Manual Therapy 20 (2015) 200–205

Contents lists available at ScienceDirect

Manual Therapy

journal homepage: www.elsevier.com/math

Original article

# Prevalence and risk factors of diastasis recti abdominis from late pregnancy to 6 months postpartum, and relationship with lumbo-pelvic pain

Patrícia Gonçalves Fernandes da Mota [a, *], Augusto Gil Brites Andrade Pascoal [a], Ana Isabel Andrade Dinis Carita [b], Kari Bø [c]

[a] Univ Lisboa, Fac Motricidade Humana, CIPER, LBMF, P-1499-002 Lisboa, Portugal
[b] Univ Lisboa, Fac Motricidade Humana, CIPER, BIOLAD, P-1499-002 Lisboa, Portugal
[c] Department of Sports Medicine, Norwegian School of Sports Sciences, Oslo, Norway

ARTICLE INFO

*Article history:*
Received 21 March 2014
Received in revised form
3 September 2014
Accepted 11 September 2014

*Keywords:*
Abdominal exercise
Pregnancy
Diastasis recti
Ultrasound

ABSTRACT

Diastasis recti abdominis (DRA) is an impairment characterized by a midline separation of the rectus abdominis muscles along the linea alba. It has its onset during pregnancy and the first weeks following childbirth. There is scant knowledge on both prevalence and risk factors for development of the condition.

The aim of this study was to investigate the prevalence of DRA at gestational week 35 and three timepoints postpartum, possible risk factors, and the relationship between DRA and lumbo-pelvic pain.

Ultrasound images of inter rectus distance (IRD) were recorded in 84 healthy primiparous women, at three locations on the linea alba. The IRD was measured at: gestational week 35 and 6–8, 12–14, and 24–26 weeks postpartum. Diagnosis of DRA was defined as 16 mm at 2 cm below the umbilicus. Independent sample *t*-test and binary logistic regression was used to assess differences and risk factors in women with and without DRA and women with and without lumbo-pelvic pain. $P < 0.05$ was considered statistically significant.

The prevalence of DRA decreased from 100% at gestational week 35–39% at 6 months postpartum. No statistically significant differences were found in prepregnancy body mass index (BMI), weight gain, baby's birth weight or abdominal circumference between women with and without DRA at 6 months postpartum. Women with DRA at 6 months postpartum were not more likely to report lumbo-pelvic pain than women without DRA.

DRA is prevalent at 6 months postpartum, but is not linked with lumbo-pelvic pain.



## 1. 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) may be present congenitally, but most commonly develops during pregnancy and in the early postpartum period (Boissonnault and Blaschak, 1988; Gilleard and Brown, 1996).

Studies have found that DRA may affect between 30% and 70% of pregnant women (Boissonnault and Blaschak, 1988), and that it may remain separated in the immediate postpartum period in 35%–60% of women (Bursch, 1987). However the condition has also been found in 39% of older, parous women undergoing abdominal hysterectomy (Ranney, 1990) and in 52% of urogynecological menopausal patients (Spitznagle et al., 2007). 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; Gilleard and Brown, 1996; Rath et al., 1996; Chiarello et al., 2005; Spitznagle et al., 2007; Beer et al., 2009) and use of different measurement methods. Most prevalence studies are based on palpation (Bursch, 1987; Boissonnault and Blaschak, 1988; Mantle et al., 2004) or calipers (Boxer and Jones, 1997; Hsia and Jones, 2000) which may be less reliable than

* Corresponding author. Faculdade de Motricidade Humana, Universidade de Lisboa, Estrada da Costa, Cruz Quebrada, 1495-688 Lisboa, Portugal. Tel.: +351 934479492.
*E-mail address:* patimota@gmail.com (P.G.F. Mota).

http://dx.doi.org/10.1016/j.math.2014.09.002
1356-689X/

ultrasonography (Mota et al., 2013). To date there are few studies about the normal width of the IRD in postpartum women (Coldron et al., 2008; Liaw et al., 2011), and there is scant knowledge about risk factors for DRA (Benjamin et al., 2014).

