

Effectiveness of Pilates-based exercises on the diastasis recti abdominis in climacteric women: a randomized controlled trial

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ABSTRACT

Introduction: Recent studies have related the climacteric period with changes in connective tissue elasticity that may be related to diastasis recti abdominis. Mat Pilates is a method of exercise without impact that currently has more practitioners, due to its satisfactory results. However, there are no studies that evaluate the effectiveness of mat Pilates for women with diastasis recti abdominis. **Objective:** To evaluate the effectiveness of the mat Pilates program in climacteric women with diastasis recti abdominis. **Methods:** This randomized single-blinded clinical trial evaluated climacteric women with diastasis recti abdominis. The participants were randomized into the experimental group, which participated in 3 weekly sessions of mat Pilates for 12 weeks for a total of 36 sessions, and the control group (without exercises). The inter-rectus distance was measured with a digital caliper. The G*Power Version 3.1.9.2. software was used for the sample calculation, and the SPSS 20.0 program was used for statistical analysis. **Results:** The study comprised 21 women, including 10 in the control group and 11 in the experimental group, with mean ages of 54.3 ± 7.1 and 55.3 ± 6.0 years and body mass index values of 28.8 ± 5.5 kg/m² and 29.9 ± 4.48 kg/m², respectively. In the experimental group, reductions were observed in all the measures related to diastasis recti abdominis ($p < 0.05$) in the supraumbilical, umbilical, and infra-umbilical regions. **Conclusion:** The mat Pilates method is effective for reducing diastasis recti abdominis in the climacteric period.

Keywords: climacteric; clinical trial; exercise therapy; personal health services; exercise movement techniques; rectus abdominis; women's health.

INTRODUCTION

Diastasis Recti Abdominis (DRA) is characterized by the separation of the rectus abdominis muscle along the linea alba (supraumbilical, umbilical, and supraumbilical regions) and can lead to a mechanical deficit, resulting in a reduced force production capacity of the abdominal musculature¹. Despite the cosmetic implications among women, important functions may be negatively impacted, such as posture, support of the abdominal viscera, and trunk and pelvic stability². DRA has also been associated with pelvic floor dysfunctions³. With regards to the lack of consensus about the risk factors

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for the development of DRA, higher age, increased body mass index, and parity have been proposed⁴. Spitznagle et al.³ found that 65.13% of menopausal women had DRA.

Although surgical treatment for DRA is well established in the literature⁵, physical exercise has recently been under investigation as an excellent therapeutic alternative⁶. Many techniques and treatments are employed, such treatments frequently include abdominal exercises⁷. However, no gold standard exercise program is available for DRA, and most studies have been conducted during the gestational or postpartum period without specific exercise techniques⁸. Within the different options of therapeutic physical exercise, we will focus on the practice of Pilates given its beneficial effect on the health outcomes of women, minimal impact, and few contraindications⁹. Pilates-based exercises are currently in use for several rehabilitative purposes: improving isokinetic torque of the knee extensors and flexors, postural balance¹⁰, physical fitness and reducing the risk of falls in the elderly¹¹, rehabilitation, improving quality of life in patients with postmenopausal osteoporosis¹², pelvic floor muscle function¹³, and low back pain treatment¹⁴.

The Pilates method is based on six basic principles: concentration, control, centering, fluidity, precision, and diaphragmatic breathing⁹. The core, also called the “Powerhouse” according to the Pilates method, includes the abdominal muscles, low back muscles, hip extensors, hip flexors, and the pelvic floor muscles. The exercises can be performed on specialized equipment (i.e., equipment-based Pilates) or the ground using a mat with body weight serving as resistance (i.e., mat Pilates)¹⁵. Mat Pilates is a method of exercise that has been increasing in popularity among practitioners due to its beneficial effects. We conducted this study using mat Pilates based on accessibility to a larger number of participants, as equipment was not required.

Although some clinical trials have been published in the last years describing the role of mat Pilates in patient improvement¹⁶, no articles were found in the researched databases (PubMed[®] and Scielo), that mat Pilates may be effective in the treatment of DRA in the climacteric period. Given the high prevalence and negative effects of DRA and the potential positive effects of mat Pilates, researching the effectiveness of an exercise program such as the mat Pilates method to improve DRA among climacteric women is important.

This study aimed to investigate the effectiveness of mat Pilates in climacteric women with DRA.

