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Original Article

Immediate effect of application of the pressure technique to the psoas major on lumbar lordosis

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Abstract. [Purpose] To demonstrate immediate alteration in lumbar lordosis and the lumbar angle in each segment after the application of the mechanical pressure technique to the psoas major muscle (PM). [Participants and Methods] In all, 34 participants were assigned to either the PM pressure technique group (n=17) or control group (n=17). Three dimensional (3D) coordinates of the 12th thoracic spinous process and lumbar spinous processes were measured with a 3D digitizer in the prone position with 15° bilateral hip extension to compare the changes in lumbar lordosis and the lumbar extension angle in each segment in both the PM pressure technique group and control group. [Results] Mann-Whitney's U test revealed no significant differences in lumbar lordosis in either group. However, the lumbar extension angle at L4 decreased significantly after the PM pressure technique compared with that before the pressure technique. Additionally, the lumbar extension angle at L4 also decreased significantly after the PM pressure technique compared with the control group. Conversely, lumbar extension angle at L1 increased significantly after the PM pressure technique compared with that before. There was no significant difference in the lumbar extension angle at L2, L3 and L5 after the PM pressure technique. [Conclusion] This study suggests that the PM pressure technique possibly attenuates PM stiffness while reducing lumbar extension in each segment.

Key words: Psoas major, Pressure technique, Lumbar lordosis

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INTRODUCTION

The psoas major muscle (PM) is the largest in cross section at the lower levels of the lumbar spine[1)]. PM fascicles have fibrous attachments to the anterior aspect of all lumbar transverse processes and vertebral bodies. The PM is activated intermittently on either standing or sitting[2)]. According to several biomechanical and electromyographic studies, lumbar curvature is controlled by the PM in the sitting position[2–4)]. Sitting commonly exacerbates low back pain (LBP)[5)], and difficulty adopting midrange lumbar lordosis postures have been observed in individuals with LBP[6)]. When the activities of the erector spinae muscles are decreased, the PM is activated at much higher levels excessively[7)]. Deeply located trunk muscles with segmental attachments to the lumbar vertebrae such as the PM and the multifidus are common targets of clinical interventions for LBP.

Furthermore, myofasciopathy of the PM may cause anterior hip and/or lower back pain[8)]. Previous study indicated that stiffened PM contributes shear stiffness to the lumbar motion segment[9)]. Therefore, it is assumed that manual therapy or stretching technique are helpful to attenuate these stiffened PM clinically.

One previous study reported that manual myofascial technique addressing to the PM was effective for attenuating lumbar lordosis in persons who have impaired PM with LBP[10)]. Another study indicated that there were significant positive correlations between iliopsoas muscles stiffness and lumbar lordosis[11)]. Ryan et al.[12)] reported a strong positive correlation was demonstrated between lumbar lordosis and hip extension at prone position. Hence, the authors hypothesized that the myofascial

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technique with appropriate stimulus for PM may decrease the lumbar lordosis with hip extension in prone position instantly.

Clinicians commonly use pressure techniques to improve PM stiffness as well as myofascial technique. Pressure technique is considered as a specialized method which reduces stiffness of the PM fascicles. Interestingly, Fligg[13] mentioned that pressure technique made the PM more flexible, but this was not supported by any evidence. This technique is also known as the "Fox maneuver"[14]. The PM could be palpated in the supine positions[15, 16], with the hip flexed at 30° and deeper palpation into the abdomen[8], and this technique has long been considered as a useful method (Fig.1A).

However, it is unclear whether the pressure technique of the PM alters its stiffness and results in decreasing lumbar lordosis or not due to a limited number of evidences. Additionally, it is unknown how much pressure force is required to decrease PM stiffness quantitatively.

The purpose of this study was to compare the immediate alteration in lumbar lordosis and each segment of lumbar angle following the application of a mechanical pressure technique to PM.

