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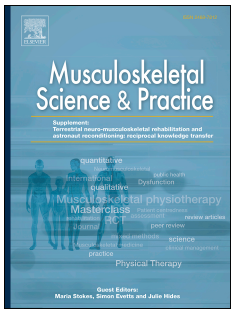

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PII: S2468-7812(18)30044-4

DOI: 10.1016/j.msksp.2018.02.004

Reference: MSKSP 165

To appear in: *Musculoskeletal Science and Practice*

Received Date: 6 November 2017

Revised Date: 5 February 2018

Accepted Date: 18 February 2018

Please cite this article as: Mota, Patrí., Pascoal, A.G., Carita, A.I., Bø, K., Normal width of the inter-recti distance in pregnant and postpartum primiparous women, *Musculoskeletal Science and Practice* (2018), doi: 10.1016/j.msksp.2018.02.004.

NORMAL WIDTH OF THE INTER-RECTI DISTANCE IN PREGNANT AND POSTPARTUM PRIMIPAROUS WOMEN

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The Review Board of the University of Lisbon, Faculty of Human Kinetics, approved the study.

The authors certify that they have no affiliation with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article.

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NORMAL WIDTH OF THE INTER-RECTI DISTANCE IN PREGNANT AND POSTPARTUM PRIMIPAROUS WOMEN

Abstract

STUDY DESIGN: Longitudinal descriptive exploratory study.

OBJECTIVES: Evaluate the normal width of the linea alba in first-time pregnant women during pregnancy and postpartum.

BACKGROUND: There are normative values on the width of the linea alba for nulliparous women, but limited knowledge about the normal width of the inter-rectus distance (IRD) in pregnant and postpartum women.

METHODS: Ultrasound images were recorded in 84 primiparous women, at 3 locations on the linea alba (2 cm below the umbilicus, and 2 and 5 cm above the umbilicus) and at 4 time points (gestational weeks 35-41 and 6^{th} to 8^{th}, 12^{th} to 14^{th}, and 24^{th} to 26^{th} weeks postpartum). The 20th and 80th percentiles were used to define the normal width of the linea alba.

RESULTS: During pregnancy, the 20^{th} and the 80^{th} percentile corresponded to 49 to 79 mm below the umbilicus, 54 to 86 mm at 2 cm above the umbilicus and 44 to 79 mm at 5 cm above the umbilicus. At 6 months postpartum, the 20^{th} and the 80^{th} percentile corresponded to 9 to 21 mm at 2 cm below the umbilicus, from 17 to 28 mm at 2 cm above the umbilicus and from 12 to 24 mm at 5 cm above the umbilicus.

CONCLUSION: Different normative values for the width of the linea alba were found at different locations of the anterior abdominal wall. In primiparous women, the IRD may be considered “normal” up to values wider than in nulliparous.

(242 words)

KEYWORDS: abdominals, diastasis recti, ultrasound imaging, linea alba.

Introduction

Diastasis recti abdominis (DRA) has been defined as an impairment characterized by the separation of the two rectus abdominis muscles along the linea alba.(Axer et al. 2001) This increased inter-rectus distance (IRD) is commonly reported to begin during pregnancy, mostly during the third trimester, and remain for the first weeks following childbirth (Mota et al. 2015b; Bø et al. 2017). Persistent pronounced rectus diastasis can contribute to a bulging of the anterior abdominal wall (Brauman 2008), and postnatal women often wish to resume abdominal exercises shortly after delivery to improve trunk function and restore abdominal figure and fitness (Mota et al. 2015a; Keshwani et al. 2017). It has also been postulated that the diastasis may alter trunk mechanics, compromise pelvic stability and change posture and thus increase the risk of low back and pelvic girdle pain (Gilleard and Brown 1996; Lee et al. 2008; Benjamin et al. 2014; Bø et al. 2017).