There are some theories stating that failure to treat DRA successfully can lead to long term sequelae (Candido et al., 2005), including abnormal posture (Boissonnault and Blaschak, 1988), lumbo-pelvic pain and cosmetic defects (Candido et al., 2005). However, to our knowledge there are no high quality clinical studies to support these statements.

The aims of the present study were to investigate:

1. the prevalence of DRA at gestational week 35, and 6–8, 12–14, and 24–26 weeks postpartum;
2. possible risk factors related to the presence of DRA at 6 months postpartum;
3. whether women with DRA at 6 months postpartum have more lumbo-pelvic pain than women without DRA.

## 2. Methods

This was a longitudinal observational study following first time pregnant women from gestational week 35 till 6 months postpartum.

### 2.1. Participants

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

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 daily-living activities or with 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 one of the 4 testing sessions was missed.

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

### 2.2. Instrumentation and procedures

To assess DRA during pregnancy and postpartum we used a reliable ultrasound method (Mota et al., 2012).

Identification of possible risk factors related to the presence of DRA at 6 months postpartum was based in former published studies (Candido et al., 2005; Spitznagle et al., 2007; Beer et al., 2009; Liaw et al., 2011) and included: women's age, pre-pregnancy body mass index (BMI), weight gain during pregnancy, BMI at 6 months postpartum, hypermobility score, baby weight at birth, abdominal circumference in late pregnancy and level of exercise training.

Lumbo-pelvic pain (low back and pelvic girdle pain (Mørkved et al., 2007)) was studied to analyse whether women with DRA at 6 months postpartum have more complaints than women without DRA.

### 2.3. Ultrasound data collection

An ultrasound scanner (GE Logic-*e*) with a 4–12 MHz, 39 mm linear transducer was used to collect images in brightness mode (B-mode) of both rectus abdominis muscles and linea alba. All examinations were done by the same examiner. The investigator was a physiotherapist with specific training in image capturing and measuring IRD.

The transducer was placed transversely along the midline of the abdomen, at 2 cm below the umbilicus center. The measurement location was previously marked on the skin in order to standardize the position of the transducer (Mota et al., 2012).

Still images were collected immediately at the end of exhalation (Teyhen et al., 2008) with subjects in the supine resting position (knees bent at 90° and feet resting on the plinth, arms alongside the body).

The ultrasound images recorded at 4 time points of measurements (gestational week 35, 6–8 weeks postpartum, 12–14 weeks postpartum, and 24–26 weeks postpartum) were exported in Digital Imaging and Communications in Medicine (DICOM) format for further offline processing. The investigator was blinded to the subjects' identification and to the values of the IRD from previous examinations.

### 2.4. Inter-rectus distance measurement and cut-off point for diastasis recti abdominis

Analyses of 2D ultrasound distances were conducted offline by the same investigator, using a customized code made on specific software (Matlab, Image Processing Toolbox, Mathworks Matlab, USA). Mota et al. (2012) found ultrasound imaging and this procedure to be a reliable method to measure IRD with intra-rater Intraclass Correlation Coefficient (ICC) values above 0.90.

Using the definition of Beer et al. (2009) the cut-off value for DRA was set at IRD >16 mm at 2 cm below the umbilicus.

### 2.5. Anthropometric measurements

Anthropometric parameters included: 1) height (cm) and weight (kg), obtained according the International Society for the Advancement of Kinanthropometry (ISAK) protocol (Marfell-Jones et al., 2012); 2) and the abdominal circumference (cm) measured 2 cm below the umbilicus. The measurements were collected by the same anthropometrist accredited by ISAK, using an anthropometer and a large sliding caliper (DKSH, Switzerland), a calibrated precision scale (Seca Vogel & Halke, model 761 7019009, Germany) and an anthropometric tape (Rosscraft Innovations, Vancouver, Canada). Gestational weight gain and postpartum weight loss (obtained on the basis of reported pre-pregnancy weight) was calculated for each evaluation moment.

