The Relationship Between Abdominal Muscle Thickness and Lumbopelvic Pain During Pregnancy: a Cross-sectional Study

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Abstract

BACKGROUND: Lumbopelvic pain (LPP) is a very common cause of discomfort during pregnancy, but its etiology remains unclear. The association between abdominal muscle thickness and LPP in pregnant women has not been studied extensively, despite the significant abdominal changes that occur during pregnancy. This study aimed to examine the relationship between abdominal muscle thickness and LPP during pregnancy.

METHODS: In this study, 49 pregnant women in their second trimester participated. The intensity of LPP was assessed using a numerical rating scale. Ultrasound imaging was used to measure the thickness of abdominal muscles, including the rectus abdominis, external oblique, internal oblique, and transversus abdominis muscles. Participants were classified into two groups, the LPP group and non-LPP group, and the abdominal muscle thickness was compared between the two groups. The statistical significance level was set at $p<0.05$.

RESULTS: There were 24 and 25 participants in the LPP and non-LPP groups, respectively. Internal oblique (IO) thickness was significantly thinner in the LPP group than in the non-LPP group (5.4±0.2 mm vs. 6.1±0.2 mm; $p=0.042$). Multivariate logistic regression analysis showed that IO thickness was significantly associated with LPP (odds ratio, 0.516; 95% confidence interval, 0.284-0.935; $p=0.019$).

CONCLUSIONS: This study suggested that LPP in second trimester pregnancy might be related to IO thickness. Further longitudinal studies are needed to understand the role of this muscle as an LPP risk factor for pregnant women.

1. Background

Lumbopelvic pain (LPP) is one of the most common complaints during pregnancy [1–5]. LPP is the collective term for lower back pain and/or pelvic girdle pain, and it influences basic activity abilities, such as sitting, walking, and standing, during pregnancy [1, 6, 7]. Severe LPP disturbs sleep and contributes to the serious need for a sick leave [1, 2]. Thus, LPP interferes with activities of daily living and reduces quality of life during pregnancy. Previous studies reported that approximately 50% or more of all pregnant women experience LPP [1–3]. Furthermore, it has been described that about half of the women who reported LPP during pregnancy continuously experience pain 1 year after delivery [4], and 17% of the women continue to experience pain 3 years postpartum [6]. Therefore, LPP is not a temporary problem during pregnancy, with the potential of such discomfort becoming chronic and continuing beyond the postpartum period. A countermeasure to LPP during pregnancy should be clarified and addressed to allow more comfortable pregnancies and postpartum periods. However, the exact etiology of LPP remains unknown, with the evaluation methods for screening factors and treatment options often being poor.

It is well known that abdominal muscles contribute to posture control, lumbar spinal stabilization, pelvic stabilization, and movement coordination [8, 9]. In the non-pregnant population, several reports focus on the relationship between lower back pain and abdominal muscle dysfunction [10–12]. Therefore, appropriate abdominal muscle function can be considered a critical factor in LPP management not only for the non-pregnant population but also for pregnant women.

Some significant biomechanical changes occur in pregnant women, and the swelling of the abdomen with fetal growth and weight gain is one of the major changes. As a result of this change, abdominal muscles may be morphologically and functionally affected. Previous studies reported the differences in abdominal muscle condition caused by pregnancy, including changes in thickness [13, 14], length [15], and muscle function [9, 15, 16], compared with nulliparous pregnancy. Overstretching of the abdominal muscles during pregnancy may cause increasing strain on the lower back and pelvis because these muscles maintain posture and stabilize the pelvis against external loads [7, 17]. Hence, the stretching of the abdominal muscles induced by fetal growth may lead to muscle weakness and loss of muscle function, which may cause LPP during pregnancy. Nevertheless, there are few reports about the relationship between abdominal muscle conditions and LPP during pregnancy [18], and the knowledge surrounding this correlation remains insufficient.

Ultrasound imaging is often used to observe fetal growth in obstetrics and gynecology, and it is a familiar technique for pregnant women. Many studies have also reported the use of ultrasound imaging because it is a noninvasive and easy-to-use method for evaluating muscles [10, 13, 14, 18, 19]. Regarding the use of ultrasound to specifically measure abdominal muscle thickness, the reliability of quantitative assessment has been reported [20]. Therefore, ultrasound imaging has the potential to be a useful and safe tool to examine abdominal muscle thickness in pregnant women.