Studies have found that DRA may affect between 30%-100% of pregnant women, (Boissonnault and Blaschak 1988; Mota et al. 2015b) and that it may remain in 35%-60% of women in the immediate postpartum period (Bursch 1987; Mota et al. 2015b). However, the reported prevalence of DRA or increased IRD varies and may be inaccurate due to different cut-off points for the diagnosis (Bursch 1987; Boissonnault and Blaschak 1988; Rath et al. 1996; Spitznagle et al. 2007; Beer et al. 2009; Chiarello and McAuley 2013), use of different measurement points along the linea alba and different assessment methods (Boissonnault and Blaschak 1988; Coldron et al. 2008; Mota et al. 2013). To date there is no international consensus on the best measurement location. In addition, few studies, with different and less reliable instruments exist to compare the width of the linea alba (Benjamin et al. 2014; van de Water and Benjamin 2015). Based on a cadaver study, Rath et al (1996) defined pathological DRA as an IRD widening more than 10 mm above the umbilicus, 27 mm at the level of the umbilicus, and 9 mm below the umbilicus. Others defined DRA as an IRD greater than 25

mm at one or more locations (Candido et al. 2005). In a more recent study, using ultrasound imaging, Beer et al (2009) suggested that, in nulliparous women (women who have not given birth), the normal width of the linea alba, i.e. the IRD, should be less than 15 mm at the xiphoid level, 22 mm at 3 cm above the umbilicus, and 16 mm at 2 cm below the umbilicus. However, to date, knowledge on the normal width of the linea alba during pregnancy and after childbirth is scant (Coldron et al. 2008; Liaw et al. 2011).

The aim of the present study, therefore, was to evaluate the normal width of the linea alba at three levels of the abdominal wall, in a homogeneous group of women at four time points, one in late pregnancy and three in the postpartum period.

Methods

This study used data from a longitudinal study on the prevalence of DRA (Mota et al. 2015b). The width of the IRD was assessed at gestational week 35 to 41 and at 6 to 8, 12 to 14, and 24 to 26 weeks postpartum.

Participants

Women attending pre-natal courses in the Lisbon area were referred to the study by community gynecologists, physiotherapists, fitness coaches, and nurses. One hundred and twenty-three pregnant women agreed to participate in the study.

The participants were eligible for the study if they were first-time pregnant and agreed to participate in four testing sessions. Exclusion criteria were any kind of conditions affecting the ability to perform activities of daily living or having symptoms that required medical attention e.g., high-risk pregnancies, stillbirth or delivery before gestational week 37, previous spinal or abdominal surgery and neuromuscular diseases. Subjects were also excluded if any of the four testing sessions was missed. Self-report of mode of delivery,

baby's birth weight, and participation in regular exercise training defined as ≥ 3 times per week before, during and after pregnancy was registered. Demographic variables included age, level of education, and the anthropometric parameters of height (cm) and weight (kg), and were obtained according to the International Society for the Advancement of Kinanthropometry (ISAK) protocol (Marfell-Jones et al. 2012).

The Review Board of the University of Lisbon, Faculty of Human Kinetics, approved the study. Written informed consent was obtained before participation, and the rights of the participants were provided in verbal and written form following the Helsinki declaration.

Instrumentation and Procedures

Static ultrasound images were collected using an ultrasound scanner (LOGIQ e; GE Healthcare, Waukesha, WI) with a 4 to 12-MHz, 39-mm linear transducer, set to a fixed frequency of 12 MHz in brightness mode (B-mode), with participants in a supine resting position (knees bent at 90°, feet resting on the plinth and arms alongside the body).

The ultrasound data-collection protocol and analysis of the images were discussed and practiced with an experienced radiologist prior to the start of the study. The investigator, who performed all measurements, was a physical therapist with specific training in ultrasound imaging, including experience assessing IRD (Mota et al. 2012).

The ultrasound transducer was placed transversely at three locations along the midline of the abdomen, using the center of the umbilicus as a reference: 2 cm below the umbilicus, and 2 and 5 cm above the umbilicus. To standardize the transducer position, each measurement location was marked with ink on the skin. The procedures in the present study have been previously described in detail in a former study (Mota et al. 2012).

