

Effect of the Pilates Method in the Treatment of Diastasis of the Rectus Abdominals in Women: A Randomized Controlled Clinical Trial

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ABSTRACT

Introduction: Diastasis Recti Abdominis (DRA) is a common condition during pregnancy and the postpartum period and may persist throughout a woman's life. An increased inter-rectus distance (IRD) is associated with musculoskeletal dysfunctions, altered body image perception, and a reduced quality of life. While the Pilates Method is considered a potentially effective approach or managing this condition, few studies have investigated its effects on IRD and associated dysfunctions.

Aims: To evaluate the effects of Pilates Method exercises on IRD, complaints related to pelvic floor dysfunctions, and abdominal function in women with DRA.

Method: This randomized controlled clinical trial included 44 women diagnose with IRD, 22 for control group and 22 for intervention group. Participants were randomly assigned to one of two groups: the Pilates Group, which performed Pilates exercises twice a week for 50 minutes over 12 weeks, and the Control Group, which received no intervention. Assessments were conduct before and after the 12-week period, measuring IRD via ultrasound and evaluating the impact of pelvic floor dysfunctions using the Pelvic Floor Bother Questionnaire. Additionally, abdominal muscle function was assessed using plank and modified plank tests. A repeated measures ANOVA was used to compare the groups.

Results: A significant interaction between group and time was observed for IRD in the supraumbilical region at rest [$F(1,38) = 7.61$; $p = 0.009$]. After the intervention, the Pilates Group exhibited significantly lower IRD values compared to the Control Group ($p < 0.001$). The post hoc test also revealed a significant increase in the duration of right and left side plank holds exclusively in the Pilates Group, with a significant difference between the groups after the intervention ($p < 0.001$). However, no statistically significant differences were found between the groups regarding pelvic floor complaints ($p > 0.05$).

Conclusion: Pilates intervention effectively reduced supraumbilical IRD and improved abdominal muscle function in women with IRD. However, it did not significantly impact complaints related to pelvic floor dysfunctions.

Keywords: Pilates; Diastasis Recti Abdominis; Muscle Function

Abbreviations: DRA: Diastasis Recti Abdominis; IRD: Inter-Rectus Distance; CONSORT: Consolidated Standards of Reporting Trials; IPAQ: International Physical Activity Questionnaire; ICC: Intraclass Correlation Coefficient; SD: Standard Deviations; CI: Confidence Intervals; SPSS: Statistical Package for the Social Sciences; PFQ: Pelvic Floor Bother Questionnaire

Introduction

Diastasis recti abdominis (DRA) is a common condition during pregnancy and postpartum, characterized by widening of the connective tissue and separation of the rectus abdominis muscles along the linea alba (CHEN, et al. [1]). This process may occur in response to the stretching of the abdominal wall during pregnancy as the fetus grows. The prevalence of DRA varies between 70% and 100% during pregnancy, and in some cases, spontaneous closure occurs postpartum (DEMARTINI, et al. [2]). However, approximately 60% of women still have DRA six weeks after delivery, and approximately 33% remain with the condition after 12 months (THEODORSEN, et al. [3]). DRA is associated with abdominal muscle weakness, trunk biomechanical changes, pelvic instability, and reduced abdominal wall function (THEODORSEN, et al. [3,4]). In addition to musculoskeletal dysfunctions, increased inter-rectus distance (IRD) also correlates with distress, fear and hesitation of movement, changes in body image perception, and reduced quality of life in women (CROMMERT, et al. [5,6]). Despite its high prevalence and negative impacts on women's health, there is still no gold standard treatment for managing ARD (CARLSTEDT, et al. [7]). Among the exercise-based therapeutic approaches, the Pilates method has been widely used.

