with either the Bodyblade® or Staby Professional device training, the present study is the first to find a significant increase in shoulder ER and IR strength in both devices.

Lake failed to find a significant improvement in shoulder IR and ER strength in a 10-week Bodyblade® training program in 26 collegiate athletes, although they did find a significant increase in throwing velocity following Bodyblade® training. Sugimoto and Blanpied also found no significant improvement in shoulder IR and ER strength in the Bodyblade® group over TheraBand™ training or a control group. Although improvements were noted from pre-test to post-test in shoulder IR and ER strength for the Bodyblade® group, these findings were not statistically significant. This lack of significance may have been attributed to their control group, which had a disproportionally higher number of males with greater height, weight, and strength values than the Bodyblade® and TheraBand™ groups. Additionally, their study failed to include a variety of Bodyblade® exercises used to target shoulder ER/IR strengthening. Only two exercises were included in their study; the first exercise with the shoulder in neutral abduction and 10° of IR and the second exercise with the shoulder in neutral abduction and 65° of ER.

In contrast, the present study included 5 exercises in the training program, all in the standing position, involving forward flexion at 90°, shoulder abduction at 90°, overhead flexion at 180°, scaption at 45° of horizontal abduction, and external rotation at 0° abduction with the elbow flexed to 90° and the wrist in neutral. The variety of exercises in this study may have been a factor in increasing shoulder ER and IR average peak isometric force from pre-test to post-test in the Bodyblade® and Staby Professional device groups as there were more opportunities to load these muscles in different positions. The rotator cuff muscles may have also been challenged to maintain a greater muscular effort in sustaining device vibration in these 5 different positions, as several were quite demanding compared to the effort of everyday activities.
In this study the majority of participants verbally reported that the most difficult exercise to perform was overhead flexion at 180°. This may be explained by the fact that the glenohumeral joint is more unstable in the overhead flexion position, where the rotator cuff limits translation of the humeral head. Therefore, participants may have found overhead flexion to be more challenging as the joint needed greater stabilization from the rotator cuff muscles in this position.

Improving the ER/IR average peak isometric force ratio may be a key in preventing shoulder injuries. Clarsen et al has showed a significant association between ER weakness and increased probability of substantial shoulder problems for the season in elite male handball players. In healthy individuals, ER/IR work ratios maintain a muscle balance closer to or greater than one. Genevois et al conducted a 6-week sling training program on 26 female handball players and found that after 6 weeks of sling training, the ER/IR strength ratio improved (6.3% increase), although this change was not statistically significant. The present study also found the ER/IR average peak isometric force ratio to improve a little for the Bodyblade® (4% increase) and the Staby Professional device group (5.7% increase) with changes not statistically significant for either the Bodyblade® (p = .416) or Staby Professional device (p = .308) group. This finding can be explained because localized vibratory devices such as the Staby and Bodyblade® function through oscillation and therefore target both agonists and antagonists during an exercise. Gains would be noted in both ER and IR strength, as found in the present study. These devices also have a unique advantage over other upper extremity strengthening equipment in that these devices efficiently target both sides of the joint (agonists and antagonists) during the same exercise. In addition, training periods are brief, as described in this study, only requiring a user commitment of 10 to 12 minutes a day.
Although the findings of the present study do not support gains in shoulder ER/IR strength ratios, they do support the use of the Bodyblade® and Staby Professional device as tools to strengthen shoulder musculature, which may be important in injury prevention and management. Abdulla et al conducted a systematic review on the effectiveness of exercise therapy (stretching, strengthening, and aerobic exercises) compared to controls (placebo or no interventions) and concluded that supervised progressive shoulder exercises alone or combined with home-based shoulder exercises (strengthening with or without stretching) can be effective for the short-term management of subacromial impingement syndrome.\textsuperscript{45}

