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Effects of obesity on abdominal wall morphology and diastasis recti abdominis in women

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Abstract

Objectives: Obesity can lead to structural alterations in the abdominal wall, which are important to assess for effective obesity management. This study aimed to investigate the impact of obesity on abdominal wall morphology and the presence of diastasis recti abdominis (DRA) in women, as well as the correlation between body mass index (BMI) and abdominal wall parameters.

Methods: Women were divided into two groups based on BMI: non-obese (BMI<30 kg/m², n=37) and obese (BMI≥30 kg/m², n=36). Using ultrasound, measurements were taken for umbilical subcutaneous adipose tissue (SCAT) thickness, abdominal muscle thickness, linea alba (LA) distortion (using a distortion index formula) and width (using inter-rectus distance, IRD), and presence of DRA.

Results: The obese group showed significantly greater umbilical SCAT thickness, distortion index scores, and IRD measured 2 cm above the umbilicus compared to the non-obese group (p<0.05). No significant differences were observed in abdominal muscle thickness between the groups (p>0.05). The prevalence of DRA was higher in the obese group (33.3%) than in the non-obese group (10.8%) (p<0.05). Significant positive correlations were found between BMI and umbilical SCAT thickness (ρ=0.610), distortion index scores (ρ=0.489), and IRD measured 2 cm above (ρ=0.359) and below the umbilicus (ρ=0.304) (p<0.05).

Conclusion: Women with obesity exhibited increased umbilical SCAT thickness, greater linea alba distortion and width, and a higher prevalence of DRA compared to non-obese women. These findings suggest that elevated BMI may negatively influence abdominal wall morphology. Considering these morphological changes may be important in the clinical evaluation and management of obesity.

Keywords: abdominal muscles; diastasis recti abdominis; obesity; ultrasonography

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Introduction

Globally, obesity is a major public health concern, with its prevalence rising in both developed and developing countries.[1] It is a condition linked to the development of numerous chronic and metabolic diseases, as well as musculoskeletal disorders involving both inflammatory and mechanical components.[2] Musculoskeletal issues, particularly abdominal and lumbopelvic dysfunctions, are strongly associated with increased body mass index (BMI) and accumulation of adipose tissue, especially in the abdominal region.[3,4] Several studies have also reported a higher incidence of postural abnormalities in individuals with elevated BMI and obesity.[5] Furthermore, increased BMI has been associated with reduced trunk stability and decreased endurance of the trunk musculature.[6] Notably, obesity-related factors such as visceral adiposity, chronic systemic inflammation, increased adipokine production, vascular alterations, and elevated intra-abdominal pressure may negatively impact the structural integrity of the abdominal wall.[7]

Anatomically, the abdominal wall is composed of the skin, superficial fascia, muscles and their fascia, fascia transversalis, extraperitoneal fascia and peritoneum.[8] It performs multiple functions, including support for internal organs, facilitation of breathing, coughing, vomiting, labor, micturition, and defecation, and contributes to trunk stability, mobility, and motor control of both trunk and extremities.[9] Age and gender related differences in the abdominal wall structure have also been documented.[10] Morphological changes in the abdominal wall, reductions in muscle strength, and the presence of conditions such as diastasis recti abdominis (DRA) can impair lumbopelvic stability, postural control, and abdominal organ support.[11] Optimal performance of these functions depends on the coordinated and functional integrity of the abdominal muscles, fasciae, and the linea alba (LA).[9]

Given the complexity of the abdominal wall, detailed examination of its structure is crucial.[12,13] Ultrasound imaging has gained popularity in both clinical assessment and rehabilitation of the abdominal muscles due to its ability to evaluate deep muscle morphology and DRA in a non-invasive manner.[14,15] It also offers valuable information regarding the structure of the LA and the thickness of subcutaneous adipose tissue (SCAT), a key indicator of total body fat.[16,17]

This study aimed to investigate the effects of obesity on abdominal wall morphology and the presence of DRA in women, as well as the correlation between BMI and abdominal wall structural parameters. The underlying hypothesis was that increasing BMI negatively affects the structural integrity of the abdominal wall in women.

