

Effects Of Attentional Focus On Repetitions-To-Failure & Motor Unit Excitation During Submaximal Bench Press Performance

Connor Collum MS¹, Ronald L. Snarr, PhD, CSCS,*D, NSCA-CPT, TSAC-F¹, Nicholas J. Siekirk, PhD, CSCS¹, and Samuel J. Wilson, PhD¹.

¹Department of Health Sciences & Kinesiology, Georgia Southern University, Statesboro, GA.

ABSTRACT

Attentional focus strategies refer to the use of cues or other stimuli to enhance an individual's concentration for the purpose of improving performance within a given task. **Purpose:** To examine the effects of an internal (INT), external proximal (EPr), and external distal (ED) method of attentional focus on motor unit excitation and repetitions-to-failure (RTF) during submaximal bench press performance. **Methods:** Twenty-five recreationally-active males and females completed a one-repetition maximum (1RM) bench press test, followed by three days of submaximal testing at 85% 1RM to muscular failure. For each submaximal day, a specific attentional focus strategy was given by auditory cues (i.e., INT, EPr, ED) with the individual instructed to focus solely on the cue. Motor unit recruitment of the anterior deltoid, pectoralis major, and triceps brachii was measured, via electromyography (EMG), for each repetition for all interventions. **Results:** Results indicated no differences for motor unit excitation (chest: $p=0.59$; triceps: $p=0.50$; deltoids: $p=0.17$) or RTF ($p=0.89$) among the three conditions. The INT cue, as compared to EPr and ED, elicited a ~7-10% average increase in pectoralis major motor unit excitation, despite an average of one less repetition. All effect sizes were deemed small or trivial, except for RTF between INT and ED which elicited a moderate effect size ($ES=0.55$). **Conclusions:** These findings support previous literature demonstrating increases in motor unit excitation with an internal attentional focus. However, this strategy may place a greater demand on the targeted musculature to complete a given task; thus, decreasing performance.

Keywords: Resistance training; Cues; electromyography; strength training; feedback.

INTRODUCTION

Cueing is a common tool used by strength and conditioning professionals, athletes, and recreationally trained individuals to improve performance of a given task (e.g., resistance training exercise). If applied properly, a coach can use various forms of cueing in strength and conditioning and competitive settings to teach proper form, correct mechanical errors, and potentially reduce injury risk (23). Cues can take on multiple forms based on either the method of delivery (e.g., attentional focus, demonstrative, and palpation) or individualized learning-styles. For instance, demonstrative cues, which can be used for visual learners, involves the practitioner performing an exercise, themselves, followed by the athlete mimicking the movement. While palpation (e.g., communicating through contact to ensure the correct musculature is targeted) may be a favorable method for individuals who benefit from more tactile and proprioceptive feedback. However, these strategies (i.e., demonstrative and palpation) may be more appropriate for beginners or for those first learning a new resistance training exercise. Thus, as the athlete develops and begins to master a given movement, cues will transition to more of an attentional focus (e.g., actively concentrating on a given focal point) strategy which includes an auditory (e.g., verbal commands) and visual (e.g., focal point) component (4).

Due to the complexity of certain exercises (e.g., Olympic lifts, back squat, deadlift), athletes are typically given a cue to divert concentration to focus on a specific muscle group, joint movement, or objective to reinforce proper movement or increase task efficiency. This process, known as attentional focus, can take on multiple forms (i.e., internal, external) based on the cue given (2,14,20,22). For instance, an internal attentional focus (INT) strategy drives the attention of the athlete inwards towards a specific muscle group or joint while performing the movement (e.g., 'use the muscles of the leg to jump as far as possible'). Alternatively, an external attentional focus strategy (EXT) directs the athlete's attention outwards towards a visual focal point to serve as an 'endpoint' (e.g., "jump towards the cone"). INT strategies may be more beneficial for beginners or when learning a new movement in order to reinforce proprioception and perceptual feedback (e.g., feeling the working muscle). Although, as the individual gains mastery of the task in question, INT cues may overstimulate them and cause the athlete to overthink. Therefore, experienced athletes may benefit more from EXT cues which serve only as reminders of proper form without interference in the natural thought process (34). EXT attentional focus strategies can also be divided further into proximal and distal cues. An external proximal focus (EPr) uses a prop relatively close to the individual (e.g., clubface during a golf swing) to focus on technique; while an external distal focus (ED) places the attention at a greater distance (e.g., flight path of the ball) to focus on outcome (3).

While these two attentional focus strategies (i.e., INT & EXT) are commonly used within strength and conditioning, previous literature has demonstrated increases in motor unit excitation and decreases in athletic performance with an INT concentration (8,31,36). Furthermore, when performing power-based movements (e.g., vertical or broad jumps) using an EXT focus has displayed more positive responses (i.e., increased jump height or distance) compared to focusing on a specific internal action (33,35). For example, Wulf and Dufek 2009 had recreationally trained subjects use either an INT (i.e., attention on the fingertips) or EXT (i.e., attention on the measurement device) strategy during a vertical jump test. Results indicated only a small group change in vertical jump height (i.e., ~1.4 cm) using an EXT focus; however, motor unit excitation was significantly lower within the major muscle groups (i.e., biceps femoris, vastus lateralis, and rectus femoris). INT has also elicited decrements in 10-meter sprint times in male collegiate soccer

players (32). However, when the same cues were applied to experienced track sprinters, no sprint time differences were observed.

