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Electromyographic effect of using different attentional foci during the front plank exercise

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ABSTRACT

Objective: The aim of this cross-sectional study was to examine whether an internal focus on different core muscles during the isometric prone plank exercise increase muscle activity.

Design: Twenty university students performed 5 different conditions: regular prone plank (external focus) and prone plank with an internal focus on different muscles. Surface electromyography (EMG) signals were recorded for the upper rectus abdominis (UP ABS), lower rectus abdominis (LOW ABS), external oblique (OBLIQ) and lumbar erector spinae (LUMB).

Results: For the UP ABS, an internal focus on using any muscle increased activity. For the LOW ABS, internal focus on any muscle except the LUMB increased activity. No changes were found for OBLIQ and LUMB activity.

Conclusion: UP ABS and LOW ABS activities increased during an internal focus on the abdominal muscles. OBLIQ and LUMB activities were non-affected by an internal focus on any muscle.

Keywords: *bridging, low back, focus, core, trunk, mind-muscle*

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Introduction

Low back pain is a major cause of work absenteeism and disability[1] and will affect most people at some point in life.[2] Core stability training has been a hot scientific topic during the last years especially due to the clinical implications for improving and restoring motor control in those with low back pain.[3] Appropriate core stability also allows for effectively resisting or producing force, having important implications for daily life activities.[4] The term core stability can be defined as the ability to stabilize the spine as a result of muscle activity.[5] Muscular strength and especially muscular endurance and sensory-motor control are relevant aspects to provide sufficient core stability.[6,7] Thus, investigations about exercise methods to increase core muscle activity and stability are warranted.

Isometric planks have been the most used and investigated exercises to improve core stability.[8] Interestingly, isometric core training based on planks have recently demonstrated superior torso stiffness improvements compared with dynamic core training.[9] The authors of that study claimed that the greater time under tension could be the main explanation for this finding. Isometric plank exercises provide safer spine loads than corresponding dynamic exercises[10] and a more functional way of training than traditional abdominal exercises.[11] Additionally, planks are easy to perform and can be modulated biomechanically by changing the position or by using external equipment as suspension devices[8] in order to recruit different muscles or to increase muscle activity.

Another way of changing or providing additional muscle activity during physical exercise is the use of different attentional foci.[12] Participants can externally focus the attention on the

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effect of the action, or internally focus the attention on the own action (e.g., the muscle).[12] For instance, recent studies have showed an increased muscle activity when subjects were internally focused on the specific muscle during the bench press exercise.[12,13] However, to our knowledge, whether an internal focus can be used during a core plank exercise remains investigated. Moreover, no studies have confirmed the possibility of internally focusing the attention in different abdominal muscles and its electromyographic effect. An internal focus during a plank exercise could be an easy way of providing further muscle activity, enhancing the neural drive to the muscle fibers without changing the position or using additional external equipment or loads. This could be especially useful for home-based training and during the rehabilitation setting, especially as a first step for those who cannot receive higher stress derived from using such training methods. Interestingly, a recent article supports the use of an internal focus to increase isometric strength and muscle thickness.[14]

Hence, the purpose of the present study was to examine whether an internal focus on different specific trunk muscles can increase activity during the isometric prone plank exercise, either globally of separately. It was hypothesized that participants would be able to increase general trunk muscle activity after an internal focus of attention, without increasing activity in the specific muscles by separately.

