THE EFFECT OF SHOULDER STABILITY EXERCISES ON BENCH PRESS ONE-REPETITION MAXIMUM RESULTS

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The purpose of this investigation was to determine whether the performance of shoulder stability exercises prior to a bench press 1-repetition-maximum (1RM) protocol would improve strength results. Sixteen males whom were previous or current collegiate athletes, or competitive lifters participated in 3 testing sessions separated by a minimum of 48 hours. During each testing session, a 1RM protocol was performed on the bench press. After a general warm-up, subjects performed the 1RM protocol that consisted of submaximal sets with increasing loads prior to attempting the 1RM lifts. The testing protocols were performed in a randomized order, including the standard (SD) 1RM, or

either high or low intensity shoulder-stability exercises before the 1RM protocol. The exercises consisted of a push-up plus, body row, press-up, a full-can raise, and internal and external rotations. During the light-intensity trial (L+SD), a Total Resistance Exercise Suspension Trainer (TRX) was used to raise the level of instability, while a weight-vest was used to increase the intensity of the high-intensity trial (H+SD). Analysis of the data exhibited no significant differences between the three trials (P=0.852). Regardless of the statistical insignificance, the inclusion of various forms of instability have shown increases in muscle activation, therefore, future research should investigate the possibilities of a TRX suspension trainer making its way into strength and conditioning, and/or rehabilitation programs.

CHAPTER I

THE EFFECTS OF EXERCISE MODIFICATIONS AND STRATEGIES TO ENHANCE HUMAN PERFORMANCE: A LITERATURE REVIEW

The performance of warm-up routines prior to exercise has widely been accepted through many of the realms of physical activity. One of the primary purposes of participating in a warm-up is to reap the benefits from the increase in body temperature, whether or not this is the understood goal of the participant. An increased body temperature, through passive or active techniques, is thought to contribute to decreases in stiffness, raises in nerve-conduction rates, changes in force-velocity relationships, and improvements in anaerobic energy provision (Bishop, 2003); therefore, it is important to properly activate as many of the muscles involved in the activity through a proper warm-up. In addition to these proposed temperature related changes, comes the psychological effect of feeling “more prepared,” as well as other physiological changes including differences in elevated baseline oxygen consumptions (VO_2) and improvements in post-activation potentiation (PAP) protocols (Bishop, 2003). The amount either of these two physiological changes improves performance is dependent on the type of exercise being tested. During longer, aerobically driven activities, the increased VO_2 baseline would help preserve intramuscular energy stores by reducing anaerobic metabolism, whereas

PAP protocols may bring improvements in performance with possible mechanisms such as increasing neural drive. The object of this literature review was to compile previously completed research to determine the best practices for muscle activation and warm-up protocols, in efforts to improve upper-body strength performance.

Methods

The research articles for this review were discovered while examining information on the Physical Education Index, Google Scholar, and SPORTdiscus databases, along with reviewing the reference lists of the relevant research articles. On each occasion the databases were reviewed with key words "warm-ups," "potentiation," "muscle activation," "instability," "rotator cuff," "shoulder stability," "bench press," and "resistance training." All articles included in this review were found via the university's library database or as an interlibrary loan. They all had to be written in English, and have been published in a peer-reviewed journal post 1980. Articles were excluded if they were subjective in nature, or a case study. Using these techniques, 53 studies were gathered and evaluated for applicability to this research. The studies were then split into experimental and non-experimental groups. This was in order to allow the focus to be placed on experimental research only.

Results

This literature examination recognized 25 articles for having contributing information. Of these articles, 6 examined differing warm-up protocols, 12 covered muscle activation techniques, and 7 evaluated the effects of post-activation potentiation. Though not all of the research encountered significant effects, all but one for each category, most all provided sufficient insight into their experimental processes. This allowed for adequate judgment of their research designs, and aided in determining which practices to implement into this experimental research study.

Discussion

Warm-ups

Research findings encompassing different warm-up protocols, ranging from general to specific (e.g. light aerobic activities-to-high intensity sets of the questioned exercise), have been tested for improvements in athletic performances. Six-research articles addressing the effects of warm-ups on various performances were assessed, with all but 1 showing significant improvements. Pearce, Rowe, & Whyte (2012) observed decreases in muscle fiber conduction times in the abductor pollicis brevis (APB) and the gastrocnemius using transcranial magnetic stimulation (TMS) and M-wave techniques when studying 18 healthy males. After the general warm-up activity, consisting of 5 minutes of running at 65% heart rate max (HR_{max}), the average decreases in conduction times (time to peak force) were 0.43 ms and 0.30 ms in the APB (passive muscle), and 0.29 ms and 0.87 ms in the gastrocnemius (active muscle), for TMS and M-wave techniques respectively. Latency was used to measure neural conduction time, from brain to muscle, using motor evoked potential (MEP), where the stimulus causes depolarization of neural tissue to elicit a response. Unlike the significant results seen in the muscle fiber conduction times, there were no significant differences in the neural conduction times. The limitation to this study is that the specific mechanisms behind the 5-8.5% improvements in muscle conduction times were not established. More research is needed to differentiate the effects of muscular and core temperature on neural and muscular conduction times.

Concurring with the aforementioned study by Pearce et al. (2012), general warm-ups are believed to be appropriate for increasing body temperature. In addition to this, a study by Abad, Prado, Ugrinowitsch, Tricoli, & Barroso (2011), stated that specific warm-ups should be used to increase neuromuscular activation, but the combination of the two warm-ups needed to be tested. In efforts to determine if both a general and specific warm-up is superior to just a specific warm-up, Abad et al. (2011) tested 13 healthy males on one-repetition maximum (1RM) leg press. The first warm-up condition was the specific warm-up only (SWU), and was comprised of 1 set of 8 repetitions at approximately 50% of the estimated 1RM followed by another set of 3 repetitions at 70% of the estimated 1RM. The second condition consisted of a 20-minute general warm-up on a stationary cycle at 60% HR_{max} and the same specific warm-up as the SWU. Strength results from the general + specific warm-up (G+SWU) condition were significantly higher than that of the SWU trial by 8.4%, and were attributed to temperature-dependent neuromuscular adjustments increasing the muscle force production capacities. A limitation to this study is the lack of temperature measurements. To contribute the differences in results to that of temperatures would seem to require the actual collection of these values for validation. To further these findings, a recommendation for future research is to determine what affects this increased temperature has on muscle coordination.

