ORIGINAL ARTICLE

Proprioceptive Stabilizer™ training of the abdominal wall muscles in healthy subjects: a quasi-experimental study

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SUMMARY

The present quasi-experimental study aimed to assess the transversus abdominis (TrA), internal oblique (IO) and external oblique (EO) thickness in healthy subjects with the proprioceptive Stabilizer™ training in abdominal wall muscles. A sample of 41 healthy participants (age: 31.9 ± 4.5 y; height: 1.7 ± 0.1 m; weight: 68.3 ± 13.1 kg; body mass index, BMI: 22.9 ± 2.7 kg/m²) were recruited to participate in this study. Ultrasound images of the EO, IO, TrA, rectus anterior (RA) and interrecti distance (IRD) were measured and analyzed by the ImageJ software. Measurements were made at rest and during the abdominal drawing-maneuver (ADIM) developed by the patients with the Stabilizer™ located in the low back holding 40 mmHg for 10 seconds with a visual stimulus provided by a circular pressure marker. Ultrasound measurements for the abdominal wall muscles showed statistically significant differences (Π < .05) for a thickness decrease of the EO, IO and a thickness increase of TrA. A proprioceptive Stabilizer™ training produced a thickness increase in TrA muscle and a thickness decrease in EO and IO muscles in healthy subjects. These findings suggest that a proprioceptive Stabilizer™ training could be useful in individuals with low back pain and lumbopelvic pain.

KEYWORDS: *Motor control. Ultrasound imaging. Proprioception*

INTRODUCTION

Abdominal wall muscles act providing protection and stability to the spine.[1] These muscles form a ring surrounding the spine, laterally 3 overlapping layers conformed by the external oblique (EO), internal oblique (IO) and transversus abdominis (TrA); moreover the rectus abdominis (RA) in the midline.[2] These muscles work in a synchronized way with lumbar multifidus, diaphragm and pelvic floor muscles, to administrate internal and external loads around the trunk and balance abdominal pressures.[1] For example, TrA is activated independently of the other abdominal wall muscles to increase the stability and preparing the spine for body movements, external loads and postural disturbances.[3] Contractions of TrA muscle do not have a conscious pattern; this activation arises automatically synchronized with deep trunk muscles to protect the lumbar spine.[3]

Dysfunction of the abdominal wall muscles

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is considered a risk factor of LBP.[4] In addiction, Hodges et al.[5] found that TrA muscle activity was decreased in subjects with lower back pain (LBP), compared with controls without LBP, and Vasseljen et al.[6] reported that the thickness of the TrA muscle during the abdominal drawing-maneuver (ADIM) was lower in individuals with chronic LBP than in controls without LBP. Teyhen et al.[7] found a decreased thickness of deep abdominal muscles during the active straight leg raise test in subjects with LPP, concluding that the spine protection mechanism does not normally work in subjects with pain. Conservative interventions have been carried out to restore morphological features, such as TrA activations in patients with LBP.[8] Besides, Vasseljen and Fladmark[6] found that an increased TrA and decreased IO thickness ratios, measured with ultrasound imaging examination (USI), in response to an 8-week exercise intervention explained 18% of the variance in temporal LBP reduction. Sihawong et al.[9] showed that an exercise program with an endurance training and muscle stretching is effective to reduce LBP in office workers. A systematic review carried out by Brumitt et al.[10] presented that motor control and general exercise program was effective in reducing pain in subacute and chronic LBP subjects. Moreover, Ferreira et al.[11] showed that patients with chronic LBP who received motor control exercise had an improvement in recruitment TrA muscle when compared with patients receiving general exercise or spinal manipulative therapy.

USI is beneficial to assess muscle changes in individuals with or without the pathology.[12] USI has been validated as a reliable tool to measure TrA morphology compared with a magnetic resonance images.[13] USI is a relatively economical, non-invasive and portable tool which can be used to provide a diagnosis and treatment.