### 2.6. Joint hypermobility

Hypermobility was defined as four or more positive tests out of nine on Beighton scoring system (Beighton et al., 1973). The tests include 1) passive extension of each 5th finger past 90°; 2) passive apposition of each thumb to the forearm; 3) hyperextension of each elbow past 10°; 4) hyperextension of each knee past 10°; 5) and trunk flexion to allow palms flat on the floor (Beighton et al., 1973). The scoring system has an ICC of 0.75 for intra-observer and 0.78 for inter-observer reliability (Remvig et al., 2007).

### 2.7. Lumbo-pelvic pain

*Low back pain* was defined as localized pain in the L2-L5 area with and without radiation to the lower limb. *Pelvic girdle pain* was defined as pain located at the sacroiliac joints, unilaterally or bilaterally and at the pubic symphysis (Grotle et al., 2012). Pain location was assessed with the subjects pointing out the body area

in which they had pain and classified in 5 categories: 1) localized low back pain; 2) low back pain with radiation; 3) pain in the pubic symphysis; 4) unilateral sacroiliac joint pain; 5) and bilateral sacroiliac joint pain. Pain intensity was scored on each location as: 0 = "no pain"; 1 = "moderate pain"; 2 = "severe pain" (Bjelland et al., 2013a, 2013b).

Lumbo-pelvic pain was defined as the presence of pain (moderate or severe) at least in one of the assessed locations. The participants were classified as either with or without lumbo-pelvic pain at 6 months postpartum.

### 2.8. Statistical analyses

All statistical analyses were made using specific software (IBM-SPSS, Version 21). Background variables and possible risk factors are reported as either means with standard deviation (SD)/range or numbers and percentages (%). The independent sample *t*-test or Chi-square test were used to assess the differences in mean values or frequencies between women with and without DRA at 6 months postpartum.

The Cochran's *Q* Test was used to assess changes in prevalence of DRA between the 4 measurement moments from gestational week 35 until 6 months postpartum. To predict possible risk factors associated with the presence of DRA at 6 months postpartum, binary logistic analysis was performed. The Pearson Chi-Square tests and odds ratios were used to assess the independence between women with and without lumbo-pelvic pain and presence of DRA.

A critical level of $p < 0.05$ was considered statistically significant.

## 3. Results

Eighty-four of 123 first time pregnant women concluded the longitudinal study (Fig. 1). Twenty-two women were excluded before the first measurement: 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 missed at least one measurement due to personal issues, and were excluded.

The mean age of the 84 participants was 32.1 years (range 25–37) and 81% of the women had undergone university education. They gave birth at mean gestational week 38.8 (range 37–41), 61.9% had vaginal delivery and 38.1% had cesarean sections, and the mean birth weight was 3130 g (range 2300–4000).

At gestational week 35 the mean IRD was 64.6 mm (SD 19.0) and ranged from 22.1 mm to 126.0 mm at rest on measurement 2 cm below the umbilicus, with a prevalence of DRA of 100%. At 6–8 weeks postpartum, the mean IRD at rest was 18.8 mm (SD 10.7) with a prevalence of 52.4%. At 12–14 postpartum weeks the mean IRD at rest was 17.2 mm (SD 8.9); prevalence of 53.6%, and at 6 months postpartum the mean IRD decreased to 15.3 mm (SD 8.4) with a prevalence of 39.3% of the subjects.

There were significant differences in prevalence of DRA between 6 months postpartum and all the other measurement moments ($p < 0.001$).

Background variables and possible risk factors for women with and without DRA at 6 months postpartum are presented in Table 1. There were no statistically significant differences between groups for any factor.

Table 2 shows the binary logistic analysis to predict possible risk factors associated with the presence of DRA at 6 months postpartum. No significant factors were found in the logistic regression models for DRA at 6 months postpartum.

There were no significant differences in prevalence of lumbo-pelvic pain between women with and without DRA (Table 3).