In regard to resistance training, Nadzalan et al. (2015) reported that an EXT focus on the barbell during a bench press and deadlift led to more repetitions (i.e., ~2) at a submaximal standardized load (i.e., 80% of one-repetition maximum [1RM]). The INT bench press cues used for this study focused the attention of the individual on the application of force through the arms (INT); while, the deadlift INT cue focused on specific joint movements (i.e., extension of the knees and hips). Additionally, INT strategies have demonstrated greater motor unit excitation in both the primary (~6%) and secondary (~4%) movers versus an EXT approach in submaximal bench press (i.e., 50% one-repetition maximum) performance (8,9). While an INT focus may decrease certain performance outcomes, attentional focus on a specific muscle group during resistance training may be advantageous to promote skeletal muscle hypertrophy. For instance, utilizing an INT focus has been shown to increase elbow flexor and muscle thickness by ~150% in an untrained male sample over an eight-week resistance training program (26). While an abundance of literature has previously examined sport performance outcomes while using various attentional focus strategies (2,14,32,33,36), less research is available in reference to the application of INT and EXT cues within resistance training (8,20,23,26). Furthermore, the studies that have examined resistance training have done so with single or limited outcome variables (e.g., either repetitions-to-failure or motor unit excitation only). Thus, the purpose of the current study was to examine the effect of an INT, EPr, and ED method of attentional focus on motor unit excitation and repetitions-to-failure during submaximal bench press performance.

METHODS

Experimental Design

This study used a repeated measures, randomized design in order to examine the effects of attentional focus strategies (i.e., INT, EPr, ED) on barbell bench press repetitions-to-failure (RTF) and motor unit excitation using a standardized load (i.e., 85% 1RM). Each participant completed three sets of repetitions-to-failure separated by 48-72 hours. One condition required the participants to use an INT focus strategy driven by auditory cues to focus on

the primary musculature given by the researchers; while, the additional conditions used an EXT focus (i.e., proximal and distal). The EXT conditions were visually cued by requiring the participants to focus on pushing the barbell towards a proximal prop (i.e., ruler) or a distal point (i.e., ceiling), respectively. The dependent variables for each condition for the current study were motor unit excitation from the major muscle groups (i.e., pectoralis major, anterior deltoid, and triceps brachii), RTF, ratings of perceived exertion (RPE), and adherence level to given cue.

Subjects

Twenty-five, apparently healthy, recreationally active males and females ($n = 16$ males, $n = 9$ females) aged 18-40 years participated in the study. Descriptive data for participants is presented in Table 1. An a priori power analysis, using G*Power statistics, with an alpha level of 0.05 and effect size, based upon similar studies (23,36), of 0.53, revealed a sample size of 30 individuals would be adequate for a power level of 0.8. Healthy was defined as not possessing any neuromuscular, cardiovascular, respiratory, or musculoskeletal ailments, in addition to no upper body injuries within the last six months prior to testing. Recreationally active was defined as currently resistance training, 3-6 hours per week for the past six months, in addition to being familiar with and currently performing the bench press as a part of the individuals resistance training regimen. Additionally, participants were asked to refrain from pressing exercises (e.g., bench press, shoulder press) within 48 hours of data collection and heavy-intensity lifting 24 hours prior. Lastly, ergogenic aids were prohibited the day of testing (e.g., caffeine, creatine, pre-workout supplements, wrist wraps, weightlifting belts). This investigation was approved by the Institutional Review Board (protocol H18141) and prior to testing, written informed consent, physical activity, and health history questionnaires were obtained from each participant.

Procedures

Surface Electromyography

Electromyography (EMG) was obtained with an electronic signal acquisition system (MP-160 Physiograph, BIOPAC System, Inc., Goleta, CA). For each submaximal trial, EMG signals from the pectoralis major, anterior deltoid, and triceps brachii were collected using two Ag/AgCl-surface electrodes (2 cm apart) during each visit.

Age (y)	21.96 ± 1.72
Height (cm)	175.13 ± 8.89
Weight (kg)	75.12 ± 11.73
Body Composition (%)	16.76 ± 6.30
Experience (y)	5.39 ± 2.78
1RM* (lbs)	168.48 ± 59.05

*1RM= One repetition maximum

Table 1. Descriptive data of subjects (reported as mean ± SD).

EMG locations followed previously established recommendations and were confirmed by palpation (13). EMG signal was checked for clarity (i.e. noise, artifact) prior to data collection. Two electrodes were placed approximately 4 cm, parallel to the muscle fibers, below the clavicle for anterior deltoid. Pectoralis major electrodes were placed on the chest approximately 2 cm below the clavicle and 2 cm medial to the axillary fold at an oblique angle towards the clavicle. Triceps brachii EMG location was approximately half the distance between the acromion and the olecranon process. Prior to all electrode placement, skin was cleaned with alcohol wipes and, if warranted, shaved to reduce signal impedance.

Prior to the bench press protocol, a maximal voluntary isometric contraction (MVC) was assessed for each muscle group. The pectoralis major was collected by having participants assume a traditional bench press position on an exercise bench. An overloaded, fixed barbell was then placed ~7.6 cm above the subject's chest on a safety rack to mimic the "sticking point" for each individual. The participant was then instructed to push against the bar "as hard as possible" to elicit a maximal isometric effort for five seconds. The anterior deltoid MVC was collected by having participants seated on a bench while facing an overloaded, fixed barbell. The height of the bar was adjusted so that the shoulder was flexed ~45 degrees with the elbow joint fully extended. The hand was placed directly underneath the bar, with the palm facing inward, at a level just proximal to the radial styloid process. Participants were instructed to attempt to lift the bar off the rack by flexing the shoulder joint "as hard as possible", in a controlled manner, for five seconds. The triceps brachii was assessed by having participants assume a kneeling position facing a bench with the right elbow placed on the bench at ~90° with a neutral wrist. Participants were then instructed to extend the elbow joint "as hard as possible" against a matched resistance (i.e., researcher). Three trials of each MVC were completed for all muscle groups prior to each day of testing to serve as a reference value (i.e., %MVC) for

the subsequent data collection. While MVCs were recorded for five seconds each, only the middle three seconds were used for analysis (13).