Moreover, USI can be used to give clinical biofeedback of the abdominal wall muscles in patients with chronic LBP.[14]

A study developed by Gallego-Izquierdo et al.[15] showed that a craniocervical flexion training in patients with chronic neck pain using an air-filled pressure sensor (Stabilizer™, Chattanooga Group Inc., Tennessee, USA) (Figure 1A) produced an improvement in activation and endurance of the deep cervical flexors, as well as an improvement in pain and disability. Moreover, Stabilizer™ tool has a circular marker that allows seeing the pressure in mmHg. The present pilot study aimed to assess the TrA, IO and EO thickness in healthy subjects with the proprioceptive Stabilizer™ training in abdominal wall muscles.

METHODS

Study design

A quasi-experimental (NCT03434756) study was performed following the Template for Intervention Description and Replication (TIDierR) guidelines.[16]

Participants

A sample of 41 healthy participants (age: 31.9 ± 4.5 y; height: 1.7 ± 0.1 m; weight: 68.3 ± 13.1 kg; body mass index, BMI: 22.9 ± 2.7 kg/m²) were recruited

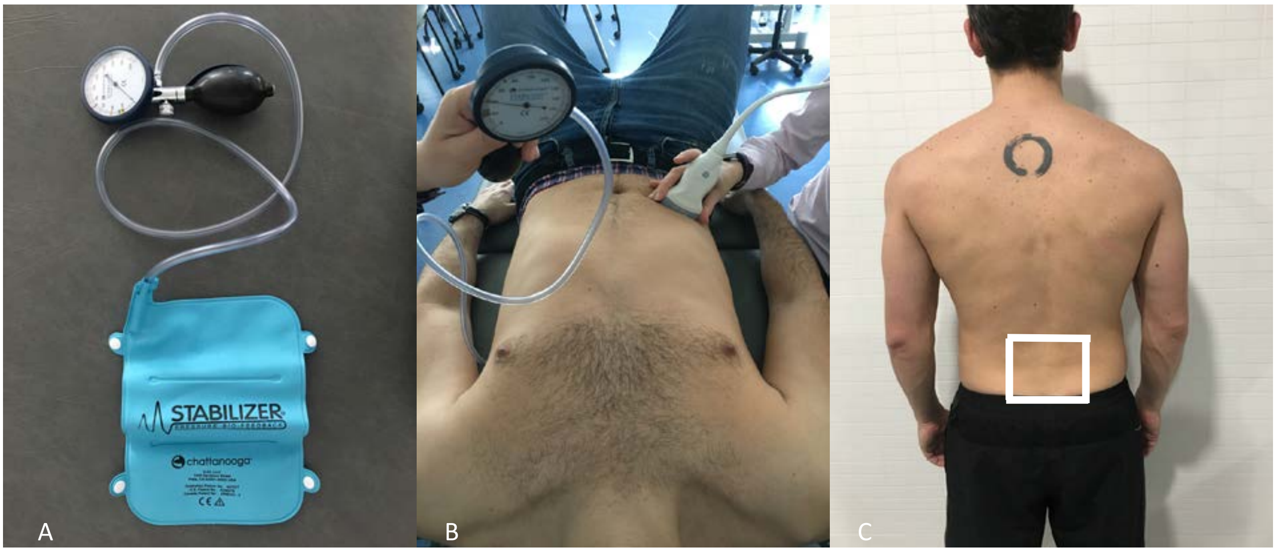

FIGURE 1 STABILIZER™ TOOL AND LOCATION AT THE PATIENTS

to participate in this study. Exclusion criteria were a BMI higher than 31 kg/m², hypocapnia,[17] any musculoskeletal condition in lumbopelvic region,[2] skin and lower limb pathology (i.e., fracture, surgery)[2].