Veering toward improvements in anaerobic athletic performances, Needham, Morse, & Degens, (2009) researched the effects of 3 different warm-up strategies on a countermovement jump, 10m, and 20m sprints on 22 elite youth soccer players. All trials consisted of 5 minutes of low-intensity jogging, followed by a 10-minute static stretching

(SS), dynamic stretching (DS), or dynamic stretch plus resistance (DSR) protocol. The stretching sessions focused on lower-extremity muscle groups including the gastrocnemius, quadriceps, hip flexors, adductors, hamstrings, and gluteus muscles. The difference in the DSR protocol was the performance of 8 front squats while holding 2 dumbbells at the shoulders, combining for 20% of the participants' body mass. All participants then performed the countermovement jump, 10 m, and 20 m sprint immediately and 3 and 6 minutes after each warm-up, resulting in the DSR protocol significantly outperforming the other trials in vertical jump, with the DS trial coming in second in performance outcomes, followed by the SS trial. The dynamic stretching trials were also superior in the sprint performances compared to the SS trial, but no additional improvement seen by adding the resistance, like the vertical jump. The determination of power by measuring "flight-time" is a possible limitation to this study, due to variations in landing mechanics between subjects, and trials. A continuation of the research should investigate various warm-up structures in team sports, similar to that of Zois, Bishop, Ball, & Aughey (2011). Also focusing on soccer athletes, Zois et al. (2011) assessed the acute effects of 3 different warm-ups on 10 male amateurs for power, agility, and speed performance. The warm-up protocols consisted of a small side game (SSG), a 5RM seated leg-press, or a team-sport warm-up. The SSG warm-up consisted of 3-on-3 matchups with 2 minute intervals of play and rest, lasting approximately 12 minutes. The 5RM leg-press warm-up, lasting about 15 seconds, and was performed after a 5 minute jog. The last warm-up protocol was a premier league soccer club warm-up, including general calisthenics, and specific agility and sprint drills, total lasting approximately 23 minutes. Power, assessed via a countermovement jump, along with the agility measurements were improved following the SSG and 5RM leg-press protocols, but not the team-sport warm-up. The 5RM leg-press also displayed improvements in the 20 m sprint when compared to the other two protocols. These results suggest that either a heavy resistance exercise or a small-side game may be appropriate to elicit acute enhancements in team-performance tests. However, it could not be determined whether potentiation or fatigue was the cause of the differing performance outcomes. More research is needed to determine whether the most suitable tools and time frames are being utilized for team-sport specific warm-ups. In efforts to determine the proper protocol to supply the greatest force production results, Biasioto, Studdard, Ritter, & Barr (1982), tested 24 male powerlifters on the bench press. Participants either completed a warm-up consisting of 12 repetitions at 35%, 8 at 50%, 5 at 65%, 3 at 75% and 1 at 85%, or sat quietly for 15 minutes prior to having 3 attempts to achieve a 1RM. Results showed no significant differences between the groups, thus indicating no need for a warm-up to perform maximal lifts on the bench press successfully. These results should be interpreted loosely, due to the absence of any statistical information.

Muscle Activation

To properly activate the musculature of the shoulder, allowing for adequate stabilization of both the glenohumeral and scapulothoracic joints, multiple movements through the joints' full range of motion may be required (Wagner, 2003). Twelve experimental research articles were assessed, with 11 displaying significant differences in muscle activation. Decker, Hintermeister, Faber, & Hawkins (1999) investigated 8 exercises, deemed appropriate to activate the musculature for scapulohumeral movements, on 20 healthy males. Exercises included shoulder extension, forward punch, serratus anterior punch, dynamic hug, scaption (with external rotation), press-up, push-up plus, and knee push-up plus, with electromyographic (EMG) data collected on the middle serratus, upper and middle trapezius, and anterior and posterior deltoids. With resistance being applied by means of body-weight, bands, or dumbbells, the serratus anterior punch, scaption, dynamic hug, push-up plus, and knee push-up plus exercises repeatedly produced serratus anterior activation 20% greater than the maximum voluntary contraction. The push-up plus and the dynamic hug were producers of the highest levels of activation for the serratus anterior due to the protracted and upwardly rotated scapula. The push-up plus had the highest average muscle activation at 63% maximum voluntary contraction (MVC), while the dynamic hug had the highest peak muscle activation at 109% MVC for the serratus anterior. The push-up plus also had the highest average and peak muscle activation for the anterior deltoids with 103% and 185%, respectively. Additionally, the only exercise to activate the middle trapezius above 20% MVC was scaption. Limiting to this research is the absence of the values of applied forces, making replication of this research design more challenging. Further research may want to determine better ways to standardize the resistances chosen per individual.

The upper and lower subscapularis muscles are independently innervated requiring separate activation. To determine which exercises would elicit the greatest activation of both upper and lower segments, Decker, Tokish, Ellis, Torry, & Hawkins (2003) performed a similar study to the one previously mention, by Decker et al. (1999). Fifteen healthy subjects were required to perform 7 exercises including the push-up plus, diagonal raise, forward punch, internal shoulder rotation, and the dynamic hug, with EMG data collected on the latissimus dorsi, teres major, pectoralis major, infraspinatus, supraspinatus, and upper and lower subscapularis. After MVCs were determined, the upper subscapularis was found to have higher levels of activation in all but the internal rotation exercise, with the diagonal raise and again the push-up plus giving the greatest results. These two exercises also produced the highest EMG readings for the latissimus dorsi, pectoralis major, and the teres major. Unfortunately, the upper and lower subscapularis electrode placements were not verified with a magnetics resonance imaging (MRI) or computed tomography (CT), so even though proper placement techniques were implemented, EMG results may be skewed and techniques should be revised in future research. During another examination of the rotator cuff, and the shoulder girdle musculature (supraspinatus, infraspinatus, subscapularis, pectoralis, latissimus dorsi, and the 3 segments of the deltoid), in 11 healthy males, 29 isometric contractions were performed in an array of positions (Kelly, Kadrmas, & Speer, 1996). The analysis was then able to identify the "optimal test," to best activate each of the rotator cuff muscles. The optimal test for the supraspinatus was the full-can raise. Though no differences were seen in muscle activation during what would be an empty-can raise, more subacromial impingement pain was associated with it. There was also less infraspinatus activation, indicating better isolation of the supraspinatus. External rotation was best for infraspinatus activity, also minimizing the activation of the supraspinatus and posterior deltoids. Lastly, the subscapularis was most activated during a test referred to as the Gerber test, where the hand is place behind the back, palm outward and elbow at 45°, with a force produced backward, way from the body. This allowed minimal activation of the pectoralis and latissimus dorsi. Oddly, no reason was given for the use of only the non-dominant arm, which in turn limits the applicability of these findings to athletic performances where frequently the demands placed on the body are not bilaterally equivalent. Future research may want to determine if dominant-to-non-dominant differences exist. With similar intensions, Kronberg, Nemeth, & Brostrom (1990), performed an analysis of the shoulder during "loaded" movements, using EMG recordings attached to the subscapularis, supraspinatus, infraspinatus, pectoralis major (sternoclavicular part), the anterior, middle, and posterior deltoid, and the latissimus dorsi. The participants took both shoulders through a range of motion consisting of flexion, extension, abduction, external rotation, and internal rotation at 0°, 45°, and 90° of abduction. The results displayed both the agonist and antagonist muscles were activating simultaneously, and therefore showing that the stabilization of a joint is dependent upon the muscles involved working together. Examples of this were the infraspinatus, subscapularis, and latissimus dorsi working as the stabilizers during flexion, and the subscapularis and supraspinatus as stabilizers during extension.