The orientation of the transducer was adjusted during image acquisition in order to optimize

visualization of the desired anatomy. Images were collected immediately at the end of exhalation follow the recommendations of Teyhen et al (2008).

For each participant, 12 images were captured referring to three abdominal locations (2 cm below and 2 and 5 cm above the umbilicus) and four time points (gestational weeks 35 to 41, 6 to 8 weeks postpartum, 12 to 14 weeks postpartum, and 24 to 26 weeks postpartum). The images were exported in Digital Imaging and Communications in Medicine (DICOM) format for further offline processing. The investigator was blinded to the participants' identification and to the values of the IRD from previous examinations (Mota et al. 2012).

IRD Measurements

Measurements of 2-dimensional ultrasound distances correspondent to the IRD were conducted offline by the same investigator, using a customized program (MATLAB Image Processing Toolbox. The MathWorks, Inc, Natick, MA) (Mota et al. 2012). The detailed description of this program and measurement procedures can be obtained from a formerly published reliability study (Mota et al. 2012). Throughout the study, the examiner was blinded to the IRD values of all participants, location and time. Once the offline measurements were completed at the end of the study, the IRD values of all the participants, conditions, locations, and time points were imported into SPSS software (IBM Corporation, Armonk, NY) for statistical analysis. Intrarrater ICC values for measuring IRD were greater than 0.90 (Mota et al. 2012).

Statistical Analysis

All statistical analyses were performed using SPSS Version 21, IBM Corporation. Continuous variables were summarized as the mean ± standard deviation. The 20th and 80th percentiles were calculated to define the normal width of the linea alba. Comparison of the widths of the linea alba at the three abdominal levels was carried out by using the Wilcoxon

signed rank test. To address the problem of multiple comparisons, we utilized the Bonferroni correction and considered tests with P-values less than or equal to 0.017 as statistically significant. Correlations between continuous variables were analyzed using Pearson correlation.

Results

Eighty-four of 123 first time pregnant women (68.3%) concluded the longitudinal study (Mota et al. 2015b). Before the first measurement, twenty-two women were excluded: 11 because of pregnancy complications, 3 lived too far away to attend the measurements after birth, 6 were not able to meet for the first measurement and 2 for unknown reasons. Seventeen women were excluded because they missed at least one measurement due to personal issues.

Table 1 presents the anthropometric data and background information for the final sample. The examination revealed a broad range of values at the three measured reference points (Table 2). There was no significant correlation of age or body height with the widths of the linea alba.

The linea alba was widest at 2 cm above the umbilicus at all time points both during pregnancy (percentile 80^{th}: 86 mm) and at 6 months postpartum (percentile 80^{th}: 28 mm). During pregnancy, the linea alba width at 2 cm above the umbilicus was significantly greater than that at 5 cm above the umbilicus ($p < 0.001$; $S^{+}=2732$; $S^{-}=838$; $Z=-4.223$; $N=84$).

At 6 months postpartum the linea alba width was significantly greater at 2 cm above the umbilicus than at 2 cm below ($p < 0.001$; $S^{+}=3410$; $S^{-}=160$; $Z=-7.247$; $N=84$), and 5 cm above the umbilicus ($p < 0.001$; $S^{+}=3063$; $S^{-}=507$; $Z=-5.700$; $N=84$).

Table 3 presents the 20th, 50th, and 80th percentiles. The values reveal that the linea alba width can be considered ‘‘normal’’ during pregnancy from 49 to 79 mm at 2 cm below the

umbilicus, from 54 to 86 mm at 2 cm above the umbilicus and from 44 to 79 mm at 5 cm above the umbilicus. At 6 months postpartum, the linea alba width can be considered ‘‘normal’’ from 9 to 21 mm at 2 cm below the umbilicus, from 17 to 28 mm at 2 cm above the umbilicus and from 12 to 24 mm at 5 cm above the umbilicus.

TABLE 1. Demographic variables (n=84). *Data are mean (minimum-maximum).

** Participation in general physical activity defined as participation in regular exercise sessions 3 or more times a week, obtained by self-report.

