

# The normal width of the linea alba in cadavers – a parameter to define rectus diastasis

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## Abstract

**Objectives:** The aim of the present study was to evaluate the width of the linea alba in cadavers with no abdominal wall defects.

**Methods:** Fifty-three fresh adult male cadavers were dissected. The cadavers were placed supine and a xiphopubic incision was made, exposing the myoaponeurotic layer. Two horizontal lines were marked, at 3 cm superiorly and 2 cm inferiorly to the umbilicus, to measure the distance between the recti muscles. Measurements were performed with a digital pachymeter. Statistical analysis was performed using the t-test for 2 independent means where the considered p value was less than 5%.

**Results:** The normality test of the sample revealed no significant variations. The average length of the linea alba and recti muscles were similar (33.02 cm). The mean values for the width of the rectus muscles were 7.37 cm on the right side and 6.84 cm on the left side with no statistical significance between these values ( $p=0.479$ ). The mean values of the width of the linea alba of the 53 cadavers were 2.17 cm at the supraumbilical level and 1.51 cm at the infraumbilical level; comparing these, a statistically significant difference was observed, with higher values for the supraumbilical level ( $p=0.034$ ).

**Conclusion:** The width of the alba line was greater at the supraumbilical level and the right abdominal rectus muscle was wider than the left.

**Keywords:** abdomen, anatomy, anthropometry, cadaver, rectus abdominis

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## Introduction

Abdominal wall deformities are very frequent and can be due to congenital or acquired etiology.<sup>[1]</sup> Rectus abdominis diastasis occurs due to many factors that weaken the abdominal wall. The causes described in the etiopathogenesis of the phenomenon can be divided into congenital and/or acquired.<sup>[2,3]</sup> Major risk factors for the development of acquired rectus diastasis include conditions that increase intra-abdominal wall pressure such as obesity, pregnancy, abdominal surgeries and connective tissue disorders.<sup>[4]</sup>

Large abdominal wall deformities and defects may be associated with problems such as low back pain, breathing disorders and also misperception of body image.<sup>[5,6]</sup> Congenital defects are also associated with abdominal wall muscles hypoplasia as described in Cantrell's pentalogy

(thoracoabdominal syndrome), Beckwith-Wiedemann syndrome, Opitz syndrome, midline defect syndrome and plum belly syndrome; however, those require a complex abdominal wall reconstruction.<sup>[1]</sup>

Excessive separation of the abdominal muscles may compromise the function of the abdominal wall<sup>[7]</sup> and is noticed when the patient sits up during clinical examination.<sup>[8]</sup> When a patient with rectus diastasis lifts his head and starts to sit, a fusiform bulging appears in the midline from the xiphoid to the umbilicus or pubis.<sup>[9,10]</sup> This can also be confirmed with the Valsalva's maneuver.

One of the most frequent deformities is the rectus abdominis diastasis after pregnancy, and treatment is performed by abdominoplasty, and the correction of the rectus diastasis is an important step of the procedure.<sup>[4]</sup>

Although there is no specific definition, some authors define rectus muscle diastasis, when the distance between the medial aspect of the rectus muscle (the width of the linea alba) is greater than 2 cm.<sup>[4,9]</sup> However, it is not a consensus because there is no objective data to define this value. Therefore, the aim of the present study is to evaluate the width of the linea alba in cadavers with no abdominal wall defects, in order to determine which measurements could be considered as normal.

## Materials and Methods

After obtaining the informed consent from the relatives, fifty-three fresh adult cadavers were dissected at room temperature (22–25°C) at the Legal Medical Institute. Male cadavers were selected, regardless of race. Anthropometric data were recorded. Cadaver was placed supine and a xipho-pubic incision was made, including skin and subcutaneous, surrounding the umbilicus, down to fascia. A suprafascial undermining was performed, exposing the anterior lateral abdominal muscles (**Figure 1**).

The separation between the recti abdominis muscles was marked. Two reference levels were marked 3 cm superior (supraumbilical level) and 2 cm inferior (infraumbilical level) to umbilicus for to measure the distance between the medial aspect of the muscles.<sup>[5]</sup> Measurements were performed with a digital pachymeter, by two examiners, and the mean value between them was considered. General data of the sample was displayed in the **Table 1**.

The width of the left rectus muscle was compared with the right side. The width of the linea alba obtained at the supraumbilical level was also compared to the infraumbilical pre- marked levels.