Abdominal muscle thickness could be influenced not only by the muscle quantitative difference, but also by the degree of stretch via the expansion of the abdomen due to fetal growth; hence, it is necessary to consider this when assessing muscle thickness [17]. With or without LPP, it can be assumed that there is a considerable difference between the degree of abdominal muscle stretch in early and that in late pregnancy because the degree of stretching may increase with the duration of pregnancy. Hence, it would be necessary to consider the gestational ages of participants when assessing differences in muscle thickness. We considered the above issues by limiting the weeks of gestation in participants. Moreover, LPP usually starts between the fifth and seventh month of pregnancy (in second trimester pregnancy), and the average gestational age at the start of pain is reported to be 22.1 weeks [1, 3]. Another study reported that LPP in early pregnancy is associated with disability and pain intensity in late pregnancy and during the postpartum period [21]. Therefore, focusing on the second trimester may help to understand the pathophysiology of LPP during pregnancy and the postpartum period.

In this study, the aim was to reveal the difference in the thickness of abdominal muscles between those with or without LPP in the second trimester of pregnancy, a period in which pregnant women commonly start to feel pain.

2. Methods

2.1. Study design and participants

This was a cross-sectional study conducted in accordance with the guidelines of the Declaration of Helsinki. The Ethics Committee of Kyoto University Graduate School of Medicine approved the study (Approval number R1840).

Pregnant women were recruited at the obstetrics and gynecology clinic in Aichi Prefecture, Japan. The inclusion criteria were women who were 16–27 weeks pregnant (second trimester). Women with high-risk pregnancies and those with serious orthopedic disorders or neurological diseases, such as thsoe that occur after surgery for total hip arthroplasty or multiple sclerosis, were excluded from the study. Those with lower back disorders, such as hernias, before pregnancy were also excluded. The obstetricians and midwives in the study's implementation clinics checked whether the pregnant women fit the inclusion criteria among those that attended the clinic for gynecological checkups. All participants received written and oral information about the study, particularly its purpose and methods. Written informed consent was obtained from all participants. Finally, 49 pregnant women who met the inclusion criteria and agreed to participate in the study were included. Data were collected at regular checkups and at midwives' health promotion days.

2.2. Questionnaire

Personal characteristics (age, height, current weight, weight before pregnancy, and parity) and current condition of LPP were obtained using self-administered questionnaires. Moreover, the estimated weight of the fetus was obtained from the clinical data on the current pregnancy. LPP assessment was conducted using the numerical rating scale (NRS). The NRS is an 11-point pain rating scale with the lower endpoint, 0, representing "no pain" and the higher endpoint, 10, representing "worst pain imaginable." Participants circled the number that best represented their level of pain. We defined NRS > 0 as the presence of LPP, based on previous studies [22]. The location of the pain was explained using a figure of the human body (Fig. 1), and lower back pain, pubic symphysis pain, and sacroiliac joint pain were assessed. Lower back pain and pelvic pain are frequently considered together [1, 3]. Therefore, the presence of LPP was decided based on the presence of one or more locations experiencing pain. Participants were divided into the following two groups based on the results of an interview about the current presence or absence of LPP: the LPP group and the non-LPP group.

The three locations of pain were assessed by self-report.

2.3. Muscle thickness measurements

B-mode ultrasound imaging, Noblus (HITACHI Aloka Medical, Tokyo, Japan), was used to measure each participant's abdominal muscle thickness. Ultrasound measurements were performed at rest for all four abdominal muscles: the rectus abdominis (RA), external oblique (EO), internal oblique (IO), and transversus abdominis (TrA) muscles. The RA muscle was measured at 4 cm lateral to the umbilicus, while the EO, IO, and TrA muscles were measured at 2.5 cm anterior to the axillary line, at the height of the umbilicus [18]. They were measured on the left side while participants were in a relaxed supine posture based on the assumption of symmetry [23]. The ultrasound probe was held perpendicular to the skin surface using the minimum pressure required to achieve a clear image, and the image was frozen at the end of exhalation [23]. All examinations and measurements were performed for each muscle with great care by an experienced investigator who was blinded for information about the presence of LPP. Muscle thickness was measured between the fascia, and ultrasound images are provided in Figs. 2 and 3.