In an assessment focused on common external rotation exercises, it was found that side-lying external rotations produce greater EMG activity in the infraspinatus and teres minor in 10 healthy subjects (Reinold, Wilk, Fleisig, Zheng, Barrentine, Chmielewski, & Andrews, 2004). This study also concluded that the prone horizontal abduction at 100° was best for supraspinatus, middle and posterior deltoid activation, but did not perform any similar raises, such as a full or empty can raise for comparison. A mentioned limitation to this study was the low statistical power, possibly due to the small sample size; thus, future research may want to verify these results with a larger sample size including asymptomatic and symptomatic individuals with pathologies such as subacromial impingement or instability issues. Also investigating supraspinatus activation was Takeda, Kashiwaguchi, Endo, Matsuura, & Sasa (2002), who similarly used a prone horizontal abduction exercise, along with a full and empty can raise on 6 healthy males. After performing 3 sets of 15 repetitions for each exercise, separated by 2 minute rest periods, both standing raises developed approximately 3 times greater changes in muscle relaxation time, showing them to be more appropriate for activating the supraspinatus. With no differences being found between the full and empty can raise both were recommended for rehabilitation, therefore, similar to Reinold et al. (2004), more research is needed. Both of these raises have also been utilized to determine the presence of tears in the supraspinatus tendon (Itoi, Kido, Sano, Urayama, & Sato, 1999). After an assessment for the presence of pain, weakness, or both on 143 shoulders, there were no significant differences between the accuracy of the tests, with the detection of pain in 43% and 50% of shoulders, in the full and empty can raises respectively. This study was limited to individuals with various shoulder symptoms, making it difficult to validate that these results would also be seen in a general population. As a result, more research in needed to determine if one is superior to the other. Results of a recent experimental research study have again shown the push-up plus exercise as a superior method for activation of the subscapularis (Swanik, Bilven, & Swanik, 2011). In this study, the push-up plus along with 3 other exercises (pitchback, proprioceptive neuromuscular facilitation (PNF) D2 pattern with tubing, and slide-board horizontal abduction and adduction) were used to test 33 healthy males. Along with the push-up plus being the superior exercise, it was found that the subscapularis had higher activation levels than both the teres minor and infraspinatus combined, possibly indicating a greater reliance on it for anterior glenohumeral joint stability. Inopportunely, not measuring the rest of the shoulder's musculature is limiting to this study, along with the subscapularis activity being measured from a single site instead of two separate sites. This would have made it possible to differentiate between the activation of the upper and lower segments of the subscapularis.

Other muscle activation techniques have been performed using more familiar exercises, such as bench press or bench throw (Barnett, Kippers, & Turner, 1995; Newton, Kraemer, Hakkinen, Humphries, & Murphy, 1996; Sakamoto & Sinclair, 2012; Tucci Ciol, De Araujo, De Andrade, Martins, McQuade, & Oliveira, 2011). While using various inclinations of the bench press to analyze EMG activity on 6 males, Barnett et al. (1995) found the pectoralis major to have increased activity during the horizontal and inclined positions, and decreased activity in the military press. The triceps brachii followed this same pattern, whereas the anterior deltoids were seen to have increased activation in the vertical position, and decreased values in the decline. Lastly, though there were low levels of EMG activity for the latissimus dorsi in all positions, it was significantly higher in the declined position, possibly due to the increased adduction of the shoulders. Also worth mentioning is the activation of secondary muscles during pressing exercises. Tucci et al. (2011) examined differences in EMG activity between an isometric wall and flat bench press. Twenty males were tested on both exercises, and results displayed the muscle with highest levels of activation during both exercises was the serratus anterior. It had activation levels 20% above MVC values. Their use of isometric contractions limit the potential relationship with dynamic exercises and unfortunately scapular movements were not monitored, possibly affecting serratus anterior EMG results. With the low levels of EMG activity attained, future research should test whether these exercises may be more appropriate for rehabilitation programs. Additionally, the amount of repetitions that can be completed of an exercise is dependent on the speed at which it is performed (Sakamoto & Sinclair, 2012). After testing 13 males on the bench press using 5 different intensities and 3 different speeds, it was concluded that faster conditions result in a higher repetition count. This was assumed to be because of a reduced level of muscle activation at the end of the concentric phase in faster conditions, which in turn reduced fatigue. Though the bench press and bench throw require the same muscles to be activated, Newton et al. (1996) found increased average EMG activity in all muscle groups (pectoralis major, anterior deltoids, triceps brachii, and biceps brachii) during the throw. This was due to the ability to maintain the level of explosive force through the entire range of motion unlike the press, which maxed its acceleration level at 40% completion. Though their use of 45% of 1RM was justified, future research should look at multiple intensities to find the range these differences can still be achieved.