PARTICIPANTS AND METHODS

A randomized controlled experimental trial design was chosen to allow elimination of variability between individuals. The sample size and power calculations were performed with a statistical software (JMP ver. 11.0 by SAS Institute Inc., Cary, NC, USA). Sorensen et al.[17] reported that the average lumbar angle of non-LBP group was calculated as the angle of a vector from L1 to L3 relative to a vector from L3 to L5 was 21.0 (degree) while the LBP group was 25.4 (degree). From their results, our calculations were set to detect differences of 5.0 (degree) at post data, assuming a standard deviation of 3.0 (degree) in maximum change, an α level of 0.05, and a desired power of 80%. These assumptions generated a sample size of 14 participants per group in this experiment. All data were collected in the laboratory of our university.

Thirty-four healthy males were recruited for this study. The general characteristics of the participants are summarized in Table 1. Participants were excluded if they had any disorder of circulatory, cardiorespiratory, orthopedic, or neurological conditions or any history of back pain or back/abdominal surgery. All procedures were approved by the Ethics Committee at the Saitama Medical University, Saitama, Japan (No. 118) and were conducted in accordance with the Declaration of Helsinki. All participants read and signed an approved informed consent document. The 34 participants were randomly allocated to the PM pressure technique group (n=17) and control group (n=17).

In the PM pressure technique group, pressure was applied to both PM which were identified by ultrasonography at the lateral aspect of the trunk between the navel and the anterior superior iliac spine (ASIS) beforehand (Fig. 2). Hand-held dynamometer (Model 3050, AIKOH Engineering Co. Ltd., Japan) with a modified the tip (φ: 15.0 mm; L: 80.0 mm) (Fig.1B) was applied to the PM as a quantitative pressure force at rest in the supine position. This modified tip was covered with a piece of gauze in order not to exceed a level that was comfortable for all participants (Fig.1C). Firstly, hip flexion contraction was used to identify the lower portion of PM and trunk flexion to identify rectus abdominis (RA). Secondly, an examiner palpated the PM under real time ultrasonography, and the probe was placed on the skin where the PM was located. After

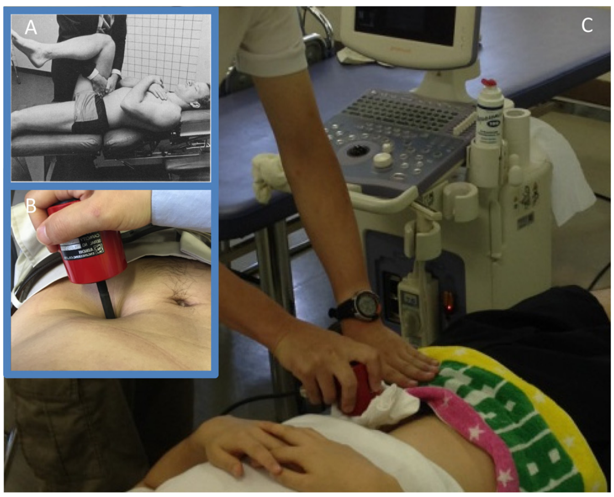

Fig. 1. Applying mechanical pressure to the psoas major.
A: Pressure technique to the psoas major reported by Fligg DB in 1985[13].
B: Mechanical pressure technique after identifying psoas major by ultrasonography.
C: Experimental setting.

Table 1. General characteristics of the participants (n=34)

Variables	Mean (standard deviation)	
	Pressure technique (n=17)	Control (n=17)
Age (years)	21.8 (1.1)	21.7 (2.1)
Height (cm)	174.0 (9.2)	171.0 (3.3)
Weight (kg)	65.7 (9.7)	62.5 (5.1)
Ave pressure force (N)	36.1 (7.2)	34.2 (5.9)

All data are reported as mean (standard deviation).
There is no significant differences for all variables between pressure technique group (n=17) and control group (n=17).
Pressure technique: An examiner applied pressure via a hand-held dynamometer to the bilateral psoas major.
Control: An examiner applied pressure via a hand-held dynamometer to the bilateral rectus abdominis.
Ave pressure force (N) was applied 15 seconds per a set × 4 sets × bilateral side.
Participants were provided 15 seconds rest between these sets.

that, another examiner identified the PM from this ultrasonography. Lastly, pressure force was gradually applied by the hand-held dynamometer, and the force was determined as "not uncomfortable feeling" for each participant. In the control group, pressure was applied to both RA which were also identified by same fashion as PM pressure technique group. The pressure was applied bilaterally in 4 sets lasting 15 seconds each side ultrasonographically. The participants were allowed 15 seconds rest between each set. During the pressure technique, the examiner avoided compressing their abdominal aorta by using ultrasonography. The average force resulted in 36.1 ± 7.2 (N) in the pressure technique group and 34.2 ± 5.9 (N) in the control group (Table 1).

