Pregnancy Inter-Recti Abdominis Distance Has No Impact on Respiratory Strength

ANDREA LEMOS, PhD, PT1), ARIANI IMPIERI DE SOUZA PhD, MD2), ARMÉLE DORNELAS DE ANDRADE PhD, PT1), JOSÉ NATAL FIGUEIROA, PhD2), JOSÉ EULÁLIO CABRAL-FILHO, PhD, MD2)

1) Departament of Physical Therapy, Universidade Federal de Pernambuco: Depto Fisioterapia, Av Prof. Moraes Rego, 1235- Cidade Universitária, Recife, Pernambuco, 50670-901 Brazil. TEL: +55 81-2126-8490, FAX: +55 81-3721-1847, E-mail: lemosandrea@bol.com.br
2) Instituto de Medicina Integral Prof. Fernando Figueira

Abstract. [Purpose] This study compared the association between the Inter-Recti Abdominis Distance (IRD) and respiratory muscle strength in primiparous women and determined the prevalence of IRD rise in primiparous compared to nulliparous women. [Subjects] One hundred and twenty pregnant women and forty non-pregnant women participated in this study. IRD was measured by a digital caliper 4.5 cm above and below the umbilicus, as well as at the umbilical level. Respiratory strength was measured as maximum inspiratory (PImax) and expiratory (PEmax) pressures using a digital pressure transducer. [Results] There was no correlation between PImax and PEmax at any of the abdominal anatomical levels assessed, despite a positive correlation being found for IRD and the length of the gestation weeks. Nulligesta IRD of nulliparous women values were lower than those of pregnant women at all the three umbilical levels. Prevalence values varied from 27.5% to 99% depending on the literature values used. IRD rises with duration of pregnancy but doesn’t interfere with the PImax and PEmax. [Conclusion] Since there is no evidence in the literature for an accurate cutoff point to identify pathological IRD there is a need to define reliable patterns as a reference for diagnosing pathologic IRD according to age and gender.

Key words: Rectus abdominis, Pregnancy, Respiratory muscles

INTRODUCTION

During pregnancy the abdominal muscles are submitted to intense progressive stretching. The waist can increase by up to 50 cm and the recti abdominis muscle can be stretched by up to 20 cm1).

Under the hormonal influences of relaxin and of progesterone, which acts in the conjuctive fiber provoking modifications in the collagen fibers inside the abdominal muscles and also on the linea alba, both strips of the recti abdominis muscle, which are normally parallel, drift apart. This increase in the inter-recti abdominis distance (IRD) is called recti abdominis muscle diastasis1,2). It is a fairly common phenomenon occurring in nearly two thirds of pregnant women, in their last trimester, and it present with a higher frequency (52%) in the umbilical region3).

Extensive distension of the abdominal muscle can damage its force vector reducing its contraction capacity4). However, in the literature 5–7), there are few studies of the effect of this separation on abdominal strength capacity and its consequences for functionality. The few available studies report that the increase in IRD potentially reduces the abdominal capacity for stabilizing the trunk6), lowers synergetic action with perineal muscles7), may interfere with the abdominal pressure during labor, and has a possible effect on the respiratory system8). However a parameter with a cutoff point indicating the presence of a diastasis that is considered pathological with functional repercussions in the various systems, has not yet been established.

Despite the possibility of IRD influencing the functional activity of the respiratory system, we could find no study in the literature, verifying the influence of this condition on respiratory muscle strength.

The present study aimed to evaluate the association between inter-recti abdominis distance and respiratory muscle strength, measured through maximum inspiratory and expiratory pressures (PImax and PEmax) on primigestational women; and to determine the degree of the increase of this distance in primiparous compared with nulliparous women.

SUBJECTS AND METHODS

This was a cross-sectional study in which the sample was selected sequentially and by convenience. It included 120 primigravidas from the 5th to the 40th week of gestation and 40 nulliparous women aged 20 to 29.

All participants were selected at the Women’s Clinic public service in the city of Recife, Brazil. After being invited to join the study, the subjects freely consented to
participation. The collection of data occurred during the period between January 2008 and March of 2009, with approval from the Ethical and Research on Human Beings Committee of the Women’s Clinic, under protocol number: 986/2007.