EMG Analysis

Motor unit excitation was quantified through an MP-160 Physiograph at a sampling rate of 2 kHz, with a fourth order Butterworth filter applied to a 20-400 Hz frequency range (28). Additionally, a 60 Hz notch filter was used to filter out power/electrical noise. EMG recordings were deemed viable when signal impedance was below 5 k Ω . Signals were captured with a linear band-pass and notch filter (i.e., 60 Hz). All raw signals acquired were quantified using root-mean-square transformations, along with conversion from analog to digital signals. All EMG data was analyzed using Acqknowledge software (BIOPAC System, Inc., Goleta, CA, USA).

Bench Press Testing

Data collection consisted of four separate testing sessions with 48-96 hours between trials. The first day consisted of the collection of written informed consent and medical history, participant demographic data (e.g., height, body mass, and body composition), a 1RM bench press test, and familiarization of the lifting cadence, and EMG electrode placement. Lifting cadence for all bench press trials (i.e., days 1-4) was set to a metronome, at a rate of 60 beats per minute, with subjects instructed to perform a two second eccentric phase, one second isometric pause at the chest, one second concentric phase, and one second isometric hold at the starting position for each repetition (i.e., 2-1-1-1). Additionally, participants were informed of proper exercise technique (i.e., 1-1.5x shoulder-width, closed, overhand grip; bar touching chest at terminal eccentric, full elbow extension, and appropriate maintenance of the 2-1-1-1 cadence) which was monitored by the researchers during each set. If the individual was unable to adhere to the desired technique or cadence for any of the trials, all data was removed from analysis.

To complete the 1RM test, participants estimated their 1RM which served as a starting point for warm-up and testing trials. Prior to bench press trials for each day, participants completed a dynamic warm-up which consisted of two sets of shoulder rotations (i.e., external, internal) and arm circles for 30 seconds with a one-minute break between sets. Following the dynamic warm-up, subjects completed a bench press-specific warm-up of 50%, 60%, and 70% of

their estimated 1RM (21). Following the warm-up sets, participants performed one repetition per set, while intensity increased by 5-10% until a 1RM was achieved. All 1RM trials were completed within three to five working sets.

On Days 2-4, participants completed one set of bench press to failure using the various attentional focus techniques. The attentional focus (i.e. INT, ED, EPr) on each day of testing was determined using a random sequence generator (n = 25 total sequences). For each day, participants completed the dynamic warm-up and two warm-up sets on the bench press (i.e., 50% and 65% 1RM) in accordance with National Strength and Conditioning Association recommendations (21). Upon the completion of each warm-up set, participants were instructed to rest for three minutes before attempting the following set. Each day of testing required the athlete to complete one set to failure at 85% of the measured 1RM (Day 1). Participants were instructed to complete as many repetitions as possible while focusing their attention according to the researcher's instructions for that day. The EPr cue involved pushing the barbell towards a meter stick approximately three feet above the individual (i.e., "drive the weight towards the ruler"); while, the ED focus used the ceiling as the focal point (i.e., "drive the weight towards the ceiling"). INT directed the participant to focus on the contraction of chest musculature while completing the movement (i.e., "drive the weight with your chest"). The cues were uniform with respect to each condition and provided prior to the start of each set and after every two repetitions (specifically at the end of the eccentric phase) by the same researcher. Additionally, each participant had the same spotters (n = 2), positioned on each end of the barbell, for every testing session to minimize confounding variables based on spotter differences. After completion of the last repetition (i.e., muscle failure), subjects provided ratings of perceived exertion (RPE) to quantify internal load using the OMNI scale. This scale uses a rating system of 1-10 and has been previously validated for resistance trained male and female recreational weightlifters (24). Additionally, a 100-millimeter visual analog scale was used to gauge participant adherence to the instructed attentional focus strategy. Once testing was completed, the participant was asked to mark a perpendicular line on the scale indicating how much focus was placed on the cue throughout the entire working set with '0' being "No focus on the cue at all" and '100' was "Focused solely on the cue".

Statistical Analysis

All data was analyzed using SPSS version 25.0 (IBM, New York, USA). Prior to analysis, data was tested for normality including skewness, kurtosis, histogram analysis, and Shapiro-Wilks. Data was analyzed using multiple 1 x 3 repeated measures analyses of covariance (ANCOVA) to examine differences in attentional focus (i.e., INT, EPr, ED) between bench press RTF and EMG amplitude. Years of resistance training experience was used as a covariate to determine any interaction between independent and dependent variables. Due to the ordinal nature of the RPE scale, a 1 x 3 Friedman's ANOVA was used to examine attentional strategies (i.e. INT vs. ED vs. EPr) between conditions. Post hoc pairwise comparisons were performed with a Bonferroni correction for multiple comparisons. Cohen's d statistics were calculated to determine practical significance using the Hopkin's scale of magnitude (11,15). The scale classified effect sizes based on the following values: trivial (0 - 0.19), small (0.2 - 0.49), moderate (0.5 - 1.19), large (1.2 - 1.9), or very large (≥ 2.0). Furthermore, Pearson's product moment correlations were used to analyze relationships between %MVC and adherence to attentional strategies. Cohen's correlation scale was used to classify the strength of relationships: weak (0.10 - 0.30), moderate (0.31 - 0.50), and strong (≥ 0.51) correlations (9). An a priori alpha level was set at ($p < 0.05$).