Methods

Participants

A total of 20 university students (13 men and 7 women) voluntarily participated in the study, which was performed during November-December 2015. The participants were physically

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active, performing at least 2 exercise sessions per week at moderate to vigorous intensity, but were not familiarized with the specific front plank exercise and did not have previous experience with the use of different attentional foci. All participants were free from musculoskeletal pain, neuromuscular disorders, or any form of joint or bone disease. 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 study conformed to The Declaration of Helsinki and was approved (H1460994903890) by the committee on research ethics at the institution in which the research was conducted in accordance with the Declaration of the World Medical Association. Data reported in the present study forms part of a research project investigating muscle activity during different core stability exercises. Previous data from this project has already been published.[8,15] This article adheres to the STROBE guidelines This article adheres to the STROBE guidelines (see Checklist, Supplemental Digital Content 1, http://links.lww.com/PHM/A644). [16]

Procedures

Each participant took part in 2 sessions: familiarization and experimental sessions both at the same hour during the morning and separated by 48-72 h. Several restrictions were imposed on the volunteers: no food, drinks or stimulants (e.g. caffeine) to be consumed two hrs before the sessions and no physical activity more intense than daily activities 24 hrs before the exercises. They were instructed to sleep at least 7-8 hrs the night before data collection. To control the influence of external factors possibly affecting exercise performance, all measurements were made by the same two investigators and were conducted in the same facility. The two investigators had previous experience with EMG measurements and were: an exercise

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physiologist (PhD) and Strength & Conditioning Specialist (CSCS) and an exercise physiologist and physiotherapist (PhD).

During the familiarization session, height (IP0955, Invicta Plastics Limited, Leicester, England), body mass and body fat percentages (Tanita model BF- 350, Tokyo, Japan) were obtained. Then, participants were familiarized with the exercise and conditions (different attentional foci) that would later be used during data collection. Participants practiced at least 3 times for each condition, until they felt confident of understanding the task.

The protocol started with a light warm-up, where each participant performed 3 minutes of light walking. Then, the protocol continued with the preparation of participants' skin, followed by electrode placement, maximum voluntary isometric contractions (MVICs) collection and exercise performance. Hair was removed from the skin overlying the muscles of interest and the skin was then cleaned by rubbing with cotton wool dipped in alcohol for the subsequent electrode placement. Electrodes were placed according to established recommendations on the upper rectus abdominis (UP ABS),[17] lower rectus abdominis (LOW ABS),[18] external oblique (OBLIQ)[17] and lumbar erector spinae (LUMB)[17] on the dominant side of the body. Pre-gelled bipolar silver/silver chloride surface electrodes (Blue Sensor M-00-S, Medicotest, Olstykke, Denmark) were placed with an inter-electrode distance of 2 cm. The reference electrode was placed between the active electrodes, approximately 10 cm away from each muscle, according to the manufacturer's specifications. All signals were acquired at a sampling frequency of 1kHz, amplified and converted from analog to digital. All records of myoelectrical activity (in microvolts) were stored on a hard drive for later analysis. To acquire the surface EMG signals

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produced during exercise, an ME6000P8 (Mega Electronics, Ltd., Kuopio, Finland) biosignal conditioner was used. Prior to the exercise performance described below, two MVICs of 5 sec duration were performed for each muscle and the trial with the highest EMG was selected.[19] Participants performed a non-maximal practice trial to ensure that they understood the task. One minute of rest was given between each MVIC and verbal encouragement was provided to motivate all participants to achieve maximal muscle activity. Positions during the MVICs were based on standardized muscle testing procedures[20] for the 1) UP ABS and LOWS AB, 2) OBLIQ, 3) LUMB, and were performed against a fixed immovable resistance (i.e., Smith machine). Specifically, 1) curl up at 40º with arms on chest and pressing against the bar with the participant lying on the exercise mat and feet flat on the floor, 2) curl up at 40º with arms on chest and pressing against the bar in an oblique direction with the participant lying on the exercise mat, with the feet flat on the floor and the knees bent at 90º and 3) trunk extension with the participant lying on a bench and pelvis fixated, the trunk was extended against the bar.