Materials and Methods

A case-control study design was employed and all procedures were conducted in accordance with the Declaration of Helsinki. The research was carried out in the Department of Radiology of Bilkent City Hospital. Written informed consent was obtained from all participants.

Initially, 82 individuals were enrolled (non-obese group: n=42; obese group: n=40). In the non-obese group, five individuals were excluded due to unwillingness to participate (n=2), neurological disorders (n=2), and spinal deformity (n=1), resulting in 37 participants (BMI=22.58 [18.71–24.77] kg/m²). In the obese group, four participants were excluded (unwillingness to participate: n=2; abdominal surgery: n=2), resulting in 36 participants (BMI=30.70 [30.00–38.67] kg/m²). Demographic data, surgical history, chronic conditions, and pain status were collected through face-to-face interviews.

All measurements were performed in the morning, following a fasting period of at least 8 hours and avoidance of excessive fluid intake or physical activity. Height was measured using a portable stadiometer (in cm) while participants stood barefoot. Weight was measured using a digital scale (precision: 0.01 kg) with participants in light clothing and barefoot. BMI was calculated as weight divided by height squared (kg/m²). Participants were classified into two groups based on BMI: non-obese (BMI<30 kg/m², n=37) and obese (BMI≥30 kg/m², n=36).[18]

Ultrasound assessments were performed using a Logiq S7 Expert device (General Electric, Canada) with a 9–11 MHz linear transducer in B-mode by a radiologist experienced in musculoskeletal imaging. All scans were conducted with participants in the supine hook-lying position, with pillows under their knees.

SCAT was measured 5 cm above the umbilicus along the midline (**Figure 1a**). The transducer was positioned transversely, and the anteroposterior thickness from the skin to the LA was recorded.[17]

Transverse images of the right and left rectus abdominis (RA) were obtained by placing the transducer lateral to the umbilicus until the RA was centered on the screen. Anteroposterior thickness was measured (**Figure 1b**). For the anterolateral abdominal muscles (external oblique [EO], internal oblique [IO], transversus abdominis [TrA]), the transducer was placed 10 cm lateral to the umbilicus and held perpendicular to the muscle layers (**Figure 1c**). Images were acquired at the end of quiet expiration to standardize measurements and minimize respiratory influence.[19]

The measurement was performed at the midpoint between the umbilicus and the xiphoid process. The shortest linear distance between the medial edges of the RA was calculated. The actual curved path of the LA was then traced, and the area between this path and the shortest distance was computed. The distortion index was calculated as the area divided by the shortest distance (distortion index=bounded area/shortest path).[16]

Inter-rectus distance (IRD) measurements were evaluated for the DRA. To standardize the measurement points, the skin marks were made on 2 cm above and below the umbilicus.[15,20] The transducer was placed transversely on each mark. Images were taken 2 cm above and below the umbilicus at rest and during curl-up.[20] The resting IRD was recorded as the LA width. The occurrence of DRA was determined with a cut-off point of IRD>25 mm at 2 cm above or 2 cm below the umbilicus.[11]

Sample size was calculated using G*Power (v3.0.10, Germany). Based on a pilot study of 10 participants, an effect size of 0.733 was determined from the SCAT measurement. To achieve 80% statistical power at α=0.05, at

