Mind-muscle connection: effects of verbal instructions on muscle activity during bench press exercise

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Abstract

Different attentional foci may modify muscle activation during exercises. Our aim was to determine if it is possible to selectively activate the pectoralis major or triceps brachii muscles according to specific verbal instructions provided during the bench press exercise. 13 resistance-trained males (25.6±5.4 yrs, 182.7±9.1 cm, 86.4±9.7 kg) underwent an electromyographic signals acquisition of the sternocostal head, clavicular head of the pectoralis major, the anterior deltoid, and the long head of the triceps brachii (LT) during bench press exercise. Participants performed one non-instructed set (NIS) of 4 repetitions at 50% 1-repetition maximum (1-RM) and one NIS of 4 repetitions at 80% 1-RM. Four additional sets of 4 repetitions at 50% and 80% 1-RM were randomly performed with verbal instructions to isolate the chest muscles (chest instructed set, CIS) or to isolate the triceps muscles (triceps instructed set, TIS). Participants showed significantly higher LT activation during TIS compared to non-instructed set both at 50% (p=0.0199) and 80% 1-RM (p=0.0061) respectively. TIS elicited a significant (p=0.0250) higher activation of LT compared to CIS. Our results suggest that verbal instructions seem to be effective for increasing activity of the triceps brachii but not the pectoralis major during the bench press.

Key Words: resistance training; bench press; mind-muscle connection; internal focus.

Attentional focus is considered an integral strategy in the field of motor learning. Attentional focus can be operationally defined as what an individual thinks about when carrying out a given movement or activity.[1,2] There are two basic attentional focus strategies during performance of a task: internal and external. An internal focus involves thinking about a given bodily movement during performance while an external focus involves shifting performance-oriented concentration to the environment. There is compelling evidence that an external focus is superior to an internal focus for the execution of a wide array of tasks. A recent review of literature on the topic showed greater motor learning benefits when adopting an external focus in over 90% of published studies.[3] These results held constant across a plethora of activities and outcome measures, thereby strengthening the rationale to focus externally when seeking to enhance physical performance. The application of attentional focus to resistance exercise remains somewhat equivocal. Limited research indicates that an external focus can enhance economy of movement during a lift by increasing force production and reducing ancillary muscular activity.[4] It has been postulated that an internal focus may be more desirable to target specific muscles when the goal is to rehabilitate a musculoskeletal injury[5] or promote regional-specific hypertrophy.[6,7] Several studies have endeavoured to investigate the ability to selectively target different muscles,[8-11] but the results have been conflicting. Moreover, there is evidence of an upper intensity

Table 1. *Demographics and resistance training variables (n = 13, all men)*

	Average ± SD
Age (years)	25.6 ± 5.4
Height (cm)	182.7 ± 9.1
Body weight (kg)	86.4 ± 9.7
RT experience (years)	5.6 ± 2.4
1-RM (kg)	109.1 ± 12.8

threshold whereby heavy load training diminishes the ability to activate a given muscle;[8] however, this findings requires confirmation. In these studies, surface electromyography (sEMG) was the most widely used method to quantify muscle activity while comparing different attentional foci during the bench press exercise. In one of the above-mentioned study,[9] sEMG underlined that male football players could mainly increase the muscle activity of their bench press prime movers at 50% 1-repetition maximum (RM) compared to 80% 1-RM, after verbal instructions of focusing on those muscles. More recently, Calatayud [8] pointed out that male recreationally males were able to modify triceps brachii and pectoralis major to a greater extent only for loads below 60% 1-RM during bench press. On this topic and with a similar approach Daniels[11] did not find significant differences in the sEMG activity of the bench press prime movers comparing trained and untrained males. Contrary to the author's hypothesis, trained males did not exhibit higher sEMG activity of the pectoralis and triceps muscles compared than the untrained males after verbal instructions to focus on chest or arm muscles.

