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ORIGINAL RESEARCH

Contribution of the practice of resistance exercises and the type of delivery to the diastasis of the rectus abdominis muscles in primiparous women

Contribuição da prática de exercício resistido e do tipo de parto para a diástase dos músculos retos do abdome em primíparas

Contribución de la práctica de ejercicios de resistencia y el tipo de parto a la diástasis de los músculos rectos abdominales en mujeres primíparas

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ABSTRACT | Maternal organism suffers physiological and biomechanical changes during pregnancy, including the separation of rectus abdominis muscles (RAM). This cross-sectional study aimed to compare the distance between the RAM among sedentary and active primiparous women who had vaginal childbirth and cesarean section, to correlate RAM separation with maternal and child variables and to compare these variables between primiparous women with and without RAM diastasis. In total, 56 women were evaluated in their ninth postpartum week, divided into four groups according to the mode of delivery and the practice of resistance exercises. RAM distance was calipered in the supraumbilical, umbilical, and infraumbilical regions. The values obtained were verified via analysis of variance (ANOVA), Pearson's correlation, and independent *t*-test. We found no main effect between mode of delivery and practice of resistance exercises or interaction between mode of delivery and practice of resistance exercises ($p \geq 0.118$) for RAM distance. We found significant correlation between body weight before pregnancy and RAM distance ($p < 0.001$). There was no association between body weight gain during pregnancy and the newborn's weight with RAM distance ($p \geq 0.132$). We observed significant difference in body weight before pregnancy between primiparous women with and without RAM diastasis ($p < 0.005$). We found no differences between groups regarding body weight gain during pregnancy and the newborn's weight ($p \geq 0.122$). It was concluded that the practice of resistance exercises and the mode of delivery have no impact on the separation of supraumbilical, umbilical, and infraumbilical regions of RAM in primiparous women.

Keywords | Diastasis Muscle; Physical Exercise; Physical Therapy; Pregnancy; Postpartum Period.

RESUMO | O organismo materno sofre alterações fisiológicas e biomecânicas durante a gestação, dentre elas o afastamento dos músculos retos do abdome (MRAs). Os objetivos deste estudo transversal foram: comparar a distância entre os MRAs entre primíparas treinadas e sedentárias que realizaram parto vaginal e cesárea; correlacionar o afastamento dos MRAs com variáveis materno-infantis; e comparar essas variáveis entre primíparas com e sem diástase dos MRAs. Foram avaliadas 56 mulheres na nona semana pós-parto, divididas em

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quatro grupos de acordo com o tipo de parto e a prática de exercício resistido. A distância entre os MRAs foi mensurada com paquímetro nas regiões supraumbilical, umbilical e infraumbilical. Os dados foram submetidos à análise de variância (Anova), correlação de Pearson e teste t independente. Não houve efeito do tipo de parto, da prática de exercício resistido ou da interação tipo de parto e prática de exercício resistido (p≥0,118) para a distância entre os MRAs. Houve correlação significativa entre peso antes da gestação e distância entre os MRAs (p<0,001). Não houve associação entre ganho de peso na gestação e peso do bebê com a distância entre os MRAs (p≥0,132). Houve diferença significativa no peso antes da gestação entre primíparas com e sem diástase dos MRAs (p<0,005). Não houve diferença entre grupos no ganho de peso na gestação e no peso do bebê (p≥0,122). Conclui-se que a prática de exercício resistido e o tipo de parto não têm impacto no afastamento entre os MRAs nas regiões supraumbilical, umbilical e infraumbilical em primíparas.
Descritores | Diástase Muscular; Exercício Físico; Fisioterapia; Gravidez; Período Pós-Parto.

RESUMEN | El cuerpo materno sufre cambios fisiológicos y biomecánicos durante el embarazo, entre los cuales se destaca el alejamiento de los músculos rectos abdominales (MRA). Los objetivos de este estudio transversal fueron: comparar la distancia entre los MRA entre mujeres primíparas que realizaban entrenamiento y las sedentarias que se sometieron a parto vaginal y cesárea; correlacionar el alejamiento de los MRA con las variables materno-infantiles; y comparar estas variables entre mujeres primíparas con y sin diástasis de los MRA. Se evaluaron a 56 mujeres en la novena semana posparto, quienes fueron divididas en cuatro grupos según el tipo de parto y la práctica de ejercicios de resistencia. La distancia entre los MRA se midió con un calibre en las regiones supraumbilical, umbilical e infraumbilical. En los datos se aplicaron el análisis de varianza (Anova), la correlación de Pearson y la prueba t independiente. No hubo efecto del tipo de parto, la práctica de ejercicios de resistencia o la interacción del tipo de parto y la práctica de ejercicios de resistencia (p≥0,118) en la distancia entre los MRA. Hubo una correlación significativa entre el peso antes del embarazo y la distancia entre los MRA (p<0,001). No hubo asociación entre el aumento de peso durante el embarazo y el peso del bebé con la distancia entre los MRA (p≥0,132). Hubo una diferencia significativa en el peso antes del embarazo entre mujeres primíparas con y sin diástasis de los MRA (p<0,005). No hubo diferencia entre los grupos en el aumento de peso durante el embarazo y el peso del bebé (p≥0,122). Se concluye que la práctica de ejercicios de resistencia y el tipo de parto no tienen impacto en el alejamiento de los MRA en las regiones supraumbilical, umbilical e infraumbilical en mujeres primíparas.
Palabras clave | Diástasis Muscular; Ejercicio Físico; Fisioterapia; Embarazo; Periodo Posparto.

