

Submitted:  
13.02.2024  
Accepted:  
26.04.2024  
Published:  
26.11.2024

## Diastasis recti in children – results of ultrasonographic study

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DOI: 10.15557/JoU.2024.0036

### Keywords

rectus abdominis;  
abnormalities;  
anatomy;  
child;  
diastasis recti

### Abstract

**Aim:** Diastasis recti is a common contour abnormality of the anterior abdominal wall, where an increased distance between the rectus abdominis muscles results in a visible or palpable bulge in this area. This study aimed to characterize this clinical entity in children. **Material and methods:** Anatomy of the rectus abdominis muscles and the linea alba, with a special focus on the interrectus distance (distance between two bellies of the rectus abdominis muscles), was studied using ultrasound. Anthropometric and ultrasonographic assessments were performed on 38 children aged 7–12 years. According to the clinical definition of bulging in the epigastrium, diastasis was diagnosed in 12 children (31.6%), significantly more often in boys than in girls (50.0% vs. 6.3%). Other clinical and anthropometric variables, such as age, history of preterm birth, body mass, body mass index, waist circumference, and height, were not significantly associated with diastasis recti. **Results:** Diastasis recti, defined by the ultrasonographic criterion of interrectus distance >20 mm, was found in 10 children (26.3%), with no significant differences between boys and girls. Still, there was a moderate agreement between these two modes of diagnosing diastasis: the Cohen's kappa coefficient was 0.49. This suggests that ultrasonographic measurement of the interrectus distance should not be considered an alternative and more precise method of diagnosing diastasis. **Conclusions:** Our study indicates that diastasis recti is quite common in the pediatric population, especially among boys. However, more studies are needed in children to understand the functional relevance and natural course of this clinical entity.

## Introduction

The rectus abdominis muscles are paired muscles that are separated in the midline by a band of connective tissue fibers called the linea alba. Diastasis recti (DR) is a condition in which there is an increased distance between these muscles but with no fascia defect. This means that in the individuals presenting with DR the linea alba is stretched and thinned, but no actual hernia sac is present<sup>(1–5)</sup>.

DR is a quite common condition and can be found in many otherwise healthy individuals, especially women in the postpartum period<sup>(6)</sup>. Most studies on DR have been conducted on adults, hence the definitions of this condition (albeit debatable) regard the adult population. On the other hand, although it is known that DR can also be found in children, data regarding the physiological values of the distance between the two bellies of the rectus abdominis muscles, the prevalence of DR, and association of this condition with clinical and anthropometric parameters are lacking in the pediatric population.

Our study aimed to investigate the anatomy of the rectus abdominis muscles and the linea alba in children, especially regarding DR, using ultrasonographic evaluation of these anatomical structures.

## Material and methods

Questionnaires, anthropometric measurements, and ultrasonographic examinations were conducted on 42 children from April 2023 to May 2023 in the Department of Anatomy at the Institute of Medical Sciences of the University of Opole. Participants for this study were recruited in schools and through advertisements on social media.

The study protocol was approved by the Ethics Committee at the University of Opole (approval No. UO/0005/KB/2023). Informed consent was obtained from all parents or legal guardians of children participating in the survey.

The inclusion criteria of the study comprised:

- child aged 7–12 years;
- maturity level allowing participation in the study, especially regarding ultrasonographic examination;
- no co-morbidities;
- informed consent given by parent or legal guardian.

The exclusion criteria comprised:

- history of abdominal surgery;

- previous or active gastrointestinal disease;
- history of neurological disease (e.g. cerebral palsy or muscular dystrophy);
- abdominal hernia (active or after treatment).

The questionnaire, answered by the child's parent or legal guardian, included questions regarding gestational age at birth, body mass at birth; body length at birth, concomitant diseases, previous surgical treatments, and medications. Also, there were questions about symptoms such as abdominal pain during or just after physical exertion, constipation, fecal and/or urinary incontinence, and family history of muscle disease. The anthropometric measurements included body mass, height, and abdominal circumference. Body mass index (BMI) was calculated for each child. Using standard percentile charts of the local pediatric population, the percentiles of body mass, height, and BMI were assessed for each child participating in this study. Ultrasound examination was performed with the use of GE Versana Active set, with a 10 MHz linear probe and the muscular preset (Fig. 1).