To assess the effectiveness of the pressure technique, 3D coordinates of the spinous process of the Th12, the lumbar vertebrae and a sacral plane were measured with a 3D digitizer (Microscribe® G2X, Revware Inc., USA) and compared between pre- and post- pressure technique. Participants were securely strapped onto the treatment bed with non-elastic belts in the prone position. The positions of the left and right greater trochanters were adjusted to the starting point of inclination of the treatment bed to maintain 15° extension of both left and right hip joints (Fig. 3). In all participants, the spinous processes of the Th12 and the 1st, 2nd, 3rd, 4th and 5th lumbar vertebrae (L1, L2 L3, L4 and L5) were identified. The sacral plane was identified using points immediately medial to the posterior superior iliac spine and the sacral cornu by palpation in the prone position. The PM cannot be palpated posteriorly because iliocostalis and multifidus muscles are covered with their back area. Therefore, participants were positioned to be in supine during PM pressure technique as a previous study[13]. Since the authors considered to minimize the effect of perturbation in upright standing, the angle of lumbar lordosis was measured in prone position by 3D digitizer. After these indices were reconfirmed by a marker, the probe of the 3D digitizer was placed and each of the 3D coordinates were recorded. After these values were integrated visually, each segment of lumbar angle and lumbar lordosis were calculated by 3D modeling software (Rhinoceros Ver.5.0, Robert McNeel & Associates, USA). Lumbar lordosis was calculated as the angle of vector from L1 to L3 related to a vector from L3 to L5[17] (Fig. 4).

The data are described as means ± standard deviations. After the normal data was verified using the Kolmogorov-Smirnov test, the assumption of normality was violated. Therefore, Mann-Whitney's U test was performed to identify statistically significant differences in the angle of each lumbar vertebra at 15° extensions of both hip joints. Statistical analysis was performed with SPSS Statistics version 22.0 (IBM Corp.). The level of statistical significance was set at α=0.05.

RESULTS

There were no significant differences in lumbar lordosis both PM pressure technique group and control group. However, lumbar extension angle at L4 was decreased significantly after the PM pressure technique compared with that before the pressure technique (mean difference=7.5°, p=0.025, Cohen's d=0.88). Additionally, lumbar extension angle at L4 was also decreased significantly after the PM pressure technique compared with control group (mean difference=10.1°, p=0.005 Cohen's d=0.92). Conversely, lumbar extension angle at L1 was increased significantly after PM pressure technique compared with that before the PM pressure technique (mean difference=6.5°, p=0.037, Cohen's d=0.63). Lumbar angle at L2, L3 and L5 were no significant differences after the PM pressure technique compared with those before the pressure technique. There

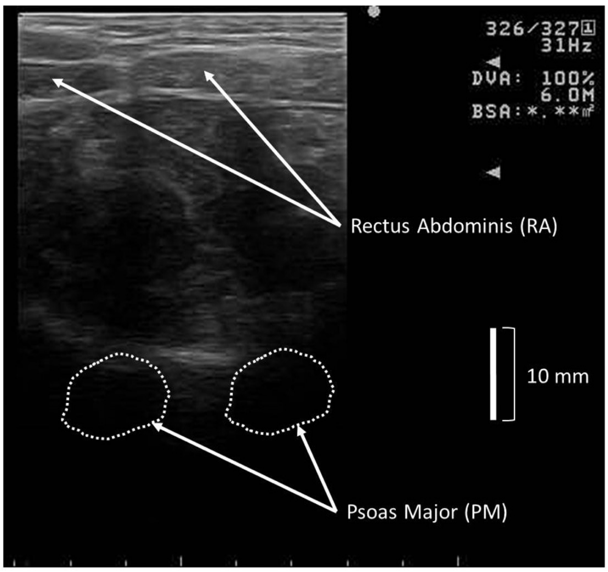

Fig. 2. Ultrasonography of PM and RA.