2.4. Statistical analysis

All statistical analyses were conducted using JMP pro, version 16 (SAS Institute, Cary, NC, USA). The primary outcome was thickness measurements of each of the four muscles (RA, EO, IO, and TrA). The Shapiro-Wilk test was used to confirm the statistical normality of the outcome variables. Subsequently, unpaired 2-tailed t-test or Mann-Whitney U test was used to assess the significant differences in characteristics between the two groups and to compare abdominal muscle thickness. After observing a significant difference in the unpaired 2-tailed t-test or Mann-Whitney U test, we performed a multivariate logistic regression analysis, with Body Mass Index (BMI) and parity as adjustment variables [3]. Data are expressed as mean ± standard deviation. The statistical significance level was set at $p < 0.05$.

3. Results

In this study, 49 pregnant women were included (mean ± standard deviation, gestational weeks: 23.1 ± 2.7 weeks), with 24 (49.0%) and 25 (51.0%) patients in the LPP and non-LPP groups, respectively. Table 1 shows the characteristics of the participants in this study. No significant differences in characteristics were found between the two groups. The differences in abdominal muscle thickness between the LPP and non-LPP groups are shown in Table 2. In addition, the representative images of each group are shown in Fig. 4a-d.

Table 1
Characteristics of study participants. This table shows the results of the unpaired 2-tailed t-test or Mann-Whitney U test for characteristics. Data are expressed as mean (standard deviation). BMI = body mass index.

	total (n = 49)	LPP group (n = 24)	non-LPP group (n = 25)	p-value
Age, years	31.8 (4.3)	31.4 (4.9)	32.2 (3.6)	0.79
Height, cm	158.0 (5.7)	157.2 (6.2)	158.8 (5.3)	0.33
Weight before pregnancy, kg	52.5 (6.2)	51.8 (7.0)	51.2 (5.4)	0.74
Weight, kg	55.8 (6.8)	56.6 (7.8)	55.1 (5.8)	0.46
BMI, kg/m^2	22.3 (2.3)	22.9 (2.7)	21.8 (1.7)	0.11
Estimated fetal weight, g	711.4 (226.3)	751.4 (212.7)	663.5 (238.2)	0.20
Parity	0.9 (0.8)	1.0 (0.8)	0.8 (0.9)	0.32

Table 2
Comparison of Mean Abdominal Thickness (mm) between groups. This table shows the results of the unpaired 2-tailed t-test or Mann-Whitney U test for abdominal thickness. Data are expressed as mean (standard deviation). [a] Significant difference ($p < 0.05$).

	LPP group (n = 24)	non-LPP group (n = 25)	p-value
Rectus abdominis muscle, mm	5.58 (1.29)	5.88 (1.05)	0.360
External oblique muscle, mm	4.38 (0.21)	4.63 (0.21)	0.394
Internal oblique muscle, mm	5.36 (0.23)	6.05 (0.23)	0.042[a]
Transversus abdominis muscle, mm	2.00 (0.50)	2.06 (0.58)	0.960

A statistically significant difference was found in the thickness of the IO muscle (p = 0.042) between the groups; those in the LPP group (5.4 ± 0.2 mm) had significantly thinner IO muscle thicknesses than those in the non-LPP group (6.1 ± 0.2 mm). No significant differences were observed in the remaining 3 muscles. Furthermore, multivariate logistic regression analysis was conducted on IO muscle thickness. The results of the multivariate logistic regression analysis, with BMI and parity as adjustment variables, are shown in Table 3. IO muscle thickness and BMI were significant variables for LPP. In particular, IO muscle thickness was significantly associated with LPP in the second trimester pregnancy (odds ratio, 0.516; 95% confidence interval, 0.284–0.935; p = 0.019).

Table 3

The result of multivariate logistic regression analysis. This table shows the results of multivariate logistic regression analysis in internal oblique muscle thickness, using adjustment for BMI and parity. CI, Confidence Interval; BMI, Body Mass Index. [a] Significant difference ($p < 0.05$).

	odds ratio	95% CI	p-value
Internal oblique muscle	0.516	(0.284–0.935)	0.019[a]
BMI	1.376	(1.007–1.879)	0.030[a]
Parity	1.316	(0.609–2.842)	0.481

4. Discussion

In this study, we compared the abdominal muscle thicknesses of pregnant women in their second trimesters between those in the LPP and non-LPP groups. The results showed that those in the LPP group had significantly thinner IO muscles compared to those in the non-LPP group. In the non-pregnant population, some literature has reported significant differences in abdominal muscle thickness between those with and without back pain [10]. However, this is the first study to show a significant difference between pregnant women with and without LPP. Therefore, the results may suggest that it is important to focus on the function of IO muscles in pregnant women to understand LPP during pregnancy.