While this study has several strong design features (a randomized design; a standardized exercise protocol; validated objective force measure), some limitations exist. The primary limitation was the lack of a true control group, which would have served as a non-treatment comparison for both the Bodyblade® group and Staby Professional device group to guard against maturational effects. In addition, pre-test and post-test assessments were not blind to group assignment. Nevertheless, blinding is more critical when subjective measures are used; in this study standardized procedures and dynamometer instrumentation were employed. The level of intensity of the vibrating devices could not be confirmed objectively during the protocol. While it might have been possible that some subjects used the devices incorrectly, all were trained and supervised during the protocol. Although attendance rates were high and similar between groups, 3 female participants did drop out in the study. Nevertheless, attrition amounted to far less than 20% of the sample and was limited to the same gender. Finally, generalizability of findings are limited to a young healthy population using static strength outcomes rather than to persons with shoulder pathology or athletes with dynamic performance requirements.

CONCLUSION
After 6 weeks of training, the Staby Professional device did not have a significant effect on shoulder IR and ER strengthening over the Bodyblade® device. However, both device groups did significantly improve in IR and ER strength at posttest compared to their pretest. Upper extremity localized vibratory devices should be evaluated in persons undergoing shoulder rehabilitation. In addition, rotator cuff injury wellness and prevention programs using these devices should be evaluated in populations at risk.
REFERENCES


Table 1. Study Recruitment Consort Diagram

| Enrolment | Assessed for eligibility $n = 32$ | Excluded $n = 2$
Did not meet inclusion criteria $n = 2$
Refused to participate $n = 0$
Other reasons $n = 0$

| Allocation | Randomized $n = 30$

| Allocation to Bodyblade® group $n = 15$
Received intervention $n = 15$
Did not receive intervention $n = 0$

| Allocation to Staby Professional device group $n = 15$
Received intervention $n = 15$
Did not receive intervention $n = 0$

| Follow-up | Discontinued intervention $n = 1$
Reason: Time constraints

| Discontinued intervention $n = 2$
Reason: Bored with exercises
Reason: Illness unrelated to exercise

| Analysis | Analyzed $n = 14$
Excluded from analysis $n = 1$
Reason: Incomplete data

| Analyzed $n = 13$
Excluded from analysis $n = 2$
Reason: Incomplete data |
Table 2. Oscillation Training Exercise Program

