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EFFECTS OF FLOSSING TECHNIQUE ON TRANSVERSUS ABDOMINIS/INTERNAL ABDOMINAL OBLIQUE MUSCLE ACTIVATION IN HEALTHY INDIVIDUALS: A PILOT STUDY

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ABSTRACT

Background: This study aimed to compare the effects of the flossing technique on transversus abdominis/internal abdominal oblique (TrA/IO) muscle activation in healthy individuals.

Materials and methods: Twenty-one participants were randomized into 3 groups: abdominal hollowing (AH) group, flossing technique (FT) group, and flossing technique with abdominal hollowing (FTAH) group. TrA/IO muscle activation was measured at baseline and again after the interventions 1, 5, 10, 15, 30, 45, and 60 minutes.

Results: There was a significant main effect for time ($F = 6.28$, $p < 0.001$) in the FTAH group only. No significant main effect for group or group × time interaction was found.

Conclusions: The 2-minute FTAH intervention program can increase TrA/IO muscle activation significantly.

KEYWORDS

Tissue flossing, abdominal muscle activation, abdominal hollowing, blood flow restriction

INTRODUCTION

The transversus abdominis (TrA) and internal oblique (IO) are deep abdominal muscles that typically function together rather than independently[1], therefore, they are often referred to as the TrA/IO[2]. This muscle group plays a crucial role in stabilizing the spine and maintaining spinal stability, which helps prevent low back conditions[3-6]. Abdominal hollowing (AH) is an exercise commonly used to enhance TrA/IO activation[3,7,8]. However, teaching AH can be challenging, as many individuals find it difficult to correctly perform the movement due to the complexity of properly engaging these muscles[9].

The introduction of the flossing technique (FT) to healthy people and individuals with musculoskeletal conditions has become popular[10-12]. Several studies have described the benefits of FT in increasing muscle activation reported in both upper and lower extremities[10-28]. Yasuda et al. investigated the effects of the FT on triceps and biceps muscle activation. After four sets of exercise, they observed significant increases in muscle activation of 46% for the

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triceps and 69% for the biceps[27]. Similarly, Driller et al. found that 2 minutes of ankle ROM exercise together with FT showed significant improvements in ankle ROM, jump, and sprint performance until 45 minutes after the intervention[16,17].

To the best of our knowledge, the FT has not yet been applied to the trunk region to facilitate TrA/IO muscle activation. Therefore, the aim of this study was to examine the effects of FT on TrA/IO activation in comparison with the AH alone, as well as with the combined approach of FT and AH (FTAH). We hypothesized that both FT and FTAH would lead to greater TrA/IO activation than AH alone.

METHODS

Study population and design

Participants were recruited from October to December 2018. The inclusion criteria were as follows: 18 years of age or older; body mass index between 18.5 and 22.9; no history of back or abdominal pain; no cardiovascular problems; and no experience with core stabilization training. The exclusion criteria were as follows: any neurological conditions; musculoskeletal problems that might be harmful due to surgical operations, fever, menstrual period; and anti-platelet or corticosteroid drug use. For the sample size of this study, we calculated using G*Power 3.1.9.2 with an estimated effect size (Cohen's d) of 0.6, a statistical power of 80%, and an alpha level of 0.05. The needed sample size was 21 in total to detect a statistically significant difference.

This study is a participant-blinded 3-arm randomized controlled trial. The participants were randomized into 3 groups with age, and gender-matched block randomization. The 3 groups were the abdominal hollowing (AH) group, flossing technique (FT) group, and flossing technique with abdominal hollowing (FTAH) group. The study was conducted at the Faculty of Physical Therapy, Mahidol University. Ethical approval was obtained from Mahidol University Central Institutional Review Board (MU-CIRB), protocol number MU-CIRB2018/179.1109. Informed consent was obtained from all participants before participation in the study.

Surface electromyography (sEMG) measurement

TrA/IO muscle activation was assessed as the combination of TrA and IO together and reported as the percentage of maximum voluntary isometric contraction (%MVIC), measured by sEMG (Telemyo 2400 G2, Noraxon, USA, Inc.). Before the assessment, the participant's skin over the TrA/IO area on the right side of the body was shaved and cleaned with alcohol and sandpaper to reach 1.4 kΩ or lower for skin impedance. Bipolar sEMG electrodes with 1 cm apart between two electrodes (Ag/AgCl, blue sensor, diameter 34 mm and sensor area 13.2 mm^2) were placed on the prepared skin[29].

To elicit maximal voluntary isometric contraction (MVIC) of TrA/IO, the participants were supine lying, the left knees bent, while the right legs (tested side) straight were resisted in the direction of isometric hip flexion. This data was obtained as MVIC for TrA/IO of each participant. To determine the percentage of maximal voluntary isometric contraction (%MVIC) of TrA/IO, the participants were asked to perform the contraction of TrA/IO supine lying with both knees bent on the couch. The participants were asked to contract TrA/IO in the pattern of the abdominal drawing-in maneuver. The data of TrA/IO were recorded and calculated using pre-collected MVIC to be calculated and reported as %MVIC of TrA/IO at baseline, and again at 1, 5, 10, 15, 30, 45, and 60 minutes after pre-specified interventions accordingly.