The Pilates method is a technique that encompasses a series of exercises based on six basic principles: control, fluidity, precision, breathing, concentration, and centering (CASTRO, et al. [8]). According to CASTRO, et al. [8], the method's exercises involve activating the powerhouse, a term that refers to the contraction of the deep abdominal muscles, including the rectus abdominis, transversus abdominis, internal and external obliques, as well as the deep erector spinae and pelvic floor muscles (MAZZARINO, et al. [9]). The constant activation of the abdominal muscles during exercises makes the Pilates method a potentially safe and accessible approach for treating ARF. However, to date, only one randomized controlled clinical trial has demonstrated positive effects of the method in women with ARF (LEE, et al. [10]). Therefore, further studies are needed to investigate interventions that can be widely implemented and that promote both functional improvements and aesthetic benefits for this population. Given this context, the present study aimed to evaluate the effects of a Pilates-based intervention on IRF, abdominal muscle function, and complaints of pelvic floor dysfunction in women with ARF.

Methods

Study Design and Ethical Considerations

The research consisted of a randomized, controlled, parallel-group clinical trial with concealed allocation, blinded assessor, and intention-to-treat analysis, following the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The primary outcome was the inter-rectus abdominis distance, and the secondary outcomes were complaints of pelvic floor dysfunction and abdominal function.

The study was approved by the Ethics Committee of the Federal University of Uberlândia (No. 6,222,030) and registered with the Brazilian Clinical Trials Registry (No. RBR-66sfk5k).

Setting and Participants

The study was conducted on the premises of the School of Physical Education and Physiotherapy at the Federal University of Uberlândia, from January to September 2024. To determine the sample, the study was widely publicized to the Uberlândia community by the UFU Social Communications department and through social media. The inclusion criteria were: women aged 18 or older, who had previously been pregnant; and a diagnosis of ARD (defined as a 2 cm deviation anywhere along the linea alba) (THABET [11]). The exclusion criteria were: current pregnancy; history of previous abdominal cosmetic surgery; musculoskeletal conditions that prevented abdominal exercises; a diagnosis of midline hernia; and obesity (body mass index equal to or greater than 30 kg/m²). Based on a literature study (THABET [11]), a minimum change in the mean rectus abdominis diastasis between the groups of 1.0 mm (SD 0.92) was considered, considering a test power of 90% and a significance level of 5%. Therefore, it was concluded that at least 22 participants would be necessary for each group, resulting in a sample of 44 women for the present study. Participants who met the inclusion criteria were randomized into two groups: the group that underwent Pilates exercise training (n=22) and the group that received no intervention (n=22).

Randomization was performed by an independent researcher. A list of random numbers was computer-generated and placed in opaque, sealed, and numbered envelopes before the interventions, separating them into two groups.

Selection and Assessments

Volunteers who met the inclusion and exclusion criteria were carefully informed in clear and accessible language about the proposed procedure. They were then instructed to sign the Informed Consent Form. Initially, participants underwent an assessment, including a standard questionnaire covering socioeconomic data, urogynecological/obstetric history, and lifestyle habits. To characterize the sample, the International Physical Activity Questionnaire (IPAQ) (SARDINHA, et al. [12]) was also administered to assess participants' physical activity levels. Before and after 12 weeks, all participants were assessed for the primary and secondary outcomes. The primary outcome, inter-rectum distance (IRD), was assessed by ultrasound. An independent, blinded researcher with more than three years of experience in ultrasound for assessing ARI performed the examinations using a two-dimensional PHILIPS EPIQ5 USA device with a 5-12 MHz linear probe and musculoskeletal preset. To ensure data reproducibility, a test-retest reproducibility analysis was initially performed. Fifteen nulliparous women were assessed for inter-rectum distance at two different time points, one week apart. The intraclass correlation coefficient (ICC) was calculated for all ultrasound variables.