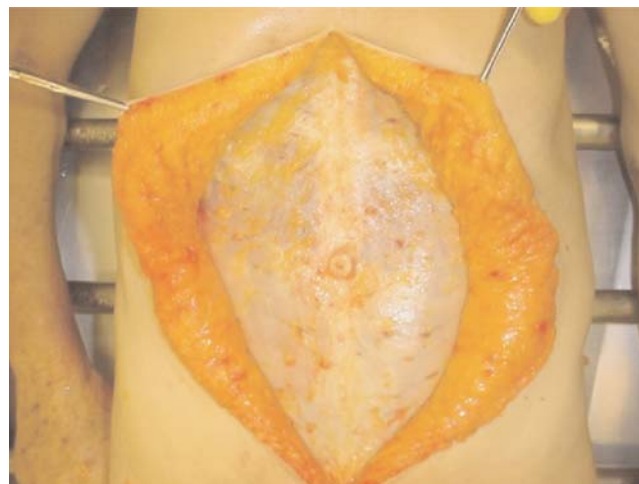
The t-test for two independent means was applied for statistical test, considering as significant where the considered p-value was less than 5%.

## Results

The normality analysis of the sample revealed no significant variations. The length of the linea alba and rectus abdominis muscles were similar, with an average of 33.02 cm.

The mean value of the width of the right rectus muscle was 7.37 cm whereas the left was 6.84 cm. Although the right muscle was wider than the left when the values were compared, there was no statistically significant difference ( $p=0.479$ ) (**Figure 2**).

The mean width of the linea alba was 2.17 cm at the supraumbilical level and 1.51 cm at the infraumbilical level. A statistically significant difference was found when these values were compared, demonstrating that the linea alba is wider at the supraumbilical level ( $p=0.034$ ) (**Figure 3**).



**Figure 1.** Exposure of the anterior lateral abdominal muscles.

## Discussion

Rectus diastasis is a common deformity that may lead to an increase in the overall anterior projection of the abdominal wall, mainly observed at the profile position.<sup>[9]</sup> This anatomic deformity can contribute to postural changes and low back pain, secondary to the alteration of the corporal gravity axis. It usually occurs due to weight variation, age, congenital condition and pregnancy.<sup>[11,12]</sup>

Correction of this deformity is considered as an important step during abdominoplasty and lipoabdominoplasty.<sup>[13]</sup> A special attention should be taken in the preoperative evaluation of the abdominal wall integrity when performing lipoabdominoplasty because of the risk of intestinal perforation during liposuction. Small hernias of 1 or 2 mm diameter may be found in the area of diastasis, especially in the supraumbilical area, what may facilitate the risk of cannula insertion in the abdominal cavity during liposuction.<sup>[2]</sup>

The definition of rectus diastasis is quite heterogeneous and varies from any distance between the recti mus-

**Table 1**

Average of the anthropometric data of the 53 cadavers.

Anthropometric data	Cadavers (n=53)
Age (years)	42.07
Weight (kg)	73.06
Height (m)	1.68
BMI (kg/m <sup>2</sup> )	25.55
XP (cm)	33.02
CC (cm)	26.80

BMI: Body mass index; CC: distance between the iliac crests; XP: xiphopubic distance.