First, the IO muscle may perform an important function of maintaining proper posture. Previous studies have reported, although these results are inconsistent associations between individuals, that postural changes often occur during pregnancy, such as lumbar lordosis [5], lumbar flattening [24], and forward tilting of the pelvis [5]. Passive postures, which are commonly reported during pregnancy, rely on the lumbar pelvis structure to maintain an upright posture against gravity [25], and this may cause fatigue and muscular strain in later stages of LPP [8]. In addition, it has also been clinically reported that these passive postures frequently exacerbate pain [25, 26]. However, in proper posture, bones and joints are in the position to withstand the stress of weight and movement, as they are firmly balanced to hold the body organs in place [8] and may reduce the strain on the lower back and pelvis. Regarding the effects of the IO muscle on posture, muscle activity decreased in slump sitting and sway standing postures, which are passive postures [25, 27], but increased in proper postures. In addition, another previous study has examined the contribution of abdominal muscles to lumbar stability, using two different abdominal activation strategies, and it was reported that the IO is the most important muscle for stability [28], indicating a postural stabilizing function of the muscle. Accordingly, when the IO muscle loses the ability to perform its usual function, lumbar stability decreases, making it difficult to maintain proper posture and possibly leading to LPP during pregnancy. Second, it is necessary to focus on the function of IO muscles for pelvic stability. Hormonal loosening of the pelvic ligaments during pregnancy increases the possibility of instability of lumbopelvic joints, such as the sacroiliac joint (SIJ), leading to inflammation in the back and pelvic region and LPP [5, 7]. Protection against shear loading of the pelvic joints can be provided by transversely oriented muscles such as the IO. Based on fiber orientation, IO muscles can be divided anatomically into two parts, and the lower fibers in the pelvis run horizontally. The anteroinferior portion of the IO can produce SIJ compression, which increases the friction between joint surfaces [29]. This is called the self-bracing mechanism, and it stabilizes the position of the sacrum between the iliac bones. Moreover, Snijders et al. reported that IO muscle activity decreased significantly when applying a pelvic belt, while it increased significantly when the belt was taken off [27]. They claimed that the IO muscle has a role like the pelvic belt. These reports have described that IO forces an increase in the stability of the pelvis, particularly that of the SIJ. In contrast to pelvic instability due to laxity of the ligaments and joints during pregnancy, IO muscles may play a role in keeping the pelvis in place. Thus, the non-LPP group might have had optimal pelvic joint stability, more retained IO function, and had thicker muscle thickness than the LPP group in this study. Hence, overstretching of the abdominal muscles during pregnancy might thin the muscle and affect these functions. Furthermore, muscle activities of the IO decrease in passive postures and while using pelvic belts during pregnancy [25, 27], which may contribute to muscle thinning and possibly contributes to LPP. Conversely, there may be a reverse causation with the thinning of IO as a result of LPP onset during pregnancy, involving prolonged passive postural activity, extended pelvic belt using time, and decreased overall physical activity [7, 25, 27].

The results of our study showed that thinner IO muscles might be related to LPP. The most obvious visible change during pregnancy is the expansion of the abdomen, and the influence on abdominal muscle thickness is inevitable. Most biomechanical studies show that TrA is more important in LPP [10, 12, 23, 30], but our results showed that there is no difference in the TrA muscle thickness with or without LPP. In addition to the results of this study, a previous study in women during the postpartum period reported that their IO muscles were thinner than those of nulliparous women, while no significant differences were observed in TrA muscles [14]. Therefore, it is considered that the IO muscle thickness can be more influenced by biomechanical changes during pregnancy than TrA muscle thickness and tends to remain thin even during the postpartum period. This may be a feature in the association between abdominal muscles and perinatal LPP. Although it has been suggested that exercise programs focused on TrA are important for non-pregnant patients with lower back pain [30], exercises focused on strengthening the IO muscles may be more effective in pregnant women as a countermeasure against LPP.

Consequently, assessing the morphological information of the abdominal muscle, particularly the IO, may be a useful way of screening women with LPP for muscle overstretching and weakness during pregnancy.