## 4. Discussion

The present study found that prevalence of DRA at 2 cm below the umbilicus decreased from 100% in late pregnancy to 39% at 6 months postpartum. No significant risk factors were found for the

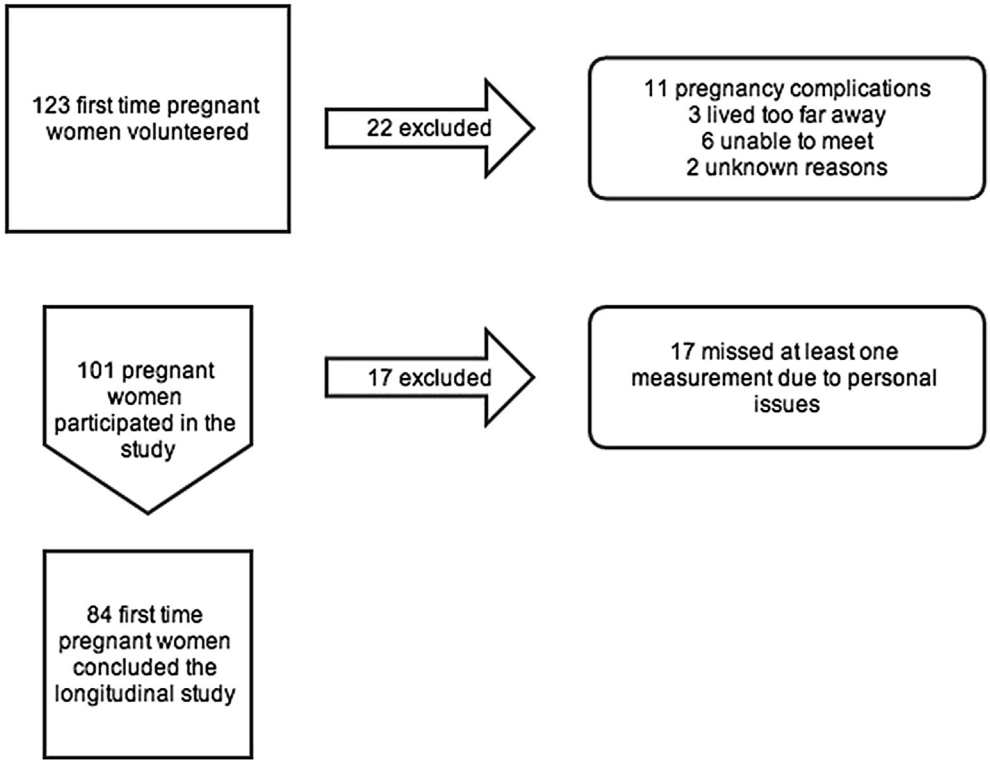


**Fig. 1.** Flowchart of the participants in this study.

**Table 1**
Background variables and potential risk factors for diastasis recti abdominis (DRA) at 6 months postpartum. ($P < 0.05$).

| | | Women with DRA $N = 33$ | Women without DRA $N = 51$ | Test | $P$ value |
|---|---|---|---|---|---|
| Age (years) [Mean (SD)] | | 31.6 (2.2) | 32.5 (2.9) | −1.48[a] | 0.14 |
| BMI before pregnancy (kg/m$^2$) [Mean (SD)] | | 21.7 (3.5) | 22.2 (3.0) | −0.634[a] | 0.53 |
| BMI at 6 months postpartum (kg/m$^2$) [Mean (SD)] | | 22.3 (3.7) | 22.5 (3.2) | −0.266[a] | 0.80 |
| Weight gain during pregnancy (kg) [Mean (SD)] | | 12.8 (3.3) | 12.4 (3.5) | 0.323[a] | 0.75 |
| Baby weight birth (kg) [Mean (SD)] | | 3.2 (0.3) | 3.1 (0.3) | 0.373[a] | 0.71 |
| Abdominal circumference in late pregnancy (cm) [Mean (SD)] | | 105.5 (7.2) | 104.7 (7.1) | 0.522[a] | 0.60 |
| Hypermobility (positive ≥ 4 out of 9 on Beighton) [$N$ (%)] | | 13 (39.3%) | 17 (33.3%) | 0.321[b] | 0.57 |
| Vaginal birth [$N$ (%)] | | 24 (72.7%) | 28 (54.9%) | 2.70[b] | 0.10 |
| Regular exercise training (≥3 times per week) [$N$ (%)] | Before pregnancy | 17 (51.5%) | 25 (49.0%) | 0.05[b] | 0.82 |
| | During pregnancy | 21 (63.6%) | 32 (62.7%) | 0.007[b] | 0.93 |
| | At 6 months postpartum | 14 (42.4%) | 24 (47.1%) | 0.174[b] | 0.68 |