Age (years)*		32.1 ± 2.7
Gestational week of birth*		38.8 ± 1.0
Birth weight of baby (kg)*		3.1 ± 0.3
University education, n (%)		68 (81%)
Vaginal delivery, n (%)		52 (61.9%)
Caesarean section, n (%)		32 (38.1%)
Weight gain during pregnancy (kg)*		12.5 ± 3.4
Regular exercise training (≥ 3 times per week) [N (%)] **	before pregnancy	19 (22.6%)
	during pregnancy	16 (19.0%)
	at 6 months postpartum	24 (28.6%)

TABLE 2. Inter-rectus distance (IRD). Data are means ± standard deviations for the IRD measured at rest in mm. N=84 participants. Abbreviations: AU, above the umbilicus; BU, below the umbilicus.

		Gestational week 35 - 41	Postpartum week 6 - 8	Postpartum week 12 -14	Postpartum week 24 -26
IRD at Rest	5 cm AU	61.0 ± 19.3	23.0 ± 9.2	19.7 ± 7.8	18.7 ± 8.4
	2 cm AU	66.9 ± 19.4	26.8 ± 9.3	23.8 ± 7.3	22.4 ± 7.4
	2 cm BU	64.6 ± 19.0	18.8 ± 10.7	17.2 ± 8.9	15.3 ± 8.4

T**ABLE 3.** Percentiles of the width of the linea alba at the three abdominal levels. Data are percentiles for the IRD measured at rest in mm.

N=84 participants. Abbreviations: AU, above the umbilicus; BU, below the umbilicus.

		Percentiles								
		10%	20%	30%	40%	50%	60%	70%	80%	90%
Pregnancy	5 cm AU	37	44	51	57	59	62	67	79	86
	2 cm AU	44	54	57	61	64	69	74	86	93
	2 cm BU	42	49	55	58	63	69	75	79	89
Postpartum	5 cm AU	10	12	14	16	17	19	21	24	28
	2 cm AU	13	17	20	20	22	23	25	28	30
	2 cm BU	7	9	10	12	14	16	18	21	26

Discussion

The present study revealed that the IRD varied along the linea alba suggesting that the normative values for the width of the IRD should be defined at different reference locations. The linea alba was widest at 2 cm above the umbilicus at all time points, from pregnancy to 6 months postpartum, and in this population, the values found for the IRD were wider than in nulliparous women (Beer et al. 2009).

When defining the normal width of the linea alba, the question arises as to which method is optimal and whether ultrasound can be used as a reliable and valid method for examination. Computed tomography and magnetic resonance imaging are currently considered the methods of choice to examine the abdominal wall (Mota et al. 2013). However, they are expensive, and computed tomography exposes the patient to radiation,(Mendes et al. 2007) making it contraindicated to use in pregnant women. The reliability and validity of ultrasound in examining the IRD in this population is well established (Mota et al. 2012; 2013).

In this study, a statistical approach was used to define the lower and upper limit of the IRD, beyond which the linea alba width cannot be considered normal. A formerly published study, in the same population, found a prevalence of diastasis up to 39% at 6 months postpartum

(Mota et al. 2015b), assuming “normality” equivalent to the IRD values found for nulliparous women (Beer et al. 2009). However, the question whether nulliparous or primiparous women (women having given birth to only one child) should be the norm is a difficult one to answer. Using nulliparous as the norm may overestimate the prevalence in pregnant and postpartum women. For instance, using the cut-off value found in this study for the 80% percentile, the prevalence of diastasis in primiparous women would be 20%, instead of 39% reported previously (Mota et al. 2015b).

DRA has been noted by the 26th week of gestation (Gilleard and Brown 1996) and in 66% of women during the third trimester (Boissonnault and Blaschak 1988). Previous studies have noted that there is a partial resolution of a DRA by four weeks (Gilleard and Brown 1996; Hsia and Jones 2000) and 8 weeks (Boissonnault and Blaschak 1988) postpartum and these findings agree with those of the current study. As expected, the widest values were found during pregnancy, which is in line with other studies using different assessment methods, both finger width, caliper, and ultrasound (Boissonnault and Blaschak 1988; Gilleard and Brown 1996; Coldron et al. 2008). In the present study, at 6 months postpartum, the IRD was wider than in nulliparous women, which is in line with previous findings by Liaw et al. (2011) also using ultrasonography.

