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Effect of pelvic floor and transversus abdominis muscle contraction on inter-rectus distance in postpartum women: a cross-sectional experimental study

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Abstract

Objectives To investigate the effect of acute isometric contraction of the pelvic floor muscles (PFM) and transversus abdominis muscle (TrAM) on inter-rectus distance (IRD) from resting values in postpartum women with diastasis rectus abdominis (DRA).
Design Cross sectional experimental study.
Setting Physiotherapy clinic.
Participants Thirty eight postpartum women presenting with DRA of at least two finger widths.
Methods Two dimensional ultrasound images of IRD were recorded using a linear probe (5 to 10 MHz) at rest, during PFM contraction, during TrAM contraction, and during combined PFM and TrAM contraction. IRD data were normally distributed.
Main outcome measure Change in IRD.
Results There was a significant increase in IRD during PFM and TrAM contraction compared with IRD at rest. At 2 cm above the umbilicus, mean PFM was 26.9 [standard deviation (SD) 8.8] mm vs rest 25.7 (SD 8.5) mm {mean difference 1.2 [95% confidence interval (CI) 0.7 to 1.7] mm}; and mean TrAM was 28.4 (SD 9.0) mm vs rest 25.7 (SD 8.5) mm [mean difference 2.8 (95% CI 1.9 to 3.6) mm]. Similarly, 2 cm below the umbilicus, mean PFM was 22 (SD 8.3) mm vs rest 21 (SD 7.9) mm [mean difference 0.9 (95% CI 0.4 to 1.6) mm]; and mean TrAM was 23.3 (SD 8.7) mm vs rest 21 (SD 7.9) mm [mean difference 2.3 (95% CI 1.5 to 3.1) mm]. Combined TrAM and PFM contraction measured 2 cm above the umbilicus caused the greatest increase in IRD: mean PFM + TrAM 29.6 (SD 9.4) mm vs rest 25.7 (SD 8.5) mm [mean difference 3.9 (95% CI 2.8 to 5.0) mm].
Conclusion Both PFM and TrAM contraction, and combined PFM and TrAM contraction increased IRD in postpartum women with DRA.

Keywords: Diastasis rectus abdominis; Inter-rectus distance; Pelvic floor; Transversus abdominis; Ultrasonography; Measurement

Introduction

Diastasis rectus abdominis (DRA) is an impairment of the connective tissue causing the two muscle bellies of the rectus abdominis muscle to separate through the midline of the linea alba [1]. The distance between the medial borders of the two rectus abdominis muscle bellies is referred to as the ‘inter-rectus distance’ (IRD) [2]. The location of DRA can be above, below and/or at the level of the umbilicus [3]. The prevalence of DRA is reported to be between 30% and 70% in pregnant women and up to 60% in postpartum women [4–6]. Women‘s health physiotherapists often treat patients, both during pregnancy and after childbirth, presenting with DRA [1,7]. The majority of these patients are also referred to physiotherapy with a combination of other musculoskeletal complaints, such as low back pain, pelvic girdle pain and/or pelvic floor dysfunction [7].

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There are several classifications of a clinically significant DRA, with IRD ranging from 1.5 cm to 2.7 cm [1]. Furthermore, there seems to be no consensus about where this distance should be measured, varying from one or more assessment points along the linea alba to the level of the umbilicus alone [1]. DRA is usually measured using palpation by the fingerwidth method, dial calipers or two dimensional ultrasound imaging [8]. Although palpation and dial calipers are considered valid and reliable screening methods for measuring the presence of DRA in clinical practice, the use of ultrasound imaging is a more accurate and reliable method [2,5,8].

Conservative rehabilitation of DRA has mainly focused on reducing the distance by prescribing therapeutic exercises addressing the strength and function of the transversus abdominis muscle (TrAM) [7]. The TrAM is the deepest of the lateral abdominal muscles, originating from the deep surface of the six lower costal cartilages, the lumbar fascia, the anterior two thirds of the iliac crest, and the lateral third of the inguinal ligament. It inserts into the xiphoid process, the linea alba and the symphysis pubis. It is considered a major abdominal muscle contributor to control and stabilise the lower segments of the spine [9]. Due to its strong facial links to the linea alba, activation of the TrAM has long been postulated to pull the medial borders of the two rectus abdominis muscle bellies together, hence reducing IRD [1,10]. However, recent studies have shown that activation of the TrAM, on the contrary, may increase IRD due to the strong lateral pull of the deep abdominal muscles caused by their posterior origins [2,11–14].