METHOD

Trial design

This prospective, single-blinded, randomized clinical trial with 12 weeks of follow-up was registered in the Brazilian Registry of Clinical Trials (RBR-2cfy62) in 2016. Ethical approval was

provided by the Human Ethics Committee of Centro Universitário Sagrado Coração (UNISAGRADO) and by the Declaration of Helsinki. Written informed consent was obtained from all the participants (explaining each stage of the research and whether they agreed to participate in the study even with the possibility of being allocated to a control group). This study followed the statement and guidelines of the Consolidated Standards of Reporting Trials (CONSORT).

Participants and randomization

The study was conducted at a private physiotherapy clinic in Ourinhos, São Paulo, Brazil, between January to July 2017. Participants were recruited through advertisements on websites, newspapers, and social media. The inclusion criteria were as follows: female, aged 50 to 65 years; a diagnosis of DRA in at least one region (supraumbilical, umbilical, and supraumbilical regions); not having practiced pilates before; considered active according to the International Physical Activity Questionnaire (IPAQ- short form); and the ability to understand simple instructions (Mini-Mental State Examination with a minimum score of 20). The participants also agreed not to engage in any other type of physical activity during this study. The exclusion criteria were history of fracture, hormone replacement therapy, severe osteoporosis, abdominal hernia surgery, inflammatory, rheumatic, or neurological disorders, failure to complete the Mini-Mental State questionnaire, and being considered inactive according to the IPAQ-short form. To preserve the accuracy of the intervention, participants who failed to attend 90% of the sessions were excluded from the study.

The participants were randomly assigned, using a computer-generated table of random numbers (<https://www.randomizer.org/>) to the control group (CG) or the experimental group (EG). The randomization schedule was performed by a researcher who was not involved in the recruitment and treatment of the participants. All participants were evaluated before the intervention and after 12 weeks of intervention by a blinded assessor.

Intervention

A mat Pilates-based intervention comprising a total of 16 exercises was designed to improve overall muscle strength, emphasizing the musculature related to DRA. The exercises chosen were adapted and planned specifically for the study. Three weekly sessions lasting 60 minutes each for 12 weeks with at least 1 day between sessions (a total of 36 sessions). All sessions were supervised by 4 experienced Pilates-certificated physiotherapists. The participants were informed about the principles of the method that must be respected during the execution of each exercise. Blood pressure and cardiac frequency measurements were obtained before and after the sessions. Sixteen Pilates exercises were divided into five steps, with 10 repetitions for each exercise and 30-second rest

intervals between each set of repetitions. Trunk rotation exercises were initially avoided because the shear force of contraction of the oblique muscles can strain the abdominal fascia, increasing the separation of the rectus abdominis muscle and consequently exacerbating DRA¹⁷. Therefore, these exercises were incorporated into the intervention after the 24th session. The materials used were mats, swiss balls, and dumbbells (Table 1).

The control group received no intervention and only verbal instructions about DRA and its risk factors.

Outcome measures

All participants were assessed before the intervention and 12 weeks after the randomization by a blinded assessor who did not know which group each participant had been allocated.

The physiotherapists and participants were not blinded due to the characteristics of the intervention. The outcome of the present study was the occurrence of women diagnosed with DRA after 12 weeks of intervention. The participants' socio-demographic and questionnaire information were reported before the intervention. Clinical data, including age, weight, height, body mass index (BMI), and abdominal circumference (cm) 2 cm below the umbilicus were collected at baseline and 12 weeks after randomization.

To measure DRA, the inter-rectus distance was quantified with the women in dorsal decubitus with the knees and hips flexed, feet resting on the bed, and arms along the body. Three regions were demarcated with a tape measure and a dermatographic pencil: the supraumbilical region (4.5 cm above the umbilical scar), the umbilical region, and the infraumbilical region (4.5 cm below the