Ethical considerations

The Scientific Committee of the European University of Madrid (CIPI/087/17) approved this study. The study also adhered to the ethical standards of the Declaration of Helsinki for human experimentation.[18]

Experimental design and data collection

Initially, baseline measurements were made following Whittaker et al.[12] guidelines to measure the thickness of the abdominal wall muscles (EO, IO, TrA, and RA). All evaluations were carried out by a single operator (B.M.P), who was a specialized physical therapist with 3 years of USI experience. A diagnostic ultrasound tool (LogiQ S7, GE Healthcare; UK) with a 3.1 to 10-MHz-range linear transducer (9L- D type; 44-mm footprint) was used for B mode ultrasound imaging. According to Whittaker et al.[12], ultrasound images of the EO, IO, and TrAb muscles were carried out with the patients in supine position, with a cross-reference point placed between the iliac crest and the inferior border of subcostal line, and the midaxillary line on the right side; RA muscle was aligned with the umbilicus, and interrecti distance (IRD) was measured just under the umbilicus. The mean measure for the thickness during rest was performed, and 3 repeated values were collected for each measure at the end of expiration, maintaining the transducer at the same point. IRD was only evaluated in the midline. Muscle thickness was considered as the distance between the inside caliper lines of each muscle border. IRD was described as the distance between the inside caliper lines of each RA muscles.[12] ImageJ software (version 2.0; US National Institutes of Health, Bethesda, Maryland, USA) was employed for measuring all the images offline. [19]

Once baseline measurements were carried out, the same measurements were made while the patients performed the exercise. This exercise specifically targets the abdominal wall muscles (EO, IO, TrA, and RA). In the beginning, patients were in a supine position (Figure 1B), the lower edge of the Stabilizer™ was placed between the posterior superior iliac spines, aligned with the sacral base (Figure 1C) and inflated up to 40 mmHg. ADIM was developed by the patients holding the 40 mmHg of pressure for 10 seconds with a visual stimulus provided by a circular pressure marker. Prior to the examination, each subject practiced the ADIM three times.[20]

Statistical analysis

SPSS 22.0 software (IBM SPSS Statistics for Windows; NY: IBM Corp.) was used for the analysis of data. An α error of 0.05 (95% confidence interval) and a desired power of 80% (β error of 0.2) were used. First, the Kolmogorov-Smirnov test was utilized to assess normality. Second, a descriptive analysis was carried out for the total sample. Finally, repeated measures t-test for independent samples were applied.

RESULTS

Regarding the Table 1, ultrasound measurements for the abdominal wall muscles showed statistically significant differences ($P < .05$) for a thickness decrease of the EO [0.65 ± 0.11 (0.02–0.10)], IO [1.10 ± 0.15 (0.05–0.15)] and a thickness increase of TrA [-0.04 ± 0.09 (-0.07–0.01)]. No statistically significant differences ($P > .05$) were observed for RA and IRD variables.

DISCUSSION

To our knowledge, this is the first study to assess whether a proprioceptive training is capable of generating an activation in deep abdominal wall muscles, such as TrA, demonstrating that it could be useful to patients who want to re-educate motor control. Our results showed that proprioceptive Stabilizer™ training with visual feedback produced a TrA activation

TABLE 1. ULTRASOUND IMAGING OF THE ABDOMINAL WALL MUSCLES

Measurement	Thickness difference*	P-value
Distance (cm)		
IRD	0.14 ± 0.09 (-0.01–0.04) *	0.355**
Thickness (cm)		
RA	-0.07. ± 0.29 (-0.17–0.16) *	0.104**
EO	0.65 ± 0.11 (0.02–0.10) *	0.001**
IO	1.10 ± 0.15 (0.05–0.15) *	0.001**
TrA	-0.04 ± 0.09 (-0.07–0.01) *	0.008**

Abbreviations: EO, external oblique; IO, internal oblique; IRD, interrecti distance; RA, rectus anterior; TrA, transversus abdominis distance; RA, rectus anterior; TrA, transversus abdominis. * Mean ± standard deviation (SD) (minimum-maximum) was applied. ** Student's t-test for independent samples was performed.

with a thickness increase and an EO and IO thickness decrease at the same time. According to Teyhen et al.[7], TrA muscle increased in thickness while the patients performed the ADIM. Springer et al.[21] showed that the TrA muscle represented 52% of the lateral abdominal muscle thickness when contracted with the ADIM, which confirms the importance of the TrA reeducation with motor control. Miura et al.[21] reported that the thickness of the TrA muscle might be associated with an activation of the muscle during a voluntary contraction with the ADIM. These findings could be an interesting starting point for clinicians to perform assessments and treatments.