INTRODUCTION

Maternal organism undergoes several physiological and biomechanical changes during pregnancy. These changes are caused by hormonal changes (relaxin, progesterone, and estrogen), uterine development, and increased body weight with consequent change of the center of gravity[1,2]. These factors stimulate the stretching of the abdominal muscles, separating the rectus abdominis muscles (RAM), which is called diastasis of the rectus abdominis muscles (DRAM) when it exceeds physiological values[3,4].

DRAM affects about 66% of women in the third trimester of pregnancy, 53% in the acute postpartum period, and 60% in the late postpartum period[5,6]. It occurs more frequently in the umbilical region, with incidence in 52% of women[7]. However, supraumbilical DRAM affects about 36% of women, and infraumbilical occurs in 11%[7]. The incidence of DRAM is lower in the infraumbilical region due to the anatomical difference between the order of fascia that cover the RAM, thus reducing the stretching in the infraumbilical region[8]. However, besides identifying the affected regions, it is necessary to determine the values considered harmful to this distance between the muscles.

Although the literature present no consensus regarding the values considered relevant on RAM separation, Mesquita et al.[9] and Alvarenga and Ferreira[10] suggest a classification that considers RAM separation as physiological up to 3cm. However, Rett et al.[8] consider that values greater than 2.5cm are classified as DRAM in the supraumbilical and umbilical regions, thus hindering the abdominal muscles from stabilizing the trunk and negatively affecting functions such as posture, lumbar stabilization, defecation, parturition, and viscera containment[11,12]. Regarding the infraumbilical region, the values suggested by the literature are approximately 1cm[4,13].

Predisposing factors that may cause greater abdominal distension are multiparity, obesity, polyhydramnios,

fetal macrosomia, and abdominal muscular flaccidity[14]. Furthermore, some studies have suggested that the mode of delivery (cesarean section or vaginal childbirth) may be related to DRAM[7,15-17], especially cesarean section, which injures the fascia and abdominal muscles, hindering the DRAM recovery process[7,17]. DRAM can be considered an important contributing factor for the development of pelvic floor dysfunctions, such as fecal incontinence, stress urinary incontinence, and pelvic organ prolapse[11]. Knowing the many dysfunctions caused by DRAM, it is necessary to seek measures to avoid long RAM separation, thus preventing this condition in pregnant women.

The regular practice of physical exercises before and during pregnancy benefits women's health, promoting a lower incidence of gestational diabetes mellitus, preeclampsia, excessive weight gain, and premature births[18]. Although evidence of the effects of resistance exercises for pregnant women exist[19-21], their relationship with RAM distance is scarce in the literature. Moreover, when practiced before pregnancy, exercises seem to be related to strong and well-toned abdominal muscles, which may affect RAM separation[5,14]. Thus, this study aimed to compare RAM distance between active and sedentary primiparous women who underwent vaginal delivery and cesarean section, to correlate RAM separation with maternal and child variables, and to compare these variables between primiparous women with and without DRAM.

METHODOLOGY

Study design

This is an exploratory, observational, and cross-sectional study. All participants signed an informed consent form after being verbally oriented regarding the objectives and procedures of the research, agreeing to participate in the study.

Sample

The number of study participants was obtained by sample estimation based on the data found by Câmara et al.[22], who obtained RAM separation values of 3.58cm for sedentary puerperal women and 2.45cm for active puerperal women. For this estimation, the G*POWER 3.1 program was used, considering a 0.05 α value and 0.80 β value. According to the estimation, 56 volunteers would be needed for the study (14 in each group), who should meet the inclusion criteria described below.

The study included primiparous volunteers aged 18–40 years, who had undergone vaginal delivery or cesarean section and were in the ninth week postpartum. The choice to measure RAM distance in pregnant women who were specifically in the ninth week postpartum was based on the fact that spontaneous return from RAM separation can occur around the fourth and eighth week after delivery[23].

The participants who met the aforementioned inclusion criteria were divided into four groups: Active Vaginal Delivery Group (AVDG), Active Cesarean Section Group (ACSG), Sedentary Vaginal Delivery Group (SVDG), and Sedentary Cesarean Section Group (SCSG). Each group had 14 volunteers, totaling 56 participants. Participants were allocated according to each group inclusion criteria (practice or not of resistance training and mode of delivery). AVDG consisted of women who practiced some type of resistance training for at least one year before pregnancy and at least three months during pregnancy and underwent vaginal delivery. ACSG consisted of women who practiced some type of resistance training for at least one year before pregnancy and at least three months during pregnancy and underwent cesarean section. SVDG consisted of women who did not practice any type of physical activity for at least one year before and during pregnancy (sedentary women) and underwent vaginal delivery SCSG consisted of sedentary women who underwent cesarean section.

The study excluded volunteers who presented previous pregnancies, twin pregnancies, abortion, premature delivery (before 37 gestational weeks), degenerative muscle diseases, or those not in the postpartum period proposed for the study (<9 weeks). If any volunteer could not perform all the trunk flexions requested during measurements due to fatigue or pain, they would also be excluded from the study.