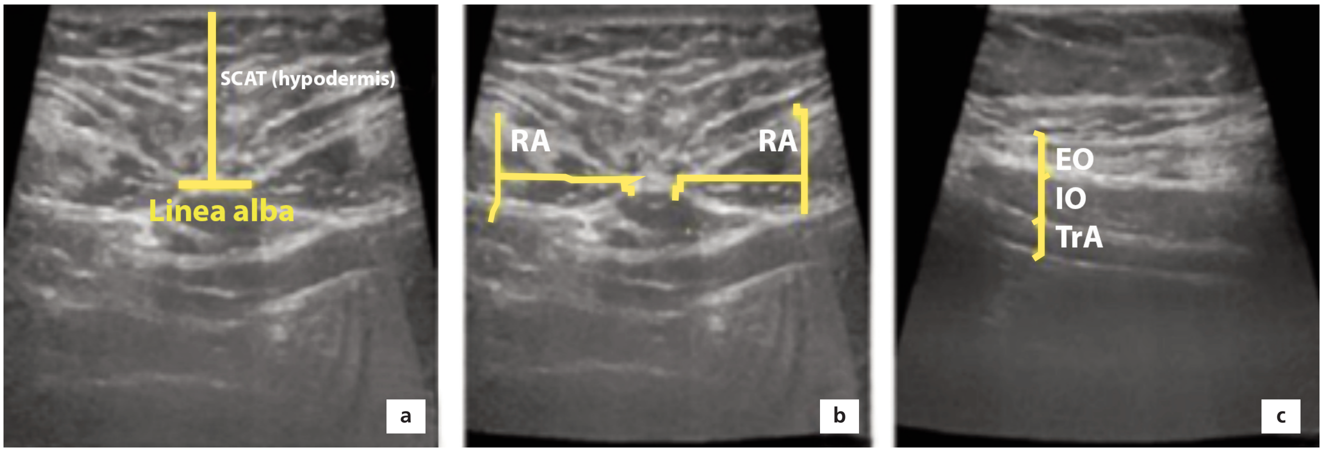

Figure 1. Ultrasound imaging showing measurements. (**a**) Umbilical SCAT measurement; (**b**) RA muscle thickness; (**c**) EO, IO and TrA muscle thickness. **EO:** external oblique; **IO:** internal oblique; **RA:** rectus abdominis; **SCAT:** subcutaneous adipose tissue; **TrA:** transversus abdominis.

least 62 participants (31 per group) were required. Considering potential data loss (≥10%), a total sample size of at least 69 participants was targeted.

Normality of distribution was assessed using visual and analytical methods. Data were presented as mean ± standard deviation ($\bar{X}$± SD), median (min–max), and frequency (n, %) for normally distributed, non-normally distributed, and categorical variables, respectively. Between-group comparisons were performed using the t-test or Mann–Whitney U test for numerical variables, and Chi-square test for categorical data. The Spearman correlation test was applied to evaluate relationships between BMI and abdominal wall parameters. Correlation strength was categorized as: very weak (<0.2), weak (0.3–0.5), moderate (0.6–0.7), strong (0.8–0.9), and very strong (=1).[21] Statistical analyses were conducted using IBM SPSS Statistics (v22.0, Armonk, NY, USA). A p-value <0.05 was considered statistically significant.

Results

The age distribution between the obese and non-obese groups was comparable, with no statistically significant difference observed (p>0.05), except for BMI (**Table 1**). As presented in **Table 2**, significant differences were observed in specific abdominal wall parameters between the groups. Umbilical SCAT thickness, distortion index scores, and IRD measured at 2 cm above the umbilicus were significantly higher in the obese group compared to the non-obese group (p<0.05). However, no significant differences were found between the groups regarding the thickness measurements of the RA, EO, IO, and TrA muscles (p>0.05). The prevalence of DRA was also higher in the obese group. Specifically, DRA was observed in 33.3% (n=12) of women in the obese group and in 10.8% (n=4) of women in the non-obese group, representing a statistically significant difference in DRA occurrence between the two groups (p<0.05).

Correlation analysis revealed a positive weak to moderate association between BMI and several abdominal wall parameters. Specifically, BMI was positively correlated with umbilical SCAT thickness (rho=0.610, p<0.001), the distortion index scores (rho=0.489; p<0.001) and the IRD, measuring at 2 cm above (rho=0.359; p=0.002) and below the umbilicus (rho=0.304; p=0.009). No significant correlations were found between BMI and the thickness values

Table 1
The features of the groups.

Features	Non-obese group (n=37)	Obese group (n=36)	p-value
Age (years, X±SD)	35.11±9.22	38.81±10.76	0.122
BMI (kg/m^2, median (min-max))	22.58 (18.71–24.77)	30.70 (30.00–38.67)	<0.001*

*p<0.05. **SD:** standard deviation; **max:** maximum; **min:** minimum; **X:** mean.