Potentiation

The enhancement of performances is at times desired, and has been accomplished through exercise that produce muscle activation prior to an event. Seven articles were reviewed to attain an understanding of this training technique, with 6 showing significant differences in their results. When 20 physically active men were tested with a warm-up protocol consisting of 2 repetitions at 5 progressively higher intensities (20-90% 1RM), results in the vertical jump were significantly improved by 2.39% (Gourgoulis, Aggeloussis, Kasimatis, Mavromatis, & Garas, 2003). A more in-depth analysis of the results also displayed that the improvement seen were more so in the participants with greater maximal strength (4.01%), vs. lower maximal strength (.42%). Improvements were reported to possibly be from motor neurons having a higher tolerance of activation frequencies, and/or more discharge synchronization, but there was no reference to cross-sectional area. Without more specific information on the type and density of muscle fibers present, these results should be carefully considered. Future research should test similar types of athletes, this limiting the variation of muscle characteristics. A study which did not use progressively increasing intensities, but rather 5 sets of 1 repetition at 90% 1RM on a squat exercise followed by a rebound jump or a concentric-only jump squat (Chiu, Fry, Weiss, Schilling, Brown, & Smith, 2003). The jumps were performed with loads of 30% 50%, and 70% 1RM after a 5 minute recovery and again at 18.5 minutes. As a group, the heavy load did not have a significant effect, but when the groups were split between athletes (n=7) and non-athletes (n=17), the potentiation effects were significantly greater in the athletes in both jump activities. The improvements were seen in both force and power at various loads. Since the potentiation was seen in the athletic groups, future research may want to compare different types of athletes using this same concept. French, Kraemer, & Cooke (2003) decided to focus solely on track athletes, testing 14 athletes on drop-jumps, countermovement jumps, cycle sprints, and knee extensions after performing MVCs of 3 repetitions for 3 seconds, or 3 repetitions for 5 seconds, against a control trial performing neither MVC protocols. Significant differences were seen in jump height (5.03%), max force (4.94%), and acceleration impulse (9.49%) in the drop-jump's 3 repetitions for 3 second trial. The types of track athletes used were unfortunately not mentioned (e.g. distance vs. sprint runners, shot-putt vs. hammer throwers), which may have given insight to benefits of varying training regimens. Also narrowing the focus to athletes, Kilduff, Bevan, Kingsley, Owen, Bennett, Bunce, & Cunningham (2007) tested 23 professional rugby players not only on countermovement jumps, but bench throws as well. After a 3RM on the bench and squat, the exercises tested were performed at 6 time-points (15 second, 4, 8, 12, 16, and 20 minutes), where significant results were seen in both tests. For both exercises, the 15 second time-point showed significant decreases in peak power output, while the 12 minute time-point displayed significant increases in peak power output. Like some of the previously mentioned research, relative strength also had a significant correlation to the potentiation results; however, the strength differences were not available for comparison. Also with a focus on rugby athletes, Baker (2003) sought to test a theory of alternating resistances affecting power performance, and recruited 16 players to test on bench throws. With the experimental group performing a 6 repetition set of bench press (65% 1RM) a significant difference of 4.5% improvement in power was seen at post-test. Though the mechanisms are not know, Baker theorized the lighter (65% 1RM) resistance allow speed of movements to remain high, opposed to a heavy resistance causing slower neural output speeds. These results suggest that heavy resistances may not be required to provide a neural training stimulus. This study was limited due to its use of only one intensity in the experimental trials. Future research should test a range of intensities to find more precise percentages that produce potentiating effects. A similar potentiation design was tested using high-frequency submaximal percutaneous electrical stimulation (PES) on 12 healthy males performing bench throws as well (Requena, Zabala, Ribas, Ereline, Passuke, & Gonzalez-Badillo, 2005). Three differing stimulation protocols were used; a 7 second 10 second, and 8 x 1 second pulses (separated by 20 second rest periods) were used, all with a pulse rate of 0.3 seconds. Bench throws were then performed after 5, 8, and 11 minutes, but no significant differences were witnessed for any of the trials. Their reasoning for the lack of significance was the sample size; therefore, future research could test different combinations of the stimulus with a larger sample size. Unlike all of the previously mentioned post-activation potentiation studies, Wilcox, Larson, Brochu, & Faigenbaum (2006) analyzed the possible potentiation effects explosive (power) exercises would have on strength performance utilizing the bench press opposed to a throw. Twelve collegiate athletes were tested on 3 separate occasions, with the first being a general 1RM protocol, and the other two having either 2 plyometric push-ups or 2 medicine ball chest passes, 30 seconds prior to each 1RM attempt. Three-minute rest periods separated the attempts. The incorporation of the explosive movements occurred after the resistance reached 85% of their 1RM during the experimental trials. Statistically significant results were seen between trials, with both plyometric push-ups and medicine-ball throws demonstrating improvements of 2.4% and 2.6% respectively. A limitation was the absence of a second 1RM trial without a form of PAP, possibly concealing a learning effect that may have been present. Future research could randomize all of the trials to prevent this potential learning effect.

Conclusion

The manipulation of training protocols to elicit specific acute effects, desired to improve performance outcomes, has been well documented. As discussed in this review, all but 3 experimental studies found appropriate methods to achieve their desired outcome, including those utilizing post-activation potentiation protocols. It was determined that there are certain exercises that are better at activating the musculature of the shoulder. The push-up plus was best at activating the serratus anterior, anterior deltoids, and subscapularis. External rotations displayed the highest activation of the infraspinatus and teres minor. The full-can raise was best for activation of the supraspinatus, and also activated the trapezius, due to its similarities to scaption. Even with the use of a general warm-up, increased muscle conduction times can be attained, which in turn could lead to an array of different performance improvements. With the addition of specific warm-ups, possibly even with resistance, strength and power improvements can be even further advanced. The use of potentiation has many independent variables linked to its success. One of which is the fatigue vs. potentiation time frame, which seems to change based on the intensity of the activity being utilized. When using light intensities in an explosive type manner as a form of potentiation, positive effects have been seen in as little as 30 seconds post-PAP protocol. When using near maximal intensities as a form of potentiation, ≥12 minutes have been needed to produce improvements (Kilduff et al., 2007). However, moderate intensities have also shown improvements in performance, making it more challenging to determine the best practices for using a PAP protocol.

In spite of all of the beneficial information this review encompasses, contradicting data still brings question to the proper protocols needed to peak one’s performance. Some research has shown that maximal strength outcomes can be achieved without the use of a warm-up protocol. While others have found that unlike post-activation potentiation (PAP), muscle activation by electrical stimulation (post-tetanic potentiation) has displayed no performance enhancements (Requena et al., 2005). Thus, it is evident that research is still lacking on the best practices for activating the musculature needed during desired peak athletic performances.