The purpose of the present study was twofold: 1) To determine whether resistance-trained individuals could selectively target the triceps and pectorals during the barbell bench press by employing an internal,[12] versus a control where no instructions were provided, and; 2) To determine if differences in activation exist when carrying out performance at 50% 1RM versus 80% 1RM.

Materials and Methods

Participants

Thirteen resistance trained males participated in this study (see Table 1). To be recruited, each participant was required to have at least 2 years of resistance training (RT) experience, performing at least 3 sessions per week at moderate to high intensity. In addition, they were familiarized with the barbell bench press exercise. Barbell bench press exercise is a multi-joint exercise that involves multiple muscle groups.[13] Moreover, participants had not to present any injuries at shoulders, elbows, wrist and back over the last 6 months. All participants were informed about the purpose and content of the investigation. Informed consent was obtained from all individual participants included in the study. The experimental protocol was approved by the local Institutional Review Board (approval n. HEC-DSB12/16).

Experimental procedures

The general procedure for the study is outlined in Figure 1. Participants reported to the laboratory on one occasion. After an individual 10-minute warm up, they were asked to perform a 5-RM bench press test which allowed to estimate the 1-RM bench press.[14-15] Then participants rested for an hour before being prepared for the sEMG data collection of the following muscles: sternocostal head (SP) and clavicular head (CP) of pectoralis major, anterior deltoid (AD), and long head of triceps (LT). To help control for the undue influence of external factors possibly affecting bench press performance, all measurements were conducted by the same investigator and in the same facility. Participants started all the bench press sets with fully extended arms and with a self-selected pronate grip width. Feet were kept at about shoulders width. During the eccentric phase, elbows flexed until the bar touched the chest. Scapula and spine were respectively hold retracted and in flat position.
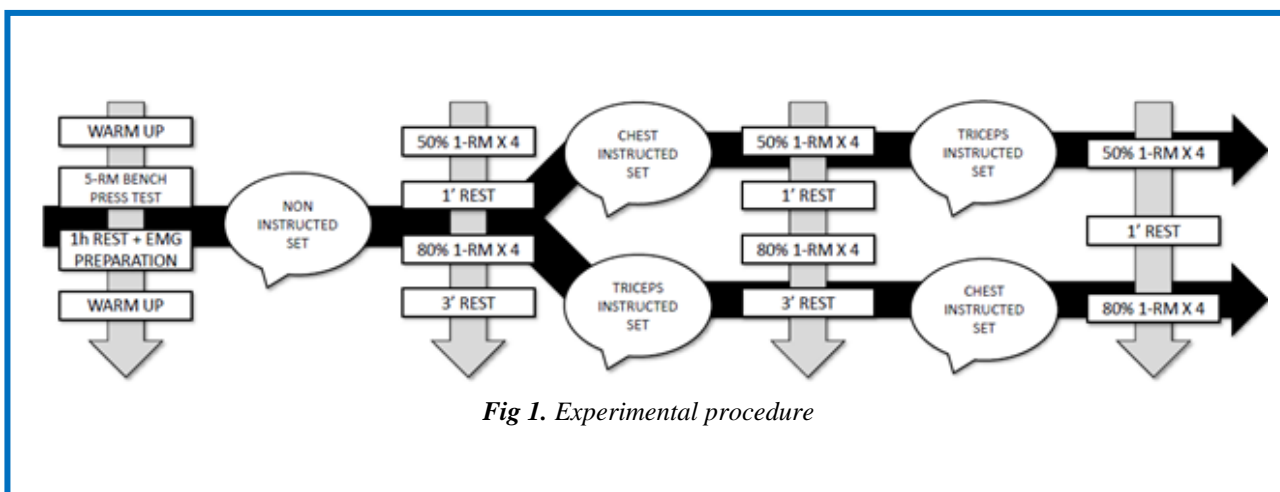