Abbreviations: BMI, Body Mass Index; SD, Standard Deviation.
[a] $T$ test.
[b] Chi-square test.

presence of DRA at 6 months postpartum. Women with DRA were not more likely to report lumbo-pelvic pain than women without DRA.

Criteria and cut off point for the diagnosis of DRA vary in the literature (Bursch, 1987; Boissonnault and Blaschak, 1988; Ranney, 1990; Gilleard and Brown, 1996; Rath et al., 1996; Candido et al., 2005; Spitznagle et al., 2007; Beer et al., 2009; Akram and Matzen, 2014), and to date there is no international consensus on the measurement location. In a cadaver study, Rath et al. (1996) defined a widening of the IRD more than 10 mm above the umbilicus, 27 mm at the level of the umbilicus and 9 mm below the umbilicus, as pathological DRA. Others defined DRA as a widening of the IRD more than 2.5 cm at one or more assessment points using digital calipers (Chiarello et al., 2005). In a more recent ultrasound study Beer et al. (2009) suggest that in nulliparous women, the linea alba should be considered "normal" when the IRD width is 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. As Beer et al. (2009) were the only research group using an ultrasound method tested for reliability, we used this definition and chose the location 2 cm below the umbilicus (Mota et al., 2012). The cut-off value for normal IRD proposed by Beer et al. (2009) was set for nulliparous women, and may be considered narrow for women during pregnancy and in the postpartum period. However, our prevalence of DRA of 39% is within the range of other prevalence studies (Bursch, 1987; Boissonnault and Blaschak, 1988; Spitznagle et al., 2007).

**Table 2**
Results of binary logistic analysis to predict possible risk factors associated with the presence of DRA at 6 months postpartum. ($P < 0.05$).

| | | Coefficient | OR | 95% CI for OR | $P$ value |
|---|---|---|---|---|---|
| Age (years) | | −0.127 | 0.881 | (0.743, 1.044) | 0.144 |
| BMI (kg/m$^2$) (Pre-pregnancy) | | −0.046 | 0.995 | (0.828, 1.101) | 0.524 |
| BMI (kg/m$^2$) (6 months postpartum) | | −0.018 | 0.982 | (0.862, 1.119) | 0.788 |
| Weight gain during pregnancy (kg) | | 0.023 | 1.024 | (0.899, 1.165) | 0.125 |
| Hypermobility | | 0.046 | 1.047 | (0.877, 1.249) | 0.612 |
| Baby weight birth (positive ≥ 4 out of 9 on Beighton) | | 0.261 | 1.298 | (0.334, 5.041) | 0.706 |
| Abdominal circumference (cm) in late pregnancy at 2 cm below the umbilicus | | 0.004 | 1.004 | (0.953, 1.058) | 0.881 |
| Regular exercise training (≥3 times per week) | Before pregnancy | 0.100 | 1.105 | (0.460, 2.654) | 0.823 |
| | During pregnancy | 0.038 | 1.039 | (0.419, 2.577) | 0.934 |
| | At 6 months postpartum | −0.188 | 0.829 | (0.343, 2.004) | 0.677 |

Abbreviations: OR, odds ratio; CI, confidence intervals.

Published case reports indicate a partial resolution of the DRA at 4 weeks (Hsia and Jones, 2000) and 8 weeks postpartum (Boissonnault and Blaschak, 1988), which confers with the results of our study, where the prevalence of DRA decreased from 100% during pregnancy to 52.4% at 4–6 weeks after childbirth. Even so, at 6 months postpartum 39% of the women had DRA suggesting that at 6 months postpartum, recovery is still in progress. Unfortunately we have no data beyond this time point.