This study has several limitations. First, it was a cross-sectional study; therefore, it is difficult to refer to a clear causal relationship between abdominal muscle thickness and LPP during pregnancy. Additionally, the participants of this study were exclusively second trimester pregnant women, so the relationship between abdominal muscle thickness and LPP throughout pregnancy was not revealed. Second, this study was limited to quantitative evaluation using muscle thickness measurement. Qualitative and functional evaluation could not be performed. Therefore, there may be insufficient points for muscle evaluation. Another limitation was the relatively small sample size. Thus, it is necessary to conduct studies with more participants or longitudinal research that follows muscle changes from early pregnancy, to investigate the causal relationship during pregnancy. Further investigations about the relationship between abdominal muscle and LPP during pregnancy may help to better understand chronological muscle changes throughout pregnancy and the risk factors for LPP, and this will lead to the establishment of an effective approach to the abdominal muscles, for evaluation at each period of pregnancy. Consequently, this research may lead to an improvement in quality of life and activity of daily living during pregnancy and postpartum periods.

5. Conclusion

The findings of this study suggest that IO muscle thickness is associated with LPP during the second trimester pregnancy. This thinner IO muscle in pregnant women with LPP could indicate muscle overstretching and weakness, which may make it difficult for the IO to function. IO muscles being responsible for proper posture and pelvic stability may be an essential factor related to the onset of LPP. There also may be a reverse causation with thinning of IO as a result of LPP during pregnancy. Therefore, the assessment of abdominal muscle thickness during pregnancy might be useful in the management of LPP.

6. List Of Abbreviations

LPP: Lumbopelvic pain

RA: rectus abdominis

EO: external oblique

IO: internal oblique

TrA: transversus abdominis

BMI: Body Mass Index

SIJ: sacroiliac joint

7. Declarations

Ethics approval and consent to participate

The Ethics Committee of Kyoto University Graduate School of Medicine approved the study (Approval number R1840).

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Conceptualization: RK, **Data curation:** RK, **Formal analysis:** RK, **Investigation:** RK, MI, CY, KN, CYC, MK, NK, HH, FU, MY, **Methodology:** RK, HH, MY, TA, **Project administration:** RK, TA, **Resources:** RK, MI, MK, NK, HH, FU, MY, **Writing – original draft:** RK, **Writing – review & editing:** TA, SM, MN-T.

All authors read and approved the final manuscript.