RESULTS

Two participants failed to complete all trials due to scheduling conflicts; thus, only 23 subjects were included within the data analyses. No violations of assumptions for normality occurred for %MVC, RTF, or adherence were analyzed using parametric statistics and reported as means \pm standard deviation, unless otherwise stated.

Repetitions-to-failure

Results indicated no statistical differences between RTF and attentional focus strategies. Additionally, years of resistance training experience ($F(2,19) = 0.47$; $p = 0.89$) demonstrated no interaction effect on RTF across all conditions. However, on average, the ED cue resulted in approximately one more repetition as compared to INT ($d = 0.55$) and EPr ($d = 0.33$). While no between-group differences were found, it is worth noting the presence of large within-group variability across conditions (Figure 1). Individual variation within the INT group had a repetition range of 2-8 at the standardized 80% 1RM load, which was comparable to the EPr cue (i.e., 3-8 repetitions). More interestingly, the ED strategy, which focused on pushing the weight towards the ceiling, produced the largest range of 3-14 repetitions.

	Int	ED	EPr
RTF	5.22 \pm 1.59	6.30 \pm 2.34	5.65 \pm 1.53
Chest %MVC	100.45 \pm 28.55	93.46 \pm 16.40	90.62 \pm 20.22
Deltoid %MVC	97.25 \pm 17.60	95.11 \pm 15.20	95.45 \pm 21.27
Triceps %MVC	75.301 \pm 32.04	76.43 \pm 20.81	71.14 \pm 24.54
Adherence	66.87 \pm 22.40	66.52 \pm 23.11	72.61 \pm 23.98
RPE	7 [7,8]	7 [7,8]	7 [7,8]

All values reported as mean \pm SD, except RPE (median [IQR]); RTF= Repetitions-to-failure; Int= Internal; ED= External distal; EPr= External proximal; %MVC= Percent of maximal voluntary contraction; Adherence measured in millimeters; RPE= Rating of perceived exertion.

Table 2. Repetitions-to-failure and motor unit excitation levels associated with various attentional focus methods.

Motor Unit Excitation

Findings indicated no between-group differences for the attentional focus conditions within pectoralis EMG amplitude ($F(2,20)$; $p = 0.59$). Furthermore, years of resistance training experience ($p = 0.17$) had no interaction effect on motor unit excitation levels across conditions. Although no between group differences were found, the INT strategy elicited the highest group mean %MVC which was ~7-10% greater than ED ($d = 0.30$) and EPr ($d = 0.40$). Based on the individual plots of difference (Figure 2), ED provided the lowest individual %MVC variation. For the anterior deltoid, there was no between-group differences ($F(2,20) = 1.86$; $p = 0.17$) or interaction

with years of experience ($p = 0.24$). Despite various attentional focus strategies, only a ~2%MVC difference was present between group means (Figure 3), with all effect sizes deemed trivial. Lastly, the triceps brachii ANCOVA for %MVC violated Mauchly's test of sphericity; thus, a Greenhouse-Geisser degrees of freedom correction was utilized. Results indicated that there was an interaction effect between years of training experience and the attentional focus conditions ($F(1.52,20) = 3.71$; $p = 0.047$), despite no between group differences ($p = 0.05$). Despite similar %MVC's between ED ($d = 0.04$) and INT groups (i.e., ~1% difference), EPr demonstrated a ~4-5% reduction in activity ($d = 0.15$). However, all practical significance was determined to be trivial.

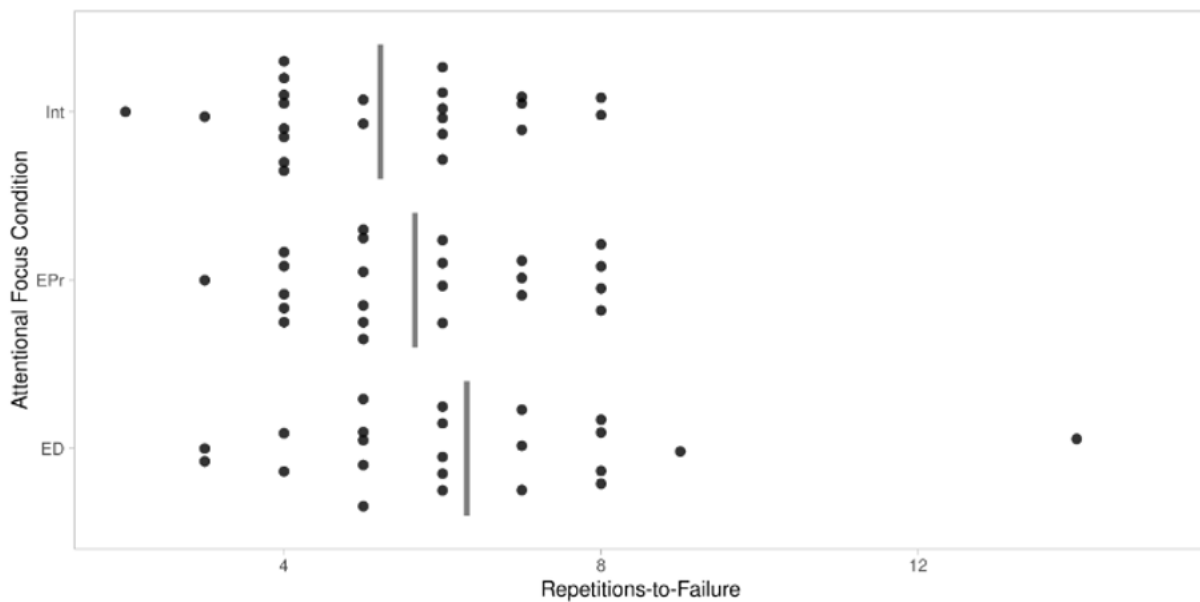


Figure 1. Repetitions-to-failure cross attentional focus conditions.