We did not find any significant risk factors for the presence of DRA at 6 months postpartum with respect to age, BMI before pregnancy and at 6 months postpartum, weight gain during pregnancy, Beighton's hypermobility score, baby weight at birth, abdominal circumference at gestational week 35 or exercise training level before during and after pregnancy. As we did not perform an a-priori power calculation for these comparisons, a small sample size may explain the non-significant results. There are few studies for comparison in this area. Candido et al. (2005) found that women with and without DRA did not differ significantly with respect to age, ethnicity, height, weight gain during pregnancy, pre-pregnancy weight, gestational age at delivery, but this study was also limited by the small sample size (Candido et al., 2005). Previous reported studies have found than 10% of pregnant women have severe lumbo-pelvic pain that interferes with daily activities (Fast et al., 1990) and the prevalence of pregnant women suffering from lumbo-pelvic pain is about 20% (Vleeming et al., 2008; Grotle et al., 2012). In the postpartum period reported lumbo-pelvic pain is expected to be high (Parker et al., 2009) and it may affect between 9% and 48% (Bø and Backe-Hansen, 2007) of women. The prevalence of these conditions in our study was within the range of other prevalence studies. However we did not perform a detailed pain-history (Fast et al., 1990; Stafne et al., 2012; Robinson et al., 2014) and we did not make any clinical assessment to evaluate the condition, which may underestimate the results. On the other hand, the sample was drawn from a population attending pre-natal courses in private centers, and therefore was not definitive in its ability to delineate prevalence of lumbo-pelvic pain in other populations.

**Table 3**
Prevalence of lumbo-pelvic pain and DRA at 6 months postpartum.

| Women | With DRA ($N = 33$) | Without DRA ($N = 51$) | $P$ value | OR |
|---|---|---|---|---|
| Lumbo-pelvic Pain | $N = 9$ 27.3% | $N = 14$ 27.5% | 0.986 | 0.99 CI 95%: 0.37, 2.65 |
| No Lumbo-pelvic pain | $N = 24$ 72.7% | $N = 37$ 72.5% | | |

Abbreviations: OR, odds ratio; CI, confidence intervals.

In our study prevalence of lumbo-pelvic pain was similar for women with and without DRA (27.3% and 27.5% respectively). Women with DRA were not more likely to report lumbo-pelvic pain than women without DRA ($p > 0.05$). The Odds Ratio observed were approximately 1 (OR = 0.991), showing that women with DRA have the same chances to having lumbo-pelvic pain than those without DRA. This is in line with the results found by Parker et al. (2009), who did not find a significant difference between women with and without DRA in lumbo-pelvic pain.

As far as we have ascertained this is the first longitudinal study following a cohort with ultrasound assessment of the IRD from late pregnancy till 6 months postpartum. Other strengths of the study are the number of subjects followed and the use of a reliable ultrasound method to assess IRD with a blinding investigator. The limitations of the study were the lack of pre-pregnancy assessment of the condition and an a-priori power size calculation for comparisons between women with and without DRA. Few subjects in some of the comparison groups may be a limitation of the study, and our results may serve as a source for power calculations for future studies. However, measurement of nulliparous women planning to become pregnant is a challenge in all studies on pregnant women, and there are few studies in this group of women worldwide.

The IRD was the only structural parameter measured in this study, which may not reflect all the structural changes that may take place in the fascial and muscular structures of the abdominal wall in primiparous women. Measurements of other structures (muscle length, thickness), comparison with multiparous women, and a longer follow-up than 6 months postpartum could be of value in future studies.

The IRD cut-off value for categorizing DRA needs to be further observed. As it was established for nulliparous women, it could be interesting to study IRD values for women during pregnancy and postpartum in a large sample size.