For the examination, the participants were positioned supine with their knees and hips semi-flexed and their feet on the examination table, with their arms resting at their sides. To standardize the measurement site, two markings were made on the abdomen, 2 cm above and below the navel. Then, conductive gel was applied to the abdomen, the transducer was placed transversely at the previously marked points, and two images were obtained 2 cm above (ICC=0.90) and 2 cm below the navel (ICC=0.84). Immediately afterward, the participants were instructed to flex their trunk during expiration until the lower edges of the scapula no longer touched the examination table. Images were collected at the end of expiration at the points above (ICC=0.93) and below the navel (ICC=0.84). For data analysis, the average of two values collected during two attempts at each of the points marked above and below the navel was used, both at rest and during trunk flexion (GLUPPE [13,14]). To assess complaints related to pelvic floor dysfunctions, the Pelvic Floor Bother Questionnaire (Pelvic Floor Bother Questionnaire – Appendix 1) was used. This instrument covers nine symptoms associated with urinary incontinence, urinary urgency, urinary difficulty, bowel obstruction, fecal incontinence, pelvic organ prolapse, and pain during sexual intercourse (PETERSON, et al. [15]).

Validated for the Portuguese language, the questionnaire uses a scale of 0 to 5 points per question, totaling a score that can range from 0 to 45 points, where higher values indicate greater discomfort. Furthermore, it has high reliability, internal validity in test-retest, and reproducibility (ICC = 0.986) (PETERSON, et al. [15]). Next, the Plank Test (The Bridge Test) was administered to assess abdominal muscle function (BOHANNON, et al. [16]). In this test, participants were instructed to maintain a neutral and active posture, with only their forearms and toes touching the surface and their legs extended. Time was recorded in seconds from the moment they maintained the correct posture until they voluntarily stopped or were unable to maintain it (BOHANNON, et al. [16]). The side plank variation test was also conducted, in which the volunteer assumes a side-lying position, supporting themselves on their forearm and lateral foot, with their feet aligned in front of each other. During this variation, the volun-

teer keeps their body aligned, forming a straight line from head to toe. The test was performed on both the left and right sides with timing in seconds from the moment they maintained the correct posture until they voluntarily interrupted it or were unable to maintain it (MCGILL, et.al. [17]).

Intervention

The intervention group completed Pilates Method Exercises training for 12 weeks, with two 30-minute sessions per week, led by a qualified Pilates instructor. Activities were conducted in groups of up to four participants per session. The exercise protocol was implemented according to the method described by Joseph Humbert Pilates [18], with the difficulty of the exercises increasing every four weeks. The sessions began with Powerhouse activation and respiratory control, followed by pelvic floor activation and contraction in the supine position with legs extended and flexed, with feet flat on the floor. PFM contraction was requested so that these women would have body awareness of these muscles during the interventions, as activation would be required throughout the intervention classes (three repetitions of 15 sets) (LIMA, et al. [19,20]). Pilates exercises were performed immediately afterward, with up to six exercises per session. The activities were conducted in groups of up to four participants per session. The intervention group consisted of Joseph Pilates method exercises, with repetitions and sets controlled by a responsible practitioner with over five years of experience with the Pilates method. The control group did not perform any training during the 12 weeks. The exercise protocol was performed according to the method described by Joseph Humbert Pilates.

There is no specific methodology within the method that describes the sequence of classes or the difficulty of the exercises for each participant’s individual needs. Joseph and his method are for everyone, making Pilates a harmless activity for those who participate in the classes. Thus, the intervention classes were designed according to a Pilates class preparation within clinical practice, with stretching, postural control, breathing control, concentration, and then exercise execution. The sequence is shown in Table 1.

Table 1: Pilates Intervention Program.

Semanas	Semana 1	Semana 2	Semana 3
Níveis/ Intensidade	Fácil	Intermediário	Difícil
Séries	3x15	3x15	3x15
	The Hundred	The Saw	The Cork Screw
	The Roll Up	The Swan	The Neck Pull
	The One Leg Circle	The Side Kick	The Side Bend
	The One Leg Stretch	The Side Kick Kneeling	The Hip Twist Stretched Arms
	The double Leg Stretch	The Swimming	The Teaser
	The One Leg Kick	The Double Kick	

Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) software, led by a researcher independent of the assessment and intervention process. Baseline variables were presented as means and standard deviations (SD) or as numbers and percentages, as applicable. The analysis was conducted following the intention-to-treat principle, ensuring that all participants were included, including those who did not fully complete the training. The normality of data distribution was verified using the Shapiro-Wilk test. For descriptive analysis of quantitative and qualitative variables, Student's t-test and chi-square test (χ^2) were used, respectively. Variations between variables in the control (CG) and intervention (IG) groups were compared using analysis of variance (ANOVA for repeated measures), followed by Tukey's post-hoc test to assess intra- and intergroup differences. Differences in changes between groups from baseline to week 12 were reported with 95% confidence intervals (CI). The significance level was set at 5% ($p < 0.05$).