<table>
<thead>
<tr>
<th>Week</th>
<th>Axis</th>
<th>Oscillation</th>
<th>Upper extremity</th>
<th>Shoulder Movement Exercise</th>
<th>Position</th>
<th>Sets (per set)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>Superior/Inferior</td>
<td>Dominant</td>
<td>Flexion/Extension at 90°</td>
<td>Standing</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>Medial/Lateral</td>
<td></td>
<td>Abduction/Adduction</td>
<td></td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Internal/External rotation</td>
<td>Bilaterally</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Horizontal Abduct/Add</td>
<td></td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td>2</td>
<td>X</td>
<td>Superior/Inferior</td>
<td>Dominant</td>
<td>Flexion/Extension at 90°</td>
<td>Standing</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>Medial/Lateral</td>
<td></td>
<td>Abduction/Adduction</td>
<td></td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Internal/External rotation</td>
<td>Bilaterally</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Horizontal Abduct/Add</td>
<td></td>
<td>2</td>
<td>30sec</td>
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<tr>
<td>3</td>
<td>X</td>
<td>Superior/Inferior</td>
<td>Dominant</td>
<td>Flexion/Extension at 90°</td>
<td>Standing</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>Medial/Lateral</td>
<td></td>
<td>Abduction/Adduction</td>
<td></td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Internal/External rotation</td>
<td>Bilaterally</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Horizontal Abduct/Add</td>
<td></td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td>4</td>
<td>X</td>
<td>Superior/Inferior</td>
<td>Dominant</td>
<td>Flexion/Extension at 90°</td>
<td>Standing</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
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<td>Z</td>
<td>Medial/Lateral</td>
<td></td>
<td>Abduction/Adduction</td>
<td></td>
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<td>30sec</td>
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<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Internal/External rotation</td>
<td>Bilaterally</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
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<td>Horizontal Abduct/Add</td>
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<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td>5</td>
<td>X</td>
<td>Superior/Inferior</td>
<td>Dominant</td>
<td>Flexion/Extension at 90°</td>
<td>Standing</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>Medial/Lateral</td>
<td></td>
<td>Abduction/Adduction</td>
<td></td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
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<td>Medial/Lateral</td>
<td></td>
<td>Internal/External rotation</td>
<td>Bilaterally</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Horizontal Abduct/Add</td>
<td></td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>Superior/Inferior</td>
<td>Dominant</td>
<td>Flexion/Extension at 180°</td>
<td></td>
<td>1</td>
<td>30sec</td>
</tr>
<tr>
<td>6</td>
<td>X</td>
<td>Superior/Inferior</td>
<td>Dominant</td>
<td>Flexion/Extension at 90°</td>
<td>Standing</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Z</td>
<td>Medial/Lateral</td>
<td></td>
<td>Abduction/Adduction</td>
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<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Internal/External rotation</td>
<td>Bilaterally</td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>Y</td>
<td>Medial/Lateral</td>
<td></td>
<td>Horizontal Abduct/Add</td>
<td></td>
<td>2</td>
<td>30sec</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>Superior/Inferior</td>
<td>Dominant</td>
<td>Flexion/Extension at 180°</td>
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<td>2</td>
<td>30sec</td>
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### Table 3. Group Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Bodyblade®</th>
<th>Staby Professional device</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (male/female)</td>
<td>14 (6/8)</td>
<td>13 (6/7)</td>
<td>27 (12/15)</td>
</tr>
<tr>
<td>Mean age (SD), years</td>
<td>28.6 (4.4)</td>
<td>27.1 (4.2)</td>
<td>27.9 (4.3)</td>
</tr>
<tr>
<td>Attendance Rate</td>
<td>92%</td>
<td>94%</td>
<td>93%</td>
</tr>
<tr>
<td>Shoulder dominance</td>
<td>Right:13</td>
<td>Left: 1</td>
<td>Right:26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Left: 1</td>
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</table>

*Independent t-test on age between groups (p= .354) was not significant.

### Table 4. Group Equivalence at Pre-test

<table>
<thead>
<tr>
<th>Independent t-test</th>
<th>N</th>
<th>Mean and Standard Deviation</th>
<th>Sig. (1 tailed)</th>
<th>95% Confidence Interval of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Pre-test External</td>
<td>Bodyblade®</td>
<td>14 (7.2 (1.45)</td>
<td>.157</td>
<td>.606</td>
</tr>
<tr>
<td>rotation Average</td>
<td></td>
<td></td>
<td></td>
<td>Upper</td>
</tr>
<tr>
<td>Peak Isometric</td>
<td></td>
<td></td>
<td></td>
<td>1.815</td>
</tr>
<tr>
<td>force (Kgs)</td>
<td>Staby Professional device</td>
<td>13 (6.6 (1.61)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test Internal</td>
<td>Bodyblade®</td>
<td>14 (10.3 (3.85)</td>
<td>.403</td>
<td>-2.498</td>
</tr>
<tr>
<td>rotation Average</td>
<td></td>
<td></td>
<td></td>
<td>Upper</td>
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<tr>
<td>Peak Isometric</td>
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<td></td>
<td></td>
<td>3.181</td>
</tr>
<tr>
<td>force (Kgs)</td>
<td>Staby Professional device</td>
<td>13 (9.9 (3.26))</td>
<td></td>
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</tr>
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</table>
### Table 5. Group Differences at Post-test