Table 2
The abdominal wall structure parameters of the groups.

Abdominal wall structures	Non-obese group X±SD Median (min-max) n (%) (n=37)	Obese group X±SD Median (min-max) n (%) (n=36)	p-value
Subcutaneous adipose tissue (mm)			
Umblical SCAT	15.20±5.28	20.02±5.21	<0.001*
Abdominal muscle thickness (mm)			
RA_R	6.28±1.32	6.61±1.56	0.338
RA_L	6.02±1.35	6.40±1.47	0.250
EO_R	2.70 (1.30–6.40)	2.65 (1.70–8.50)	0.934
EO_L	3.00 (1.10–4.50)	2.85 (1.90–5.60)	0.331
IO_R	5.10 (3.50–9.30)	5.10 (3.20–8.50)	0.320
IO_L	5.04±1.26	5.41±1.56	0.270
TrA_R	2.60 (2.00–4.50)	2.80 (2.00–4.70)	0.158
TrA_L	2.50 (1.50–4.30)	2.55 (2.00–4.10)	0.332
Linea alba distortion and width (mm)			
Distortion index	0.053 (0.025–0.487)	0.077 (0.028–0.875)	0.005*
IRD_2 cm above umbilicus	12.20 (3.70–34.20)	17.00 (3.20–47.40)	0.032*
IRD_2 cm below umbilicus	4.60 (1.80–20.20)	5.10 (1.30–32.30)	0.200
DRA			
Absent	33 (89.2)	24 (66.7)	0.020*
Presence	4 (10.8)	12 (33.3)	

*p<0.05. **DRA**:diastasis recti abdominis; **EO**: external oblique; **IRD**: inter-rectus distance; **IO**: internal oblique; **L**: left, **R**: right; **RA**: rectus abdominis; **SCAT**: subcutaneous adipose tissue; **TrA**: transversus abdominis.

of the abdominal muscles, including RA (Right (R)= 0.399, Left (L)=0.264), EO (R=0.877, L=0.095), IO (R=0.506, L=0.110), and TrA muscles (R=0.178, L=0.260) was found.

Discussion

Obesity, which may alter the structural integrity of the abdominal wall, remains a major public health concern. In the current study, obese women demonstrated significantly greater umbilical SCAT, IRD, LA distortion and width, as well as a higher occurrence of DRA compared to non-obese women. These findings were further supported by weak-to-moderate positive correlations between body mass index (BMI) and umbilical SCAT thickness, LA distortion, and IRD measurements. In contrast, no significant differences or correlations were observed in the thickness of abdominal muscles between the groups.

Abdominal fat comprises subcutaneous, pre-peritoneal, and visceral components, with visceral fat being particularly implicated in cardiometabolic risk.[22] Various techniques, such as skinfold calipers, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound, have been employed to quantify abdominal fat.[17,23,24] Few studies, however, have examined umbilical SCAT thickness in relation to BMI. Kim et al.[25] using CT, reported a positive correlation between BMI and SCAT thickness, independent of age or surgical history. Similarly, Torun et al.[17] also found that there was a positive correlation between BMI and umbilical SCAT thickness, measured with ultrasound. In our study, it was seen that women in the obese group had high umbilical SCAT and also there was a positive correlation between BMI and umbilical SCAT thickness. Our findings are in agreement, suggesting that BMI can serve as a reliable proxy for umbilical SCAT thickness.