Procedures

After signing the consent form, an identification questionnaire was applied addressing personal and occupational questions, life habits, and information on pregnancy, delivery, and the newborn. Information such as schooling level; marital status; physical activity

before and during pregnancy; weight before, during, and after pregnancy; and delivery. All data obtained via the questionnaire were self-reported. Then, physical evaluation was performed to quantify RAM distance and verify the presence of DRAM.

A 200mm analog model and 0.05mm accuracy caliper (Mitutoyo, São Paulo) was used to measure RAM distance. The caliper is an instrument widely used in engineering and has been widely used to quantify RAM separation in the umbilical, supraumbilical, and infraumbilical regions[10].

Prior to the study, intra-examiner reliability test was performed with 10 women to verify the consistency of the measurements. The reliability test occurred in two moments, with a one-day interval between measurements. Each region was measured three times, and the mean of these three values (in centimeters) was considered for analysis. The results obtained were analyzed using the intraclass correlation coefficient (ICC) to verify the reliability of the measurements, and the following values were obtained: supraumbilical region=0.919 (95%CI=0.674–0.980, p<0.001), umbilical region=0.942 (95%CI=0.767–0.986, p<0.001), and infraumbilical region=0.944 (95%CI=0.776–0.986, p<0.001).

Contact with the puerperal women was made via physical therapy clinics that offer Pilates and weight training gyms, functional training, and CrossFit®, as well as gym clinics and gynecological clinics in the city of Divinópolis (MG). The initial contact aimed to inform them about the study and its objectives, as well as inviting them to participate. Both the application of the questionnaire and measurement of RAM distance were performed at the location chosen by the puerperal women. Data were collected from May to November 2021.

The application of the questionnaire and the measurement of RAM distance was performed in a single day, with a maximum duration of 30 minutes. A single researcher was responsible for applying the questionnaire. The measurement of RAM distance was performed by another researcher, previously trained to use the caliper. After being informed about the objectives and procedures of the study, the volunteers who agreed to participate signed an informed consent form and answered the questionnaire.

Then, RAM distance was calipered. Three points were delimited with dermatograph pencils: 4.5cm above the umbilical scar (supraumbilical region), 4.5cm below the umbilical scar (infraumbilical region), and over the umbilical region. The markings were removed with water after the evaluation. For measuring RAM distance, patients were in a supine position, with hips and knees flexed at 90°, their feet resting on the stretcher, and their upper limbs extended to the side of the body. Maintaining this position, participants were instructed to perform trunk flexion until the lower angle of the scapulae was outside the stretcher. At that moment, the examiner palpated the limits of the medial edges of the RAM and calipered their distance in the three previously delimited regions. Three repetitions were performed for each region, totaling nine repetitions of trunk flexion. The mean of these values (in centimeters) was used in the analysis. To characterize DRAM, the separation of the medial border of the RAM was considered ≥2.5cm in the supraumbilical and umbilical regions and ≥1.0cm in the infraumbilical region[8].

Data analysis

After measuring RAM distance and verifying all the questionnaire information, the data obtained were subjected to descriptive and inferential statistical analysis. A descriptive analysis of the sample was performed using data such as age, schooling level, weight, height, and marital status. Moreover, a frequency analysis was performed to characterize RAM separation as diastasis.

Regarding the values obtained by measuring RAM distance, two-way analyses of variance (ANOVA) were performed to compare the main effects: resistance exercise practice and mode of delivery and practical interaction of resistance exercise and mode of delivery.

Pearson's correlations were used to verify the association between maternal and child data (weight before pregnancy, weight gain during pregnancy, newborn's weight) and the values of RAM distance. Correlation values of ≤0.25 are considered very low associations; from 0.26–0.49, low associations; from 0.50–0.69, moderate associations; from 0.70–0.89, high associations; and from 0.90–1.00, very high associations[24].

For independent groups *t*-tests were used to compare maternal and child data (newborn's weight, weight before pregnancy, and weight gain during pregnancy) between primiparous patients with and without DRAM.

The significance level established in all analyses was 0.05.

RESULTS

Based on the exclusion criteria, 46 volunteers were excluded from the study, of which 24 did not fit the

proposed period for measuring DRAM (ninth week postpartum), 14 were not primiparous, seven had miscarriage, and one had undergone twin gestation. No volunteer was excluded from the study for not performing the trunk flexions requested during the measurements. Thus, 56 volunteers were evaluated in the ninth week after delivery, with a mean age of 28.5±5.2 years and mean height of 1.65±0.06 meters, divided into four groups according to the mode of delivery and the practice of resistance exercise. Among volunteers, 51.8% were married, 53.6% had complete higher education, 8.9% had complications during pregnancy, and 10.7% had complications during labor. Regarding the categorization of RAM distance above 2.5cm as diastasis for the supraumbilical and umbilical regions, 33.9% and 25.0% of primiparous women presented DRAM, respectively. Regarding the categorization of RAM distance above 1.0cm as diastasis for the infraumbilical region, 32.1% had a positive result. Tables 1, 2, and 3 show the descriptive data of the sample, and Tables 2 and 3 presents data for each study group (AVDG, ACSG, SVDG, SCSG).

