



Original Article

## Curative effect of long-term intervention using a new device in patients with chronic low back pain

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**Abstract.** [Purpose] This study aimed to observe the changes in the thickness of the transverse abdominis muscle after long-term training with a new device using ultrasound imaging and to determine the impact of these changes on chronic low back pain (CLBP). [Participants and Methods] This study included 60 participants with CLBP, who were divided into groups that adopted different positions during the training regimen: new device intervention group (NDG), sitting training group (STG), and supine training group (SPTG). Patients in the NDG used the new device during training. We measured the thickness of the transverse abdominis muscle and determined the pain level using the visual analog scale (VAS). [Results] After 8 weeks of training, the thickness of the transverse abdominis muscle changed in all the three groups, with the change being significantly greater in the NDG than in the other groups. Additionally, the VAS results indicated that the pain relief was highest when the new device was used. [Conclusion] The thickness of the transverse abdominis muscle increased the most in patients who were trained with the new interventional device, and the CLBP was significantly relieved in them.

**Key words:** Chronic low back pain (CLBP), New device, Transverse abdominis muscle

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### INTRODUCTION

Several countries around the world have aging populations. Japan is a renowned aging society and is experiencing challenges that China may also encounter. For example, in Japan, the number of persons suffering from chronic low back pain (CLBP) is gradually increasing<sup>1)</sup>, and the causes are often related to their occupation or work environment<sup>2, 3)</sup>. Currently, the incidence of CLBP is also high in China. An epidemiological survey revealed that >70% of the participants experienced symptoms of low back pain<sup>4)</sup>. Low back pain is the most common cause of CLBP, with an incidence of approximately 80%<sup>5)</sup>. With the aging Chinese population, it is projected that there will be an increase in the number of patients with CLBP.

Currently, several rehabilitation methods are available for treating CLBP. Several studies have reported that core muscle training relieves low back pain. An example of this is training the transverse abdominis and multifidus muscle<sup>6)</sup>.

In cases of female urinary incontinence and low back pain, changes in the thickness of the transverse abdominis muscle, when it contracts simultaneously with the pelvic floor muscle, significantly affect treatment<sup>7, 8)</sup>. In the context of CLBP, the

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correlation between the change in the thickness of the transverse abdominis muscle during contraction and the improvement of low back pain has yet to be confirmed.

Therefore, in this study, we aimed to observe the effect of simultaneous contraction of the transverse abdominis and pelvic floor muscle on the thickness of the transverse abdominis muscle in adults with CLBP using a new device.

## PARTICIPANTS AND METHODS

We recruited 60 participants with CLBP by word of mouth and poster promotions and randomly assigned them to the control (males: 16, females: 26) and experimental (males: 8, females: 10) groups. The experimental group was termed the new device intervention training group (NDG). The control group was divided into no training (NTG, n=10), supine training (SPTG, n=17), and sitting training (STG, n=15) groups. The characteristics of the participants are presented in Table 1.

In clinical practice, repeated contraction of the transverse abdominis is difficult to complete, resulting in unsatisfactory recovery of the core muscle groups such as the transverse abdominis. To better activate the contractile capacity of the transverse abdominis, I led a team to develop a new device that appears similar to a common treatment bed (Fig. 1), termed the transverse abdominis training bed (model: MKXL-B, manufacturer: Beijing Dongfang Mingkang Medical Equipment Co., LTD., Beijing, China).

Our previous study<sup>9)</sup> indicated that the difficulty of transverse abdominis contraction varied when performing transverse abdominis training at different angles. To stimulate the contraction, enhance thickness of the transverse abdominis, and improve the core function of the muscle groups, our training bed was designed to install adjustable inclined boards under the pelvis and torso. The training angles of the torso and pelvis were set to 0–90° and 0–30°, respectively.

Before initiating training, we determined the visual analog scores (VAS) for participants in both groups. We trained the participants to perform the exercise accurately by observing changes in the thickness of the transverse abdominis when the transverse abdominis and pelvis were contracted simultaneously using an ultrasonic image diagnostic device. Subsequently, the physiotherapist used ultrasound images to observe the transverse abdominis along the short-axis of the right side of the participant's body and measured the thickness of the transversus abdominis at the junction of the mid-axillary line and the anterior superior iliac spine (the thickness of the transverse abdominis muscle is the distance between the two strong echo fascias close to the abdominal cavity<sup>10)</sup>). During this process, we measured the thickness of the transversus abdominis at the end of expiration. Based on the group to which the participant was assigned, the measurement was taken in the supine position (SPTG), in the sitting position (STG), or with the new device (NDG). Each value was measured twice, and the mean of the values was taken as the representative value. After 8 weeks of training, we repeated the procedure to obtain the post-training data.

NDG: the training position was set to 50°/10° (forward flexion of the trunk/backward inclination of the pelvis)<sup>9)</sup>; the participant's hands were positioned naturally on both sides of the body, feet were positioned shoulder-width apart, knees were bent at 90°, and the participant was instructed to practice contracting the transverse abdominis and pelvic floor muscles simultaneously. These angles provided the best measurement results.

SPTG: the participant's hands were placed naturally on both sides of the body, feet were positioned shoulder-width apart, knees were bent at 90°, and the participant was instructed to practice contracting the transverse abdominis and pelvic floor muscles simultaneously.

STG: the participant's hands were naturally placed on both sides of the body, feet were positioned shoulder-width apart, and the participant was instructed to practice contracting the transverse abdominis and pelvic floor muscles simultaneously.