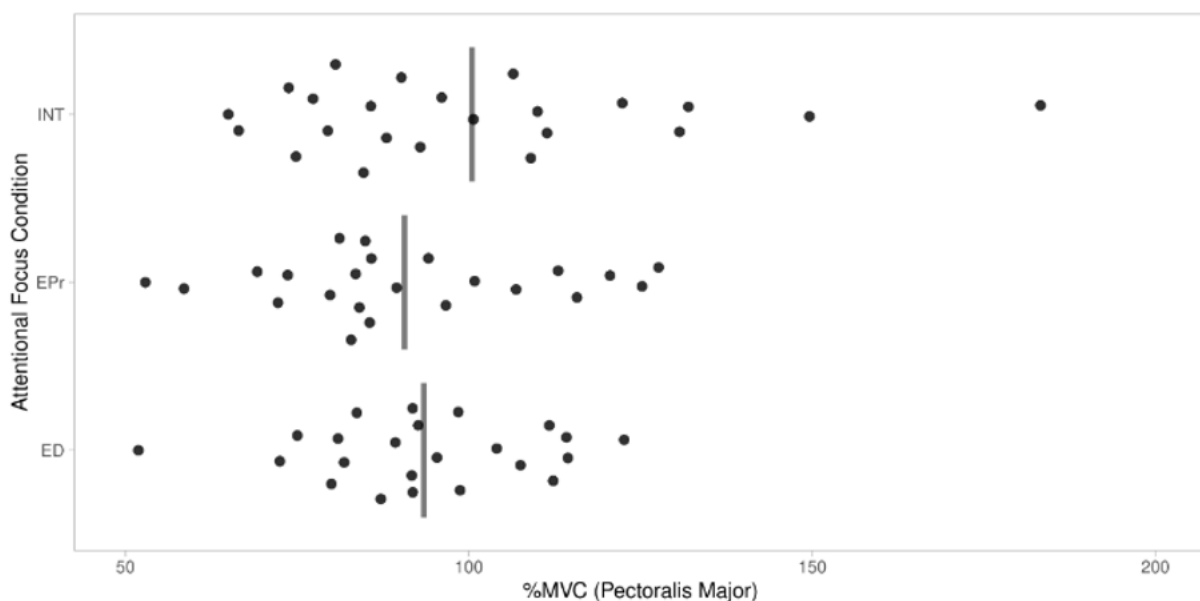


Figure 2. Motor unit exciation (%MVC) across attentional focus conditions for the pectoralis major.

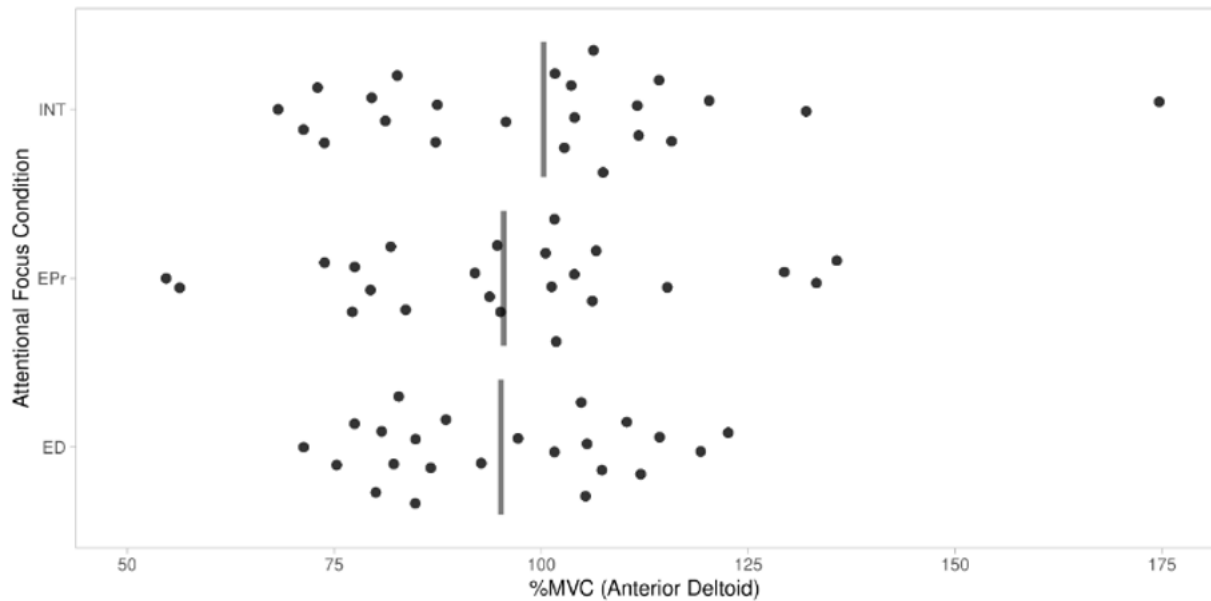


Figure 3. Motor unit Excitation (%MVC) across attentional focus conditions for the anterior deltoid.

