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# Inter-rectus distance in postpartum women can be reduced by isometric contraction of the abdominal muscles: a preliminary case–control study

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**Abstract**

**Objectives** To determine the effect of isometric contraction of the abdominal muscles on inter-rectus distance in postpartum women.
**Design** Preliminary case–control study.
**Setting** Research laboratory.
**Participants** Ten postpartum women {mean age 30 [standard deviation (SD) 4] years; mean weight 58 (SD 7) kg; mean height 159 (SD 4) cm} and 10 nulliparous (control) women [mean age 28 (SD 2) years; mean weight 56 (SD 6) kg; mean height 160 (SD 6) cm].
**Interventions** Ultrasound images from the anterior abdominal wall were recorded at rest (supine position) and during an abdominal isometric contraction, with the subject actively performing an abdominal crunch (crook lying position). Two-way analysis of variance was used to compare the inter-rectus distance between groups (postpartum vs control) and between levels of abdominal muscle activation (rest vs isometric contraction).
**Main outcome measures** Inter-rectus distance 2 cm above the level of the umbilicus.
**Results** The inter-rectus distance was significantly greater in the postpartum group compared with the control group [14.7 (SD 3.1) mm vs 9.6 (SD 2.8) mm; mean difference 5.1 mm; 95% confidence interval (CI) 3.4 to 6.8]. The inter-rectus distance was significantly lower during isometric contraction compared with rest [10.7 (SD 3.1) mm vs 13.4 (SD 3.1) mm; mean difference 2.8 mm; 95% CI 1.2 to 4.5]. No interaction was found between group and muscle contraction.
**Conclusions** The inter-rectus distance was significantly higher in postpartum women compared with controls, and significantly lower during isometric contraction of the abdominal muscles (abdominal crunch) compared with rest.


*Keywords:* Inter-rectus distance; Diastasis abdominis; Ultrasound scanning; Post partum; Abdominal strength exercises

## Introduction

During the postpartum period, many women continue, or begin, abdominal strength exercise programmes in order to restore their figure and fitness. However, prescription of these abdominal exercise programmes in the postpartum period is not based on evidence, and very little literature exists about the effect of exercise on abdominal muscle morphology during and after pregnancy. It is recognised that pregnancy imposes substantial morphological changes on the abdominal muscles, with implications for the functional capacity of women during the postpartum period [1,2]. The rectus abdominis muscles, which extend along the entire length of the anterior abdomen from the xiphoid process to the pubic symphysis, undergo changes during pregnancy. As the fetus grows, the bellies of the rectus abdominis muscles, connected by a fascia tendon, the linea alba, elongate and curve round as the abdominal wall expands, with most separation occurring at the level of the umbilicus [1,3,4]. This gap, called the 'inter-rectus distance', may vary from 2 to 3 cm wide and 2 to 5 cm long to 20 cm wide and extending along the entire length of both rectus abdominis muscles [2]. The augmented inter-rectus distance, often referred to as 'diastasis rectus abdominis' [2,3], is described as a change in the abdominal musculature, specifically in the linea alba

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and rectus abdominis sheath, with onset in the last trimester of pregnancy; the incidence of diastasis rectus abdominis peaks immediately after birth [2,3]. Although some studies have suggested that diastasis rectus abdominis could reduce abdominal integrity and functional strength, contributing to pelvic instability and back pain [1,5], to the authors' knowledge, no scientific evidence exists about the functional consequences of an increased inter-rectus distance, or about the effect of exercise on prevention and/or reduction of inter-rectus distance. The available evidence suggests that diastasis rectus abdominis is common immediately after birth, with spontaneous resolution during the postpartum period [2,6]. Partial resolution of diastasis rectus abdominis has been reported by 4 weeks [1] and 8 weeks [2,3] after birth. However, for many women, diastasis rectus abdominis does not resolve spontaneously during the postpartum period, or even months or years after birth [2,3].

Most postpartum women are encouraged to attend exercise programmes to restore their figure and fitness. The rationale behind abdominal strengthening programmes is the assumption that the contraction of all abdominal muscles will reduce the abdominal horizontal diameter in such a way that a horizontal force will be generated, which reduce the distance between of both rectus abdominis muscles, particularly at the level of the umbilicus [7]. However, there is no evidence that this horizontal tension will produce an approximation of the rectus abdominis muscles. The horizontal force is the result of the overall action of the deep abdominal muscles (internal and external, oblique and transversus muscles), which are attached anteriorly to the lateral side of each rectus abdominis muscle [8] and connected posteriorly to the lumbar vertebral column. Thus, the horizontal tension produced by these deep abdominal muscles could pull the rectus abdominis muscles laterally towards the fixed sites on the vertebral column, increasing the inter-rectus distance.