The pelvic floor muscles (PFM) consist of the pelvic diaphragm, the urogenital diaphragm, and the sphincters and erectile muscles of the urogenital and intestinal tract. The pelvic diaphragm is a funnel shaped structure that: (1) gives structural support to the pelvic organs; (2) counteracts increased intra-abdominal pressure; and (3) allows for the passage of urine and defecation. The levator ani is the largest component of the PFM and consists of three separate muscles: pubococcygeus, puborectalis and iliococcygeus. These muscles attach anteriorly lateral to the symphysis pubis and to the thickened fascia of the obturator internus, and posteriorly to the coccyx. A voluntary contraction of the PFM will cause the muscle fibres to pull and lift the internal organs, and tighten the openings of the anus, vagina and urethra (levator hiatus). The PFM are postulated to play an important role during childbirth, and may also contribute to sexual function [15]. The synergistic co contraction of the TrAM and the PFM [16–18] has resulted in published theories that PFM contraction may play an important role in reducing DRA [10,19]. However, a recent study found that there was no difference in PFM strength between postpartum women with and without DRA, and hence encouraged clinicians to be cautious when explaining associations between the PFM and abdominal muscle function [20].

The paucity of common clinical guidelines for postpartum women presenting with DRA identifies the need for further research. To date, there is limited knowledge about the relationship between the PFM and TrAM and DRA. There are conflicting theories [11,14,21] of how TrAM contraction influences IRD, and the relationship between the PFM and IRD is yet to be examined. The main aim of this study was to identify the acute effect of PFM and TrAM contraction, and combined PFM and TrAM contraction, on IRD in postpartum women presenting with DRA.

Materials and methods

Design

A cross sectional experimental study was applied. Prior to participation, all subjects were given oral and written information about the study, and only participants who signed a consent form were included. The study was approved by the Regional Medical Ethics Committee (2016/706), and procedures agreed with the Helsinki Declaration.

Participants

Participants were postpartum women presenting with DRA, recruited from local physiotherapy clinics, pre- and postpartum exercise classes, local health centres and the local hospital's women‘s health department. A power calculation was performed based on data from a previous study [2]. A clinically significant difference of 5 mm was used between IRD 2 cm above the umbilicus at rest and IRD during contraction of the TrAM, with an estimated standard deviation (SD) for the difference of 11 mm. A significance level of 0.05 and power of 0.80 was applied. Based on these calculations, a sample of 38 parous women in the postpartum period (<6 months after delivery) were to be included in the present study.

The inclusion criteria were healthy primi- and multiparous women, including both single and multiple births. The participants had to present with DRA of at least two finger widths or more at the level of the umbilicus, and/or 2 cm below and above the umbilicus on initial assessment. These cut off values were chosen to ensure a clinically significant DRA and to include all variations regarding location. The length of DRA was not measured [8]. Subjects with an abdominal wall protrusion were also classified as having DRA and were included in the study despite the fact that IRD was palpated to less than two finger widths [22]. Exclusion criteria were: DRA measured to less than two finger widths; inability to perform PFM and/or TrAM contraction correctly; pregnancy; inability to understand the Scandinavian language; failure to complete and present an informed consent form; and chronic physical or mental illness.

All participants completed a short questionnaire to provide background information. Symptoms of urinary incontinence were assessed by the International Consultation on Urinary Incontinence Short Form Questionnaire [23]. The Modified

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Oswestry Disability Index [24] was used to assess back pain, and symptoms of pelvic girdle pain were assessed by the Pelvic Girdle Questionnaire [25].

All assessments were performed by the same investigator − a women's health physiotherapist with 16 years of clinical experience (N-MT) who had undergone specific training in ultrasound imaging of the pelvic floor and abdomen prior to data collection.

Primary outcome measure

Change in IRD was measured 2 cm above and 2 cm below the umbilicus, using two dimensional ultrasonography.