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Figures

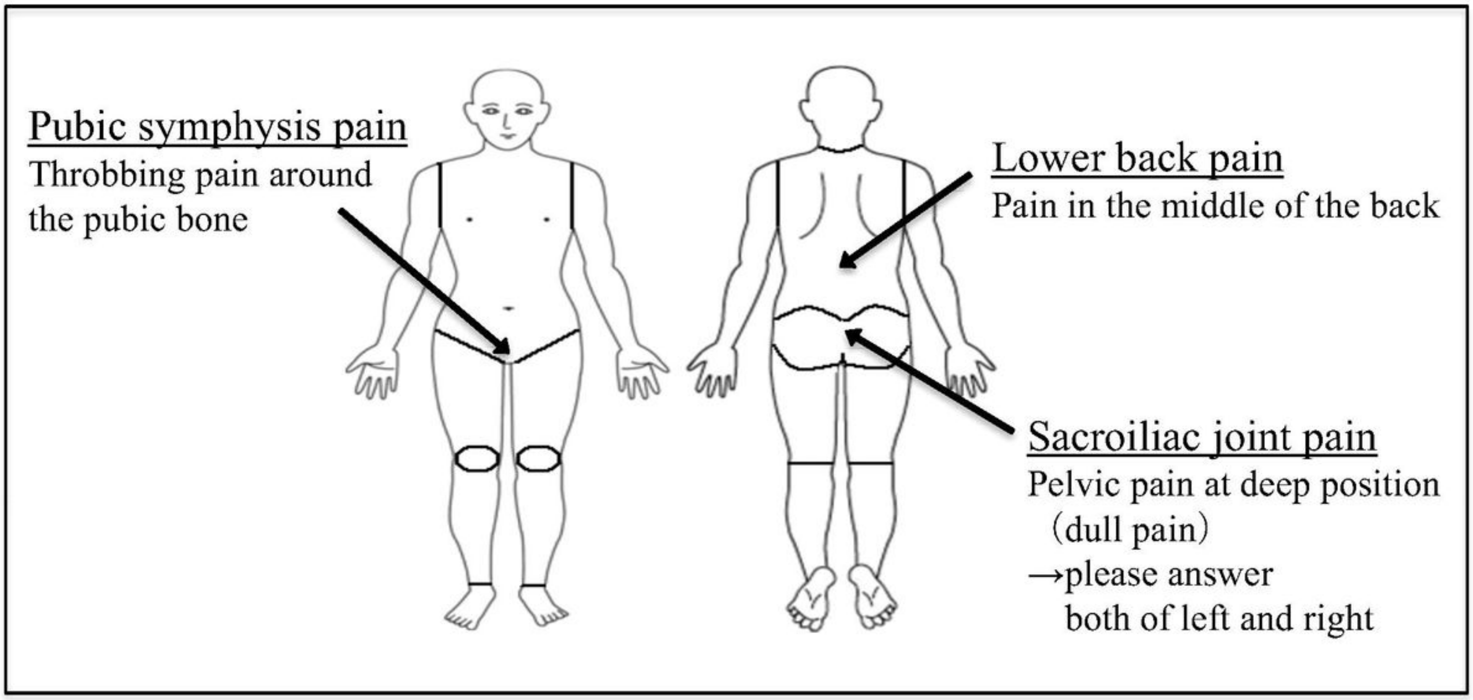

Figure 1

Figure of the human body showing the locations of Lumbopelvic pain.

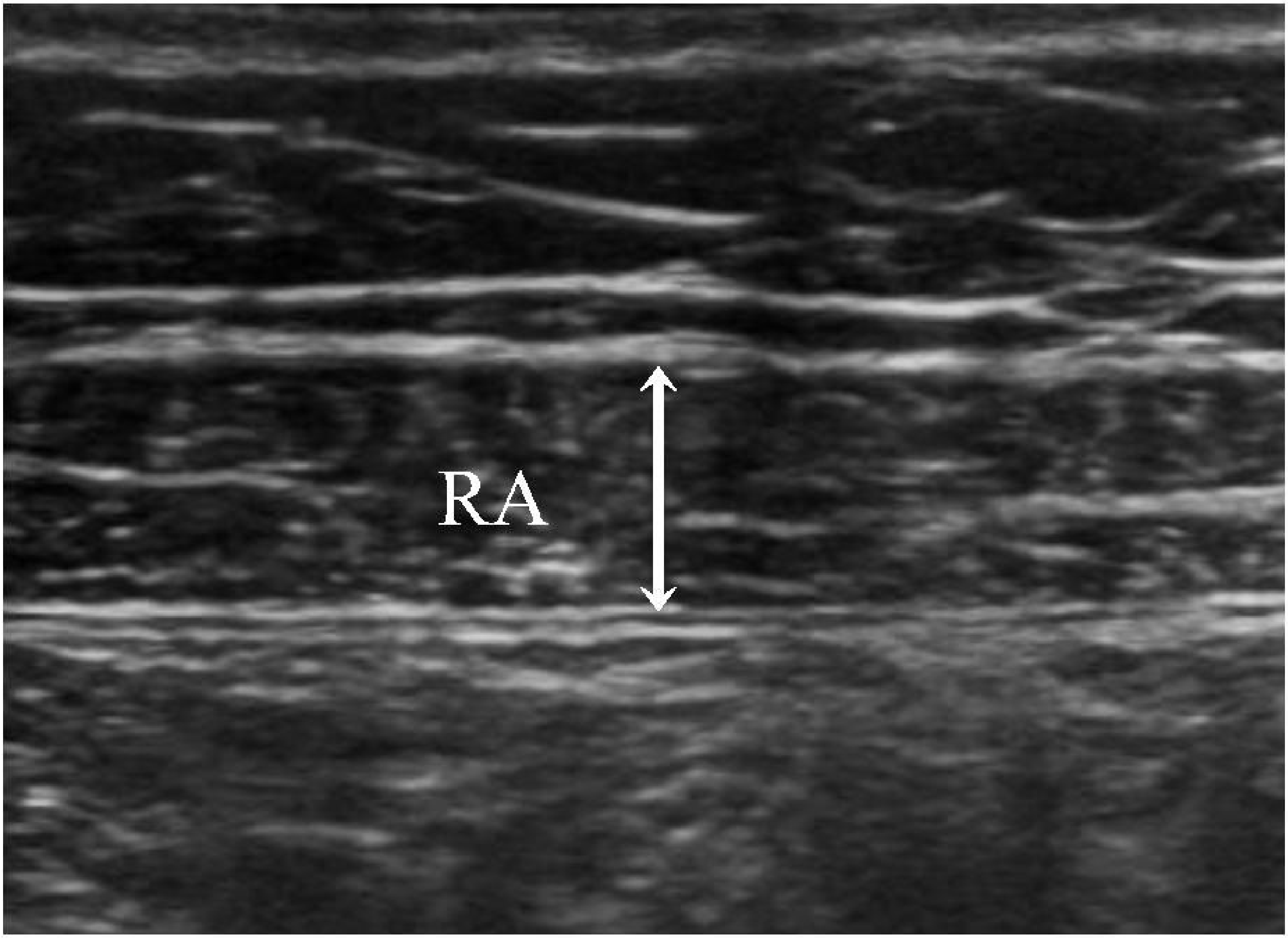

Figure 2

Ultrasound imaging of muscle thickness in the rectus abdominis muscle (RA).