The interrectus distance (IRD), i.e. the distance between two bellies of the rectus abdominis muscles, was measured at five points:

- Xiphoid – defined as the point just below the xiphoid process;
- Xipho-umbilical – defined as the point 2 cm above the umbilicus;
- Umbilical – defined as the point at the level of the umbilicus;
- Pubo-umbilical – defined as the point 2 cm below the umbilicus;
- Pubical – defined as just above the pubic symphysis.

Diastasis of the rectus abdominis muscles was defined in three ways:

- clinically – if there was a visible or palpable bulge in the area of the linea alba on physical examination;
- ultrasonographically (a) – if the IRD at any of the above-described points exceeded 20 mm;
- ultrasonographically (b) – if the IRD at any of the above-described points exceeded 15 mm;

The first ultrasonographic criterion (a) is widely used for diagnosing DR in adults. Since there are no recognized ultrasonographic crite-

ria for pediatric patients, we also used the second (b), more liberal criterion. All ultrasonographic examinations were conducted by the same doctor and performed in three body positions: supine, sitting, and standing.

## Statistical analysis

To assess potential associations between RD and categorical variables, such as gender or preterm birth, the Fisher's exact test was used. The two-sample Kolmogorov-Smirnov test was used to assess potential links between RD and such variables as body mass or height. When these variables could be further categorized into ordinal groups, like body mass or height percentiles, the Cochran–Mantel–Haenszel test was used. The significance level for all statistical tests was set at  $p < 0.05$ . We also calculated the Cohen's kappa coefficient to evaluate the inter-rater reliability between clinical diagnosis of DR and ultrasonographic measurements of the IRD. Statistical analysis was performed using the PAST data analysis package (version 3.0; University of Oslo, Norway).

## Results

A total of 42 children participated in the study. Four children were excluded from further analysis due to previous abdominal wall surgeries (appendectomy – 1 case; inguinal hernia – 1 case; umbilical hernia – 1 case; undescended testis – 1 case). Thus, a total of 38 children (16 girls and 22 boys) were analyzed. The anthropometric characteristics of the study group are given in Tab. 1.

According to the clinical criterion, i.e. bulging in the area of the linea alba, DR was diagnosed in 12 children (31.6%): 1 girl (6.3%) and 11 boys (50.0%). Using this criterion to diagnose diastasis, DR was significantly more common in boys (Fisher's exact test:  $p = 0.005$ ). Other clinical and anthropometric variables, such as age, history of preterm birth, body mass, body mass percentile, waist circumference, height, height percentile, and body mass in-