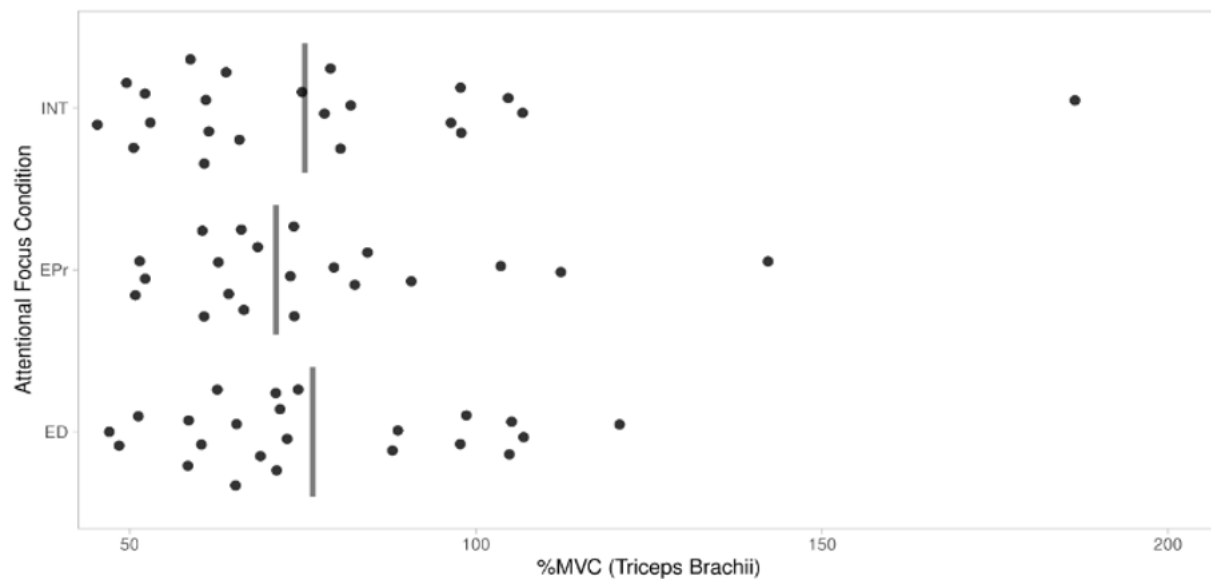


Figure 4. Motor unit Excitation (%MVC) across attentional focus conditions for the triceps brachii

Adherence and Rating of perceived exertion

Participant adherence levels to a given cue elicited similar values across conditions ($F(2,20) = 1.72$; $p = 0.21$). Based on mean group differences, EPr displayed the highest adherence value ($\Delta = +6\text{mm}$; $d = 0.25$); however, there was no difference between mean values for INT and ED ($d = 0.02$). Despite the mean difference (i.e., 6mm), responses across conditions were within the standard error range of a VAS scale (i.e., 9mm) of each other (5). Thus, adherence levels across conditions may be deemed consistent. In order to establish any relationships

between adherence level and motor unit excitation, correlations were assessed. Results indicated only a positive, moderate correlation ($r = 0.64$; $p < 0.01$) between ED adherence and EMG amplitude for the pectoralis major. No other relationships existed between attentional foci and motor unit excitation for any condition. In terms of RPE, there was no difference in perceived effort across conditions with all cues demonstrating a median and interquartile range (IQR) of 7 [7,8] ($\chi^2(2) = 0.69$; $p = 0.71$).

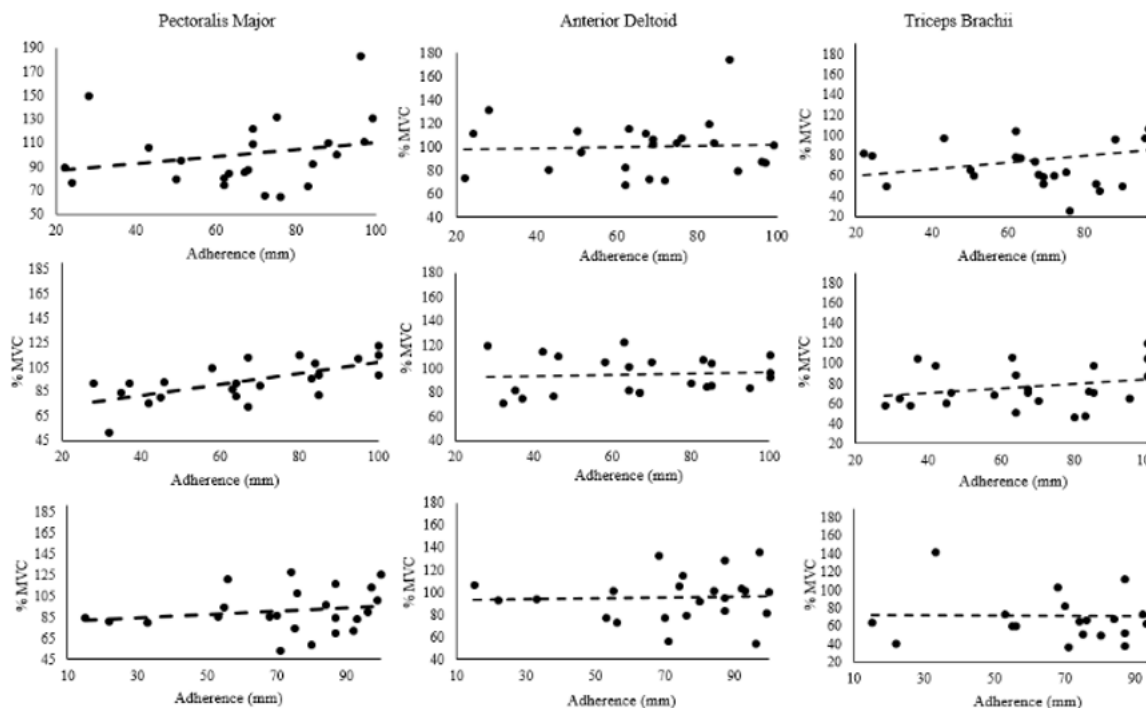


Figure 5. Scatterplots depicting the relationship between attentional focus adherence and motor unit excitation (%MVC) for each muscle group, across conditions.