Participants were instructed to maintain a prone plank position where only the feet and the forearms were in contact with the floor, with elbows placed beneath the shoulders and the upper arms perpendicular to the floor. In this position they performed 5 different conditions, randomly assigned: regular prone plank (i.e., external focus) and prone plank with an internal focus on each different muscle (UP ABS, LOW ABS, OBLIQ, LUMB). The UP ABS instruction was as follows: “during this set, try to focus on using your UP ABS only”. The LOW ABS instruction was as follows: “during this set, try to focus on using your LOW ABS only”. The OBLIQ instruction was as follows: “during this set, try to focus on using your OBLIQ only”. The LUMB instruction was as follows: “during this set, try focus on using your LUMB only”. Before

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starting, the researcher made sure to show by palpation where these muscles were located on the participant to avoid misunderstandings. In the regular condition the instruction was as follows: "during this set, try to perform the exercise in a regular way". The different conditions were maintained during 5 seconds and 1-min rest interval was given between. A trial was discarded and repeated if a participant stated that he had forgotten the instruction.

Data analysis

During later analysis all raw EMG signals obtained during the exercises were digitally filtered, consisting of 1) high-pass filtering at 10 Hz, and 2) a moving "root-mean-square" (RMS) filter of 500 ms. For each individual muscle, peak RMS EMG in each condition was determined and normalized to the maximal RMS EMG obtained during the MVIC´s.

Statistical Analyses

A repeated measures analysis of variance (Proc Mixed, SAS version 9, SAS Institute, Cary, NC, USA) was used to determine if differences existed between conditions for each muscle separately. The factor included in the model was *Instruction (5 conditions)*. Normalized EMG was the dependent variable. Values are reported as least square means (95% confidence interval) unless otherwise stated. P-values <0.05 were considered statistically significant.

Sample size calculations showed that 20 participants were sufficient to achieve a statistical power of 80% at a minimal relevant difference of 10% EMG, a Type I error probability of 1%, and a SD of 10%.[21]

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Results

The 20 participants of the present study had the following demographic characteristics: age: 20 ± 1 years; height: 173.4 ± 7.8 cm; body mass: 73.9 ± 7.7 kg; body fat percentage: 14.1 ± 4.4 %.

Table 1 shows complete normalized EMG (95% confidence interval) data during the different front plank conditions. For the UP ABS, an internal focus on any muscle increased muscle activity, with differences of least squares means ranging from 25 to 31 respects to regular front plank. For the LOW ABS, focusing on any muscle except the LUMB increased muscle activity, with differences of least squares means ranging from 25 to 31 respects to regular front plank. No changes were found for OBLIQ and LUMB activity. No concurrent activity reductions were found when focusing on a specific muscle.

Table 1 about here

Discussion

To our knowledge, this is the first study showing that participants may increase abdominal muscle activity by internally focusing the attention on using specific muscles during the front plank exercise. Furthermore, the effect was not specific for the muscle in focus. Thus, partly in accordance to our hypothesis, the effect was only found in the UP ABS and LOW ABS.

Not only the back musculature but also abdominal muscles contribute to core stability.[22] Abdominal muscle contractions increase intra-abdominal pressure and thus lumbar spine stiffness.[6] In this sense, an internal focus on different specific muscles (UP ABS, LOW ABS or

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OBLIQ) provide comparable EMG increments in the UP ABS and LOW ABS when compared with the regular front plank. The results of the present study are partially in line with previous literature examining core muscle EMG after different attentional foci when performing dynamic exercises. For instance, an internal focus compared with the other non-instructed conditions resulted in greater muscle activity in rectus abdominis, external oblique, transverses abdominis and internal oblique muscles during a squat performed at the 50% of the 1RM.[23] Similarly, greater internal and external oblique activity during a trunk curl was found after an internal focus on the oblique muscle.[24] However, only internal oblique activity was increased by a rectus abdominis emphasis, even activation in this muscle was even higher during the oblique emphasis. Specific internal instructions also have led to a higher muscle activity in comparison with external focus conditions during the pull-down exercise performed at 30% of maximal force[25] or during bench press performed at intensities from 20 to 60% of 1RM.[12,26] These results suggest that increasing muscle activity is especially possible when low intensities or body-weight exercises are used. At the present case, dissociate activity in different muscles could have been more difficult as a result of using an isometric exercise.