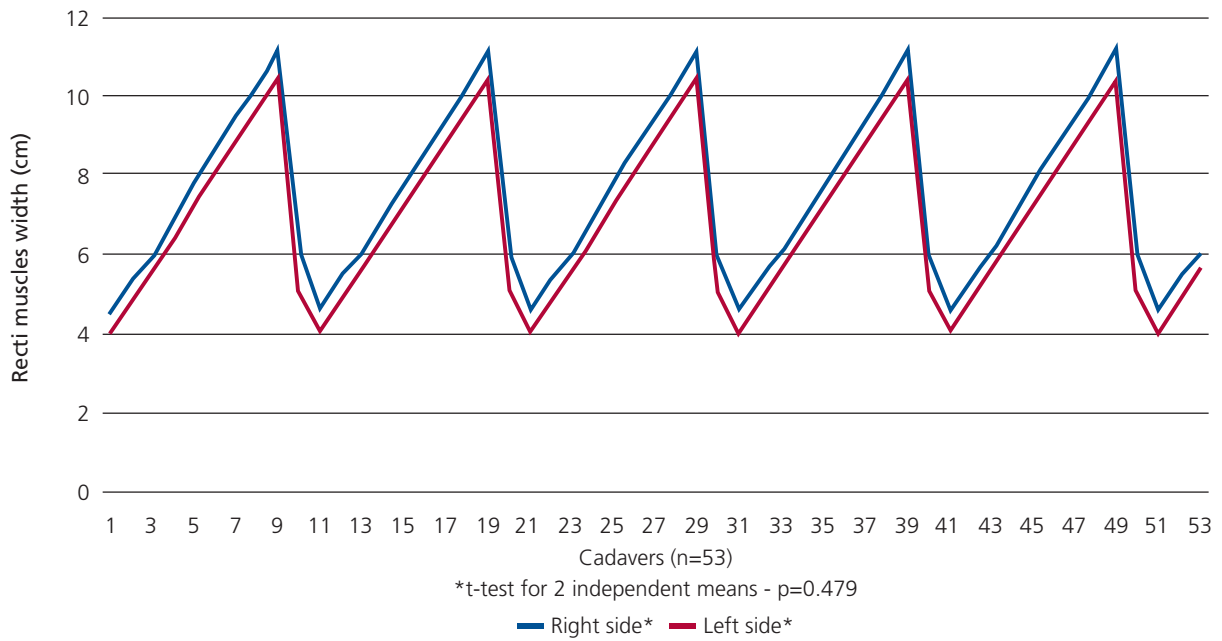


Figure 2. Rectus abdominis muscle width on both sides (cm).

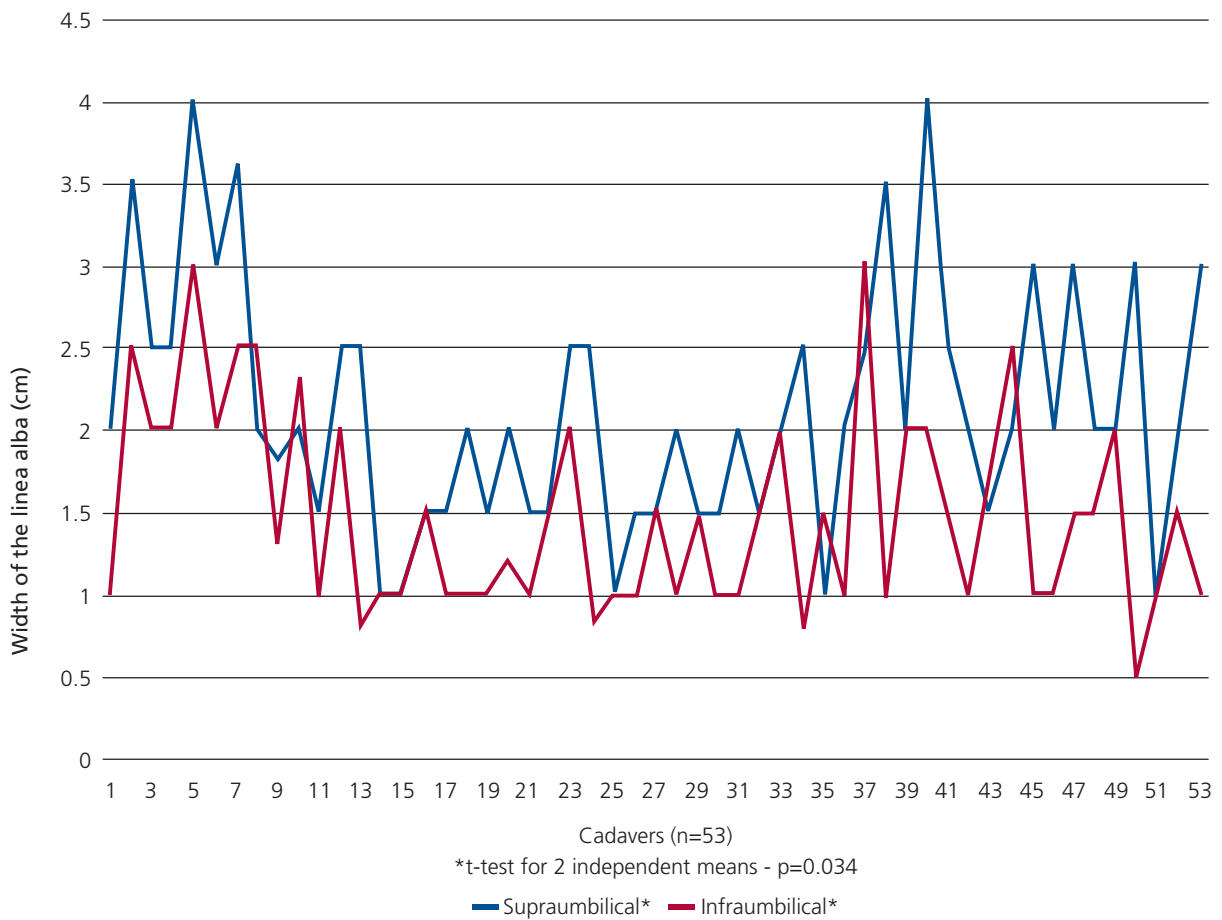


Figure 3. Comparison between the width of the linea alba at the supra and infraumbilical levels.