Table 1. Demographic and clinical data of the evaluated primiparous women (n=56). Divinópolis (MG) – Brazil, 2021

Demographic and clinical characteristic	Frequency, n (%)
Marital status	
Lover	1 (1.8)
Married	29 (51.8)
Single	16 (28.6)
Steady union	10 (17.9)
Schooling level	
Complete high school	16 (28.6)
Incomplete high school	2 (3.6)
Complete higher education	30 (53.6)
Incomplete higher education	8 (14.3)
Complications during pregnancy	
No	51 (91.1)
Yes	5 (8.9)
Complications during labor	
No	50 (89.3)
Yes	6 (10.7)
Supraumbilical DRAM (≥2.5cm)	
No	37 (66.1)
Yes	19 (33.9)
Umbilical DRAM (≥2.5cm)	
No	42 (75)
Yes	14 (25)
Infraumbilical DRAM (≥1.0cm)	
No	38 (67.9)
Yes	18 (32.1)

DRAM: diastasis of the rectus abdominis muscles.

Table 2. Presence of diastasis of the rectus abdominis muscles in each study group. Divinópolis (MG) – Brazil, 2021

Diastasis of the rectus abdominis muscles (DRAM)		Frequency, n (%)
Supraumbilical DRAM (≥2.5cm)		
ACSG	No	12 (85.7)
	Yes	2 (14.3)
AVDG	No	8 (57.1)
	Yes	6 (42.9)
SCSG	No	9 (64.3)
	Yes	5 (35.7)
SVDG	No	8 (57.1)
	Yes	6 (42.9)
Umbilical DRAM (≥2.5cm)		
ACSG	No	12 (85.7)
	Yes	2 (14.3)
AVDG	No	11 (78.6)
	Yes	3 (21.4)
SCSG	No	9 (64.3)
	Yes	5 (35.7)
SVDG	No	10 (71.4)
	Yes	4 (28.6)
Infraumbilical DRAM (≥1.0cm)		
ACSG	No	11 (78.6)
	Yes	3 (21.4)
AVDG	No	9 (64.3)
	Yes	5 (35.7)
SCSG	No	7 (50)
	Yes	7 (50)
SVDG	No	11 (78.6)
	Yes	3 (21.4)

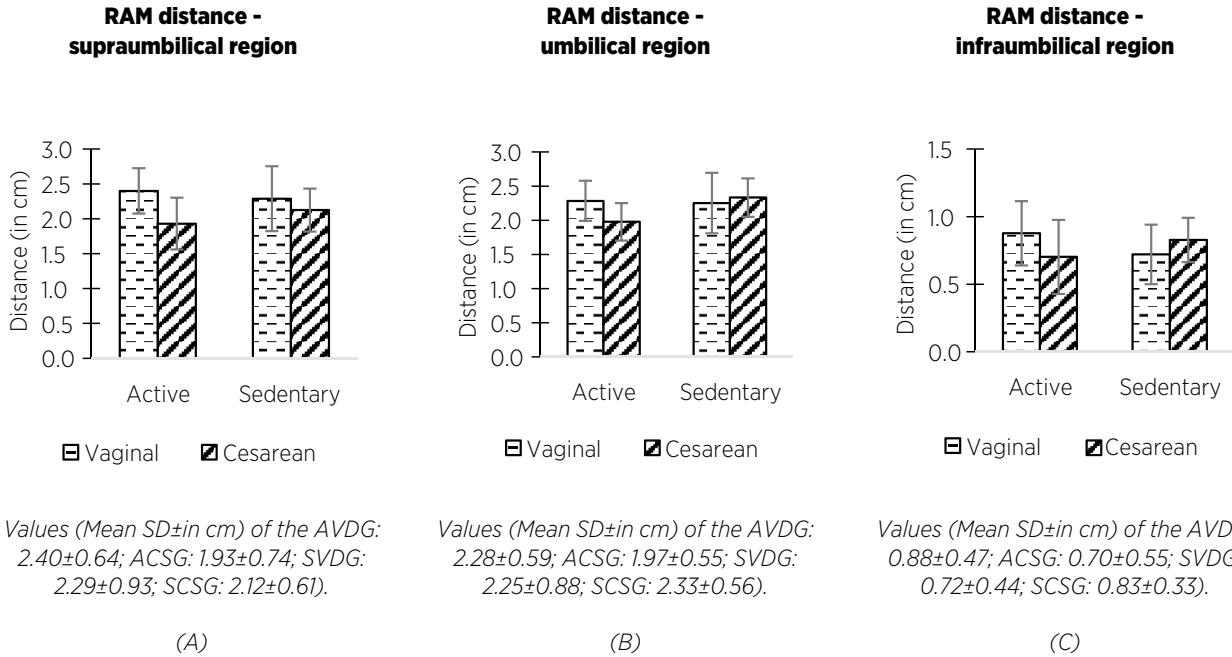
DRAM: diastasis of the rectus abdominis muscles; ACSG: Active Cesarean Section Group; AVDG: Active Vaginal Delivery Group; SCSG: Sedentary Cesarean Section Group; SVDG: Sedentary Vaginal Delivery Group.