## 5. Conclusion

At 6 months postpartum, 39% of the women were diagnosed with DRA. No risk factors were identified for the presence of DRA in the present study. Women with DRA were not more likely to report lumbo-pelvic pain than women without DRA.

## Conflict of interest

None of the authors had a conflict of interest.

## Financial interest

We confirm that we have no financial affiliation (including research funding) or involvement with any commercial organization that has direct financial interest in any matter included in this manuscript.

## Acknowledgements

The authors wish to thank the subjects studied, and Tatiana Dominguez, Miguel Basto, and all the team from *Centro Pré e Pós Parto* (Lisboa, Portugal), and Fatima Sancho and the team from *R'Equilibrius Clinic* (Oeiras, Portugal) for access facilitation to the pregnant and postpartum women. We also wish to thank Dr. José Luís García (*Centro Hospitalario Policlinico San Carlos*, Denia, Spain) for counseling on ultrasound imaging issues and suggestions for data collection and Gill Brook (Women's Health Physiotherapy Team Leader, Bradford Teaching Hospitals NHS Foundation Trust, Bradford, United Kingdom) for English revision of the manuscript.

This study is part of the research project "Effects of biomechanical loading on the musculoskeletal system in women during pregnancy and the postpartum period" (PTDC/DES/102058/2008), supported by the Portuguese Foundation for Science and Technology.

This study was also supported by the International Society of Biomechanics Dissertation Grant.

The study was approved by the Review Board of the University of Lisbon, – Faculty of Human Kinetics, Portugal.