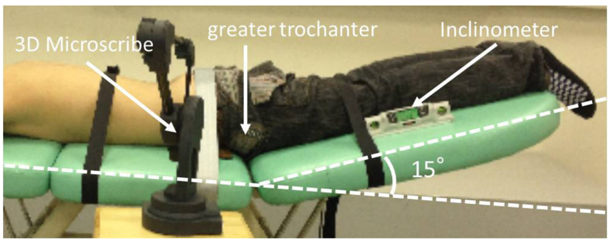

Fig. 3. Position of measurement.
Participants were securely strapped onto the treatment bed with non-elastic belts in the prone position. The positions of the left and right greater trochanters were adjusted to the starting point of inclination at the treatment bed to maintain 15° extension of both left and right hip joints.

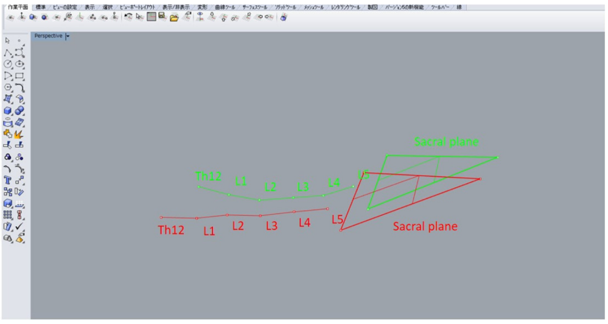

Fig. 4. Analysis of lumbar alignment using 3D modeling software.
3-dimentional of 12th of thoracic spinous process and 1st, 2nd, 3rd, 4th, 5th of lumbar spinous process, and sacral plane were measured by 3D Microscribe and these values were integrated visually.
Each angles of the lumbar vertebrae and total of lumbar lordosis were calculated by 3D modeling software.
Green: Pre-pressure technique.
Red: Post-pressure technique.

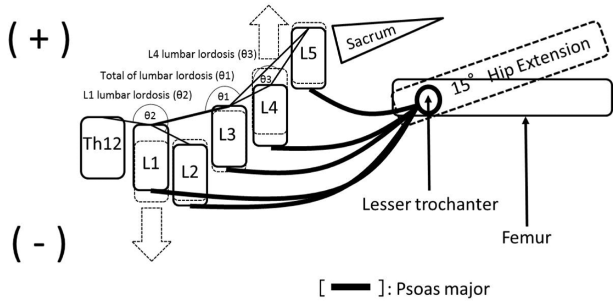

Fig. 5. Schema of changing angle of lumbar lordosis.

Table 2. Pre and post change each intervertebral angle (deg) in pressure technique

Type of stretching		Mean (standard deviation)					
		L1	L2	L3	L4	L5	Total angle of lumbar lordosis
Pressure technique	Pre	−4.3 (10.4)	−7.3 (9.5)	−4.4 (6.8)	−7.2 (8.5)	−8.2 (6.8)	−29.2 (8.1)
(n=17)	Post	−10.8 (7.3)[a]	−2.2 (10.9)	−7.9 (9.6)	0.3 (7.3)[a,b]	−6.4 (11.6)	−27.8 (9.5)
Control	Pre	−3.9 (6.1)	−8.6 (9.1)	−4.7 (5.7)	7.6 (9.3)	−5.6 (4.8)	−30.3 (6.6)
(n=17)	Post	−3.6 (8.1)	−10.7 (11.6)	−6.2 (11.2)	−9.8 (5.9)	−8.2 (3.9)	−32.5 (7.5)

All data are reported as mean (standard deviation).
[a]Significant difference between pre- and post-pressure technique applied.
[b]Significant difference between pressure technique and control in the post technique.
Total angle of lumbar lordosis was calculated as the angle of a vector from L1 to L3 relative to a vector from L3 to L5.
Positive (+) means flexion/Negative (−) means extension.

were no significant differences in the control group as to both lumbar lordosis and each segment within the lumbar angle (Table 2).