In this study, we examined the thickness of the abdominal wall muscles at rest and during the ADIM. Findings for a decreased EO and IO at rest and during the ADIM in abdominal wall muscles could be explained by the automatic synergies that have to occur between deep and superficial muscles to stabilize the spine and allow a controlled movement.[3] Therefore, clinicians should establish the motor control concept into the rehabilitative training programs as one of the primary targets.

Visual feedback could be useful to improve the planning, control, and initiation of body movements supported by cortical and subcortical circuits.[22] Moreover, the visual stimulus could help to make a greater integration of the exercises in a rehabilitation training program. In our study, the visual stimulus was carried out by the circular pressure marker to provide a goal marker (40 mmHg).

Several studies demonstrated a decreased muscle thickness of TrA muscles in patients with LBP,[20,11] suggested that a motor control exercise program could be useful to improve pain and functionally. Kiesel et al.[23] reported that patients with pain in the lumbar region found it challenging to perform the ADIM. Moreover, Teyhen et al.[24] found a small TrA thickness during an active straight leg raise in individuals with LPP. In this pilot study, we found an increased TrA muscle thickness when healthy individuals performed the proprioceptive Stabilizer™ training, suggesting that this new approach based on motor control could be useful in patients with LPP and LBP.

LIMITATIONS AND FUTURES STUDIES

Several limitations should be considered in this study. First, the investigator was not blinded to the subjects. Another limitation was that we did not include a control group that did not receive any training. Finally, muscle contraction changes were not studied during functional tasks or dynamic movements.[11]

Futures studies should be developed to assess a proprioceptive Stabilizer™ training in subjects with LPP and LBP.

CONCLUSIONS

A proprioceptive Stabilizer™ training produced a thickness increase in TrA muscle and a thickness decrease in EO and IO muscles in healthy subjects. These findings suggest that a proprioceptive Stabilizer™ training could be useful in individuals with LBP, LPP and other pathologies related to the motor control of the abdominal wall muscles.

Conflicts of Interest and Source of Funding

There are no conflicts of interest or Source of Funding.

RESUMO

O objetivo do presente estudo foi avaliar o transverso abdominal (TrA), o oblíquo interno (OI) e a espessura oblíqua externa (EO) em indivíduos saudáveis com o treinamento proprioceptivo Stabilizer™ nos músculos da parede abdominal. Uma amostra de 41 participantes saudáveis (idade: 31,9±4,5 y, altura: 1,7±0,1 m; peso: 68,3±13,1 kg; índice de massa corporal, IMC: 22,9±2,7 kg / m²) foram recrutados para participar deste estudo. As imagens de ultrassom do EO, IO, TrA, reto anterior (RA) e distância interrecti (IRD) foram medidas e analisadas pelo software ImageJ. As medidas foram feitas em repouso e durante a manobra de desenho abdominal (Adim) desenvolvida pelos pacientes com o StabilizerTM localizado na parte inferior das costas segurando 40 mmHg por 10 segundos com um estímulo visual fornecido por um marcador de pressão circular. As medidas de ultrassom para os músculos da parede abdominal apresentaram diferenças estatisticamente significativas (P<0,05) para uma diminuição da espessura do EO, IO e um aumento de espessura do TrA. Um treinamento proprioceptivo Stabilizer™ produziu um aumento de espessura no músculo TrA e uma diminuição da espessura nos músculos EO e IO em indivíduos saudáveis. Esses achados sugerem que um treinamento de Stabilizer™ proprioceptivo poderia ser útil em indivíduos com dor lombar e dor lombo-pélvica.

PALAVRAS-CHAVE: *Controle motor. Imagens de ultra-som. Propriocepção*

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