Despite previous findings showing that oblique emphasis instruction increased internal and external oblique activity while the rectus abdominis activity decreased,[24] we did not find concurrent muscle relaxation. Certainly, we found that the rest of the muscles showing no activation increments with a specific instruction (i.e., LUMB and OBLIQ) just remained unchanged. In agreement with previous results during the trunk curl exercise,[24] is likely that the primary role of the rectus abdominis during the front plank made difficult to dissociate between this muscle and the OBLIQ as well as between upper and lower rectus abdominis fibers.

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However, interestingly, when participants were focused in using LUMB, only UP ABS activity increased while LOW ABS remained unchanged. It seems that when an attempt is made to contract only the back musculature, lower abdominal fibers are less stimulated.

A way of voluntarily increasing core activity and spine stability is to perform the abdominal bracing maneuver, where participants have to maximally contract the abdominals.[27,28] Therefore, the effect of this action may be similar to both rectus abdominis foci used at the current study. In accordance with this notion, it has been found that the LUMB was the less activated trunk muscle during a maximal abdominal bracing action.[20] Likewise, we found that internal focus on either UP ABS or LOW ABS was not traduced in greater OBLIQ or LUMB EMG. The fact that a front plank position was used (which has been showed to specially activate the rectus abdominis) probably made more difficult these results.

A possible explanation for the absence of OBLIQ and LUMB activity increments is the magnitude of familiarization with the instructions. Because participants in this study can be considered recreationally trained and they only had a brief familiarization session, it is plausible that more practice sessions were needed to dissociate activity between the rest of the muscles. However, using only one familiarization session provides a more realistic approach than several practice sessions if we take into account the usual clinical practice. Moreover, the absence of specific experience with the front plank exercise or with the use of different attentional foci further improves the applicability and generalisability of our results. The use of healthy participants may be the main limitation in the present study and caution should be taken when attempting to apply the present results in patients. However, this study has relevant clinical

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applications for core stability programs. Using biofeedback could potentially have helped to focus on specific muscles and thus provided even larger differences in muscle activity, although this would be less applicable during the clinical practice or during home-based training. It has been shown that thinking about contracting muscles can train the brain, increasing cortical output signal, providing greater activation and thus enhance muscle strength.[29] In this study, the participants voluntary attempted to increase muscle activity during a certain time after instructions. These mind-muscle exercises could help to improve the sensation of the perceived timing and extent of muscle contraction, which are relevant aspects to improve proprioception[30] and motor control.[6]

Conclusions

Recreationally trained participants can almost double UP ABS and LOW ABS activity when use an internal focus on the UP ABS, LOW ABS and OBLIQ during the isometric prone plank, compared with the regular exercise (external focus) version. On the contrary, OBLIQ and LUMB muscle activity are non-affected by an internal focus on any muscle. The internal focus on some muscles can be used as an easy mode to progress from the regular front plank exercise without additional external equipment, resistance or without changing body position.

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Table 1. Normalized EMG (95% confidence interval) during the different conditions

	Regular front plank	Internal focus upper rectus abdominis	Internal focus lower rectus abdominis	Internal focus external oblique	Internal focus lumbar erector spinae
Upper rectus abdominis	33 (15-50)	62 (44-79) *	58 (40-75) *	61 (44-79) *	64 (47-81) *
Lower rectus abdominis	30 (10-50)	57 (37-77) *	61 (40-81) *	55(35-75) *	49 (29-69)
External oblique	37 (20-54)	48 (31-66)	46 (28-64)	49 (31-66)	47 (30-65)
Lumbar erector Spinae	2 (0-4)	3 (1-5)	2 (0-5)	3 (0-5)	3 (1-6)

*Statistically different from regular front plank (i.e., external focus)

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