Fig 1. *Experimental procedure*

Participants were instructed to perform each repetition within a standardized time consisting of 2 seconds down, 1 second pause at the chest, and 1 second up. Time was manually controlled with a stopwatch by the investigator. Before the beginning of the experimental protocol, participants performed a second 5-minute individual warm up to familiarize with the worn sEMG instrumentation. After the warm up, the participants were instructed to perform 1 set of 4 repetitions of the bench press at 50% of 1-RM, which is often selected in RT programs Upper body muscle activation during low- versus high-load resistance exercise in the bench press, 15 and 1 set of 4 repetitions at 80% of 1-RM, which has been demonstrated to be correlated with an increase of the pushing muscles activity.[16,17] After 3-minute rest period, participants performed 2 sets of 4 repetitions at 50% and 80% 1-RM respectively (separated by 1 minute). Verbal instructions were given before the beginning of the set to isolate chest muscles (''During this set, try to use only your chest muscles. To do this, attempt to bring your elbows to each other when you push.''). After another 3-minute rest period, participants were asked to focus on the triceps muscles to complete the lift (triceps instructed set, TIS). This time the verbal instruction reported: ''During this set, try to use only your triceps muscles. To do this, attempt to turn away your elbows from each other when you push.'' The last two conditions with the verbal instructions were performed in a randomized order.

Data collection analysis

sEMG raw signals were recorded by means of a PDA PocketEMG (BTS Bioengineering, IT). To determine the lift cycle defined by two consecutive elbow extensions an electrogoniometer (Biometrics LTD, UK) was placed on the lateral side of the right elbow to measure its flex-extension. Data were synchronously recorded at a sampling frequency of 1 kHz. Electrode placement followed the recommendations of the Surface Electromyography for Non-Invasive Assessment of Muscles (SENIAM) project.[18] The skin surface over the centre of the muscle belly was shaved with a razor and cleaned by rubbing with an alcohol pad. Pre-gelled bipolar surface electrodes (Arbo, H124SG, Kendall) were placed with an interelectrode distance of 24mm. A single reference electrode was placed over the styloid process of the radius. Once the preparation was complete, signal quality was checked asking the participant to contract each muscle against a resistance. Raw sEMG signals obtained during the trials were rectified around their mean value, then integrated with a moving window of 150 ms and finally smoothed with a 4th order Butterworth low pass filter set at 5 Hz. As reported in our previous studies[19,20], the analysis of sEMG data was based on every set excluding the first and the last repetition. For each set, the mean value of the two repetitions considered was calculated. Than the mean of the means was reported for each muscle. sEMG data analysis was performed by the Smart Analyzer software (BTS Bioengeneering, Milano, Italy).

Statistical Analysis

A two-way repeated measure ANOVA (2 load intensities x 3 verbal instructions) was used to establish whether there were significant main effects and/or interactions between the two independent variables. When a significant main effect or interaction ($P<0.05$) was found, a Bonferroni post-hoc pairwise comparison was conducted to determine the origin of these differences. All statistical analyses were computed by means of the

Table 2. sEMG activity at 50% and 80% 1-RM (mean and SD).

		NIS	CIS	TIS
SP	**50%**	0.206 ± 0.106	0.228 ± 0.110	0.187 ± 0.097
	80%	0.326 ± 0.126	0.350 ± 0.130	0.394 ± 0.177
CP	**50%**	0.286 ± 0.178	0.382 ± 204	0.298 ± 0.171
	80%	0.493 ± 0.240	0.584 ± 0.263	0.646 ± 0.332
LT	**50%**	0.134 ± 100	0.169 ± 0.123	$0.196 \pm 0.163*$
	80%	0.294 ± 0.208	0.327 ± 0.217	$0.364 \pm 0.215**$
AD	**50%**	0.277 ± 0.189	0.303 ± 0.194	0.288 ± 0.179
	80%	0.477 ± 0.309	0.500 ± 0.200	0.500 ± 0315