DISCUSSION

While the majority of literature on attentional focus has examined sport-related outcomes, limited research has investigated the influence of various cues on resistance training. Thus, the purpose of this study was to evaluate the effects of attentional focus strategies (INT, ED, EPr) on RTF and motor unit excitation when performing the bench press at a submaximal load. The key findings of this study demonstrated that changing one's attentional focus to an EXT, versus an INT, reference point reduced agonist motor unit excitation by ~7-10% with no compensatory increase in secondary musculature involvement. Additionally, RPE and attentional focus adherence were consistent across conditions.

Despite no between-group mean differences between strategies, data may suggest an advantage with an ED focus as compared to INT and EPr when performing RTF. These findings are consistent with previous literature examining RTF within various resistance training exercises. For example, Nadzalan et al (2015) found that adopting an EXT strategy increased the number of repetitions completed, compared to neutral and INT strategies in both the bench press and deadlift in recreationally trained individuals. Both exercises were performed at 85% 1RM with the EXT condition eliciting ~2 more repetitions, on average, than the INT condition. While all subjects in the current study were experienced

with resistance training for a minimum of six months, changes in RTF may be attributed to several factors, including motor unit excitation, overstimulation of the thought process, attentional focus adherence, and individual variability.

Despite similar adherence levels to the cue given, the current findings indicated a ~7-10% increase in motor unit excitation of the primary mover (i.e., pectoralis major) when adopting an INT focus. Previous research has indicated that visualizing the working musculature (INT group), otherwise known as the "mind-muscle connection", may lead to higher EMG values when compared to other focus strategies (6,16,29). In addition to an increase in motor unit excitation, the use of INT strategies can also decrease task performance, increase onset of fatigue, and decrease movement efficiency (6,8,17,20,29,31). For example, Calatayud et al. (2018) examined the differences between an INT (i.e., "focus on pectoralis musculature") and neutral (i.e., "lift the bar in a regular way") attentional focus on the bench press at a submaximal load (i.e., 50% 1RM) performed at different speeds until failure. Results indicated that when performed at a controlled speed (2-0-2-0), participants increased EMG amplitude of the pectoralis major by 6%. However, when performed explosively (i.e., controlled eccentric and explosive ascent) a neutral focus elicited a ~3% increase in EMG amplitude versus a pectoralis-specific focus (9). Furthermore, Marchant et al. (2011) examined

the effects of three cueing methods (i.e., INT, EXT, neutral) on an assisted bench press, barbell bench press, and back squat and found that the adoption of an EXT focus elicited a greater number of repetitions (~1-3) for each exercise when compared to the INT strategy. The agreement within findings, demonstrating increased EMG amplitude and decreased RTF with INT strategies, may suggest over analysis of movement leading to disruptions in neural drive.

Thus, changes in attentional focus may determine whether or not an individual intentionally “over-activates”, or increases ‘activity’ of, a primary mover based on the cue given. The constrained action hypothesis has been proposed to explain these differences between the two methods (i.e., INT and EXT). The hypothesis states that when an individual uses an INT focus it may interfere with the natural processes of the central and peripheral nervous systems that normally regulate movement. When an interruption occurs (e.g., “conscious control of once automated behavior”), this may ultimately lead to an error in task performance or early on-set of fatigue (34). This may be due to the individual giving the neural system an “extra” task by consciously contracting a muscle group beyond what is required to complete the movement. Additionally, adopting an INT focus increases antagonistic involvement, often referred to as “noise”, leading to decreased movement efficiency, increased peripheral fatigue, and ultimately decreased repetitions completed (20,31). Alternatively, an EXT focus allows for self-organization of actions to take place without disruption along with a reduced muscular effort (37).

While the current study showed an increase in the pectoralis major for the INT condition, results indicated no substantial changes (i.e., <5% MVC) within the secondary musculature (i.e., triceps and deltoid) between conditions. These findings are comparable with previous literature examining attentional focus strategies on low submaximal bench press loads (29). Individuals were able to manipulate motor unit excitation levels in selective muscle groups (i.e., pectoralis major, anterior deltoid), but activity at the secondary mover (triceps brachii) was unchanged. Not limited to the bench press, Snyder and Leech (2009) demonstrated that verbal instruction with an INT focus for the lat pull-down elicited greater motor unit excitation values for the latissimus dorsi, but values were unchanged for the biceps brachii (30). This variation in muscular demand could be due to a process known as “selective activation” which involves a direct focus upon a given area; thereby, limiting or removing attention to another location.

This process may be supported by the constrained action hypothesis that allows the secondary movers to complete a given task without interruption despite an increase in motor unit excitation in the prime mover (9). For instance, previous literature examined various INT cues during submaximal bench press which focused on either the primary (i.e., pectoralis major) or secondary mover (i.e., triceps brachii) (9). Findings indicated that when subjects concentrated on the pectoralis major, EMG amplitude increased ~6% with no compensatory change in secondary mover activity. Although, when the focus was on the triceps brachii, EMG amplitude raised by 4%, but was accompanied by a 3% increase in pectoralis major excitation. Despite these findings, selective activation may be load-dependent as motor unit excitation patterns can be highly distinguished with low submaximal loads (i.e., 20-60% 1RM). However, as loads are increased to $\geq 80\%$ 1RM, as with the current study, %MVC values display no differences potentially indicating the inability to divert selective activation to a secondary mover during a high-intensity movement (9).