cles<sup>[2]</sup> to values greater than 1–3 cm above the umbilicus, and 1–1.5 cm below the umbilicus.<sup>[3,4,6,10]</sup> Therefore, there is no well-defined pattern to determine what is a normal or abnormal width between recti muscles. There is not a reference that defines rectus diastasis. In this way the diagnosis of diastasis is usually made by the experience of the professional who examines. Therefore, despite the use of ultrasound<sup>[2]</sup> or computerized tomography,<sup>[4]</sup> which requires a relative learning curve.

The use of cadavers to evaluate the abdominal wall is well established in the literature.<sup>[5]</sup> In most studies that described and evaluated rectus diastasis, patients were not homogeneous, adding some bias to the study, such as previous pregnancy, especially because of the almost totality of the evaluated sample was female gender.<sup>[1,3,5,6,9]</sup> Pregnancy may expand the abdominal wall as a whole or more specifically in the area of the linea alba, thus promoting diastasis. Diastasis secondary to pregnancy will depend on the individual's genetic condition and weight gain. Rodrigues et al.<sup>[4]</sup> has shown that an increase in intraabdominal pressure after plication of the anterior rectus sheath is not directly related to the width of diastasis. This study demonstrated that the genetic structure of the aponeurosis is more important than the rectus diastasis itself when competency of the abdominal wall is considered. The width of the diastasis of the rectus is probably due to the loosening of the aponeurosis and, in this case, the patient will have a less intense impact on intra-abdominal pressure after the plication of the anterior rectus sheath. In the present study, the authors have chosen to evaluate only male cadavers, with normal BMI and without abdominal scars or other alteration/abnormality in the abdominal wall. This aspect was considered precisely to avoid bias in relation to the female gender due to the possibility of previous pregnancies.

The use of a paquimeter/caliper for this kind of study is well described in the literature,<sup>[2,3]</sup> with measurements taken by two observers. The average values of the width of the rectus abdominis muscles were 7.37 cm on the right and 6.64 cm on the left side did not show statistically significant difference when compared. Despite this little difference was found, no information about this tendency was found in the literature review. However, it is possible that it has a direct correlation with congenital or acquired asymmetries that can occur due to postural vices observed in the clinical practice. It may also be related to the fact that the majority of the specimens are right-handed, who use most of the time the right side of the body when doing movements, with a consequent hypertrophy of the right rectus muscle.

Corvino et al.<sup>[15]</sup> evaluated rectus diastasis in 92 women by ultrasound and found rectus diastasis in 82 patients; from these, 5 were nulliparous. The authors proposed a classification of rectus diastasis in five patterns when the most frequent (59%) was Type 1 (rectus diastasis above the umbilicus). In the present study, comparisons of the mean distances between the medial margins of the rectus muscles at the supra and infraumbilical levels, showed statistically significant difference, with greater values at the supraumbilical area, similarly to the Type 1 pattern. These data did not corroborate to the findings presented by Mendes et al.<sup>[2]</sup> who compared rectus diastasis by measuring preoperative and intraoperative values by ultrasound and found no statistical difference between the supra and infraumbilical levels. Similarly, Rett et al.<sup>[3]</sup> evaluated rectus diastasis in primiparous and multiparous women, by clinical exam (palpation) and the use of a paquimeter. They did not find significant differences between supra and infraumbilical levels. It is well known that the increase of the intra-abdominal pressure during pregnancy may promote a distension of the linea alba and even affect the integrity of the abdominal wall. However, despite these changes on the structure of the abdominal muscles during pregnancy, they still maintain their function.<sup>[15]</sup> This fact could explain the findings of the present study (using male cadavers) and others that evaluated women with previous history of pregnancy.