The eligible and included participants fell under the following criteria: non physical activity practitioners, eutrophic, and low obstetric risk for pregnant women. According to the inclusion criteria, all pregnant women had an adequate body mass index (BMI) for their gestational age, as suggested by Atalah et al. 8), and the nulliparous women had a BMI between 20 and 25 kg/m². The exclusion criteria were as follows: presence of deformities in the spinal column and/or thoracic cavity, history of smoking, pneumopathies or neuromuscular pathologies, incapacity to understand and/or carry out the procedure.

All women were submitted to an evaluation which consisted of the collection of personal and anthropometric data. The gestational age was calculated from the last menstruation date (LMD), and was confirmed by ultrasound examination in the 1st trimester, when there was doubt about the LMD.

The IRD was measured using a digital caliper (Starret; 799†), which was calibrated every six months. The subjects were placed in the dorsal decubitus position, with flexed hips and knees, feet placed on the bed, and arms resting on each side of the body. Three points were marked: 4.5 cm above the umbilicus, at the level of the umbilicus, and 4.5 cm below the umbilicus. The participant flexed the trunk until the lower ends of the scapulas no longer touched the bed. At each flexion the medial edge of the recti muscle borders was palpated, marked with a dermographic pencil and measured with the caliper perpendicular to these borders. 3)

The level of physical activity was measured through the International Physical Activity Questionnaire – IPAQ, version 8, the short version10).

PImax and PEmax values were obtained using a ± 450 cmH2O differential digital pressure transducer (G-MED®; MVD300†). The measurements were carried out with the subjects sitting on a chair, feet flat on the ground, hips and knees at a 90° angle, using a nasal clip and breathing through a connector with a 2 mm hole and an oval mouthpiece (2.8 × 0.7 cm).

Before carrying out the procedures, each volunteer received an explanation and demonstration of the use of the pressure transducer. For proper measurement of the maximum respiratory pressures 3 test procedures were executed prior to the collection of data. PImax was obtained from the Residual Volume. The subjects were asked to exhale and then inhale deeply into a manovacuometer. PEmax was obtained from the Total Pulmonary Capacity. The subjects were asked to inhale and then exhale deeply into a manovacuometer. Each woman was verbally encouraged to exert maximum effort at the moment respiratory pressures were being measured.

For each volume at least 3 procedures were carried out with 1 minute interval in between them. Only those measurements that were stably maintained for at least one second, without air leaking and with a variation of less or equal to 10% among the values were recorded. The highest values of positive and negative pressures were selected for the final analysis.

The Kolmogorov-Smirnov test showed the data had a Gaussian distribution. The mean values of the groups were compared using Student’s t test, while the associations among the respiratory pressures and the inter-recti distance values, as well as the gestational age, were examined with Pearson Correlation Coefficients.

For the statistical analysis MINITAB 1.4 and STATA 9.2 software were used and all tests used a confidence level of 95%, with results considered significant at p values < 0.05.

**RESULTS**

Table 1 shows the anthropometric and morphological characteristics and cardiorespiratory variables of the study sample as the mean and standard deviation.

There was a positive correlation between gestational age and the supra-umbilical (r = 0.22; p<0.01) , umbilical (r=0.46; p<0.01) and infra-umbilical ( r = 0.35; p<0.01) IRD values.

Table 2 shows the results of the IRD values with the respective confidence intervals for the two groups of women.

PImax and PEmax values showed no significant correlation with inter-recti abdominis distance at any of the measured anatomical levels: PImax (supra- umbilical: r=0.05/p=0.57, umbilical: r=0.02/p=0.81, and infra-umbilical r=−0.02/p=0.60) and PEmax (supra- umbilical: r=−0.06/p=0.52, umbilical: r=−0.02/p= 0.87, and infra-umbilical r=−0.08/p=0.41).