Results

A total of 60 women expressed interest in participating in the study. Of these, 16 were excluded for not meeting the inclusion cri-

teria. Therefore, 44 participants were included in the study (Figure 1). Participant characteristics can be seen in Table 2. The intervention group's session adherence rate was 86.6% (20.8 ± 1.6 sessions). Analysis of the IRD data using the ANOVA test demonstrated a group-time interaction in the IRD measurement in the region above the navel at rest [$F(1.38)=7.61$; $p=0.009$]. After the intervention, statistically lower values were observed in the Pilates group compared to the control group ($p<0.001$). No significant differences were observed in the measurements below the navel and above the umbilical region during trunk flexion ($p<0.05$). Regarding abdominal muscle function, a group-time interaction was observed in the measurements of the right lateral plank [$F(1.38)=9.29$; $p=0.004$] and left lateral plank [$F(1.38)=9.52$; $p=0.004$]. The post-rotation test demonstrated an increase in plank hold time only in the Pilates group, with a difference between the groups in the values after the intervention ($p<0.001$). No statistically significant differences were observed in the frontal plank. When pelvic floor complaints were assessed using the PFQ questionnaire, no significant differences were observed between the groups ($p>0.05$).

Tables 3-7 Final score values for the Pelvic Floor Bother Questionnaire (PFQ) and the front, right, and left side plank tests before and after the intervention for the Pilates (PG) and control (CG) groups.