Knowledge about morphological adaptations of the abdominal muscles in postpartum women, and the relationship between muscle structural changes and functional ability is required in order to develop specific abdominal strength exercise programmes for prevention or resolution of diastasis rectus abdominis in postpartum women.

The main aim of this study was to determine the effect of isometric contraction of the abdominal muscles on the inter-rectus distance in postpartum women. It was hypothesised that diastasis rectus abdominis in postpartum women would be reduced by abdominal isometric contraction.

## Methods

### *Participants*

Two groups of women were included in this study: the postpartum group ($n = 10$) and the control group ($n = 10$). The postpartum group included primiparous women who were less than 6 months post partum (one woman was 1 month post partum, one woman was 2 months post partum, four women were 3 months post partum, two women were 4 months post partum and two women were 5 months post partum). All women in the postpartum group had healthy pregnancies and vaginal deliveries, with the exception of one woman who had a caesarean section. The control group included healthy nulliparous women.

All the participants were recruited from a private physiotherapy clinic and from among colleagues, friends and family. Only women who were able to perform the abdominal crunch exercise were eligible for inclusion in the study. Before participation, the researcher gave the subjects all the relevant research information (e.g. risks and benefits), orally and in written form, allowing them to make an informed decision about participation. Only women who signed a consent form were included in the study. The study was approved by the Scientific Council of the Faculty of Human Kinetics, Technical University of Lisbon.

### *Instrumentation and procedures*

Ultrasound images in brightness mode (B-mode) were collected from the superficial abdominal musculature, including the rectus abdominis muscles and linea alba, using an ultrasound diagnostic scanner (Sonoline Prime SLC, Siemens, Erlangen, Germany) with a 60-mm linear array transducer at 7.5 MHz.

Images were collected with the abdominal muscles at rest (supine resting position) and during an abdominal isometric contraction, with the subject actively performing an abdominal crunch (crook lying position). The abdominal crunch started from the supine resting position, and the subjects were instructed to raise their head and shoulders upwards until their shoulder blades cleared the table and their fingertips touched their knees. Subjects maintained the crook lying position for 3 to 5 seconds for data collection.

During image acquisition, the transducer was placed transversely along the midline of the abdomen, with the lower border just cephalic to the umbilicus, approximately 2 cm above the centre of the umbilicus. In order to standardise the location of the transducer, an ink mark was drawn on the desired measurement location (2 cm above the umbilicus) with the subject in the supine resting position, knees bent at 90°, feet resting on the plinth and arms alongside the trunk. This measurement location has been used previously to measure the inter-rectus distance with ultrasound [2]. Although the greatest separation between the rectus abdominis muscles occurs at the level of the umbilicus, no measurements were made at this level due to technical difficulties with ultrasound. This is consistent with other ultrasound studies that have not reported measurements at the level of the umbilicus [2,9].

The transducer was positioned on the ink mark and moved laterally until the medial borders of both rectus abdominis muscles were visualised. Images were collected immediately at the end of exhalation, as determined by visual inspection of the abdomen, following the recommendations of Teyhen *et al*.

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Table 1
Demographic and anthropometric data.

| | Postpartum group [mean (SD)] | Control group [mean (SD)] | *P*-values |
|---|---|---|---|
| Age (years) | 30 (4) | 28 (2) | 0.42 |
| Weight (kg) | 58 (7) | 56 (6) | 0.50 |
| Height (cm) | 159 (4) | 160 (6) | 0.40 |
| Longitudinal length of thorax (cm) | 18.2 (3.0) | 17.0 (1.3) | 0.26 |
| Longitudinal length of abdomen (cm) | 38.3 (10.0) | 39.2 (3.7) | 0.79 |
| Abdominal circumference at the level of the umbilicus (cm) | 75.2 (6.0) | 69.7 (4.2) | 0.03[a] |
| Hip circumference (cm) | 96.9 (7.2) | 95.6 (6.1) | 0.68 |
| Body mass index | 24.1 (7.0) | 21.7 (5.3) | 0.38 |

SD, standard deviation.
[a] Significant ($P < 0.05$).

[10]. Particular attention was given to the pressure imposed on the probe in order to avoid reflexive responses from the participants. Images were frozen, recorded on a video recorder in analogue format (mini DV tape), and converted to digital format (JPG format) for further processing.

A semi-automated image analysis was conducted offline to determine the inter-rectus distance following the procedures described by Mota *et al.* [11]. The same investigator, blinded to the results, digitalised the contour of both rectus abdominis muscles, assuming ultrasound images as a pixel-based '*xy*' coordinate system. A customised Matlab© code (Image Processing Toolbox, Mathworks, Natick, Massachusetts, USA) was used to fit a parabola-like curve to the contours of both rectus abdominis muscles in order to identify the linea alba endpoints corresponding with the medial borders of the rectus abdominis muscles on the ultrasound image. The inter-rectus distance was determined by the linear distance between the medial borders of the rectus abdominis muscles [11].