Table 3. Maternal and child data from each study group. Divinópolis (MG) – Brazil, 2021

Maternal and child data	Mean (standard deviation)
Weight of the puerperal women before pregnancy (kg)	
ACSG	68.45 (11.41)
AVDG	64.93 (10.94)
SCSG	70.08 (14.22)
SVDG	68.02 (11.01)
Weight gain of puerperal women during pregnancy (kg)	
ACSG	10.75 (4.48)
AVDG	11.81 (4.95)
SCSG	13.68 (5.57)
SVDG	12.73 (5.11)
Newborn's weight (kg)	
ACSG	3.13 (0.39)
AVDG	3.04 (0.43)
SCSG	3.48 (0.39)
SVDG	3.05 (0.33)

ACSG: Active Cesarean Section Group; AVDG: Active Vaginal Delivery Group; SCSG: Sedentary Cesarean Section Group; SVDG: Sedentary Vaginal Delivery Group.

The values obtained from RAM distance were subjected to two-way ANOVA to compare the main effects: mode of delivery and practice of resistance exercise, and the interaction between mode of delivery and practice of resistance exercise. For the values of RAM distance in the supraumbilical region, we found no main effect for mode of delivery (F=2.524; p=0.118), resistance exercise practice (F=0.041; p=0.840), or interaction between mode of delivery and practice of resistance exercise (F=0.588; p=0.447). We also found no main effect for RAM distance in the umbilical region and mode of delivery (F=0.416; p=0.522) or the practice of resistance exercise (F=0.831; p=0.366), or interaction between mode of delivery and resistance exercise (F=1.204; p=0.278). Likewise, we found no main effect for RAM distance in the infraumbilical region and mode of delivery (F=0.078; p=0.781) or resistance exercise (F=0.016; p=0.900), or interaction between mode of delivery and resistance exercise (F=1.346; p=0.251). Graph 1 shows the mean and standard deviation of RAM distance (A, B, and C).

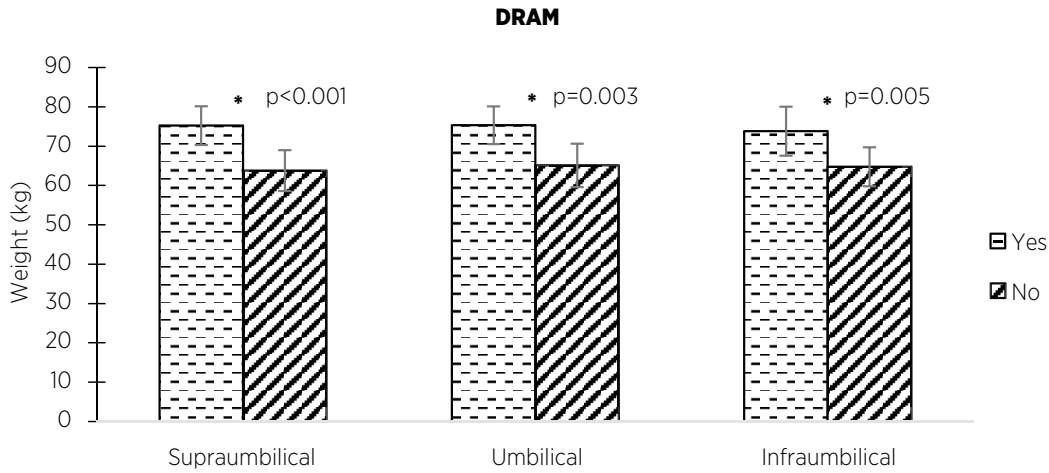


Graph 1. Mean and standard deviation of the rectus abdominis muscles distance in the supraumbilical (A), (B) umbilical and (C) infraumbilical regions

RAM: rectus abdominis muscles; ACSG: Active Cesarean Section Group; AVDG: Active Vaginal Delivery Group; SCSG: Sedentary Cesarean Section Group; SVDG: Sedentary Vaginal Delivery Group.

We found a positive, from low to moderate, and significant correlation between weight before pregnancy and RAM distance in the supraumbilical (r=0.508; p<0.001), umbilical (r=0.441; p=0.001), and infraumbilical (r=0.430; p=0.001) regions. We found no association between weight gain during pregnancy and RAM distance in the supraumbilical (r=0.204; p=0.132), umbilical (r=0.040; p=0.771), and infraumbilical (r=0.055; p=0.689) regions. Also, we did not find an association between newborn's weight and RAM distance in the supraumbilical (r=0.200; p=0.140), umbilical (r=0.146; p=0.282), and infraumbilical (r=0.111; p=0.414) regions.

The *t*-test for independent groups was used to compare women with and without DRAM regarding the following maternal and child variables: weight before pregnancy, weight gain during pregnancy, and newborn's weight. We found a significant difference in weight before pregnancy among primiparous women with and without pathological supraumbilical, (p<0.001), umbilical (p=0.003), and infraumbilical DRAM (p=0.005). Primiparous women with diastasis in the three regions presented greater weight before pregnancy (Graph 2). We found no significant difference in weight gain during pregnancy among primiparous women with and without supraumbilical (p=0.258), umbilical (p=0.854), and infraumbilical DRAM (p=0.951). Likewise, we found no significant difference in the newborn's weight among the volunteers with and without supraumbilical (p=0.148), umbilical (p=0.462), and infraumbilical DRAM (p=0.122).