PFM contraction

Ability to perform a correct PFM contraction was assessed by observation of the perineum and vaginal palpation. With a correct technique, the perineum is pulled forward and inwards [26]. The ability to contract and the strength of contraction were assessed using the modified Oxford muscle grading scale [27]. PFM contraction was also assessed using two dimensional ultrasound imaging by observing the cranioventral displacement of the pelvic floor in a sagittal plane, images being made using a 2.5 to 5 MHz curved array transducer placed in the mid sagittal plane immediately suprapubically [28].

TrAM contraction

A contraction of the TrAM is equivalent to the drawing in exercise [2]. The ability to perform a correct TrAM contraction was observed by ultrasound imaging of the lateral abdominal wall at the level of the umbilicus using a 5 to 10 MHz linear transducer [28], observing the change of muscle thickness [14,29]. The ultrasound images of both PFM and TrAM contraction were used as visual biofeedback to all subjects to ensure correct contraction.

Considerations

Prior to imaging of IRD, both an isolated PFM and TrAM contraction was ensured as described above. During this procedure, each participant received individual feedback, both verbal and visual (ultrasound), to ensure isolated contraction of the PFM and TrAM with minimal activation of other muscles. This was important, as any co contraction was not monitored when IRD images were taken.

Ultrasound imaging

Ultrasound images (B mode) of IRD were collected using a two dimensional ultrasound diagnostic scanner with a linear probe (Mindray M7, 5–10 MHz linear transducer). Measurement locations were 2 cm above and 2 cm below the umbilicus, with the centre of the umbilicus as the point of reference [14]. The locations were initially marked on the skin to standardise the position of the transducer [2,13]. The transducer was placed transversely along the midline of the abdomen, and the bottom edge of the transducer corresponded with the skin marker. Images were collected immediately at the end of exhalation [29], and care was taken so that the pressure of the probe did not cause a reflexive response of the abdominal muscles [2]. Images were frozen and converted to digital format for further processing.

The transverse linear distance between the corresponding medial borders of the two rectus abdominis muscle bellies was measured [2,30] using the ultrasound's integrated measurement tool. Mota *et al.* [2] found the intratester reliability of the ultrasound analyses for every condition they tested to be very good, with an intraclass correlation coefficient >0.90 for both IRD at rest and during TrAM contraction.

Procedures

Presence and size of DRA, and ability to perform PFM and TrAM contraction correctly were assessed prior to the experimental procedures. Feedback regarding contraction quality was given to the subjects to ensure a correct and isolated contraction of both the PFM and the TrAM. The subjects were in a supine position, knees hip width apart and bent 90 degrees, feet resting on the plinth, arms resting alongside the body and head resting on a pillow. This position was also used during the experimental procedures.

Images were collected of IRD in the following set order: at rest, during PFM contraction, during TrAM contraction, and during combined PFM and TrAM contraction. Prior to each image being taken, the subjects were instructed to relax, take a deep breath in, and exhale before contraction. The subjects were told to hold the contraction for approximately 3 seconds to allow imaging. Eight images were collected of each subject. For the image where the subjects were to contract the PFM and TrAM simultaneously, the subjects were instructed to first start contracting the PFM and then contract the TrAM [28].

Statistical analysis

Statistical Package for the Social Sciences Version 24 (IBM Corp., Armonk, NY, USA) was used for all statistical analyses. Background variables are presented as means with SD and ranges, or numbers and percentages. IRD data were found to have a normal distribution using the Kolmogorov–Smirnov test and Q–Q plots. Paired *t* tests were used to examine the difference between IRD at rest and during each contraction, and during combined PFM and TrAM contraction. Means and 95% confidence intervals (CI) are reported. The level of significance was set at $P \leq 0.05$. Measurement error is reported to be within the limits of −8.67 and 8.34 mm [2].

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Table 1
Background variables ($n = 38$).

		n (%)	Mean (SD)	Range
Age			34.6 (4.0)	28 to 42
Body mass index			24.2 (3.3)	20.3 to 34.9
Parity			2.2 (0.7)	1 to 3
Weeks since birth			15.1 (5.9)	0 to 26
DRA fingerwidth palpation			2.5 (0.6)	2 to 4
Type of birth	Vaginal	31 (82)		
	Forceps	4 (11)		
	Caesarean section	3 (8)		
Single/multiple births	Single	34 (90)		
	Multiple	4 (11)		
Postpartum exercise programme		28 (74)		
Urinary incontinence		23 (61)		
Low back pain		25 (66)		
Pelvic girdle pain		28 (74)		

DRA finger-width palpation; diastasis rectus abdominis measured by finger-width palpation; SD, standard deviation.