<table>
<thead>
<tr>
<th>Independent t-test</th>
<th>N</th>
<th>Mean and Standard Deviation</th>
<th>Sig. (1 tailed)</th>
<th>95% Confidence Interval of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-test External rotation Average Peak Isometric force (Kgs)</td>
<td>Bodyblade®</td>
<td>14</td>
<td>10.1 (2.68)</td>
<td>.171</td>
</tr>
<tr>
<td></td>
<td>Staby Professional device</td>
<td>13</td>
<td>9.2 (2.46)</td>
<td></td>
</tr>
<tr>
<td>Post-test Internal rotation Average Peak Isometric force (Kgs)</td>
<td>Bodyblade®</td>
<td>14</td>
<td>13.6 (4.85)</td>
<td>.308</td>
</tr>
<tr>
<td></td>
<td>Staby Professional device</td>
<td>13</td>
<td>12.7 (3.75)</td>
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### Table 6. Bodyblade® Group Average Peak Isometric force from Pre-test to Post-test

<table>
<thead>
<tr>
<th>Paired t-test</th>
<th>N</th>
<th>Mean and Standard Deviation</th>
<th>Percent change</th>
<th>Sig. (1 tailed)</th>
<th>95% Confidence Interval of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bodyblade®</td>
<td>Pre-test ERAPIF (Kgs)</td>
<td>14</td>
<td>7.2 (1.45)</td>
<td>40%</td>
<td>.0002</td>
</tr>
<tr>
<td></td>
<td>Post-test ERAPIF (Kgs)</td>
<td>14</td>
<td>10.1 (2.68)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pre-test IRAPIF (Kgs)</td>
<td>14</td>
<td>10.3 (3.85)</td>
<td>32%</td>
<td>.0002</td>
</tr>
<tr>
<td></td>
<td>Post-test IRAPIF (Kgs)</td>
<td>14</td>
<td>13.6 (4.85)</td>
<td></td>
<td></td>
</tr>
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</table>
Table 7. Staby Professional device Group Average Peak Isometric force from Pre-test to Post-test

<table>
<thead>
<tr>
<th>Paired t-test</th>
<th>N</th>
<th>Mean and Standard Deviation</th>
<th>Percent change</th>
<th>Sig. (1 tailed)</th>
<th>95% Confidence Interval of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Staby Professional device</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test ERAPIF (Kgs)</td>
<td>13</td>
<td>6.6 (1.61)</td>
<td>39%</td>
<td>.0002</td>
<td>1.623</td>
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<tr>
<td>Post-test ERAPIF (Kgs)</td>
<td>13</td>
<td>9.2 (2.46)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pre-test IRAPIF (Kgs)</td>
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<td>9.9 (3.26)</td>
<td>28%</td>
<td>.0002</td>
<td>1.828</td>
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<tr>
<td>Post-test IRAPIF (Kgs)</td>
<td>13</td>
<td>12.7 (3.75)</td>
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</table>

Table 8. Average Peak Isometric force ratios from Pre-test to Post-test

<table>
<thead>
<tr>
<th>Paired t-test</th>
<th>N</th>
<th>Mean and SD</th>
<th>Percent change</th>
<th>Sig. (1 tailed)</th>
<th>95% Confidence Interval of difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>Bodyblade®</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test ER/IR Strength Ratio</td>
<td>14</td>
<td>0.75 (0.15)</td>
<td>4%</td>
<td>.416</td>
<td>-0.041</td>
</tr>
<tr>
<td>Post-test ER/IR Strength Ratio</td>
<td>14</td>
<td>0.78 (0.14)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Staby Professional device</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test ER/IR Strength Ratio</td>
<td>13</td>
<td>0.70 (0.14)</td>
<td>5.7%</td>
<td>.268</td>
<td>-0.031</td>
</tr>
<tr>
<td>Post-test ER/IR Strength Ratio</td>
<td>13</td>
<td>0.74 (0.11)</td>
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</tbody>
</table>
Figure 1. Boxplot-External Rotation Average Peak Isometric force from Pre-test to Post-test

Figure 2. Boxplot- Internal Rotation Average Peak Isometric force from Pre-test to Post-test
Figure 3. Bar graph- External Rotation Average Peak Isometric force from Pre-test to Post-test

Figure 4. Bar graph- Internal Rotation Average Peak Isometric force from Pre-test to Post-test