## References

Akram J, Matzen SH. Rectus abdominis diastasis. J Plast Surg Hand Surg 2014 Jun;48(3):163–9.
Axer H, Keyserlingk DG, Prescher A. Collagen fibers in linea alba and rectus sheaths. I. General scheme and morphological aspects. J Surg Res 2001 Mar;96(1):127–34.
Beer GM, Schuster A, Seifert B, Manestar M, Mihic-Probst D, Weber SA. The normal width of the linea alba in nulliparous women. Clin Anat 2009 Sep;22(6):706–11.
Beighton P, Solomon L, Soskolne CL. Articular mobility in an African population. Ann Rheum Dis 1973 Sep;32(5):413–8.
Benjamin DR, van de Water ATM, Peiris CL. Effects of exercise on diastasis of the rectus abdominis muscle in the antenatal and postnatal periods: a systematic review. Physiotherapy 2014 Mar;100(1):1–8.
Bjelland EK, Stuge B, Engdahl B, Eberhard-Gran M. The effect of emotional distress on persistent pelvic girdle pain after delivery: a longitudinal population study. BJOG 2013a;120(1):32–40.
Bjelland EK, Stuge B, Vangen S, Stray-Pedersen B, Eberhard-Gran M. Mode of delivery and persistence of pelvic girdle syndrome 6 months postpartum. Am J Obstet Gynecol 2013b;208(4):298. e1–7.
Bø K, Backe-Hansen KL. Do elite athletes experience low back, pelvic girdle and pelvic floor complaints during and after pregnancy? Scand J Med Sci Sports 2007 Oct;17(5):480–7.
Boissonnault JS, Blaschak MJ. Incidence of diastasis recti abdominis during the childbearing year. Phys Ther 1988 Jul;68(7):1082–6.
Boxer S, Jones S. Intra-rater reliability of rectus abdominis diastasis measurement using dial calipers. Aust J Physiother 1997;43(2):109–14.
Bursch SG. Interrater reliability of diastasis recti abdominis measurement. Phys Ther 1987 Jul;67(7):1077–9.
Candido G, Lo T, Janssen PA. Risk factors for diastasis of the recti abdominis. J Assoc Chart Physiother Womens Health 2005;97:49–54.
Chiarello CM, Falzone LA, McCaslin KE, Patel MN, Ulery KR. The effects of an exercise program on diastasis recti abdominis in pregnant women. J Womens Health Phys Ther 2005;29(1):11.
Coldron Y, Stokes MJ, Newham DJ, Cook K. Postpartum characteristics of rectus abdominis on ultrasound imaging. Man Ther 2008 May;13(2):112–21.
Fast A, Weiss L, Ducommun EJ, Medina E, Butler JG. Low-back pain in pregnancy. Abdominal muscles, sit-up performance, and back pain. Spine 1990 Jan;15(1):28–30.
Gilleard WL, Brown JMM. Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate postbirth period. Physical therapy. Am Phys Ther Assoc 1996 Jul 1;76(7):750–62.
Grotle M, Garratt AM, Krogstad Jenssen H, Stuge B. Reliability and construct validity of self-report questionnaires for patients with pelvic girdle pain. Phys Ther 2012 Jan;92(1):111–23.
Hsia M, Jones S. Natural resolution of rectus abdominis diastasis. Two single case studies. Aust J Physiother 2000;46(4):301–7.
Liaw L-J, Hsu M-J, Liao C-F, Liu M-F, Hsu A-T. The relationships between inter-recti distance measured by ultrasound imaging and abdominal muscle function in postpartum women: a 6-month follow-up study. J Orthop Sports Phys Ther 2011 Jun;41(6):435–43.
Mantle J, Haslam J, Barton S, Cardozo L. Physiotherapy in obstetrics and gynaecology. 2004.
Marfell-Jones MJ, Stewart AD, de Ridder JH. International standards for anthropometric assessment. 2012.
Mørkved S, Åsmund Salvesen K, Schei B, Lydersen S, Bø K. Does group training during pregnancy prevent lumbopelvic pain? A randomized clinical trial. Acta Obstet Gynecol Scand 2007 Jan;86(3):276–82.
Mota P, Pascoal AG, Sancho F, Bø K. Test–retest and intrarater reliability of 2-dimensional ultrasound measurements of distance between rectus abdominis in women. J Orthop Sports Phys Ther 2012 Nov;42(11):940–6.
Mota P, Pascoal AG, Sancho F, Carita AI, Bø K. Reliability of the inter-rectus distance measured by palpation. Comparison of palpation and ultrasound measurements. Man Ther 2013 Aug;18(4):294–8.
Parker MA, Millar LA, Dugan SA. Diastasis rectus abdominis and – pelvic pain and dysfunction – are they related? J Womens Health Phys Ther 2009;33(2):15.
Ranney B. Diastasis recti and umbilical hernia causes, recognition and repair. S D J Med 1990 Oct;43(10):5–8.
Rath AM, Attali P, Dumas JL, Goldlust D, Zhang J, Chevrel JP. The abdominal linea alba: an anatomo-radiologic and biomechanical study. Surg Radiol Anat 1996;18(4):281–8.

Remvig L, Jensen DV, Ward RC. Are diagnostic criteria for general joint hypermobility and benign joint hypermobility syndrome based on reproducible and valid tests? A review of the literature. J Rheumatol 2007 Apr;34(4):798–803.

Robinson HS, Vøllestad NK, Veierød MB. Clinical course of pelvic girdle pain postpartum – impact of clinical findings in late pregnancy. Man Ther 2014 Jun;19(3):190–6.

Spitznagle TM, Leong FC, Van Dillen LR. Prevalence of diastasis recti abdominis in a urogynecological patient population. Int Urogynecol J Pelvic Floor Dysfunct 2007 Mar;18(3):321–8.

Stafne SN, Salvesen KÅ, Romundstad PR, Stuge B, Mørkved S. Does regular exercise during pregnancy influence lumbopelvic pain? A randomized controlled trial. Acta Obstet Gynecol Scand 2012 May;91(5):552–9.

Teyhen DS, Rieger JL, Westrick RB, Miller AC, Molloy JM, Childs JD. Changes in deep abdominal muscle thickness during common trunk-strengthening exercises using ultrasound imaging. J Orthop Sports Phys Ther 2008 Oct;38(10):596–605.

Vleeming A, Albert HB, Östgaard HC, Sturesson B, Stuge B. European guidelines for the diagnosis and treatment of pelvic girdle pain. Eur Spine J 2008 Jun;17(6):794–819.