**Table 1.** Anthropometric, morphological and cardiorespiratory differences between primiparous and nulliparous women aged from 20 to 29 years.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Nulliparous</th>
<th>Primiparous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>24.0 ± 3.0</td>
<td>23.3 ± 2.7</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.62 ± 0.1</td>
<td>1.59 ± 0.1*</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58.9 ± 6.2</td>
<td>63.4 ± 6.9*</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.1 ± 1.6</td>
<td>24.8 ± 1.9*</td>
</tr>
<tr>
<td>PAL (MET-min/week)</td>
<td>878.6 ± 709.0</td>
<td>930.1 ± 1535.5</td>
</tr>
<tr>
<td>PImax (cmH2O)</td>
<td>94.2 ± 22.6</td>
<td>88.5 ± 16.5</td>
</tr>
<tr>
<td>PEmax (cmH2O)</td>
<td>98.7 ± 20.8</td>
<td>99.7 ± 18.2</td>
</tr>
<tr>
<td>IR-SUD (mm)</td>
<td>5.8 ± 4.1</td>
<td>20.1 ± 7.7*</td>
</tr>
<tr>
<td>IR-UD (mm)</td>
<td>8.9 ± 4.5</td>
<td>25.0 ± 8.6*</td>
</tr>
<tr>
<td>IR-IUD (mm)</td>
<td>5.8 ± 4.4</td>
<td>18.2 ± 7.5*</td>
</tr>
</tbody>
</table>

* p<0.05, BMI: body mass index, PAL: physical activity level, PImax: maximum inspiratory pressure, PEmax: maximum expiratory pressure, IR-SUD: inter-recti supra umbilical distance, IR-UD: inter-recti umbilical distance; IR-IUD: inter-recti infra-umbilical distance.
**DISCUSSION**

The results of the present study show that there was no association between the inter-recti abdominis distance and respiratory muscle strength. Therefore, in spite of the fact that this distance increases with duration of pregnancy this alteration does not interfere with respiratory pressures.

To our knowledge this is the first study to investigate the interference of the recti abdominis separation on the respiratory system of pregnant women, and these findings deserve attention. In fact, it is expected that recti abdominis separation should influence respiratory strength, as with the pregnancy progression, these muscles curve around the abdominal dome altering its vertical orientation. Between pregnancy progression, these muscles curve around the separation should influence respiratory strength, as with the interference of the recti abdominis separation on the alteration does not interfere with respiratory pressures. Therefore, in spite of the fact association between the inter-recti abdominis distance and 4.5 and 11 cm during pregnancy6,14).

Another finding which points to the occurrence of possible recti abdominis muscle hypertrophy during pregnancy comes from the morphological findings of the study by Coldrom et al.15, which showed an increase in the cross-sectional area and width of this musculature which persisted in the post-partum period, from 8 weeks to 12 months. Moreover, studies16–18 using animal models (rats and rabbits) show that there is an increase in the diameters of both type I and type II fibers in the abdominal recti during pregnancy, suggesting that such alterations would also occur in humans.

Another clinical hypothesis to explaining the maintenance of the abdominal function in pregnancy which is currently diffused is that the state of hypocapnia present during pregnancy, due to hyperventilation, leads to tissue alcalose condition with consequent constriction of the various smooth muscles and modification of their ionic exchanges19. As the abdominal fascia is in constant progressive tension during pregnancy and this mechanical tension is necessary for the transition of its fibroblasts into myofibroblasts20, this would facilitate the contraction of the same through the alpha smooth muscle actin contained in the myofibroblasts19. According to Lee et al.20, these adaptations could be a protective mechanism counterbalancing the morphological alterations of the abdominal musculature.

Thus, from the data presented above we can infer that it is possible that the abdominal musculature can maintain its capacity to generate tension, despite the increase of the inter-recti distance, and continue to generate muscular strength both in the expiratory and inspiratory phases of the respiratory cycle. The abdominal visceral mass is a coparticipant in the inspiratory action of the diaphragm. The action of the abdominal visceral mass is described as an insertion component, which controls the descent of the phrenic center maintaining its fibers cranially oriented to exert its function in the lower ribs21,22.

It is important to point out that during pregnancy there is an elevation of the diaphragm of about 4–5 cm, with a consequent increase of the appositional zone, which places it in a mechanically advantageous position to generate tension and expand the thoracic cavity.23–25 This physiological adaptation can compensate for the possible mechanical disadvantage caused by the increase in the distance between the recti. Therefore, the increase of the IRD would not be enough to interfere with inspiratory mechanics.