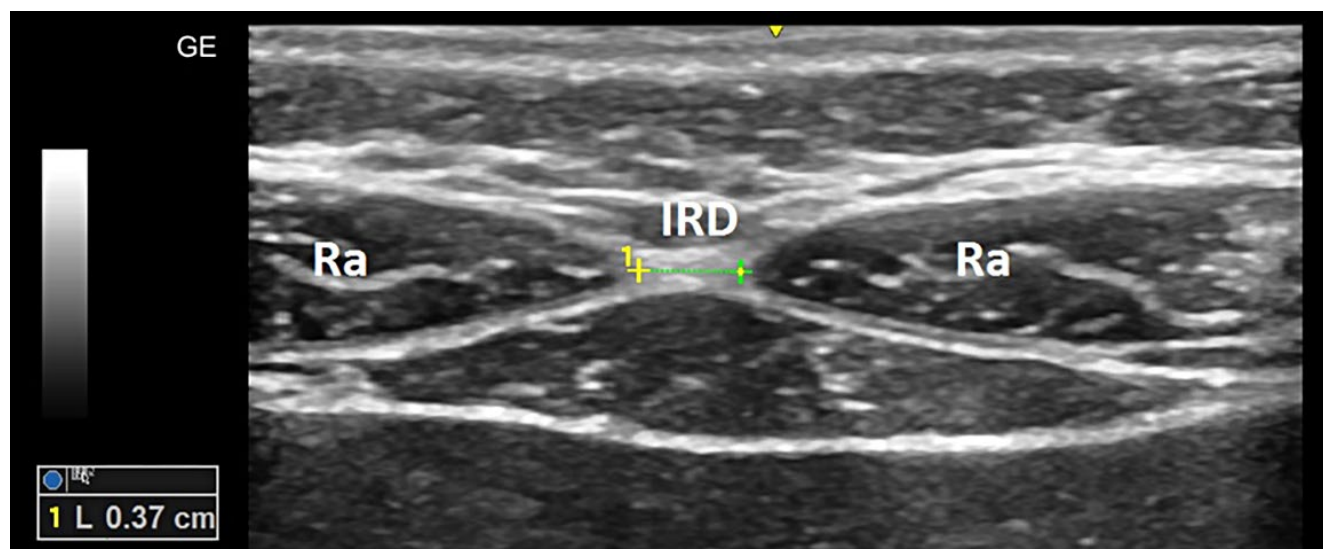


Fig. 1. Measurements of the IRD using ultrasonography. IRD – interrectus distance; Ra – rectus abdominis muscle; IRD (L) = 0.37 cm (does not meet the criteria for diastasis recti)

Tab. 1. Anthropometric characteristics of the study group

	Age (years)	Body mass (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )	Abdominal circumference (cm)	Body mass at birth (g)	Height at birth (cm)
<b>Mean</b>	8.7	31.4	134.4	16.78	63.2	3362	54.4
<b>Median</b>	8.5	27.4	133.5	15.81	60.5	3410	54.0
<b>Min</b>	7.0	17.7	114.0	12.93	49.0	2100	42.0
<b>Max</b>	12.0	80.2	164.0	29.82	101.0	4200	69.0
<b>SD</b>	1.67	12.3	13.3	3.15	10.15	517.9	4.31

dex percentile, were not significantly associated with diastasis of the rectus abdominis muscles. Several clinical features, including abdominal pain after physical exertion, constipation, fecal and urinary incontinence, and family history of muscle disease, were present in only a few children, so no statistically sound conclusions could be drawn.

DR, using the ultrasonographic criterion (a – 20 mm) in any body position, was found in 10 children (26.3%): 2 girls (12.5%) and 8 boys (36.4%). Using this criterion to diagnose diastasis, the differences between sexes were not significant (Fisher's exact test:  $p > 0.05$ ). All DR cases larger than 20 mm were found in the upper part of the linea alba: at the xiphoid point – 6 children (15.8%), at the xiphoulmbilical point – 7 children (18.4%), and at the umbilical point – 7 children (18.4%). In the supine body position, DR was diagnosed in 7 children (18.4%) – 1 girl and 6 boys; in the sitting position in 8 children (21.1%) – 1 girl and 7 boys; and in the upright body position, DR was found in 7 children (18.4%) – all boys. Of note, in some children, IRD exceeding 20 mm was revealed only in 1 or 2 out of the 3 studied body positions.

According to the ultrasonographic criterion (b – 15 mm), DR in any body position was found in 27 children (71.1%) – 10 girls (62.5%) and 17 boys (77.3%); the differences between sexes were not statistically significant. Details of the ultrasonographic assessment of the IRD are summarized in Tab. 2.

The Cohen's kappa coefficient for the diagnosis of DR using the clinical definition and ultrasonographic criterion (a) was 0.49, indicating moderate agreement between these two modes of diagnosing DR. Using ultrasonographic criterion (b), the Cohen's kappa coefficient was 0.32, revealing fair agreement between these two methods.