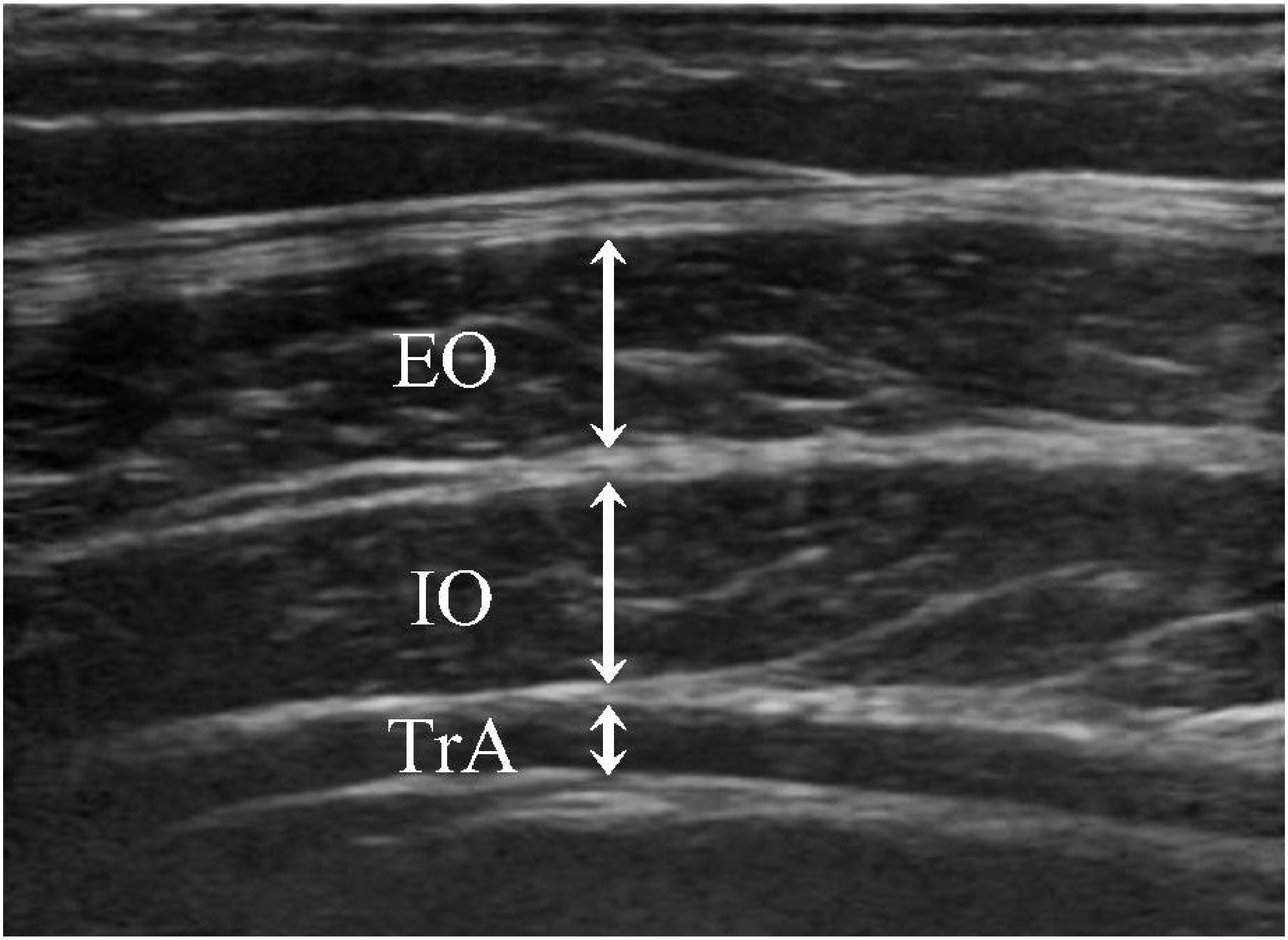

Figure 3

Ultrasound imaging of muscle thickness in the external oblique (EO), internal oblique (IO), and transversus abdominis (TrA) muscles.