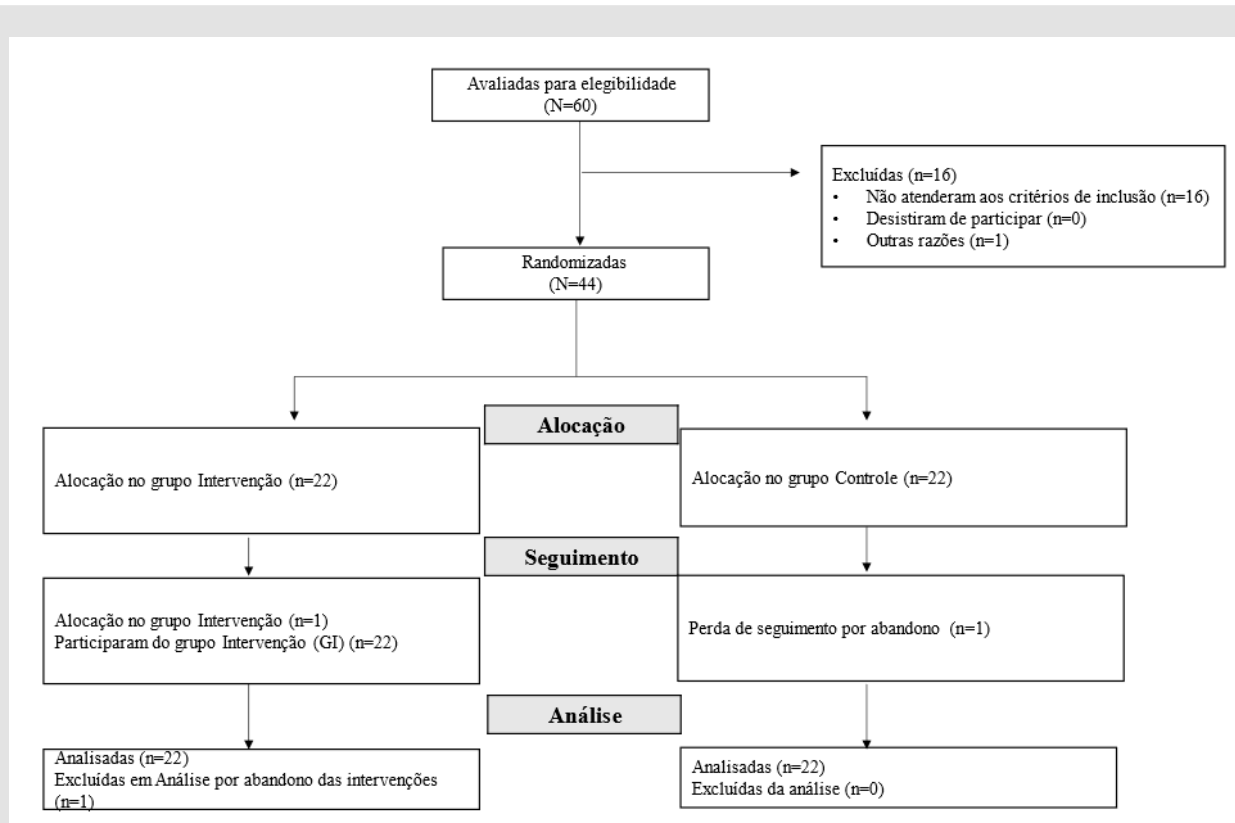


Figure 1: Study flow diagram.

Table 2: Easy Level Program.

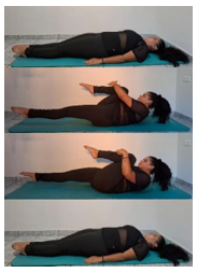
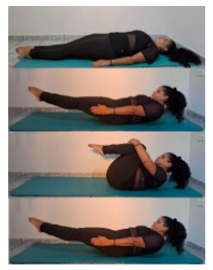
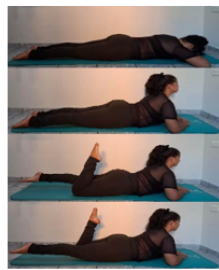
The Hundred (1ª a 4ª Semana) 	The Roll Up (1ª a 4ª Semana) 	The One Leg Circle (1ª a 4ª Semana) 
The One Leg Stretch (1ª a 4ª Semana) 	The Double Leg Stretch (1ª a 4ª Semana) 	The One Leg Kick (1ª a 4ª Semana) 

Table 3: Intermediate Level Program.

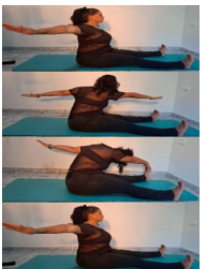
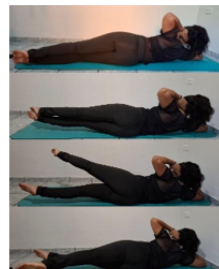
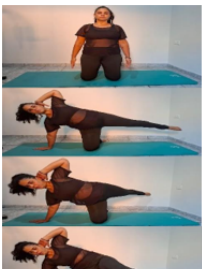
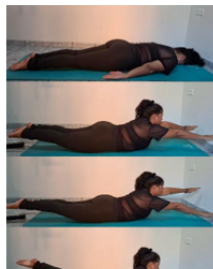
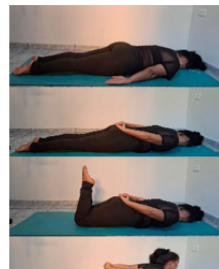
The Saw (5ª a 8ª Semana) 	The Swan Dive (5ª a 8ª Semana) 	The Side Kick (5ª a 8ª Semana) 
The Side Kick Kneeling (5ª a 8ª Semana) 	The Swimming (5ª a 8ª Semana) 	The Double Kick (5ª a 8ª Semana) 

Table 4: Hard Level Program.