## Discussion

In this study, we revealed a prevalence of DR among children in our study group. Using traditional clinical diagnosis, it was 31.6%, and thus similar to its prevalence in adults<sup>(4,5)</sup>. When the IRD was measured ultrasonographically, depending on which definition of diastasis was used, it varied from 26.3% to 71.1%. It should be em-

Tab. 2. Prevalence of diastasis recti on ultrasonographic examination; IRD – the interrectus distance

	Xiphoid point	Xipho-umbilical point	Umbilical point	Pubo-umbilical point	Pubical point
<b>IRD &gt;20 mm in supine position – all children</b>	2 (5.3%)	7 (18.4%)	2 (5.3%)	0 (0%)	0 (0%)
<b>IRD &gt;20 mm in supine position – girls</b>	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
<b>IRD &gt;20 mm in supine position – boys</b>	2 (9.1%)	7 (31.9%)	2 (9.1%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in supine position – all children</b>	12 (31.6%)	14 (36.8%)	16 (42.1%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in supine position – girls</b>	2 (12.5%)	3 (18.8%)	4 (25.0%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in supine position – boys</b>	10 (45.5%)	11 (50.0%)	12 (54.5%)	0 (0%)	0 (0%)
<b>IRD &gt;20 mm in sitting position – all children</b>	4 (10.5%)	5 (13.2%)	7 (18.4%)	0 (0%)	0 (0%)
<b>IRD &gt;20 mm in sitting position – girls</b>	1 (6.3%)	0 (0%)	1 (6.3%)	0 (0%)	0 (0%)
<b>IRD &gt;20 mm in sitting position – boys</b>	3 (13.6%)	5 (22.7%)	6 (27.3%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in sitting position – all children</b>	11 (28.9%)	18 (47.4%)	15 (39.5%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in sitting position – girls</b>	1 (6.3%)	4 (25%)	6 (37.5%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in sitting position – boys</b>	10 (45.5%)	14 (63.6%)	9 (40.9%)	0 (0%)	0 (0%)
<b>IRD &gt;20 mm in standing position – all children</b>	3 (7.9%)	5 (13.2%)	6 (15.8%)	0 (0%)	0 (0%)
<b>IRD &gt;20 mm in standing position – girls</b>	0 (0%)	0 (0%)	1 (6.3%)	0 (0%)	0 (0%)
<b>IRD &gt;20 mm in standing position – boys</b>	3 (13.6%)	5 (22.7%)	5 (22.7%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in standing position – all children</b>	14 (36.8%)	14 (36.8%)	19 (86.4%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in standing position – girls</b>	4 (25%)	3 (18.8%)	5 (31.3%)	0 (0%)	0 (0%)
<b>IRD &gt;15 mm in standing position – boys</b>	10 (45.5%)	11 (50%)	14 (63.6%)	0 (0%)	0 (0%)

phasized that the actual prevalence of DR in the pediatric population remains unknown<sup>(4)</sup>. In children, this clinical condition often accompanies umbilical hernia<sup>(7)</sup>. It is claimed that DR is a rather benign condition with unknown physiologic consequences, likely to disappear as soon as the child gains abdominal muscle strength<sup>(7)</sup>. However, relevant studies in this field are missing. To the best of our knowledge, our research is the first study on this clinical entity in otherwise healthy children. Until recently, DR has only been reported to be prevalent in children with Beckwith-Wiedemann syndrome, in whom it can be as frequent as 70%<sup>(8)</sup>.

In our study, about one third of the children presented with this condition. However, in the general population, it is probably lower, since our participants were recruited in schools and through social media. It can be expected that caregivers of children previously diagnosed with DR were more motivated to send their children for another check-up. We found a significantly higher prevalence of DR among boys, but this difference was only present in the clinical, not ultrasonographic, diagnosis of DR. The reason for this higher proportion of boys remains unclear. In the adult population, DR is primarily found in women, but good quality studies in male population are missing. Other potential risk factors, especially body weight and BMI, were not associated with a higher DR frequency in our studied cohort. Interestingly, in pregnant and postpartum women, who represent a well-known risk group for DR, diastasis is more common in those with lower pre-pregnancy, pre-delivery, and postpartum BMI, higher gestational age, and higher child's weight at birth<sup>(9)</sup>.

We acknowledge that there are several weak points in our study. Firstly, the group of examined children was rather small. We did not examine children younger than 7 years old; therefore, we cannot determine whether DR is a congenital or acquired condition. Also, as previously discussed, there was probably a substantial bias resulting from the form of recruitment.