Today's widespread information in social media recommending abdominal exercise programs to prevent and treat DRA, is in strong contrast to the lack of evidence for any positive effect shown in RCTs. In a recent search on Pubmed only 4 RCTs on treatment of DRA using abdominal exercises were found (Mesquita et al. 1999; Emanuelsson et al. 2014; Walton et al. 2016; Kamel and Yousif 2017). These studies score low on PEDro rating scale of methodological quality and both exercise protocols, assessment methods, cut-off points for diastasis and results differ. To date, there is, therefore, no knowledge whether the condition can be prevented or reduced with abdominal training or other exercises programs.

One strength of the present study is the longitudinal design following a cohort with ultrasound assessment of the IRD from late pregnancy until 6 months postpartum. Other strengths are the number of subjects followed and the use of a responsive, reliable and valid ultrasound method to assess IRD with a blinded investigator. The limitations of the study

were the lack of pre-pregnancy assessment of the condition. However, measurement of nulliparous women planning to become pregnant is a challenge in all studies on pregnant women, and there is sparse knowledge on pre-pregnant women in all areas of research. The sample size of the present study can be questioned. However, whereas power and sample size calculations are the key element for performing effective comparative studies, it is of little value in exploratory studies (Jones et al. 2003). As it is not feasible to calculate the sample size in normality studies, the present results may serve as a background for power calculations of future prevalence studies.

The sample was drawn from a well-educated population attending pre-natal courses in private centres and may therefore not be representative of the larger disperse population. However, we are not aware of any theories or empirical data suggesting that DRA is associated with educational level. Due to the demands of having a baby, it is a challenge to follow pregnant and postpartum women in research projects. Hence, to avoid losses to follow-up, subjects must be motivated to attend testing sessions in longitudinal studies. Other studies in the pregnant and postpartum population had samples varying from 6 to 115 subjects1 (Boissonnault and Blaschak 1988; Gilleard and Brown 1996; Coldron et al. 2008; Liaw et al. 2011). The largest study was a prospective cross-sectional cohort study, providing only a partial longitudinal design due to difficulties in following the population over time (Coldron et al. 2008). We suggest that the small loss to follow-up in the present study may be due to the use of portable equipment allowing great flexibility of the research physiotherapist to assess the women in their homes and at a suitable time for them. We have not been able to find other normative studies on the DRA following first time pregnant women from pregnancy till postpartum. There is a need for further studies in other ethnic groups and in groups of greater heterogeneity of both demographic and anthropometric data. As diastasis recti abdominis has been proposed to be associated with higher risk of low back and pelvic

girdle pain, we recommend that women during pregnancy and in the postpartum period with IRD above the normal values found in the present study, should be followed-up to elaborate on the association of DRA and symptoms of low back and pelvic girdle pain.

Conclusion

In primiparous women, the IRD may be considered “normal” up to values wider than for nulliparous women. During pregnancy, the linea alba can be considered normal up to 79 mm at 2 cm below the umbilicus, 86 mm at 2 cm above the umbilicus and 79 mm at 5 cm above the umbilicus, and at 6 months postpartum up to 21 mm at 2 cm below the umbilicus, to 28 mm at 2 cm above the umbilicus and to 24 mm at 5 cm above the umbilicus. Use of normative IRD values in primiparous women may be used in the diagnosis of the condition and in the decision of treatment strategies.

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- First study describing normal width of linea alba in pregnant and postpartum women;
- Assessment of Diastasis rectus abdominis (DRA) with reliable ultrasound imaging;
- Different inter-recti distance normative values in different linea alba locations.
- The linea alba is widest at 2 cm above the umbilicus, on pregnancy and postpartum;
- In primiparous normative inter-recti distance is wider than in nulliparous women.