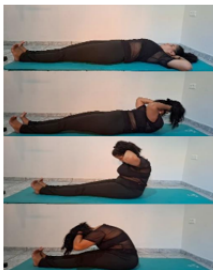
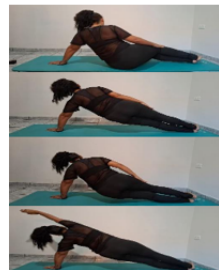
The Cork Screw (6ª a 12ª Semana) 	The Neck Pull (6ª a 12ª Semana) 	The Side Bend (6ª a 12ª Semana) 
The Hip Twist Stretched Arms (6ª a 12ª Semana) 	The Teaser (6ª a 12ª Semana) 	

Table 5: Characteristics of the participants.

	Grupo Pilates	Grupo Controle
Idade (anos)	33,5±4,0	32,5±4,4
IMC (kg/m²)	25,0±4,2	24,9±4,1
Tempo de pós parto (anos)	2,1±3,5	1,7±2,8
Tipo de parto Cesárea	13 (59,1%)	12 (54,5%)
Vaginal	9 (40,9%)	10 (45,5%)

Note: IMC: body mass index

Table 6: Values of the inter-rectum distance in millimeters before and after the intervention for the Pilates (GP) and control (GC) groups in the measurements above and below the umbilical scar.

	Pre		Pós 12 semanas			Pós menos pré	
	GI(n=22)	GC(n=22)	GI(n=22)	GC(n=22)	GI(n=22)	GI(n=22)	GI menos GC
2cm acima em repouso	25 (6)	29 (6)	19 (6)*	28 (5)	-6 (4)	-2 (6)	-9 (-7 to 1)
2cm abaixo em repouso	13 (6)	7 (9)	8 (5)	7 (8)	-5 (6)	0 (11)	0.8 (-6 to 2)
2cm acima em flexão	18 (6)	23 (5)	15 (7)	21 (5)	-3 (8)	-2 (4)	-6 (-6 to 2)
2cm abaixo em flexão	6 (3)	5 (8)	4 (3)	4 (3)	-2 (4)	-3 (8)	2 (-2 to 2)

Note: $p < 0.05$ versus post 12 weeks of GC (Turkey's post-hoc test)

Table 7.

	Pre		Pós 12 semanas			Pós menos pré	
	GP(n=22)	GC(n=22)	GP(n=22)	GP(n=22)	GP(n=22)	GP(n=22)	GP menos GC
PFQ escore (0 to 45)	6(7)	6(5)	4(5)	8(7)	-1(2)	2(7)	4 (0 a 8)
Teste de prancha frontal (s)	56(40)	26(17)	72(41)	32(21)	16(38)	6(21)	-40(-60 a -20)
Teste de prancha lateral direito (s)	27(13)	16(13)	40(15)*	17(12)	13(14)	1(11)	-23(-31 a -15)
Teste de prancha lateral esquerdo (s)	28(15)	18(14)	40(17)*	17(9)	12(16)	-1(10)	-23(31 a 15)

Note: * $p < 0.05$ versus post 12 weeks of GC (Tukey's post-hoc test)

Discussion

ARI is a condition frequently diagnosed in women during the pre-natal and postpartum periods and can persist throughout life. This dysfunction is associated with several complications, such as aesthetic changes, reduced quality of life, and impaired muscle function [CHEN, et al. [1]]. The results of this study provide significant evidence that the Pilates Method was effective in reducing ARI in the region above the navel at rest after 12 weeks of intervention. Despite the limitations of the current literature on the topic, this study contributed to the advancement of treatment for this condition. It is possible that the activation of the deep trunk muscles during Pilates Method exercises explains the approximation of the linea alba in the supraumbilical region found in this study [LEE, et al. [10]]. It is known that deep trunk contractions are essential for generating tension in the linea alba (LA), allowing for the efficient transfer of forces through the abdominal muscles. Recent studies highlight that the ability to generate tension in the LA is a crucial factor for abdominal wall function. Therefore, it is hypothesized that LA tension through the contraction of the deep abdominal muscles may promote tissue restructuring along the LA, thus allowing for the reduction of IRD [SKOURA, et al. [21]].