Therefore, studying this issue in other pediatric cohorts, such as children hospitalized for non-abdominal reasons, would provide additional epidemiological information.

The actual prevalence of DR in the general pediatric population is probably lower than among our subjects. Finally, we focused on the traditional static assessment of the anatomy in this area. Recent studies suggest dynamic imaging, using modern ultrasonographic techniques; these issues will be further debated.

Moreover, it seems that the questionnaire should include questions regarding the child's physical activity. At ages 7–12, children usually start intensive sports activities; thus, such information would add value to further analysis.

The ultrasonographic criterion of abnormal IRD value should also be discussed. Traditionally, DR is defined as bulging in the linea alba area with a palpable distance between the two bellies of the rectus abdominis muscle that is wider than one finger. Yet, this definition has been found to be highly unreliable<sup>(10)</sup>. Therefore, a more precise ultrasonographic definition of DR has been proposed, with an IRD cutoff of 20 mm<sup>(5,11)</sup>. However, the value of 20 mm has only been validated in the adult population, while normal IRD values in the pediatric population are not known. In our study, we explored whether a more liberal criterion of 15 mm could be used in children. Although no valid conclusions could be drawn from this rather

small study, it seems that the criterion of 15 mm is incorrect, since about 70% of the children examined would be diagnosed with DR. The value of 20 mm seems to be a better cutoff in children. Still, there is another issue with the ultrasonographic diagnosis of DR. In our study, the agreement between clinical and ultrasonographic diagnosis of DR, which was estimated with the Cohen's kappa coefficient, was not high. This suggests that ultrasonographic measurement of the IRD should not be considered an alternative and more precise diagnostic method. Indeed, recent studies indicate that visible and/or palpable bulging in the epigastrium and an increased IRD are not necessarily the same clinical problems.

In our study protocol, the distance between the two bellies of the rectus abdominis muscles was measured at 5 points in 3 body positions: supine, sitting, and standing. The discrepancies between the IRD measurement procedures in the adult population are widely discussed<sup>(12)</sup>.

Considering the anatomy of this part of the abdominal wall, the bellies of the rectus abdominis muscles should not be viewed as isolated structures. Actually, these paired muscles form a functional unit together with the linea alba, which is a fibrous sheath joining them in the midline, and with three layers of muscles (external oblique, internal oblique, and transversus abdominis) located laterally, which provide adequate tension to the linea alba. In this context, the linea alba is responsible for transmitting forces across the midline rather than merely joining the bellies of the rectus abdominis muscles. Therefore, an increased IRD (widened linea alba) does not necessarily mean that there will be a physically detectable bulging in the epigastrium, and this phenomenon was revealed in our study. Recent studies based on ultrasound elastography demonstrated that a visible and/or palpable diastasis resulted from decreased stiffness and enhanced distortion of the linea alba<sup>(13,14)</sup>. The authors of this study suggested that the primary role in the pathogenesis of DR was played by a weakened transversus abdominis muscle. However, it is likely that all three muscles of the anterolateral abdominal wall are responsible for the stretching and strengthening of the fibers of linea alba. If these muscles are weak, the linea alba is not under tension and can be pulled out in cases of increased intraabdominal pressure, especially if the IRD is increased and the linea alba is thin.

This suggests a focus for future studies on DR. We plan to conduct further research that will include a more precise ultrasonographic evaluation of the linea alba, including its thickness and stiffness, and studying its behavior during anterolateral abdominal wall muscle activation.

## Conclusions

In our study group, DR was a quite common finding, especially among boys. Also, the 20 mm cutoff seems to be a good benchmark for diagnosing DR using ultrasonographic measurement of the IRD. However, more studies are needed in children to understand the functional relevance and natural course of this clinical entity.

## Conflict of interest

*The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.*

## Author contributions

*Original concept of study:* AMK. *Writing of manuscript:* AMK. *Analysis and interpretation of data:* AMK, MS. *Final acceptance of manu-*

*script:* MS. *Collection, recording and/or compilation of data:* AMK. *Critical review of manuscript:* MS.

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