All sEMG data were filtered by a Butterworth filter for noise minimization. The low-pass frequency was set at 350 Hz, and the high-pass frequency was set at 30 Hz. The EMG data were rectified into full waves and then calculated into %MVIC.

Discomfort

Since FT might cause discomfort, we assessed discomfort after applying FT in both FT and FTAH groups for safety reasons. The discomfort was assessed using a 100-mm



Figure 1. *Abdominal hollowing exercise.*



Figure 2. *Flossing technique application.*

horizontal visual analog scale, with the left end labeled as "no discomfort" and the right end labeled as "extremely discomfort". The participants were asked to mark a line to indicate their level of discomfort.

Interventions

In the AH group, participants underwent 5-repetition AH training sessions and commands to make an abdominal drawing-in maneuver were given to the participants, followed by 3 diaphragmatic breathing cycles, approximately 2 minutes in total *(Fig. 1)*[30].

In the FT group, participants were wrapped around with a 3-inch-wide and 2-m-long floss band (Blueberry Band, Sanctband, Sanctuary Heath Sdn. Bhd., Malaysia). This floss band was applied around the body starting 1 inch below the last rib and above the iliac crest. It was wrapped three times circularly around the body *(Fig. 2)*. The pressure of the wrapping was applied following tthe protocol of the flossing technique, in which the pressure was set from 50% extra-long stretched from the original length, as measured by 80-82 mmHg underneath the wrapping, using a pressure biofeedback unit (Chattanooga, Australia). During the FT condition, participants were asked to breathe with a diaphragmatic pattern for 2 minutes. After finishing, the floss band was immediately removed.

FTAH group, the participants underwent the same protocol as the FT group but the FTAH participants performed AH, the same protocol as the AH group, during the application of FT for 2 minutes.

Statistical analysis

We used the SPSS program version 22.0 (IBM Corp., Armonk, NY, USA) for all statistical analysis. The demographic data was presented in mean and standard deviation and the number of participants. Shapiro-Wilk test was used to investigate the distribution of the data. All data were normally distributed. Two-way mixed analysis of variance (ANOVA) with repeated measures was used to analyze the effect of time, group, and interaction effect of time × group. If the time or group effect was significant, repeated measures and Bonferroni post-hoc test were used for within-group comparisons, while, one-way ANOVA and Bonferroni post-hoc test for between-group comparisons. The significant level, p value, was set at less than 0.05.

RESULTS

Participants

Twenty-one participants, 16 females and 5 males, were enrolled. There was no significant difference among the three groups in subjects' characteristics, as shown in *Table 1*.

Effects on TrA/IO muscle activation

The results of the repeated measures ANOVA on TrA/IO muscle activation indicated a significant main effect for time ($F = 10.81$, $p < 0.001$), but no significant main effect for group ($F = 1.66$, $p = 0.217$) or group × time interaction ($F = 1.738$, $p = 0.108$). For post-hoc comparison, we found a significant main effect for time ($F = 6.28$, $p < 0.001$) in the FTAH group only, as shown in *Table 2*.

Discomfort

The participants in the two groups, FT and FTAH groups, reported no to mild discomfort after the FT, ranging from 0 to 18.7 mm. Also, there was no adverse event found in this study.

DISCUSSION

This study demonstrated a significant time effect on TrA/IO muscle activation ($p < 0.001$) following the application of FTAH for two minutes, with the enhanced activation persisting for up to 60 minutes post-intervention. The improvement in TrA/IO activation observed with FTAH was consistent with findings from previous studies reporting acute effects[14,15,20,26,27].

Yasuda et al.[26] studied the effect of the FT on triceps brachii and pectoralis major muscle activations response during 4 sets of bench presses exercise. They reported a gradual increase of both triceps brachii and pectoralis major activation ($p < 0.05$) with FT compared to the control group. Dankel et al.[15] also examined the effect of FT in upper body exercise on muscle adaptation, by which some muscles were not directly restricted area such as chest and shoulder muscles. Both distal muscles, biceps brachii and triceps brachii muscles, and proximal muscles, chest and shoulder muscles, were increased in muscle activation, strength, and size[25]. For intermediate effects, Driller et al.[16] examined the acute and intermediate effects following the application of FT on ankle active ROM exercise for two minutes on ankle ROM and muscle performance. They found that there was greater improvement in ankle ROM and muscle performance following the application up to 45 minutes.

The previous study indicated that the FT induced the change of local metabolism balance by depleting the phosphocreatine storage and decreasing muscle pH, which is normally associated with higher muscle activation[13,18,19,21]. These effects may be linked to the stimulation of muscle spindles, which regulate muscle contraction. Another possible mechanism is the interaction of cross-bridge mechanics with the passive recoil force of the transversely applied floss band, similar to TrA muscle fibers. This may enhance actin–myosin binding distance, thereby increasing muscle activity[31,32].