Assessing abdominal muscle thickness provides insight into potential morphological adaptations of muscle tissue.[26] However, previous studies have yielded inconsistent results regarding the relationship between BMI and abdominal muscle thickness. Tahan et al.[27] evaluated the correlation between BMI and abdominal muscle thicknesses in healthy individuals (age range of 18–44 years) with ultrasound imaging. It was reported that although a positive correlation was found between the BMI and the thickness of EO and RA muscles, no correlation was seen between the BMI and the thickness of TrA and IO muscles. Springer et al.[10] similarly noted a positive correlation between the BMI and the thickness of lateral abdominal muscle, measured by ultrasound imaging, in healthy individuals (age range of 18–45 years). Saranteas et al.[7] found reduced abdominal muscle thickness in elderly obese individuals, compared to younger non-obese subjects (age=75 (70–83) years) was lower than that of young non-obese people (age=35 (28–38) years). Our study revealed no significant differences or correlations in muscle thickness between groups, potentially attributable to variations in age distribution. Previous research by Khan et al.[28] suggested that abdominal muscle thickness may increase with obesity until the fourth decade of life, followed by a decline. Additionally, as in prior studies, we assessed raw muscle thickness values without normalizing for body mass, which may have confounded results. Future studies should consider allometric scaling[29] to better interpret muscle adaptations.

The LA is formed by the aponeuroses of the EO, IO and TrA. The structural characteristic of LA ensures core stability under abdominal muscle tension and contributes transmit loads between the sides of the abdominal wall.[8] LA dysfunction is associated with pathologies such as hernias, low back pain, and reduced quality of life.[30] The tension, width and thickness of LA may change with increased intra-abdominal pressure (obesity etc.), pregnancy or abdominal surgery. In addition, the LA structure is related to the abdominal muscles activation.[30] In the study of Fan et al.,[31] it was observed that the LA thickness did not change compared to nulliparous women in different birth types (vaginal and cesarean section) and the LA width is increased in women who had cesarean section compared to nulliparous women. Fredon et al.[32] found that there was a positive correlation between the LA width and the BMI in both men and women. Grossi et al.[33] investigated the amount of collagen in the LA of obese people and comparing with non-obese cadavers. It was seen that the amount of collagen in the LA above the umbilical region in the morbidly obese people was smaller than in the non-obese cadavers. According to the authors' knowledge, no study was found examining the correlation between BMI and LA distortion related to tension or stiffness. In our study, it was also found that women in obese group had higher LA width and distortion than women in non-obese group. As a results of our study, it was seen that as the BMI increased, the LA width increased and the LA tension decreased. These findings may be due to increases in intra-abdominal pressure with obesity. In obesity rehabilitation, the LA width and distortion, important in the stability of the abdominal wall, should be evaluated and supported by different treatment approaches such as exercises.

DRA is prevalent among adult women and is influenced by factors such as obesity, pregnancy, and metabolic disease. Wu et al.[34] and Doubkova et al.[35] both identified a significant association between higher BMI and increased DRA risk. Our findings align with these results, as a higher prevalence of DRA was observed among obese women. It is plausible that clinical subtypes of obesity (e.g., sarcopenic obesity or visceral adiposity) exacerbate LA separation by compromising muscular support or increasing intra-abdominal tension. Therefore, obesity prevention may serve as a means of reducing DRA prevalence, though further investigation into these obesity subtypes is warranted.However, more detailed studies are needed on these issues.

This study has several limitations. First, obesity was defined solely by BMI, which may not reflect clinical subtypes such as sarcopenic or metabolically healthy obesity.[18] Second, subgroup analyses based on obesity severity were not performed, though such stratification may yield further insights into the structural changes observed. Third, only women were included to ensure a homogeneous sample; hence, the findings may not be generalizable to men. Lastly, as this was a single-center study, future multi-center investigations with broader demographics are recommended.

Conclusion

This study demonstrates that obese women exhibit significantly greater umbilical SCAT thickness, LA distortion, and DRA occurrence compared to non-obese women, while abdominal muscle thickness remains unaffected. These findings suggest that elevated BMI may negatively impact the structural integrity of the abdominal wall. Therefore, comprehensive obesity management should incorporate not only weight reduction strategies but also physiotherapy interventions—such as exercise and taping—to improve LA function and reduce DRA risk.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

MB: protocol/project development, data collection, data analysis, manuscript writing/editing; ŞTÇ: protocol/project development, data analysis, manuscript writing/editing; DÖK: protocol/project development, manuscript writing/editing.