Regarding the prevalence of diastasis, it is difficult to establish a value which determines its presence since there are no reference studies with sufficient sample sizes for determining values that could be considered normal in a non-pregnant female population. Most studies3,7,26,27 use the arbitrary value of 2 cm or the criteria of Noble1, who described pathological IRD as a width greater than "two fingers", or approximately 3 cm, without morphological or biomechanical basis.

Another parameter which has been useful as a guide for more current studies15,19, is the study of Rath et al.28. Using pelvic-abdominal tomography, they found values of 5–6 mm, 19–23 mm and 5–6 mm for the locations halfway between the umbilicus and the xiphoid process, on the

**Table 2.**  Mean values of the inter-recti supra-umbilical (IR-SUD), umbilical (IR-UD) and infra-umbilical (IR-IUD) distance, for the primiparous and nulliparous women.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Median</th>
<th>Mean</th>
<th>DP</th>
<th>CI 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primiparous</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IR-SUD (mm)</td>
<td>1.90</td>
<td>40.94</td>
<td>20.51</td>
<td>20.07</td>
<td>7.66</td>
<td>18.69–21.46</td>
</tr>
<tr>
<td>IR-UD (mm)</td>
<td>1.63</td>
<td>59.10</td>
<td>24.42</td>
<td>25.03</td>
<td>8.64</td>
<td>23.47–26.60</td>
</tr>
<tr>
<td>IR-IRD (mm)</td>
<td>1.40</td>
<td>40.31</td>
<td>18.02</td>
<td>18.23</td>
<td>7.50</td>
<td>16.88–19.59</td>
</tr>
<tr>
<td><strong>Nulliparous</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IR-SUD (mm)</td>
<td>1.46</td>
<td>18.29</td>
<td>4.58</td>
<td>5.76</td>
<td>4.06</td>
<td>4.46–7.07</td>
</tr>
<tr>
<td>IR-UD (mm)</td>
<td>1.89</td>
<td>20.8</td>
<td>8.67</td>
<td>8.99</td>
<td>4.47</td>
<td>7.57–10.43</td>
</tr>
<tr>
<td>IR-IUD (mm)</td>
<td>1.89</td>
<td>19.61</td>
<td>4.32</td>
<td>5.88</td>
<td>4.38</td>
<td>4.50–7.26</td>
</tr>
</tbody>
</table>

CI 95%. Confidence Interval for the mean.
umbilicus and halfway between the umbilicus and the pubic symphysis, respectively, in individuals under 45 years of age. From these values, the authors considered diastasis was a spread exceeding 10 mm in the supra-umbilical level, 27 mm at umbilicus and 9 mm in the infra-umbilical level. However, these results are also questionable, since there was no distinction between gender, the sample was small (20 subjects), and it included a wide age range (10–45 years).

Depending on the parameter used to consider the presence of pregnancy diastasis in the present study, there will be significant differences in prevalence. If the standard cited by Rath et al. was used, there would be a prevalence of 99.0%; that is, just 1 patient of 14 weeks of gestation would not meet the standard. If a value of 2 cm was used, as cited in most studies, the prevalence would be 78.3%. And if the Noble (3 cm) value was used, the prevalence would be 27.5%.

The values of inter-recti distances of nulliparous women averaged 5.7 mm, 8.6 mm and 4.32 mm at the supra-umbilical, umbilical and infra-umbilical levels, respectively. Such values did not differ from those proposed by Rath et al., for the supra and infra-umbilical distances, however, the umbilical separation was one third of the predicted value. Therefore, using the values proposed by Rath et al., increases of 40% for the supra and infra-umbilical distances, and of 17% for the umbilical, for a diagnosis of diastasis normality, the following values are suggested by the upper limit of the confidence intervals of the data in this study: 10 mm for the supra and infra umbilical levels and 13 mm for the umbilical level, in the age range of between 20 and 29 years.

The use of the caliper in this study, an instrument capable of high reproducibility in measurements, supports the consistency of the present findings and calls attention to the importance of the reliability of the values used as standards in the literature for the definition of pregnancy diastasis.

The present findings show that there is an increase in the distance between the recti abdominis with the advance of the gestational age, however this increase does not interfere with the values of inspiratory and expiratory pressures during pregnancy.

Moreover, our findings question the parameters described in the literature to define the presence of pathological diastasis in pregnancy and suggest the necessity of establishing reliable reference patterns for different age groups according to gender.

REFERENCES