SP: sternocostal head of pectoralis major, CP: clavicular head of pectoralis major, LT: long head of triceps, AD: anterior deltoid, NIS: non-instructed set, CIS: chest instructed set, TIS: triceps instructed set. (* = p<0.05 NIS vs TIS; ** =p<0.01 NIS vs TIS)
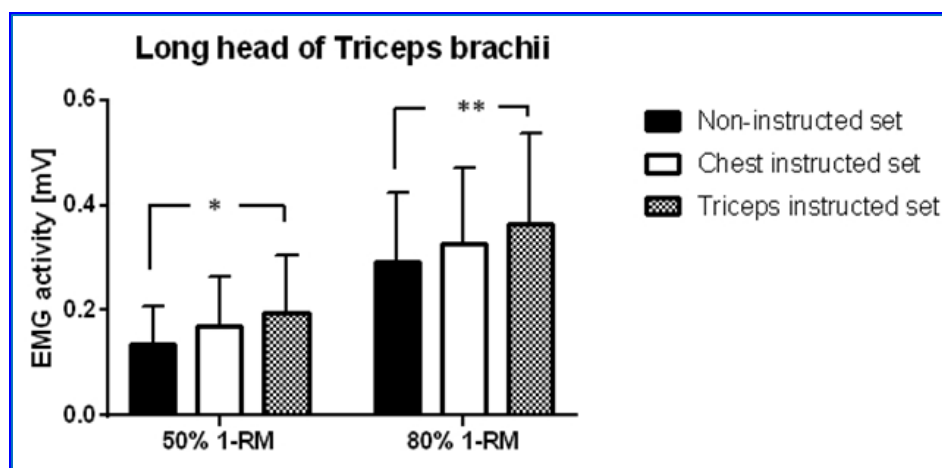
***Fig 2.** sEMG activity at 50% and 80% 1-RM (mean and SD). Data referred to LT (long Head of Triceps)*

software package GraphPad Prism version 7.00 for Windows (GraphPad Software, San Diego California USA).

Results

Data of the sEMG activity of each muscle are presented in Table 2. A significant main effect of the load intensity was detected for all muscles: SP (P < 0.001), CP (P < 0.01), LT (P < 0.001), AD (P < 0.001). On the contrary, a significant main effect of verbal instructions was effective only for the LT (P < 0.01) (Figure 2). The Bonferroni post hoc test underlined differences between 50% non-instructed set (NIS) vs 50% TIS (P < 0.05) and 80% NIS vs 80% TIS (P < 0.01). The other muscles were not affected by the verbal instructions (SP, p= 0.572; CP, p = 0.165; AD, p = 0.546). None interaction was found between the two independent variables.

Discussion

The present study showed that resistance-trained males can alter the activation of the LT, but not the pectorals, during both moderate and higher intensity bench press in response to verbal instruction. Previous research indicates that football players performing a bench press at 50% 1-RM were able to increase both SP and LT activity while maintaining proper form and similar movement speed by shifting attentional focus to the respective muscles (by 22% and 25.7%, respectively).[9] However, during training at 80% 1-RM, only the PM showed increased activation from an internal focus while activity of the LT was statistically unchanged. More recently, Calatayud et al.[8] found that activity of both the PM and LT can be increased by focusing on using the respective muscles at relative loads between 20 and 60 %, but not at 80 % of 1RM. In contrast, results of our study show that at both 50% and 80% 1-RM, the subjects were capable of altering muscle participation of the elbow extensors, but not the horizontal adductors. Even