Ethics Approval

The study was approved by the Non-Interventional Clinical Studies Institutional Review Board of Izmir Katip Celebi University (Approval date/number: 23.02.2023/0061).

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References

1. Bhurosy T, Jeewon R. Overweight and obesity epidemic in developing countries: a problem with diet, physical activity, or socioeconomic status? ScientificWorldJournal 2014;2014:964236.
2. De Heredia FP, Gómez-Martínez S, Marcos A. Obesity, inflammation and the immune system. Proc Nutr Soc 2012;71:332–8.
3. Aune D, Mahamat-Saleh Y, Norat T, Riboli E. Body mass index, abdominal fatness, weight gain and the risk of urinary incontinence: a systematic review and dose-response meta-analysis of prospective studies. BJOG 2019;126:1424–33.
4. Chowdhury D, Sarkar S, Rashid MH, Rahaman A, Sarkar SK, Roy R. Influence of body mass index on low back pain. Mymensingh Med J 2014;23:125–9.
5. Smith AJ, O'Sullivan PB, Beales DJ, de Klerk N, Straker LM. Trajectories of childhood body mass index are associated with adolescent sagittal standing posture. Int J Pediatr Obes 2011;6:e97–106.
6. AlAbdulwahab SS, Kachanathu SJ. Effects of body mass index on foot posture alignment and core stability in a healthy adult population. J Exerc Rehabil 2016;12:182–7.
7. Saranteas T, Anagnostis G, Lappas T, Christodoulopoulou T, Kostopanagiotou G. Feasibility of ultrasound imaging of the abdominal wall in elderly obese volunteers. Br J Anaesth 2010;105:549–50.
8. Flament JB, Avisse C, Delattre JF. Anatomy of the abdominal wall. In: Bendavid R, Abrahamson J, Arregui ME, Flament JB, Phillips EH, editors. Abdominal wall hernias. New York: Springer; 2001. p. 39–63.
9. Lee DG, Lee LJ, McLaughlin L. Stability, continence and breathing: the role of fascia following pregnancy and delivery. J Bodyw Mov Ther 2008;12:333–48.
10. Springer BA, Mielcarek BJ, Nesfield TK, Teyhen DS. Relationships among lateral abdominal muscles, gender, body mass ındex, and hand dominance. J Orthop Sports Phys Ther 2006;36:289–97.
11. Candido G, Lo T, Janssen PA. Risk factors for diastasis of the recti abdominis. Journal of the Association Chartered Physiotherapists in Women's Health 2005;97:49–54.
12. Pachera P, Pavan PG, Todros S, Cavinato C, Fontanella CG, Natali AN. A numerical investigation of the healthy abdominal wall structures. J Biomech 2016;49:1818–23.
13. Pirri C, Todros S, Fede C, Pianigiani S, Fan C, Foti C, Stecco C, Pavan P. Inter-rater reliability and variability of ultrasound measurements of abdominal muscles and fasciae thickness. Clin Anat 2019;32:948–60.
14. Teyhen DS. Rehabilitative ultrasound imaging symposium San Antonio, TX, May 8–10, 2006. J Orthop Sport Phys Ther 2006;36:A1–3.
15. 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 Sport Phys Ther 2012;42:940–6.
16. Lee D, Hodges PW. Behavior of the linea alba during a curl-up task in diastasis rectus abdominis: an observational study. J Orthop Sport Phys Ther 2016;46:580–9.
17. Torun BI, Balaban M, Geneci F, Hatipoglu SC. The relationship between the body mass index and the subcutaneous adipose tissue. Anatomy 2022;16:7–12.
18. Vecchié A, Dallegri F, Carbone F, Bonaventura A, Liberale L, Portincasa P, Fruhbeck G, Montecucco F. Obesity phenotypes and their paradoxical association with cardiovascular diseases. Eur J Intern Med 2018;48:6–17
19. Karakus A, Balaban M, Kaya DO, Celenay ST. Lumbopelvic muscle endurance, morphology, alignment, and mobility in women with primary dysmenorrhea: a case-control study. Clin Biomech (Bristol) 2022;92:105582.
20. Mota P, Pascoal AG, Carita AI, Bø K. The ımmediate effects on inter-rectus distance of abdominal crunch and drawing-in exercises during pregnancy and the postpartum period. J Orthop Sport Phys Ther 2015;45:781–8.
21. Akoglu H. User's guide to correlation coefficients. Turk J Emerg Med 2018;18:91–3.
22. Busetto L, Baggio MB, Zurlo F, Carraro R, Digito M, Enzi G. Assessment of abdominal fat distribution in obese patients: anthropometry versus computerized tomography. Int J Obes Relat Metab Disord 1992;16:731–6.
23. Gradmark AMI, Rydh A, Renström F, De Lucia-Rolfe E, Sleigh A, Nordström P, Brage S, Franks PW. Computed tomography-based validation of abdominal adiposity measurements from ultrasonography, dual-energy X-ray absorptiometry and anthropometry. Br J Nutr 2010;104:582–8.
24. Hastuti J, Rahmawati N, Suriyanto R, Wibowo T, Nurani N, Julia M. Patterns of body mass index, percentage body fat, and skinfold thicknesses in 7- to 18-year-old children and adolescents from Indonesia. Int J Prev Med 2020;11:129.
25. Kim J, Lim H, Lee SI, Kim YJ. Thickness of rectus abdominis muscle and abdominal subcutaneous fat tissue in adult women: correlation with age, pregnancy, laparotomy, and body mass index. Arch Plast Surg 2012;39:528–33.
26. Hildenbrand K, Noble L. Abdominal muscle activity while performing trunk-flexion exercises using the ab roller, abslide, fitball, and conventionally performed trunk curls. J Athl Train 2004;39:37–43.