Graph 2. Mean and standard deviation of weight before pregnancy in primiparous women with and without diastasis of the rectus abdominis muscles in the supraumbilical, umbilical, and infraumbilical regions

DRAM: diastasis of the rectus abdominis muscles.

DISCUSSION

This study was conducted to verify if the practice of resistance exercises and the mode of delivery influence the size of RAM separation in primiparous women. The results suggest that the activity level before and during pregnancy in primiparous women, as well as the mode of delivery, does not contribute to the size of RAM separation. On the other hand, the weight of primiparous women before pregnancy is associated with RAM distance, and this maternal variable also differentiates women with and without DRAM in all three regions (supraumbilical, umbilical, and infraumbilical).

Our outcomes do not confirm the hypothesis of a difference in primiparous women's RAM distance considering the practice or not of resistance exercise and the mode of delivery (cesarean section or vaginal childbirth). Regarding the practice of resistance exercises, this result may occur because the type of resistance exercise performed by the volunteers was not standardized. Thus, active volunteers (ASCG and AVDG) practiced different types of exercise. However, Benjamin et al.[12] showed in a systematic review that physical exercise reduces the presence of DRAM by up to 35%. However, the authors show that the analyzed studies have low methodological quality, limiting the conclusions of the review.

The exercises normally performed to prevent DRAM are strengthening of the transversus abdominis muscle and RAM[24]. The activation of the transversus abdominis muscle occurs during abdominal strengthening exercises. This activation is interconnected with the fascia of the RAM, which increases fascial tension and allows for load transfer and torque production. Thus, the activation of the transversus abdominis muscles enables the prevention, the reduction, and acceleration of the recovery of RAM separation[12,25]. However, no consensus is established on which abdominal strengthening exercises are most effective[26]. Moreover, since volunteers practiced different resistance exercises, we could not verify if these exercises promoted the activation of the abdominal muscles. Thus, further investigations are needed on the efficacy of abdominal muscle strengthening exercises to develop a specific protocol for the prevention and treatment of DRAM.

There is no consensus in the literature on which mode of delivery can be considered a risk factor for the onset of DRAM. Evidence shows that women who underwent cesarean section have higher DRAM values compared to those who underwent vaginal delivery[7,16]. This is based on the fact that, in vaginal delivery, RAM distance reached almost 32mm and, in cesarean section, the value surpassed 37mm, representing a 15% difference[15,16]. However, Leite and Araújo[2] observed a higher prevalence of DRAM in women who underwent vaginal delivery (58.9%) compared to those who had cesarean section (48.1%). Similarly to our outcomes, Sancho et al.[27] did not find significant differences between the values of RAM distance and different modes of delivery. This result suggests that the mode of delivery is not related to the onset of DRAM. However, further investigations are needed regarding the mode of delivery and the presence of DRAM.

In our study, values higher than 2.5cm characterized RAM separation as diastasis in the supraumbilical and umbilical regions, and 1cm characterized RAM for the infraumbilical region. Based on these values, a prevalence of DRAM was observed from 25% to 34% for the three regions measured. However, the values used for this categorization are controversial in the literature. Some studies consider DRAM as any distance between RAM, whereas others consider a distance greater than 1.5cm, 2.5cm, or 3cm[11,28,29]. Regarding the classification of infraumbilical DRAM, Chiarello et al.[13] classifies values higher than 1cm as diastasis. Their classification presents lower values due to the different fascial orderings that cover the RAM, thus hindering the stretching of the infraumbilical region[8]. As the literature lacks standardization regarding the minimum values for RAM distance be characterized as DRAM, clinicians and researchers should reach a consensus.

The caliper was used to measure RAM distance due to easy access and handling, as well as its low cost. Although the caliper is not recognized as the gold standard tool for measuring RAM distance, the intraexaminer reliability test was performed with 10 volunteers and all values were higher than 0.90, with the tool presenting excellent intraexaminer reliability.

Besides the lack of standardization regarding values to characterize RAM distance as diastasis and the tools used for measurement[30], there are also differences in the literature on the exact time at which this distance should be measured. We found studies that measured RAM distance during the 21st week of pregnancy, six and eight weeks after delivery, and 12 months after delivery[6,23]. Thus, it is important to have a consensus or recommendation on the most assertive postpartum period so that the measurement of DRAM is performed, considering the minimum time in which the physiological return of RAM occurs.

We found significant differences and a positive and significant correlation, from low to moderate, between weight before pregnancy and RAM distance in the supraumbilical, umbilical, and infraumbilical regions. Wu et al.[31] conducted a computed tomography study to analyze some risk factors for DRAM and found a strong correlation between body mass index (BMI) and DRAM. However, some authors did not find significant results[6,16]. Divergence between the results can be explained by the fact that some authors evaluated primiparous and multiparous women and the measurements were performed in different phases of the puerperium.