Table 2
Inter-rectus distance measurements (mm) ($n = 38$).

	Measurement location	
	2 cm above umbilicus	2 cm below umbilicus
Rest	25.7 (8.5)	21.0 (7.9)
PFM contraction	26.9 (8.8)	22.0 (8.3)
TrAM contraction	28.4 (9.0)	23.3 (8.7)
TrAM + PFM contraction	29.6 (9.4)	24.3 (8.9)

PFM, pelvic floor muscle cotraction; TrAM, transversus abdominis muscle. All measures are reported as mean (standard deviation).

Results

Forty two women agreed to participate in the study, and four were subsequently excluded as they did not meet the inclusion criteria regarding the size of DRA. Hence, the sample consisted of 38 postpartum women. Background variables are presented in Table 1.

The results of the IRD measurements at rest and during contraction are presented in Table 2. There was a significant increase in IRD during PFM and TrAM contraction compared with at rest, both 2 cm above and 2 cm below the umbilicus. Above the umbilicus, mean PFM was 26.9 (SD 8.8) mm vs rest 25.7 (SD 8.5) mm [mean difference 1.2 (95% CI 0.7 to 1.7) mm, $P < 0.001$], and mean TrAM was 28.4 (SD 9.0) mm vs rest 25.7 (SD 8.5) mm [mean difference 2.8 (95% CI 1.9 to 3.6) mm, $P < 0.001$]. Below the umbilicus, PFM was 22 (SD 8.3) mm vs rest 21 (SD 7.9) mm [mean difference 0.9 (95% CI 0.4 to 1.6) mm, $P < 0.002$], and TrAM was 23.3 (SD 8.7) mm vs rest 21 (SD 7.9) mm [mean difference 2.3 (95% CI 1.5 to 3.1) mm, $P < 0.001$].

Both above and below the umbilicus, the increase in IRD was largest with combined TrAM and PFM contraction. Above the umbilicus, mean PFM + TrAM was 29.6 (SD 9.4) mm vs rest 25.7 (SD 8.5) mm [mean difference 3.9 (95% CI 2.8 to 5.0) mm, $P < 0.001$], and below the umbilicus, mean PFM + TrAM was 24.3 (SD 8.9) mm vs rest 21 (SD 7.9) mm [mean difference 3.3 (95% CI 2.4 to 4.2) mm, $P < 0.001$].

TrAM contraction increased IRD significantly more than PFM contraction both above and below the umbilicus. Above the umbilicus, mean TrAM was 28.4 (SD 9.0) mm vs mean PFM 26.9 (SD 8.8) mm [mean difference 1.6 mm (95% CI 1.0 to 2.1), $P < 0.001$], and below the umbilicus, mean TrAM was 23.3 (SD 8.7) mm vs mean PFM 22 (SD 8.3) mm [mean difference 1.3 mm (95% CI 0.8 to 1.8), $P < 0.001$]. However, the values of increased IRD were within the limits of measurement error.

Discussion

To the authors' knowledge, this is the first study to investigate the acute effect of PFM, TrAM and combined PFM and TrAM contraction on IRD in postpartum women presenting with DRA. The study showed that both PFM contraction and TrAM contraction increased IRD significantly, both 2 cm above and 2 cm below the umbilicus in postpartum women presenting with DRA. TrAM contraction increased IRD significantly more than PFM contraction. The largest increase in IRD was measured during combined PFM and TrAM contraction.

The results of this study showed that traditionally prescribed exercises aiming to activate the TrAM and PFM to reduce IRD actually increased IRD. This is in line with results of two recent studies investigating the effect of the 'drawing in' exercise (activation of the TrAM) on IRD compared with a traditional curl up exercise, where the 'drawing in' exercise was also found to increase IRD [11,14]. The results are comparable as the designs and methods of the above referred studies are similar to the present study; measurements of IRD were performed by ultrasound imaging using standardised measurement locations and standardised measurement procedures on postpartum women. One recent study, although finding the same results, still suggests that the TrAM has a key role in the rehabilitation of DRA by strengthening the linea alba [21]. There is need for further studies to test this hypothesis.