27. Tahan N, Khademi-Kalantari K, Mohseni-Bandpei MA, Mikaili S, Baghban AA, Jaberzadeh S. Measurement of superficial and deep abdominal muscle thickness: an ultrasonography study. J Physiol Anthropol 2016;35:17.
28. Khan MA, Qureshi K, Rehman Z. Effect of age and obesity on human male anterior abdominal wall muscles: an ultrasonographic anthropometric analysis. Pakistan Journal of Medical & Health Sciences 2012;6:406–12.
29. Linek P. The importance of body mass normalisation for ultrasound measurement of the transversus abdominis muscle: the effect of age, gender and sport practice. Musculoskelet Sci Pract 2017;28:65–70.
30. Benjamin DR, Frawley HC, Shields N, van de Water ATM, Taylor NF. Relationship between diastasis of the rectus abdominis muscle (DRAM) and musculoskeletal dysfunctions, pain and quality of life: a systematic review. Physiotherapy 2019;105:24–34.
31. Fan C, Guidolin D, Ragazzo S, Fede C, Pirri C, Gaudreault N, Porzionato A, Macchi V, De Caro R, Stecco C. Effects of cesarean section and vaginal delivery on abdominal muscles and fasciae. Medicina (Kaunas) 2020;56:260.
32. Fredon F, Hardy J, Germain M, Vincent-Viry E, Taïbi A, Monteil J, Mabit C, Valleix D, Durand-Fontanier S. Correlations of the rectus abdominis muscle anatomy with anthropometric measurements. Surg Radiol Anat 2021;43:589–93.
33. Grossi JV, Nicola FF, Zepeda IA, Becker M, Trindade EN, Diemen VV, Cavazzola LT, Trindade MR. Linea alba collagen assessment in morbidly obese patients. Arq Bras Cir Dig 2016; 29(suppl 1):8–11.
34. Wu L, Gu Y, Gu Y, Wang Y, Lu X, Zhu C, Lu Z, Xu H. Diastasis recti abdominis in adult women based on abdominal computed tomography imaging: prevalence, risk factors and its impact on life. J Clin Nurs 2021;30:518–27.
35. Doubkova L, Andel R, Palascakova-Springrova I, Kolar P, Kriz J, Kobesova A. Diastasis of rectus abdominis muscles in low back pain patients. J Back Musculoskelet Rehabil 2018;31:107–12.

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