NTG: The positions were measured similar to those of SPTG.

Each contraction was maintained for 5 s, and the participants in each group repeated the exercise 20 times; training was performed 2–3 times per week.

For measurement, we an ultrasonic image diagnostic device (iuStar100, B-mode, 10 MHz linear detection, manufacturer: United Imaging Systems (Beijing) Co., Ltd., China). The image display mode was the B-mode, and the probe for electronic

**Table 1.** Participant characteristics (n=60)

	NTG, SPTG and STG (n=42)			NDG group (n=18)	Total (n=60)
	NTG (n=10)	SPTG (n=17)	STG (n=15)	NDG (n=18)	Average
Age (years)	36.5 ± 11.1	39.6 ± 10.1	36.1 ± 9.9	41.1 ± 8.9	38.7 ± 9.8
Height (cm)	165.0 ± 6.4	168.3 ± 8.8	165.0 ± 5.3	167.8 ± 8.8	166.7 ± 7.7
Weight (kg)	63.1 ± 9.9	68.2 ± 12.7	62.1 ± 9.2	67.0 ± 12.9	65.5 ± 11.6

Results are reported as mean ± standard deviation.

NTG: non-training group; SPTG: supine position training group; STG: sitting training group; NDG: new device group.



**Fig. 1.** Transverse abdominis training bed.

scanning used linear detection with a constant field of view width, L38/10–538 mm frequency, and 10 MHz. Regarding the accuracy of the ultrasonic B-mode distance measurement, the allowable range of the system is  $< \pm 2\%$ , the entire range is 1%, with an accuracy range of 0.1–30 cm, and distance resolution is 0.1 mm. By maximally enlarging the image and adjusting the gain (ultrasonic amplification), we could obtain a more accurate measurement.

The physiotherapist performing the measurements was trained on the scanning methods and techniques by ultrasound experts before the trial was initiated.

This study was approved by the Ethics Committee of the International University of Health and Welfare (approval no: 19-Io-204).

We used two-way repeated-measures analysis of variance and multiple comparisons to test for significant differences among the groups. If a significant correlation was observed, we performed the paired t-test to compare the outcome indicators before and after the intervention. Data were analyzed using the SPSS ver. 19.0 for Windows (SPSS, Chicago, IL, USA). The level of statistical significance was set at  $p < 0.05$ .

## RESULTS

Results of the thickness measurements and pain levels are summarized in Table 2.

After 8 weeks, binary variance analysis to compare changes in the thickness of the transverse abdominis muscle between the control and experimental groups revealed that the effect of simultaneous contraction training was the most significant with the new device. The results of pairwise comparisons revealed significant differences in the thickness of the transverse abdominis muscle before and after training in STG, SPTG, and NDG. Moreover, the effect of the training was the most prominent in NDG based on the change in thickness of the transverse abdominis muscle. Binary variance analysis of the pain levels showed that pain was significantly reduced after training in SPTG and NDG. We observed greater reduction in the pain scores in NDG.

## DISCUSSION

Based on the results, for SPTG, STG, and NDG, simultaneous contraction training only affected the change in the thickness of the transverse abdominis if performed over an extended period. The effect of simultaneous contraction was also long-term in NDG, being significantly greater than the effect in SPTG and STG. Application of the new device with simultaneous contraction training provided the greatest change in the thickness of the transverse abdominis muscle and the best clinical effect. The VAS results revealed that pain in both SPTG and NDG reduced after simultaneous contraction training, with a greater reduction in NDG. When the transverse abdominis muscle and pelvic floor muscle contract simultaneously, the internal pressure on the waist and abdomen increases, leading to the maintenance of spine stability. In addition, the cooperative contraction of the erector spinae and the multifidus muscle of the spine plays a stabilizing role<sup>8</sup>). Greater reduction in the pain level obtained with the new device may be due to the variation in the angle, which makes the transverse abdominis muscles contract more easily, enabling a facile coordinated movement for the surrounding core muscles; this improves the spine stability, strengthens the core muscles, and relieves pain. The improvement in pain in the sitting position was not significant, although the thickness of the transverse abdominis muscle increased. This may be because performing double muscle training at a vertical angle does not improve the pressure between the vertebrae, leading to decreased movement space in the joint capsule, resulting in the persistence of pain. Therefore, training with the new interventional device is more effective in treating CLBP.

Our research suggests that deep muscle function can be improved by training with the use of the new interventional device and that CLBP can be improved with long-term training.

**Table 2.** Comparison of the thickness of the transverse abdominis muscle and pain scores among the groups

		Thickness (mm)	VAS
NTG	Before training	2.8 ± 0.5	4.5 ± 1.6
	After training	2.7 ± 0.5	4.7 ± 1.8
SPTG	Before training	2.7 ± 0.5	5.2 ± 1.8
	After training	3.4 ± 0.3**	3.6 ± 0.9**
STG	Before training	2.9 ± 0.5	4.7 ± 1.8
	After training	3.3 ± 0.3*	4.3 ± 1.3
NDG	Before training	2.6 ± 0.3	5.2 ± 1.6
	After training	4.0 ± 0.4***††	0.4 ± 0.9***††

Before and after \* $p < 0.05$ , \*\* $p < 0.01$ . Comparison: † $p < 0.05$ , †† $p < 0.01$ .

NTG: non-training group; SPTG: supine position training group; STG: sitting training group; NDG: new device group.

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There are no conflicts of interest to declare.

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