The present study found that IRD increased significantly both above and below the umbilicus during PFM contraction. This questions the postulated synergistic associations between the PFM and DRA [10,19]. However, these studies have not investigated the direct relationship between PFM contraction and IRD; their assumptions are based on studies investigating the relationship between the PFM and the abdominal musculature in general [1,10,19]. Further studies investigating the relationship between the PFM and DRA are warranted.

One of the main objectives of the present study was to compare change in IRD between PFM and TrAM contraction. There was a significantly larger increase in IRD with TrAM contraction compared with PFM contraction. The results of the present study with regards to an increase in IRD with TrAM contraction have also been reported in other recent studies; hence, clinicians should be cautious when prescribing isolated TrAM contractions if the aim is to reduce IRD in postpartum women presenting with DRA [11,13,14]. The positive effect of PFM contractions on urinary incontinence is well established [31]. As reported in the present study (Table 1) and by Keeler et al. [7], postpartum women with DRA also report a high level of urinary incontinence. Although the present study found that PFM contraction increased IRD, this increase was minimal with a mean of 1.2 mm above the umbilicus and 0.9 mm below the umbilicus. To date, the longitudinal effects of this increase in IRD remain unknown, so postpartum women presenting with both DRA and UI should not be discouraged to perform isolated PFM contractions until further studies on the relationship between the PFM and IRD have been conducted.

The largest increase in IRD in the present study was measured during combined PFM and TrAM contraction. The postulated synergistic role between the PFM and TrAM [9,16,28] implies that PFM contraction enhances TrAM contraction and creates a more powerful pull on the TrAM, resulting in increased IRD. Further studies are recommended to challenge these findings. However, the increase in IRD is small and within the limits of measurement error.

The results of this study indicate that current theoretical assumptions influencing clinical practice should be reconsidered. Study results suggest that physiotherapists should be somewhat cautious when prescribing specific TrAM exercises and combined PFM and TrAM exercises to postpartum women presenting with DRA. However, as this was a cross sectional study and only investigated the effect of an acute, single contraction, further randomised controlled trials are needed to investigate the effect of different abdominal and/or PFM training programmes on IRD and DRA over time. Keeler *et al.* [7] reported that the majority of women's health physiotherapists responding to a questionnaire applied TrAM (89%) and PFM (87%) training to treat DRA. Hence, this is considered common physiotherapy practice. However, Benjamin *et al.* [1] concluded that, due to the poor quality of the literature, non specific exercises may or may not help to prevent or reduce DRA in pregnant and postpartum women.

Strengths and limitations

The strengths of the present study include the fact that the number of participants included was based on power calculations, and two dimensional ultrasonography was used which is known to be a reliable and valid method to assess and measure IRD [2,8]. All participants were assessed to ensure that they were able to perform PFM and TrAM contraction correctly.

Limitations of the study include the fact that a single researcher performed all assessments and measurements. The researcher was therefore not blinded to the imaging or measurement processes. One image was taken for each manoeuvere, and the measurements were taken after the assessment, using the ultrasound's integrated measurement tool. It is recommended that the procedure described by Mota *et al*. [2] should be used, where images were exported in JPG format and analysed offline using a customised code made on MATLAB image-processing software, enabling the investigator to be blinded to the subject's identification and to the values of IRD measurements. However, as the images of IRD were converted to digital format and stored, the images may also be analysed by a blinded investigator later, securing and increasing the internal validity of the measurements.

As a single researcher performed all imaging and measures in this study, bias may have been reduced if the images had been taken in a randomised order.

The participants were all self selected, resulting in a sample that may not be representative of the population. Ethnicity was not registered in the present study; hence, the results may not be representative across ethnic groups. However, both primiparous and parous women were included, as were women with both single and multiple births, which may have influenced the sample to become more reflective of the population.

Conclusion

The result of this study indicate that contraction of the PFM and the TrAM increase IRD. Further studies are needed to investigate the impact of a wide IRD, and whether IRD can be reduced by other exercises.

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Conflict of interest: None declared.

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