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CHAPTER II

THE EFFECT OF SHOULDER STABILITY EXERCISES ON BENCH PRESS ONE-REPETITION MAXIMUM RESULTS

Position statements from the National Strength and Conditioning Association (NSCA) has reported that the bench press is a quality exercise for development of the upper-body's musculature and strength, and is classified as the most popular resistance exercise in the United States (Jagessar & Gray, 2010; Wilson, Elliot, & Kerr, 1989). While the primary movers during the bench press are the pectoralis major and minor, the anterior and middle deltoids, and the triceps brachii, other muscles such as the serratus anterior, latissimus dorsi, trapezius, biceps brachii, and the rotator cuff muscles assist in the stabilization of the movement (Algra, 1982; Barnett, Kippers, & Turner, 1995; Newton, Kraemer, Hakkinen, Humphries, & Murphy, 1996; Tucci, Ciol, De Araujo, De Andrade, Martins, McQuade, & Oliveira, 2011). For optimal functionality and injury prevention it is important these muscles to work together to stabilize the scapula, as well as the glenohumeral joint since the glenoid fossa is too shallow to provide adequate support (Durall, Manske, & Davies, 2001; Swanik, Bilven, & Swanik, 2011; Tucci et al., 2011). However, the degree to which these stabilizing muscles contribute to maximal strength performance has not yet been determined, hence the purpose of this investigation.

The formation of force couples, by the simultaneous activation of opposing muscles, increase compressive forces and/or help to maintain proper alignment for a successful lift (Kronberg, Nemeth, & Brostrom, 1990; Nordin & Frankel, 2001; Swanik et al., 2011). The force couple that is created between the subscapularis, and both the infraspinatus and teres minor results in a compressive force that is essential in maintaining a stable proximal joint foundation at the glenohumeral joint and the accommodating shoulder complex ("Glenohumeral and Accommodating Scapular," n.d.; Swanik et al., 2011). Also, the ratio of muscle activation between the upper trapezius and the serratus anterior needs to be low, allowing the scapula to stay pinned against the thorax (Ludewig, Hoff, Osowski, Meschke, & Rundquist, 2004). With the lowered activation of the upper trapezius the scapula is allowed to remain retracted and rotated downward, which provides better stability for the glenohumeral joint and a stable foundation during pressing exercises (Ludewig et al., 2004). Thus, proper activation of the shoulder stabilizers, during the bench press is advantageous to strength performance.

Warm-ups help in multiple ways when it comes to performing any form of physical activity, even simply from the increase in body temperature. Warm-ups allot for stronger, faster contractions, and improved muscle relaxation/stiffness because of enhanced contractibility, elasticity, and increased nerve impulse speeds (Bishop, 2003; Lauffenburger, 1992; Pearce, Rowe, & Whyte, 2012). Moreover, specific dynamic warm-ups completed prior to physical activity can further improve the performances seen from using general warm-ups (Abad, Prado, Ugrinowitsch, Tricoli & Barroso, 2011; Needham, Morse, & Degens, 2009; Zois, Bishop, Ball, & Aughey, 2011). Performing high-intensity resistance exercise (e.g. 5 repetition maximum) or participating in a sport-specific side game (e.g. light soccer intervals with 3 minutes play and 3 minutes rest) of may better improve performances of power exercises, including countermovement jumps and sprints, and also in agility drills, vs. a general warm-up protocol (Zois et al., 2011). Similarly, leg-press 1 repetition maximum (RM) improvements are present when initiated by a proper warm-up, including both general and specific segments (Abad et al., 2011). The general warm-up was intended to increase muscle temperature, while the specific warm-up's goal was to increase neuromuscular activation. In contrary to the proposed benefits of a warm-up, a study by Biasioto, Studdard, Ritter, & Barr (1982), found that a 1RM bench press test was in fact not affected by a traditional warm-up consisting of multiple sets with increasing intensities. However, the NSCA provides a design of a 1RM protocol using 2 specific warm-up sets, followed by a near-maximal lift that is adequate for producing maximal performance (Baechle, Earle, & Wathens, 2008).

In spite of this, research is continually testing new ways to improve performance, some of which have followed the idea of post-activation potentiation (PAP). PAP protocols utilize contractile history during a warm-up to improve acute muscle force output (Hodgson, Docherty, & Robbins, 2005). It has been frequently suggested that the use of heavy resistance exercise prior to explosive power movements is beneficial to performance (Chiu, Fry, Weiss, Shilling, Brown, & Smith, 2003; French, Kraemer, & Cooke, 2003; Gourgoulis, Aggeloussis, Kasimatis, Mavromatis, & Garas, 2003; Guillich & Schmidtbleicher, 1996; Kilduff, Bevan, Kingsley, Owen, Bennett, Bunce, & Cunningham, 2007; Radcliffe & Radcliffe, 1996; Young, Jenner, & Griffiths, 1998). Additionally, lighter intensity PAP protocols (e.g. 65% 1RM) have also been successful in improving peak power output (Baker, 2003). The two most widely accepted mechanisms responsible for the proposed benefits are increased myosin light chain phosphorylation, and the improved capability of motor neurons to recruit fast-twitch muscle fibers (Grange, Vandenboom, & Houston, 1993; Sweeney, Bowman, & Stull, 1993; Tillin & Bishop, 2009). Wilcox, Larson, Brochu, & Faigenbaum (2006) found improved 1RM bench press results when explosive movements were performed prior to 1RM attempts. The exercises used were plyometric push-ups and medicine-ball chest passes performed 30 seconds prior to each attempt, with significant improvements seen in 1RM measurements versus traditional warm-up. Not yet determined through research is the influence prior activation of the stabilizing muscles has on 1RM performance. .

There is a combination of exercises that are required to activate all of the musculature of the shoulder (Decker, Hintermeister, Faber, & Hawkins, 1999; Decker, Tokish, Ellis, Torry, & Hawkins, 2003; Durall, Manske, & Davies, 2001; Itoi, Kido, Sano, Urayama, & Sato, 1999; Jobe & Moynes, 1982; Kelly, Kadrmas, & Speer, 1996; Kolber & Beekhuizen, 2009; Reinold, Escamilla, & Wilk, 2009; Reinold, Wilk, Fleisig, Zheng, Barrentine, Chmielewski, & Andrews, 2004; Ronai, 2005; Takeda, Kashiwaguchi, Endo, Matsuura, & Sasa, 2002; Wagner, 2003). To determine their impact on 1RM performance, an appropriate PAP protocol is needed. Previous research indicates there are various PAP protocol intensities that are adequate at improving performance, thus demand attention (Hodgson et al., 2005). Also, with stability of the environment impacting the level of muscle activation attainable (Anderson & Behm, 2005), environmental considerations are also required. Because lower levels of stability result in a decreased force output (Anderson & Behm, 2005), lighter loads may be necessary. Therefore, the purpose of this investigation was to determine whether the performance of shoulder stability exercises, with various intensities and levels of stability, prior to a bench press 1RM protocol would improve strength results.