We found no associations when comparing primiparous women with and without DRAM regarding weight gain during pregnancy and newborn's weight and verifying the correlation between RAM separation and these variables. Some authors corroborate the same results[6,16,32]. A possible justification for the results found on weight gain during pregnancy may be the lack of relationship between this maternal variable with RAM distance independently, but rather associated with other risk factors. Therefore, further studies are needed to verify this hypothesis. Regarding the newborn's weight, a plausible explanation is that fetal macrosomia, considered one of the predisposing factors of DRAM, is defined as birth weight of 4 or 4.5kg[33]. However, in this study, the newborn's weight was on average of 3.174kg, not reaching values that would possibly be necessary to associate it with the DRAM.

Although the study results did not show that the practice of resistance exercises influences RAM distance, exercising before and during pregnancy benefits women's health[18]. Physical exercise, when recommended by a physician and accompanied by a competent professional, is safe and beneficial for the pregnant woman and the newborn. Barakat et al.[19] showed that a program of mobility exercises and supervised strengthening during pregnancy does not increase the risk of premature birth. Lower gestational weight gain, lower birth weight, and lower probability of developing hypertension were also found in an aerobic, flexibility, and strengthening exercises program performed with 420 women[20]. Therefore, resistance training, if practiced with medical recommendation and accompanied by trained professionals, should be performed before and during the gestational period, since it does not affect or worsen RAM separation.

This study has some limitations, such as the lack of a specific type of resistance exercise to evaluate its effect on the values of RAM distance. However, this is a cross-sectional study, which does not allow to infer the causal relationship between the practice of physical exercises and the size of RAM distance. Thus, more rigorous designs regarding the type of physical exercise are necessary to achieve ways of preventing DRAM. Another limitation is related to the self-report character of the questionnaire. Thus, values on weight before pregnancy and weight gain during pregnancy could have been interfered by memory bias. Another

case to emphasize is that the study was conducted with primiparous women, a population expected to have lower values of RAM separation. Thus, further studies should verify the contribution of resistance exercises to the size of RAM separation in multiparous women. Considering the results obtained in this study, it is essential to conduct further investigations seeking effective measures to reduce RAM separation and, thus, prevent the emergence of DRAM. However, this study results should contribute to future publications since the scarcity of investigations during the literature survey hinders research on the subject.

CONCLUSION

The study suggests that the practice of resistance exercises and the mode of delivery do not influence the size of RAM separation in the supraumbilical, umbilical, and infraumbilical regions in primiparous women. A positive and significant correlation was found between weight before pregnancy and RAM distance, showing that the greater the weight of the woman before the gestational period, the greater the RAM distance in the supraumbilical, umbilical, and infraumbilical regions. Moreover, this variable also differed significantly among primiparous women with and without DRAM, and women with DRAM had a greater weight before pregnancy. A prevalence was observed from 25% to 34% of DRAM in the three regions evaluated, but the values obtained for RAM distance were not associated with maternal weight gain during pregnancy and the newborn's weight.

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REFERENCES

1. Thabet AA, Alshehri MA. Efficacy of deep core stability exercise program in postpartum women with diastasis recti abdominis: a randomised controlled trial. J Musculoskelet Neuronal Interact. 2019;19(1):62-8.
2. Leite ACNMT, Araújo KKBC. Diástase dos retos abdominais em puérperas e sua relação com variáveis obstétricas. Fisioter Mov. 2012;25(2):389-97. doi: 10.1590/S0103-51502012000200017.
3. Baracho E. Fisioterapia aplicada à saúde da mulher. 6th ed. Rio de Janeiro: Guanabara Koogan; 2018.
4. Rett MT, Almeida TV, Mendonça ACR, DeSantana JM, Ferreira APL, Araújo KCGM. Fatores materno-infantis associados à diástase dos músculos retos do abdome no puerpério imediato. Rev Bras Saude Mater. Infant. 2014;14(1):73-80. doi: 10.1590/S1519-38292014000100007.
5. Boissonnault JS, Blaschak MJ. Incidence of diastasis recti abdominis during the childbearing year. Phys Ther. 1988;68(7):1082-6. doi: 10.1093/ptj/68.7.1082.
6. Sperstad JB, Tennnfjord MK, Hilde G, Ellström-Engh M, Bø K. Diastasis recti abdominis during pregnancy and 12 months after childbirth: prevalence, risk factors and report of lumbopelvic pain. Br J Sports Med. 2016;50(17):1092-6. doi: 10.1136/bjsports-2016-096065.
7. Luna DCB, Cavalcanti ALAMH, Guendler JA, Brito VC, Oliveira BDR. Frequência da diástase abdominal em puérperas e fatores de risco associados. Fisioter Saúde Func. 2012;1(2):10-7.
8. Rett MT, Braga MD, Bernardes NO, Andrade SC. Prevalência de diástase dos músculos retoabdominais no puerpério imediato: comparação entre primíparas e multíparas. Rev Bras Fisioter. 2009;13(4):275-80. doi: 10.1590/S1413-35552009005000037.
9. Mesquita LA, Machado AV, Andrade AV. Fisioterapia para redução da diástase dos músculos retos abdominais no pós-parto. Rev Bras Ginecol Obstet. 1999;21(5):267-72. doi: 10.1590/S0100-72031999000500004.
10. Alvarenga EC, Ferreira LC. A intervenção fisioterapêutica na prevenção da diástase do músculo reto abdominal em gestantes. Rev Bras Saude Func. 2014;2(1):18-30. doi: 10.25194/rebrasf.v2i1.463.
11. Spitznagle TM, Leong FC, Van Dillen LR. Prevalence of diastasis recti abdominis in a urogynecological patient population. Int Urogynecol J Pelvic Floor Dysfunct. 2007;18(3):321-8. doi: 10.1007/s00192-006-0143-5.
12. 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;100(1):1-8. doi: 10.1016/j.physio.2013.08.005.
13. 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 Therap. 2005;29(1):11-6. doi: 10.1097/01274882-200529010-00003.
14. Lo T, Cândido G, Janssen P. Diastasis of the recti abdominis in pregnancy: risk factors and treatment. Physiother Can. 1999;51:32-7.
15. Turan V, Colluoglu C, Turkyilmaz E, Korucuoglu U. Prevalence of diastasis recti abdominis in the population of young multiparous adults in Turkey. Ginekol Pol. 2011;82(11):817-21.
16. Gitta S, Magyar Z, Tardi P, Füge I, Járomi M, Ács P, et al. A rectus diastasis prevalenciája, lehetséges rizikófaktorai és szövődményei. Orv Hetil. 2017;158(12):454-60. doi: 10.1556/650.2017.30703.
17. Fei H, Liu Y, Li M, He J, Liu L, Li J, et al. The relationship of severity in diastasis recti abdominis and pelvic floor dysfunction: a retrospective cohort study. BMC Womens Health. 2021;21(1):68. doi: 10.1186/s12905-021-01194-8.