In addition to the increased motor unit excitation and constrained action hypothesis affecting RTF, there is also the factor of individual variability. Per NSCA recommendations, an individual should be able to perform six repetitions on average at 85% of 1RM (27). The introduction of a cadence, involving a controlled timing pattern, may possibly have decreased the number of repetitions performed; however, both EXT strategies elicited six repetitions on average. While group means were consistent with NSCA standards, there was large individual variability within RTF (27). For instance, the ED cue led to a range of three to fourteen repetitions performed to failure. Within the current study, one individual elicited a value of fourteen repetitions with the ED cue; while performing eight and seven repetitions with the INT and EPr, respectively. Furthermore, multiple subjects ($n = 7$) completed two to four repetitions lower than the established guideline of six for multiple attentional focus conditions. These findings are consistent with a previous study which found substantial individual variation during low- and high-load leg press (25). During the 75% 1RM trial, subjects averaged 14.3 repetitions with a standard deviation of ± 5.8 ; although, when load was decreased to 30% 1RM, individual variability rose to ± 13.5 around a group mean of 44.9 repetitions.

One such factor underlying individual variability may be training age (i.e., the total amount of time an individual has been training). Trained individuals

have previously demonstrated a potential ability to increase the involvement of synergistic musculature during high-intensity resistance training exercises as compared to those with fewer years of experience or whom were untrained (7,19). Therefore, the current study used 'years of resistance training experience' as a covariate to determine if RTF and motor unit excitation were influenced. However, training age did not provide any interaction effects, except a positive link between training age and triceps brachii motor unit excitation suggesting that individuals that had a longer training history elicited an increase in triceps' EMG amplitude. This finding supports previous studies, which hypothesized that increased EMG output is caused by beneficial neural adaptations associated with resistance training, such as improved synergistic stabilization and decreased antagonist co-activation (7,19).

To the authors' knowledge, there have been no studies investigating participant adherence to INT and EXT attentional focus strategies. Results indicated only a slight increase in adherence to the EPr cue; however, all focus strategy adherence values were within the standard error range of 9mm. While not practically significant, this minor increase in concentration with EPr (i.e., meter stick) may have resulted from the ability to distinctly focus on a narrow target within the line of sight. For example, this is in opposition to diverting attention to the ceiling (i.e., ED), a broad visual field that can elicit large variations on areas of which an individual can focus. While literature is limited for resistance training performance, narrow cues for long jump performance displayed consistent findings with the current study (2). The narrow cue (i.e., "*focus on extending the knees as rapidly as possible*") slightly outperformed the broad cue ("*focus on using your legs*") by ~4.8cm, but the effect was deemed trivial. Alternatively, it is possible that as subjects reached repetition failure the individual's focus shifted from the cues to muscular exhaustion (e.g., "*muscle burn*"). This change in focus to bodily sensations of pain, known as associative thoughts, have provided inconsistent results in regards to performance, physiological outcomes, and RPE (1,12,18). For example, increases in heart rate and RPE were found during periods in which athletes began focusing on pain within the legs when running on a treadmill for an unknown duration (1). Although anecdotal, reports from participants in the current study suggested that adherence to the cues was much higher in the first two warm-up sets due to the lighter intensity compared to the working set. Although the various attentional focus strategies elicited different values for both RTF and motor unit

excitation, there was no difference in RPE across conditions. This finding suggests that although the ED strategy resulted in one more repetition performed, there was no difference in perceived effort.

The current study is not without limitations. For example, participants were asked to manage a variety of stimuli throughout data collection. Firstly, many individuals had not been exposed to training with a cadence prior to this study. While the subjects were given ample time and multiple sets to familiarize themselves with the cadence, this requirement may have complicated the task and interfered with their ability to focus their attention. Furthermore, the individuals were cued once every two repetitions and this timing may have either been too little or too much. To the authors' knowledge, no studies have been completed investigating the timing of cues during resistance training movements. However, to avoid disruption of the natural rhythmic pattern of the bench press exercise, timing of the cues coincided with the scheduled one-second pause between the eccentric and concentric phase. An additional limitation with a majority of EMG studies is the assumption of maximal exertion within MVC collection. MVC's assume the participants' ability to isolate the targeted muscle, which may be further complicated by performing a compound movement (i.e., bench press). However, in an attempt to mitigate these effects, MVC's were performed prior to each bench press trial under the same conditions for each participant. Due to these limitations, future research may benefit from extending the cadence familiarization period over multiple weeks to better acclimate participants to repetition timing. This elongated familiarization may potentially eliminate the effect of the metronome on attentional focus. Additionally, future studies may seek to examine the acute and chronic effects of cueing frequency at submaximal and near-maximal loads during resistance training exercise. This information would help to establish clear recommendations for the practitioner.

PRACTICAL APPLICATIONS

The use of cueing to divert attentional focus is a common tool used by practitioners to teach a new skill or improve upon an individual's task performance. If incorporated correctly, verbal instruction and cueing may aid in teaching proper form and correcting mechanical errors, which may ultimately lead to a reduced risk of injury and greater transference to daily activity or sport. However, the effect

of attentional focus, specifically within bench press performance and motor unit excitation, has limited findings. Results of the current study displayed no between group differences for either RTF, EMG amplitude, RPE, or adherence rate to the cues. Despite these findings, the EXT conditions demonstrated a ~7-10% decrease in motor unit excitation, along with ~1 additional repetition, within the pectoralis major versus the INT strategy. These findings are surprising based on no compensatory change in secondary muscle involvement. While possibly trivial for hypertrophy, the addition of one repetition per set could lead to positive benefits for strength training performance as a result of an increased volume at a standardized, relative load. Additionally, based on the current results, resistance-trained individuals seeking to enhance performance variables (e.g., RTF) may opt to adhere to an external attentional focus strategy. If hypertrophy is the training goal, individuals may benefit from an INT cue, effectively increasing motor unit excitation solely through verbal instruction without altering external load. However, future research is needed to identify the effects of attentional focus strategies on chronic resistance training adaptations before solidified recommendations can be made.

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