Methods

Participants

Sixteen males volunteered to take part in the study. All participants were current or former collegiate athletes, no more than 1-year removed, (mean ± standard deviation age 22.75 ± 2.11 years, body mass 91.5 ± 14.20 kg, height 179.9 ± 6.88 cm) and were required to have at least 2 years experience in a resistance-training regimen that involved free-weight exercises, including the bench press. Participants were informed of the procedures of the study and signed an Internal Review Board (IRB) approved informed-consent form allowing the use of human subjects. They were all then screened for any medical concerns that would limit participation. Participants were required to avoid any strenuous physical activity 24 hours prior to testing, and to avoid any upper-body physical activities 48 hours prior to testing. Participants were instructed to refrain from alcohol, caffeine, and supplements that potentially enhance performance.

Study Design

All testing sessions for each participant took place over a 4 week period. Prior to the first testing trial all of the participants were required to visit the facility to become familiar with the equipment, and perform shoulder exercises, consisting of the full-can raises (shoulder abduction with elbows pointing toward the floor), and both internal and external rotations, to determine the appropriate resistances to use when performed during the experimental trials. If 15 repetitions could be performed using a given resistance, that resistance was approximated to be 65% of a 1RM. The high intensity full-can raise and internal and external rotation resistances were calculated by using the selected resistance for the Light Intensity + Standard (L+SD) protocol as a predicted 65% 1RM resistance. Then, resistances for the High Intensity + Standard (H+SD) protocol was set at 90%, thus 4 repetitions were the approximate resulting resistance, [(L+SD resistance/.65) x .90] = H+SD resistance. Three randomly selected 1RM trials were then completed with a minimum of 48 hours recovery between sessions.

The Standard (SD) protocol required participants to jog on a treadmill for 5 minutes at 60% of their age predicted heart-rate max, in efforts to achieve the benefits of an increased body temperature (e.g. decreased stiffness, increased muscle conduction time). The participants were then instructed to warm-up with a resistance that easily allowed 5-10 repetitions, followed by a one-minute rest period. Followed by completing 3-5 repetitions while adding 10 to 20 lb. or 5-10%, followed by a 2 minute rest period. A near-maximal load was then estimated allowing for 2-3 repetitions to be completed by adding another 10-20 lb. or 5-10% followed by a 2-4 minute rest period and a load increase of 10-20 lb. or 5-10%. Next, the athletes were instructed to attempt a 1RM, and if successful, were provided a 2-4 minute rest period and repeated the load increase protocol. If unsuccessful, the weight was decreased by 5-10 lb. or 2.5-5%, and the 1RM will be reattempted. The load was continually adjusted until the participant completed a 1RM with proper form, by maintaining all points of contact, not using excessive bouncing the bar off the chest, and maintaining the bar's horizontal position. All 1RM tests were completed without exceeding 5 testing sets.

For the L+SD protocol, one set of 15 repetitions of each of the 6 supplemental exercises was performed with 30 seconds rest. A Total Resistance Exercise Suspension

Trainer (TRX) was used for the weight-bearing exercises since it has been deemed effective in adding instability and heightens neuromuscular activation (Quelch, F & Lichter, 2008). The weight-bearing exercises that were performed on the TRX were the push-up plus (shoulder retraction and protraction), body row (shoulder horizontal adduction and abduction), and press-up (shoulder depression and elevation), using body weight alone as the resistance. The full-can raise, external rotations, and internal rotations were performed with dumbbells, with both rotations being performed in a sidelying position. The set order of the exercises was: push-up plus, body row, press-up, full-can raise, external rotation, and internal rotation. All exercises were completed after the 5 minute jog, prior to the SD protocol.

The H+SD protocol performed the same exercises at 90% 1RM for 4 repetitions with 30 seconds rest in-between. For the push-up plus, body-row, and press-up 30% of the participant's body weight was added by a weight-vest. Due to the increased resistance, these 3 exercises were performed on stable surfaces. The push-up plus was performed on the floor, the body row on a stationary straight bar, and the press-up on a stationary bench. The 30% added resistance of the weight vest was determined through trial and error, from its allowance of only 4-5 repetitions to be completed. The full-can raise and internal and external rotations were performed with the resistances determined during the initial meeting's trial and error

Statistical Analysis

The effects of the implemented exercises were determined by a comparison of the baseline and two experimental trials. These measures were compared using a repeated measures analysis of variance (ANOVA). The independent variables analyzed were the treatments (supplemental low intensity exercises versus supplemental high intensity exercises versus control trial). Statistical significance was set at $P \leq .05$, and analyses were conducted using Stata, Version 12, College Station, TX. Results were evaluated as mean ± SD.

Results

Statistical Analysis for Entire Group

To determine the differences across warm-up protocols (SD, L+SD, H+SD) among the 1RM results, a repeated-measures ANOVA was conducted. No significant differences among protocols were observed, Greenhouse-Geisser epsilon = 0.804, $F_{(2,30)} = 0.11$, $p = 0.852$, partial eta squared (effect size) = 0.007, a very small effect. The mean difference in 1RM performance between the lowest and highest trials was .43 kg (.31%), seen in Table 1. To determine the effect of body size on the 1RM warm-up protocols, Pearson Product-Moment correlations were calculated between Body Mass Index (BMI) and each of the 1RM results. Table 2 reports these correlations. Each correlation between BMI and the SD protocol (P=0.014), L+SD (P=0.021), and H+SD (P=0.007) were significant.

Statistical Analysis in Relation to Body Composition

Due to the moderate correlations between BMI and the 1RM measures, BMI was used as a covariate, and all 1RM measures were adjusted for BMI. The correlation between BMI and the adjusted 1RM measures was zero for each warm-up protocol. A repeated measures ANOVA indicated that there were again no significant differences among warm-up protocols, Greenhouse-Geisser epsilon = 0.784, $F(2,30) = 0.001$, $p = 0.998$, partial eta squared (effect size) < 0.001, another very small effect. Even when adjusted for body size, there were no significant differences among the 1RM warm-up procedures.

Statistical Analysis in Relation to Overall Strength

Lastly, to determine whether the effect of the warm-up protocols influenced 1RM strength, the subjects were divided into two groups based on 1RM strength. A two-way repeated measures ANOVA was conducted to determine the interaction between strength group and warm-up procedure. This interaction was not significant, Greenhouse-Geisser epsilon = 0.783, $F(2, 28) = 0.03$, $P = 0.942$, partial eta squared (effect size) < 0.001, another very small effect. There are no significant differences among the warm-up protocols based on the 1RM strength of the subjects.