A previous study by the research team [11] found an intraclass correlation coefficient of 0.94 (95% CI 0.88 to 0.98), standard error of measurement of 1.55 mm and minimum detectable change at 95% confidence level of 4.29 mm for the technique used in this study (i.e. inter-rectus distance measured, in one testing session, 2 cm above the level of the umbilicus in a crook lying position). In this study, the difference between the groups was 5.12 mm and the difference between the conditions (i.e. rest and isometric contraction) was 2.18 mm; therefore, the error of measurement was smaller than the between-group comparison or the within-group comparison.

The inter-rectus distance (dependent variable) was analysed using standard tests for normality (Shapiro–Wilk test), and was found to satisfy assumptions of normality [12]. Demographic data were analysed using two-sample independent *t*-tests to detect between-group differences. These data (Table 1) included age, height, weight, body mass index and anthropometric data (longitudinal length of thorax and abdomen, circumference of abdomen and hips).

Two-way analysis of variance was used to test the effect of group (control vs postpartum) and level of abdominal muscle contraction (rest vs isometric contraction) on the inter-rectus distance. Independent *t*-tests for each level of muscle contraction were planned if significant interactions were found between group and muscle contraction. Effect size (partial Eta square) was reported assuming a qualitative assessment whereby a small, moderate or large change/difference was defined by partial Eta square greater than 0.20, 0.50 or 0.80, respectively [13]. Statistical Package for the Social Sciences Version 17.0 (IBM Corp., New York, USA) was used for all statistical tests, and $P < 0.05$ was considered to indicate statistical significance.

## Results

No significant differences (two-sample *t* tests) were found between the two groups of participants in terms of demographic variables (Table 1), with the exception of abdominal circumference at the level of the umbilicus, which was significantly lower in the control group.

The inter-rectus distances (mean and standard error of mean) for each group of subjects (control and postpartum) in each experimental condition (rest and isometric contraction) are presented in Fig. 1.

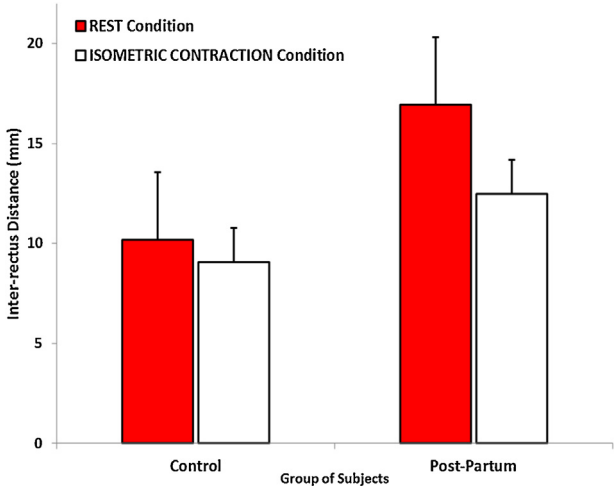


Fig. 1. Inter-rectus distance (mean and standard error of mean) for postpartum and control women at rest and during isometric contraction.

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A significant effect was obtained for group [$F(1,34) = 36.95$, $P < 0.001$] and for the level of abdominal muscle contraction [$F(1,34) = 11.12$, $P = 0.02$]. No interaction was found between the groups regarding the level of abdominal muscle contraction.

The postpartum group had a significantly greater inter-rectus distance than the control group [mean 14.67 (SD 3.14) mm vs 9.63 (SD 2.84) mm; mean difference 5.12 mm; 95% CI 3.4 to 6.8]. The inter-rectus distance was significantly lower during isometric contraction than at rest [mean 10.67 (SD 3.11) mm vs 13.38 (3.11) mm; mean difference 2.81 mm; 95% CI 1.2 to 4.5]. The difference between groups was moderate (partial Eta square = 0.43), and the difference between levels of abdominal muscle contraction was small (partial Eta square = 0.25).

In both groups, the inter-rectus distance was reduced by isometric contraction of the abdominal muscles. However, in the postpartum group, the inter-rectus distance was significantly higher at rest [mean 16.93 (SD 2.14) mm] than during isometric contraction [mean 12.48 (SD 2.28) mm], reflecting the effect of abdominal muscle contraction on the distance between the rectus abdominis muscles.

## Discussion

This study found that the inter-rectus distance was significantly higher in the postpartum group compared with the control group, and significantly lower during isometric contraction than at rest. No interaction was found between group and muscle contraction.