Few studies have analyzed the effects of Pilates Method exercises on women with AKI. A search of the PubMed database identified only one randomized controlled trial on the topic. In the study by LEE, et al. [10], the effects of the Pilates method, practiced five times a week for four weeks, were evaluated in women with AKI, compared to an inactive control group. Consistent with the results of the present study, the authors demonstrated that the intervention reduced IRD, measured by ultrasound, in addition to decreasing abdominal circum-

ference and improving abdominal muscle function in the intervention group participants compared to the control group. Other studies that conducted interventions aimed at achieving muscle strengthening to reduce IRR in women with AKI had mixed results. GLUPPE, et al. [22] performed 12 weeks of traditional abdominal exercises in women with AKI and observed no change in IRR but an increase in abdominal muscle strength and thickness. THABET, et al. [11] evaluated the effects of traditional abdominal exercises compared to stabilization exercises focusing on core muscles performed for eight weeks in women with AKI. After the intervention, the group that added core muscle exercises performed better in terms of IRR reduction measured by caliper and improved quality of life.

In the present study, it was also observed that the intervention based on Pilates exercises contributed to improved abdominal muscle function in women with Parkinson's disease. Previous studies have shown that women with this condition may experience reduced abdominal muscle strength [LIAW, et al. [23]], which can compromise the performance of functional activities [SILVA, et al. [24]]. The effect of the Pilates method on strengthening and improving the function of abdominal muscles has already been demonstrated in other populations. In a study conducted by GOZ, et al. [25], which investigated the effects of Pilates training on abdominal muscle thickness and core strength in patients with Parkinson's disease, a significant increase in the thickness of the transverse abdominis muscle was observed under different conditions: at rest, during the abdominal retraction maneuver in the supine position, and in the standing position, both post-training and at follow-up. Furthermore, Giacomini, et al. [26] presented promising findings when evaluating the effects of Mat Pi-

lates, demonstrating significant improvements in respiratory muscle strength and performance, as well as abdominal wall muscle hypertrophy in healthy women.

These results indicate that Pilates can contribute to functional gains and quality of life in different populations. Therefore, it is possible that women with AKI may also observe this benefit after intervention using the method. In the present study, Pilates practiced twice a week as a form of physical activity, but closer to the reality of this population, brings promising results for women with AKI, promoting safety, health, and well-being. Some studies observe that the pelvic floor muscles, due to their synergy with the deep abdominal muscles, may experience some level of activation during Pilates exercises (CULLIGAN, et al. [27]). In the present study, voluntary contraction of the pelvic floor muscles was requested during the exercises. However, the results did not indicate a reduction in complaints of pelvic floor muscle dysfunction after the intervention. DIAS, et al. [28-38] also did not observe an increase in the contraction capacity of the pelvic floor muscles in pregnant women after the PM intervention. It is possible that participants require isolated pelvic floor muscle training to achieve a reduction in dysfunction complaints. The lack of assessment of pelvic floor muscle contraction capacity represents a limitation of this study, and its inclusion should be considered in future investigations.

Among the strengths is the application of a robust methodology, including ultrasonography assessment of DIR, recognized as the gold standard. Thus, this study is the second to yield significant results in women with diastasis recti. There was a reduction in DIR, and there was no increase in the inter-rectum distance at any assessment point, providing safety for this group and making Pilates and other exercises viable. Furthermore, the study used randomization, evaluator blinding, and intention-to-treat analysis, ensuring greater scientific rigor and reliability of the results.

Conclusion

The results of this study found that intervention with the Pilates Method reduced supraumbilical diastasis recti and improved abdominal muscle function in women with diastasis recti. There was no increase in inter-rectum distance, as demonstrated in clinical practice, with women of various ages treated. No significant impact was identified on pelvic floor complaints. However, further studies could expand the use of Pilates in women with diastasis recti, evaluating the effect of the Method in treating diastasis recti.

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