18. American College of Obstetricians and Gynecologists. Physical activity and exercise during pregnancy and the postpartum period: ACOG Committee Opinion, Number 804. Obstet Gynecol. 2020;135(4):e178-88. doi: 10.1097/AOG.0000000000003772.

19. Barakat R, Stirling JR, Lucia A. Does exercise training during pregnancy affect gestational age? A randomised controlled trial. Br J Sports Med. 2008;42(8):674-8. doi: 10.1136/bjsm.2008.047837.

20. Barakat R, Pelaez M, Cordero Y, Perales M, Lopez C, Coteron J, et al. Exercise during pregnancy protects against hypertension and macrosomia: randomized clinical trial. Am J Obstet Gynecol. 2016;214(5):649.e1-8. doi: 10.1016/j.ajog.2015.11.039.

21. White E, Pivarnik J, Pfeiffer K. Resistance training during pregnancy and perinatal outcomes. J Phys Act Health. 2014;11(6):1141-8. doi: 10.1123/jpah.2012-0350.

22. Câmara CS, Silva DSG, Brito RCS. Análise da relação entre atividade física e diástase abdominal em puérperas. EFDeportes.com. 2011;16(157):1-3.

23. Coldron Y, Stokes MJ, Newham DJ, Cook K. Postpartum characteristics of rectus abdominis on ultrasound imaging. Man Ther. 2008;13(2):112-21. doi: 10.1016/j.math.2006.10.001.

24. Plichta SB, Kelvin EA. Munro's statistical methods for health care research. 6th ed. Philadelphia: Lippincott Williams & Wilkins; 2012.

25. Michalska A, Rokita W, Wolder D, Pogorzelska J, Kaczmarczyk K. Diastasis recti abdominis – a review of treatment methods. Ginekol Pol. 2018;89(2):97-101. doi: 10.5603/GP.a2018.0016.

26. Lee D, Hodges PW. Behavior of the linea alba during a curl-up task in diastasis rectus abdominis: an observational study. J Orthop Sports Phys Ther. 2016;46(7):580-9. doi: 10.2519/jospt.2016.6536.

27. Sancho MF, Pascoal AG, Mota P, Bø K. Abdominal exercises affect inter-rectus distance in postpartum women: a two-dimensional ultrasound study. Physiotherapy. 2015;101(3):286-91. doi: 10.1016/j.physio.2015.04.004.

28. Rett MT, Araújo FR, Rocha I, Silva RA. Diástase dos músculos retoabdominais no puerpério imediato de primíparas e multíparas após o parto vaginal. Fisioter Pesqui. 2012;19(3):236-41. doi: 10.1590/S1809-29502012000300008.

29. Noble E. Essential exercises for the childbearing year: a guide to health and comfort before and after your baby is born. 2nd ed. Boston: Houghton Mifflin; 1982.

30. Dufour S, Bernard S, Murray-Davis B, Graham N. Establishing expert-based recommendations for the conservative management of pregnancy-related diastasis rectus abdominis: a delphi consensus study. J Womens Health Phys Therap. 2019;43(2):73-81. doi 10.1097/JWH.0000000000000130.

31. Wu L, Gu Y, Gu Y, Wang Y, Lu X, Zhu C, et al. 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(3-4):518-27. doi: 10.1111/jocn.15568.

32. Mota PGF, Pascoal AGBA, Carita AIAD, Bø K. Prevalence and risk factors of diastasis recti abdominis from late pregnancy to 6 months postpartum, and relationship with lumbo-pelvic pain. Man Ther. 2015;20(1):200-5. doi: 10.1016/j.math.2014.09.002.

33. American College of Obstetricians and Gynecologists. Macrosomia: ACOG practice bulletin, number 216. Obstet Gynecol. 2020;135(1):e18-35. doi: 10.1097/AOG.0000000000003606.