In this study, the floss band with 50% tension or 80-82 mmHg in total was applied, which was lower than Yasuda et al.'s 160 to 180 mmHg[25] and Driller et al.'s 182 mmHg[16]. By the way, Sumide et al.[23] investigated the optimal pressure for flossing technique training to increase muscle strength and endurance of knee extensor muscles. They adjusted four different pressures: 0, 50, 150, and 250

Parameters	AH group (n = 7)	FT group (n = 7)	FTAH group (n = 7)	F	p value
Age (years), mean ± SD	23.14 ± 2.04	23.71 ± 1.38	23.71 ± 1.80	0.246	0.784
Sex (females/males)	5/2	5/2	6/1	N/A	N/A
Weight (kg), mean ± SD	56.43 ± 8.44	56.71 ± 8.79	54.00 ± 3.46	0.291	0.751
Height (m), mean ± SD	1.65 ± 0.95	1.64 ± 0.95	1.61 ± 0.07	0.383	0.687
BMI (kg/m^2), mean ± SD	20.68 ± 1.76	20.75 ± 1.33	20.82 ± 1.84	0.013	0.987

Table 1. *Subjects' characteristics.*

Time	AH group (n = 7) mean ± SD	FT group (n = 7) mean ± SD	FTAH group (n = 7) mean ± SD
Baseline	62.59 ± 0.59	63.80 ± 14.18	67.65 ± 23.87
After, 1 min	56.90 ± 21.65	53.15 ± 25.95	141.60 ± 33.37[a]
After, 5 min	66.32 ± 17.21	53.46 ± 21.48	113.46 ± 31.59[a]
After, 10 min	67.43 ± 22.75	70.58 ± 22.18	111.19 ± 30.97[a]
After, 15 min	66.89 ± 12.66	63.12 ± 28.17	116.31 ± 38.24[a]
After, 30 min	67.03 ± 17.25	68.60 ± 22.33	112.95 ± 38.68[a]
After, 45 min	64.35 ± 18.13	52.99 ± 26.65	111.17 ± 33.78[a]
After, 60 min	49.55 ± 12.98	72.81 ± 24.07	91.53 ± 17.86[a]
Main effect, time			
F value	1.19	0.69	6.28
p value	0.332	0.683	**<0.001*** **

Table 2. *TrA/IO muscle activation reported in the percentage of maximum voluntary isometric contraction (%MVIC).*

[a] *Significant difference between baseline and the following time, p <0.05; *** Significant difference, p <0.001*

mmHg. They reported that the useful pressure to increase muscle strength and endurance without discomfort was 50 and 150 mmHg[23]. This study, therefore, applied pressure of 80-82 mmHg, which was considered optimal for facilitating muscle activation of TrA/IO with a minimal feeling of discomfort[22].

However, we found no significant time effect in the FT group. This result suggests that FT alone, when applied for only two minutes, may not be sufficient to enhance TrA/IO muscle activation, which does not support our initial hypothesis. It is possible that an increase in TrA/IO muscle activation requires the process of muscle contraction learning, and therefore FT alone may not be adequate to elicit or optimize this activation. In contrast, the application of FT simultaneously with AH training appears to support muscle contraction and facilitate motor learning.

In addition, the lack of significant interaction may imply that the three techniques facilitated TrA/IO contraction in a similar manner, without producing differential effects between them. This suggests that while each technique is capable of enhancing TrA/IO activation to some extent, their underlying mechanisms of facilitation may converge toward a common pathway of neuromuscular recruitment.

Clinically, this finding highlights the potential flexibility in therapeutic application. Since all three techniques appear to facilitate TrA/IO contraction in a comparable direction, clinicians may tailor their choice of intervention based on individual patient needs, treatment goals, or clinical contexts rather than relying on a single preferred method. Regarding the safety and tolerability of the FT and FTAH, the discomfort scale was only no to mild. Therefore, this information affirmed the safety and tolerability of this technique.

The limitations of this study are, first, that we had no control group. Also, our results cannot be generalized to other populations because all subjects in this study were healthy young adults. Finally, this study was a pilot study, our sample was underpowered to detect the difference

between groups. In the future study, it is possible to recruit other groups for more generalizability, and also focus on the participants with low back pain or deep abdominal muscle activation deficit or with longer intervention durations.

CONCLUSIONS

The results indicated that the application of FTAH showed greater TrA/IO muscle activation compared to FT or AH alone. The discomfort was no to mild level in FT and FTAH groups, and no adverse event was found. Therefore, this additional FT to AH training was able to facilitate TrA/IO muscle activation and is considered a safe method for clinicians or professionals who engage in improving the TrA/IO muscle activation as an adjunctive technique to the core stabilization exercise.

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