These results are in line with Coldron *et al.* [2] and Liaw *et al.* [7] who also found diastasis rectus abdominis in postpartum women. Some studies [1–3] have reported that in the first days after delivery, the inter-rectus distance can vary from a small vertical 'crack' (2 to 3 cm wide and 2 to 5 cm long) to an area 12 to 20 cm wide and extending along the entire length of both rectus abdominis muscles.

To the authors' knowledge, no information exists in the literature about the effect of abdominal muscle contraction on the inter-rectus distance in postpartum women. Nevertheless, abdominal muscle strengthening exercises continue to be recommended during the postpartum period, particularly to reduce the inter-rectus distance [14]. This study found that the inter-rectus distance decreased during abdominal isometric contraction, suggesting that abdominal strengthening exercises contribute to the narrowing of the inter-rectus distance in postpartum women. However, research should be undertaken to evaluate which exercises are the most effective and safe for reduction of the inter-rectus distance in postpartum women.

The effect of isometric contraction on the inter-rectus distance was verified in both groups in this study. However, the magnitude of narrowing of the inter-rectus distance was greater in the postpartum group.

An augmented inter-rectus distance, above a certain degree, is often referred to as 'diastasis rectus abdominis' [2,15]. Criteria for the diagnosis of diastasis rectus abdominis vary, and it is suggested that abnormal separation exists between the right and left rectus abdominis muscles when the inter-rectus distance exceeds 1.5 cm [1], 2 cm [5,16] or 2.5 cm [17] when measured in a lying position at rest; or greater than 2 fingers width when measured in a crook lying position [18,19].

This variability in assessment methods hampers comparison between the results obtained by different investigations on diastasis rectus abdominis. Palpation [3] and calipers [6,15] are used most often to measure the inter-rectus distance. Recently, Mota *et al.* [20] showed that palpation has sufficient reliability to be used in clinical practice. However, ultrasound imaging is highly sensitive to changes in inter-rectus distance [11], and is recommended as a valid measurement tool for future research.

A limitation of this study was the sample size and the variability of the subjects. Factors that may influence diastasis rectus abdominis include maternal age (up to 34 years), larger babies, greater weight gain during pregnancy, caesarean section, multiple gestations, large or excess amount of fluid in the uterus, weak abdominal musculature or prolonged labour. Another limitation is that the mean inter-rectus distance for the postpartum women included in this study was relatively small (i.e. less than 20 mm, measured at rest). No information is available about the effect of muscle contraction on larger inter-rectus distances (greater than 20 mm).

The functional implications of diastasis rectus abdominis in postpartum women remain unclear; some authors have suggested that it can contribute to pelvic instability and back pain by reducing the capacity of the abdominal muscles to generate force [1,5]. In a study of six postpartum women, Gilleard and Brown [1] reported that the angle of the rectus abdominis muscle insertion, in the frontal and sagittal planes, increased after 30 weeks of gestation, and remained high until 8 weeks after birth. They suggested that this explained the reduced ability of the abdominal muscles to generate torque, as observed in women up to 8 weeks post partum with an inter-rectus distance exceeding 3 cm [1]. A possible mechanical disadvantage associated with the reduced stiffness of the abdominal passive structures, particularly the linea alba and the rectus abdominis sheath, was suggested to explain the reduced ability of the abdominal muscles to produce force in the presence of diastasis rectus abdominis [2]. A recent study by Hernandez-Gascon *et al.* [21] demonstrated that the linea alba aponeurose or recti fascia is the most important unit for the mechanical stability of the abdominal wall. In pregnant women, Landon *et al.* [22] demonstrated that the recti fascia is a weak tissue with decreased tensile strength properties. Thus, diastasis rectus abdominis could change the passive stiffness of the recti fascia, which may lead to muscle imbalance and loss of coordination across the three abdominal muscles.

Future research is needed on the implications of increased inter-rectus distance during the postpartum period, and the most effective and safe exercises to reduce inter-rectus

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separation and restore the morphology and function of the abdominal wall after pregnancy.

## Conclusions

This study found that the inter-rectus distance was reduced when isometric contraction of the abdominal muscles was performed during an abdominal crunch (crook lying position). This suggests that this exercise could be effective in narrowing the inter-rectus distance, supporting the prescription of an exercise programme of isometric contraction of the abdominal muscles for prevention and/or resolution of diastasis rectus abdominis in postpartum women. Further randomised controlled trials are needed to evaluate the effect of different abdominal exercises on inter-rectus distance and diastasis rectus abdominis both during pregnancy and in the postpartum period.

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*Conflicts of interest:* None declared.

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