This research evaluated male cadavers, without age and biotypes restriction, making the results relevant and useful in clinical practice on different areas such as plastic surgery, general surgery and physical therapy. It was also demonstrated the importance of the normal anatomy of the rectus abdominis muscle and linea alba, making the diagnosis of diastasis and myoaponeurotic distension in male patients easier. This study has some limitations, as cadaver is not a dynamic model. Although the number of studied specimens (n=53) was large, a greater sample might be necessary in order to determine the normal separation between the recti muscles. In the same way, a more representative group with different genders, ages, and ethnicity would be interesting to determine the range of values of the width of the linea alba to be considered as normal.

## Conclusion

The width of the linea alba in male cadavers is significantly wider at the supraumbilical level as compared to the infraumbilical level. The right rectus abdominis muscle has shown to be wider than the left one.

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## Conflict of Interest

The authors declare that they have no conflict of interest.

## Author Contributions

MVJB: conceptualization, methodology, formal analysis and investigation, writing manuscript, review and editing, supervision; AdLD: writing manuscript, review and editing; IB: writing manuscript, review and editing; IPBJ: writing manuscript, review and editing; FXN: conceptualization, methodology; LMF: conceptualization, formal analysis and investigation. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

## Ethics Approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (number 084-13).

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## References

- Digilio MC, Capolino R, Dallapiccola B. Autosomal dominant transmission of nonsyndromic diastasis recti and weakness of the linea alba. *Am J Med Genet A* 2008;146:254–6.
- Mendes DA, Nahas FX, Veiga DF, Mendes FV, Figueiras RG, Gomes MC, Ely PB, Novo NF, Ferreira LM. Ultrasonography for measuring rectus abdominis muscles diastasis. *Acta Cir Bras* 2007;22:182–6.
- Rett MT, Araújo FR, Rocha I, Da Silva RA. Diástase dos músculos reto abdominais no puerpério imediato de primíparas e múltiparas após o parto vaginal. *Physical Therapy and Research Journal (Revista de Fisioterapia e Pesquisa)* 2012;19:236–41.
- Nahas FX, Ferreira LM, Augusto SM, Ghelfond C. Long-term follow-up correction of rectus diastasis. *Plast Reconstr Surg* 2005;115:1736–41.
- Barbosa MV, Nahas FX, Garcia EB, Ayaviri NA, Juliano Y, Ferreira LM. Use of the anterior rectus sheath for abdominal wall reconstruction: a study in cadavers. *Scand J Plast Reconstr Surg Hand Surg* 2007;41:273–7.
- Nahas FX. An aesthetic classification of the abdomen based on the myoaponeurotic layer. *Plast Reconstr Surg* 2001;108:1787–95.
- Barbosa MV, Nahas FX, de Oliveira Filho RS, Ayaviri NA, Novo NF, Ferreira LM. A variation in the component separation technique that preserves linea semilunaris: a study in cadavers and a clinical case. *J Plast Reconstr Aesthet Surg* 2010;63:524–31.
- Nahas FX, Augusto SM, Ghelfond C. Nylon versus polydioxanone in the correction of rectus diastasis. *Plast Reconstr Surg* 2001;107:700–6.
- Beer GM, Chuster A, Seifert B, Manestar M, Mihic-Probst D, Weber SA. The normal width of the linea alba in nulliparous women. *Clin Anat* 2009;22:706–11.
- Gilleard WL, Brown JMM. Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate postbirth period. *Phys Ther* 1996;76:750–62.
- Nahas FX, Ferreira LM, Mendes JA. An efficient way to correct recurrent rectus diastasis. *Aesth Plast Surg* 2004;28:189–96.
- Nahas FX, Barbosa MV, Ferreira LM. Factors that may influence failure of the correction of the musculoaponeurotic deformities of the abdomen. *Plast Reconstr Surg* 2009;124:334.
- Saldanha OR, Azevedo SF, Delboni PS, Saldanha Filho OR, Saldanha CB, Uribe LH. Lipoabdominoplasty: the Saldanha technique. *Clin Plast Surg* 2010;37:469–81.
- Rodrigues MA, Nahas FX, Reis RP, Ferreira LM. Does diastasis width influence the variation of the intra-abdominal pressure after correction of rectus diastasis? *Aesthet Surg J* 2015;35:583–8.
- Corvino A, De Rosa D, Sbordone C, Nunziata A, Corvino F, Varelli C, Catalano O. Diastasis of rectus abdominis muscles: patterns of anatomical variation as demonstrated by ultrasound. *Pol J Radiol* 2019;84:e542–8.

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