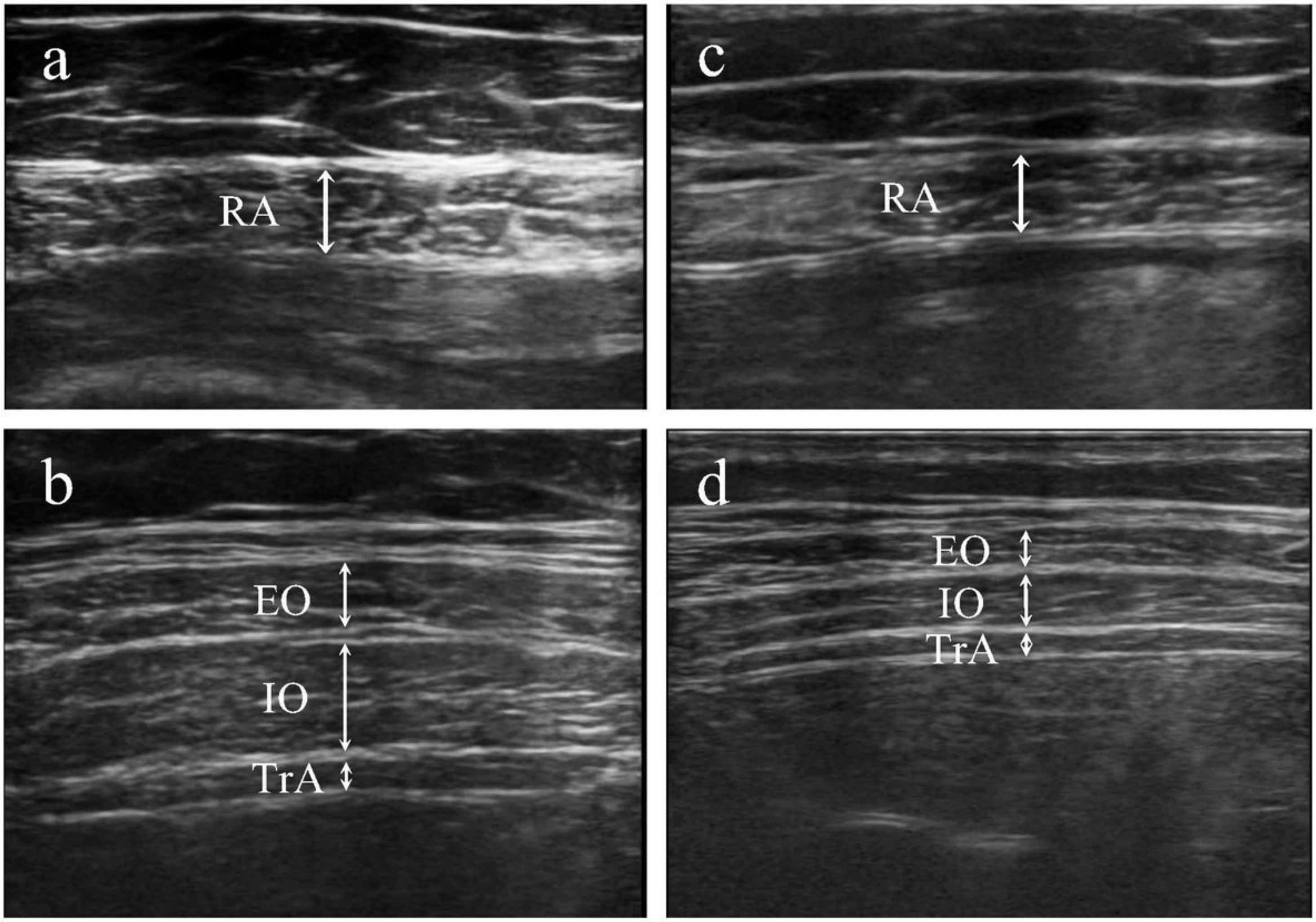

Figure 4

(a-d). Representative ultrasound imaging of muscle thickness in the non-LPP group (a,b) and the LPP (c,d) group. This shows the ultrasound imaging of muscle thickness in a woman without (a,b) and with (c,d) LPP. The images in the upper lane show the ultrasound imaging of muscle thickness in the rectus abdominis (RA) muscle, and the images below show the ultrasound imaging of muscle thickness in external oblique (EO), internal oblique (IO), and transversus abdominis (TrA) muscles. Both participants in the images were at 23 weeks of pregnancy.