Discussion

To the best of our knowledge, no previous research has demonstrated the use of shoulder-stability exercises to investigate PAP in upper-body strength. The primary findings of this investigation indicate that exercises that require use of stabilizing muscles prior to a bench press 1RM protocol do not elicit significant differences in trained males. This could imply that the few warm-up sets built-in to the SD protocol, recommended by the NSCA, are sufficient enough at getting the athlete into the needed physical state for maximal performance. The incorporation of the shoulder-stability exercises was based off of the theory that increased levels of activation, from relying on the stabilizing function, may lead to increases in strength performance (Anderson & Behm, 2005). With this idea in mind, our research design was created to test whether a focus on stability as part of a warm-up would promote higher strength measurements. The intensity-to-volume relationship during the stabilizing exercises of the experimental trials was designed to increase recruitment while avoiding fatigue. Exercises, which have previously been deemed appropriate for activating the musculature of the rotator cuff and shoulder girdle, were selected to stabilize the glenohumeral joint.

Most of the experimental studies investigating PAP have been in an attempt to improve power-dominant performances, including but not limited to jumping ability, or bench throws (Chiu et al., 2003; French et al., 2003; Gourgoulis et al., 2003; & Kilduff et al., 2007). The PAP protocol intensities in some of the previous research range from 65% 1RM to near-maximal dynamic lifts (Baker, 2003; Gourgoulis et al., 2003; Kilduff et al., 2007; Wilcox et al., 2006). Baker (2003) used a protocol of 1 set of 6 repetitions at 65% 1RM and found significant improvements in peak power performance. The author suggested that near-maximal intensities slow down subsequent neural output resulting in possible decreased lifting speeds, which are not optimal for peak power performance. To determine if intensity was a factor that impacted strength performance, the current study tested both high and low intensities.

At the same time, our protocol design may have masked the potential effects of the shoulder exercises by performing them along with the entire SD protocol. To determine if this was the case, performing either the shoulder exercises or the 2 warm-up sets in the SD protocol may show one to be a superior protocol in a future investigation. Another characteristic that differentiates previous research from the current study is the PAP protocol being performed on the same level of stability as the test protocol. Though our goal was to activate the stabilizing musculature of the shoulder, we only tested in a stable environment. This design was utilized since athletes do not perform max testing in unstable environments, but different results may be attained if the max testing would have been performed with equipment requiring different levels of stability (e.g. dumbbells).

The first 1RM attempt was performed approximately 6-8 minutes after the end of the stabilization protocol. Some PAP protocols demonstrating improved results have been seen in as little as 30 seconds of rest, while others have taken up to 12 minutes to show significant improvements (Baker, 2003; Gourgoulis et al., 2003; Kilduff et al., 2007; Wilcox et al., 2006). Though the time from the potentiation to the first 1RM attempt was 6-8 minutes, thus falling in-between these prior time frames, our participants were not at rest during this entire period. Instead, the participants followed the PAP protocol completing the traditional warm-up sets. Future research may exclude the warm-up sets in effort to provide a rest period more similar to that of previous designs, as fatigue may have been a factor from completing the PAP protocol in addition to the traditional warm-up sets. However, we chose to include the warm-up sets using free weights to incorporate the same mode during the warm-up that was used in testing.

Only 1 previous study was found to test and find significant improvements in bench-press strength performance as a result of a PAP protocol. The study by Wilcox et al. (2006) found that performing 2 repetitions of one-of-two exercises (medicine-ball chest pass or plyometric push-up), 30 seconds prior to each 1RM attempt elicited an improved 1RM bench press performance. In an effort to find additional PAP protocols that possibly improves strength performance; the current study focused its design on the recruitment of stabilizing muscles. The incorporation of instability was used to promote increased activation of stabilizing muscles, however it has also been shown to slow down the speed at which the activity can be performed (Anderson & Behm, 2006). This dictated our use of lighter intensities in our unstable protocol. To test whether this method for activating the shoulder stabilizers is superior to a stable environment, two experimental trials were completed. Volume and intensity values were also drastically different between the current study and that of Wilcox et al. (2006) since focus was not placed on power, but rather muscle activation. Unlike the 2 plyometric push-ups, or medicine-ball chest passes, our participants performed 6 different exercises prior to the start of the 1RM protocol in each of the experimental trials. The protocols consisted of either 15 repetitions at the lighter intensity, or 4 repetitions at the higher intensity. This considerable difference may have become a contributing factor in the fatigue vs. potentiation relationship.

Throughout the testing process it was observed that multiple participants with high body-mass values experienced a more difficult time during the L+SD protocol due to the instability. The TRX was set at the same length and angle for each participant, with no adjustments made for differing body sizes or compositions. Potential research may want to set different body angles for using the TRX, which would in turn raise or decrease the intensity of the exercise. The angle each participant performs an activity could be based off of the ability to perform a required RM load in an attempt to keep relative intensity the same to improve 1RM performance. Though the data did not demonstrate a superior protocol, it was mentioned by multiple participants that the L+SD improved their personal sense of “preparedness”. With all of the variation seen in potentiation designs, more research is needed to fully understand if PAP protocols improve strength. Future research may want to test different populations (e.g. athletes vs. trained, and untrained) to determine which methods improve 1RM strength. The bench press is also a fairly stable exercise; therefore, the influence of activated shoulder stabilizers is questionable. Other athletic performances, in a not so stable environment may see more benefits from performing similar shoulder exercises, and calls for further analysis.

This study was not without its limitations. The process of recruiting collegiate male athletes as participants for this study considerably decreased the population available for testing (n=16). Each participant's level of fitness and training background may have impacted their performance. While the intension of this study was to increase body temperature, recordings of temperature differences between protocols were not collected. Lastly, the height of the TRX was not modified to make relative intensities the same for all participants, similar to the adjustment made for the added resistance in the H+SD protocol. In conclusion, our results displayed no significant differences between 1RM protocols, thus supporting the position of the NSCA, of the standard protocol being a sufficient method for maximal strength performance.