DISCUSSION

Salem et al.[18] reported that average lumbar lordosis in prone position was 13.4° by 3D digitizer. Sorensen et al.[17] reported that lumbar lordosis was calculated as the angle of a vector from L1 to L3 relative to a vector from L3 to L5 was 21.0°in standing by 3-dimensional motion capture system. Compared with our results which was calculated 29.2° and 30.3° as average lumbar lordosis before intervention in the pressure technique group and in the control group, respectively. Previous studies as above showed that the degree of lumbar lordosis was small. However, Arab et al.[19] reported that average lumbar lordosis with unilateral hip active extension was 25.6°. Hence, the authors assumed that this result of lumbar lordosis was large because the participants were positioned in the prone with 15° of bilateral hip extension to measure lumbar lordosis.

The results of this study indicated that pressure technique was not effective for attenuating lumbar lordosis because lumbar lordosis calculated as the angle of a vector from L1 to L3 related to a vector from L3 to L5 did not change significantly. However, lumbar extension angle at L4 calculated as the angle of a vector from L3 to L4 related to a vector from L4 to L5 decreased due to the PM pressure technique while L1 calculated as the angle of a vector from Th12 to L1 related to a vector from L1 to L2 increased simultaneously (Fig. 5). In this study, the area of applying pressure technique to the PM was only at the level between the navel and ASIS (L3–L4 level). From these results, the authors speculated that compensational change at L1 against decreasing extension angle at L4 by the small area of PM pressure technique occurred because absolute values of change at L1 and L4 were almost equivalent (Table 2). Hence, there were no significant differences in lumbar lordosis by PM pressure technique in this experiment. The area of the pressure was also small (tip diameter of hand-held dynamometer was 15.0 mm) in this study. Further research is needed how much quantitative pressure and area are required to decrease lumbar lordosis by the PM pressure technique.

This study is the first paper to describe changes of the lumbar lordosis by the PM pressure technique. Laible et al.[20] reported that repetitive flexion in an externally rotated hip during a dancer's passé developpé, often resulted in painless internal coxa saltans. When these patients accompanied by weakness or pain with this area caused by tendonitis or bursitis, it is usually referred as iliopsoas syndrome. In case of acute low back pain or tendonitis, its sensitivity triggered by mechanical stimulus is high because enhanced nociceptive sensitivity commonly follows micro-injury through activation and sensitization of peripheral nociceptive neurons by inflammatory mediators[21]. Therefore, it is important to verify appropriate amount of pressure force for these patients when applying PM pressure technique without exacerbating sensitivity.

When attempting to prevent these injuries, several procedures including passive stretching, active stretching, manual fascial-muscular lengthening therapy (FMLT) have been described to improve the PM stiffness[22–24]. This technique included 3 locations as follows: 1) next to navel, 2) on the inside of the iliac crest, and 3) half-way between the anterior superior iliac spine and the pubic bone[24]. FMLT technique is similar our procedure in this study in term of applying pressure to the PM. Although the FMLT as a technique addressing to the PM was demonstrated, these papers did not clarify the amount of force and effectiveness on the PM stiffness[24].

This research design was to regulate the position and pressure strictly. In addition, lumbar lordosis in prone position with bilateral hip extension was applied in order to minimize the effect of perturbation instead of upright standing. The results of this study indicated that lumbar extension angle at L4 was significantly decreased by pressure technique. In conclusion, this study suggests that PM pressure technique have a possibility to attenuate PM stiffness with reducing each segment of lumbar extension angle.

This study had several limitations. Firstly, number of participants was small, included only young healthy males. Therefore, the results of this study are not generalizable to other populations. Secondly, the pressure technique was only applied to a small area for each of the PM, so it is unclear whether the same effect would be seen when the pressure technique was applied to other or multiple areas. Thirdly, it was not determined how much stiffness the PM was attenuated by the pressure technique and how the changes in lumbar extension angle observed in this study would last.

Conflict of interest

None.

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