though we used resistance trained males, the selective activation of muscles didn't occur because of the necessary effort needed to lift heavy weight by the prime movers. It seems that the subjects are primarily focused on lifting the weight when heavy weights are used. Using body weight as resistance,[21,22] or loads, varying from 30 to 50% of the 1-RM,[10,23] produces greater muscle activation after specific verbal instructions in dynamic exercises as the most studies present in literature on the topic report. Unlike the study of Calatayud,[8] the activation of the pectoralis major increased to a greater extent when subjects were asked to focus on the triceps at high intensity (80% of 1-RM). Moreover, even when subjects were asked to focus on the pectoral muscles, triceps activity showed an increase compared to the condition without focus. Our findings are in contrast with some previous research, where the activation of the alternate muscle (i.e triceps activity during CIS) as shown in our study was not observed.[22,24] As proposed by Karst and Willet,[22] subjects performing the abdominal crunch accompanied by verbal instructions could voluntary modify the activity of the rectus abdominis and external oblique in a univocal way. In fact, subjects were able to increase external oblique activity and to decrease rectus abdominis activity, but they were not able to do the opposite. Alternatively, subjects in our study were instructed to focus their attention on increasing the activity of a specific muscles and were not instructed to focus on the relaxation of the alternate muscle. This difference in instructions can illustrate the failure of "muscle isolation" in our study. It is also possible that the differences in muscles investigated between our study (pectorals and elbow flexors) and the others (abdominals and shoulder musculature, respectively)[22,24] may have at least in part accounted for the conflicting findings. A reasonable interpretation for greater muscle activity followed by specific verbal instructions could be found

in the "constrained action hypothesis." This theory, described by Wulf et al.[25] and supported by subsequent studies,[4,26,27] explains the relative benefits of adopting an external rather than an internal focus of attention. According to this theory the body's automatic control of movements is made less functional when an internal attentional focus is used. In the review of this topic by Wulf[3], studies showing improved task-oriented performance with an external focus were matched with decreased sEMG of the working musculature. The evidence of an increase in sEMG activity with verbal instructions agrees with the findings of reported studies, although our study used a multi-joint exercise and included a control condition without any instructions. Our results confirm that an internal focus could be more useful when we want to increase the activity of a specific muscle; whereas an external focus could be more indicated when we want to achieve a performance improvement. Some questions still remain opened: it is unknown how the increased activity of a muscle could occur without modifying other aspects (e.g. kinematics) of movement. In our study, subjects did not succeed in reducing the LT activity after the CIS. However, we hypothesize that subjects in previous studies performed bench press keeping their arms very close to their body, which may have increased the activity of the AD, CP and LT instead of reducing SP involvement. It is possible that fatigue may have been a confounding factor even though we randomized the different instruction sets order. However, excessive effort or fatigue were not reported by the subjects during exercises both at 50% and at 80% 1-RM, making such speculation unlikely. Our study presents both strengths and limitations. Compared to other studies that investigated verbal instructions applied to a RT protocol, a strength of our study was the expertise in RT of our subjects. A limitation lies in not having measured the activity of the antagonist muscles such as reported in the study of Snyder and Fry.[9] Finally, the amplitude of the sEMG signal reflects a combination of motor unit recruitment, firing rates and the degree of motor unit synchronization.[28] Thus, it remains to be determined which of these factors, or combinations of them,[29,30] generated the increase of the sEMG signal.

In conclusion, verbal instructions seem to be effective for increasing activity of the triceps brachii but not the pectoralis major during the bench press in resistance trained men. Future studies should investigate whether or not these effects could be increased through training with verbal instructions.

List of acronyms

CIS - chest instructed set
CP - clavicular head of the pectoralis major
LT - the long head of the triceps brachii
NIS - non-instructed set
RM - repetition maximum
RT- resistance training
sEMG - surface EMG
SP - sternocostal head of the pectoralis major
TIS - triceps instructed set

Authors contributions

AP, PZ, GM, and FQP conceived the study; MS and DG performed the experiment; MS, GM and AP analysed the data; MS and AP wrote the paper; BS and LM helped to editing the manuscript.

Conflict of Interest

Authors declare no conflicts of interest.

Ethical Publication Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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