Table 1

Descriptive Characteristics and 1RM Measures in the Sample

Variable	Mean	Std. Dev.	Min	Max
Age (y)	22.937	2.26476	20	29
Height (cm)	179.915	6.88065	167.64	189.234
Weight (kg)	91.561	14.19812	69.55	120.453
BMI	28.137	2.75828	24.74	33.839
SD (kg)	137.357	14.46876	111.36	159.09
L+SD (kg)	137.784	13.80888	113.63	163.636
H+SD (kg)	137.642	14.98321	111.36	161.363

Note: BMI= Body Mass Index, SD=standard 1RM protocol, L+SD=Light intensity warm-up + standard 1RM protocol, H+SD=High intensity warm-up + standard 1RM protocol

Table 2

Correlations between BMI and the 1RM Results

	BMI	SD	L+SD	H+SD
BMI	1.0000			
SD	0.5980	1.0000		
L+SD	0.5696	0.9593	1.0000	
H+SD	0.6449	0.9849	0.9626	1.0000

Note: BMI= Body Mass Index, SD=standard 1RM protocol, L+SD=Light intensity warm-up + standard 1RM protocol, H+SD=High intensity warm-up + standard 1RM protocol

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APPENDIX A

PRE-TEST INSTRUCTIONS

Shoulder Stability Exercises Influencing the Bench Press

Pre-test Instructions

Prior to any protocol involvement, you are to be informed of what is expected of you, and how you need to prepare for the participation in this research study.

Expectations
Upon arrival, you will be informed of the protocols that will be completed during the testing trial. You will complete a light warm-up on a treadmill, and then be escorted to the weight room, where the 1RM testing will take place. Step-by-step instructions will be provided to you during the warm-up protocols and the 1RM testing.

Prior to testing trial
You are expected to refrain from any strenuous physical activity 24 hours prior to testing, and avoid any upper-body physical activities 48 hours prior to testing. Avoid the consumption of alcohol or caffeine 24 hours prior to testing as well.

Attire
Appropriate workout clothes need to be worn for every test date. This includes gym shorts, a t-shirt, and tennis shoes.

If you have any questions in regard to what is being asked of you, please call Joseph Buckland at 512-705-1601 or e-mail him at jb2119@txstate.edu.

APPENDIX B

CONSENT FORM

CONSENT FORM

Project Title: The effect of shoulder stability exercises on bench press one-repetition maximum results (IRB # 2013D3454)

Investigator (**PI**): Joseph Buckland – 512-705-1601.

You are being asked to participate in a research project conducted through Texas State University. The subjects needed for this research are males involved in competitive lifting. The University requires that you give your signed agreement to participate in this project. The principal investigator, Joseph Buckland, will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask the investigator any questions you have to help you understand this research project. A basic explanation of the research is given below. Please read this explanation and discuss with the researcher any questions you may have. If you then decide to participate in the project, please sign at the bottom of this form in the presence of the investigator who explained the project to you. You will receive a copy of this form to keep for your personal records.

1. Purpose of the Research – The purpose of this research study is to determine if adding shoulder stability exercises to a bench-press one-repetition maximum protocol improves strength performance.

Explanation of the procedures – You will complete a series of one-repetition maximum (1RM) trials lasting 20-30 minutes each, including one using a standard protocol, one with preceding light shoulder exercises, and another with preceding high intensity shoulder exercises. Force output results will be recorded and compared by a statistical analysis.

2. Discomfort and risks anticipated - Reasonable safeguards have been taken to minimize the risks of injury (i.e. a spotter, and bar collars are used along with non-slip flooring and secured equipment). In addition, muscle soreness may occur after the tests; therefore, you will be provided time to recover after each testing session and provided with a light warm-up before participating in each session.

3. Benefits of participating in this research project- You will better understand the components that determine your performance outcome. You will increase shoulder stability that may increase the likelihood of strength improvements.

4. Participants have the right to choose not to answer any question(s) for any reason.

5. Confidentiality assurance – Confidential or anonymous data collection procedures will be conducted. Subjects who will be next in line to participate will be allowed to observe test trials to better understand the procedures but will not be provided the scores of these subjects. Names and data of individual test scores will not be used in any report, presentation or published article and will be collected directly onto a computer and placed in a secure file of the PI's computer for 5 years. If requested, a summary of the findings will be provided to you upon completion of the study by contacting Joseph Buckland at 512-705-1601.

6. Right to refuse and/or withdraw with no penalty- Refusal to participate in this study will have no effect on any future services you may be entitled from the University. Anyone who agrees to participate is free to withdraw from the study at any time without penalty.

7. IRB Contact - Any questions regarding the conduct of this research or questions pertaining to your rights as a research subject or any research-related injury should be brought to the attention of the IRB chair, Dr. Jon Lasser (512-245-3413 – lasser@txstate.edu), or to Ms. Becky Northcut, Compliance Specialist (512-245-2102).

8. IRB Approval - This project has been reviewed and approved by the Texas State IRB for the Protection of Human Subjects in Research and Research-Related Activities. This research is funded by the College of Education Graduate Student Research Grant.

____ ______________

Participant Signature Date

____ ______________

Principal Investigator Signature Date

APPENDIX C

DATA COLLECTION SHEET

Data Collection Sheet

Participant Name_________________ #______

Age: _____ (years)   Height: __________ (cm)   Body Weight: ________ (lb.) ÷2.2 lb. /lb. = __________ (kg)

Standard Protocol + Light Intensity Trial

Low Intensity Resistances:

Push-up Plus
Body Row — Body Weight: ________ (lb.)
Press-up

Internal/External rotations: __________ (lb.)

Full-can raise: __________ (lb.)

Standard Protocol + High Intensity Trial

High Intensity Resistances:

Push-up Plus
Body Row
Press-up

Body Weight + 30%:

________ (lb.) + ________ (lb.)

= ______________Total lbs.

Internal/External rotations: __________ (lb.)

Full-can raise: __________ (lb.)

	Standard Protocol Trial	Standard Protocol + Light Intensity Trial	Standard Protocol + High Intensity Trial
Warm-up weight #1 (5-10 reps)	lb.	lb.	lb.
1-min. rest period			
Warm-up weight #2 (3-5 reps)	lb.	lb.	lb.
2-min. rest period			
Near maximal weight (2-3 reps)	lb.	lb.	lb.
2-4-min. rest period			
1RM attempt	lb.	lb.	lb.
1RM attempt	lb.	lb.	lb.
1RM attempt	lb.	lb.	lb.
1RM attempt	lb.	lb.	lb.
1RM attempt	lb.	lb.	lb.

VITA

Joseph Martin Buckland was born in Cozumel, Mexico on August 30, 1986, the son of George Philip Buckland and Julieta Maria Buckland. After completing his work at Liberal High School, Liberal, KS, in 2004, he attended the University of Texas at Austin, and Texas State University-San Marcos. He received the degree of Bachelor of Exercise and Sports Science, and a minor in mathematics, with the honor of magna cum laude, from Texas State in May 2011. In July of 2011, he entered the Graduate College of Texas State University-San Marcos and began his work as a Graduate Assistant for the Department of Health & Human Performance.

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This thesis was typed by Joseph M. Buckland.