Table 1: Pilates-based group exercises program

	Exercise	Function	Muscle
1° - Spine stretching and/or mobilization exercises	01- Spine Stretch Forward	Spine mobilization, knee flexors stretching and trunk extensors.	Biceps femoris, semitendinosus, semimembranosus, and erector spinae
	02- Saw*	Flexor knee stretching, trunk extensors, and trunk lateral flexors.	Biceps femoris, semitendinosus, semimembranaceus, erector spinae, oblique external and internal abdomen
	03- Rocking on stomach	Stretching of the horizontal shoulder flexors, trunk flexors, and knee extensors	Larger and smaller pectoralis, anterior deltoid, anterior serratus, external and internal oblique abdominal rectus, and femoral quadriceps
2° - Flexors, extensors, and lateral flexors strengthening exercises	01- Hip Flexion Front	Trunk flexor muscles strengthening	Rectus abdominis, external and internal abdominal oblique, tensor fascia lata, and rectus femoris
	02- Teaser	Trunk flexor muscles strengthening	Rectus abdominis, external and internal abdominal oblique, tensor fascia lata, and rectus femoris
	03- The Hundred*	Trunk flexor muscles strengthening	Rectus abdominis, external and internal abdominal oblique, tensor fascia lata, and rectus femoris
	04- Single Leg Stretch	Trunk flexor muscles strengthening	Rectus abdominis, external and internal abdominal oblique, tensor fascia lata, and rectus femoris
	05- Double Leg Stretch	Trunk flexor muscles strengthening	Rectus abdominis, external and internal abdominal oblique, tensor fascia lata, and rectus femoris
3° - Lumbopelvic stabilization exercises	01 Side Kick: Front and Back	Lumbopelvic stabilizers and hip flexors strengthening.	Transverse abdominis, multifidus, pelvic floor, iliopsoas
	02 Leg Circles	Lumbopelvic stabilizers and hip internal and external rotator strengthening.	Transverse abdominis, multifidus, pelvic floor, tensor fascia lata, piriformis, hip adductors
	03 Leg Pull Front	Stabilizing muscles of the lumbopelvic region and trunk extensors strengthening	Transverse abdominis, multifidus, pelvic floor, erector spinae
	04 Bridge with extended MMII variation interleaving	Stabilizing muscles of the lumbopelvic region and trunk extensors strengthening	Transverse abdominis, multifidus, pelvic floor, erector spinae
4° - Upper and lower limb exercises	01 Wall Slide	Knee extensor and flexor muscles, hip extensors, and shoulder flexors strengthening.	Femoral quadriceps, biceps femoris, semine, semimembranate, gluteus maximus and deltoid
	02 Side Kick	Hip adductor muscles strengthening	Long adductor, adductor magno, short adductor pectineus and gracilis
	03 Arms Forward	Elbow flexor muscles strengthening.	Biceps Brachii
	04 Shaving	Elbow extensor muscles strengthening	Triceps brachii
5° - Relaxation exercises	01 Relax I	Relaxation Exercises	Trunk extensors muscles relaxation: spinal erectors
	02 Relax III	Relaxation Exercises	Trunk and shoulders flexors muscles relaxation: rectus abdominis, internal and external oblique, pectoralis major, and serratus anterior

*Exercises introduced after the 24th session

umbilical scar)¹⁸. Then, the woman was asked to perform anterior flexion of the trunk until the lower angle of the scapula was off the bed. The examiner palpated the limits of the medial borders of the rectus abdominis muscles and positioned the digital caliper (Digital Caliper 150 MM 6 Inches - Zaas). For each region, the mean of 3 consecutive measurements was considered the final measurement. The measurements were performed by only one trained evaluator.

The digital caliper has high intra- and inter-rater reliability¹⁹ and can be used in the diagnosis of DRA when ultrasonography is not available²⁰. The results in millimeters were transformed into centimeters (10 mm = 1 cm) and DRA is diagnosed when the abdominal inter-rectus distance value is equal or greater to 1.5 cm in the supraumbilical region, 2.7 cm in the umbilical region, and 1.4 cm in the infraumbilical region for women over 45 years of age²¹.

Sample size

The sample size calculation was performed using G*Power Version 3.1.9.2. software. The clinical outcome (i.e., DRA) was selected for the sample size calculation based on Chiarello’s study²², which considered differences in diastasis between groups of 4.81 cm ± 2.36 cm at α=0.05 and β=0.90 with a two-tailed hypothesis test, resulting in at least 7 participants required per group.

Statistical analysis

SPSS version 20.0 was used to analyze the data. The Shapiro-Wilk normality test was applied to determine the normality of the data. For characterization of the sample, Student’s t-test was performed for variables with a normal distribution, and the Mann-Whitney test was used for variables with a non-normal

distribution. Since the data presented a non-normal distribution, Mann-Whitney tests were used for the intergroup analysis, and intragroup comparisons (pre-treatment/post-treatment and post-treatment) were performed with the Wilcoxon test with Bonferroni correction. Background variables are reported as means with standard deviation or numbers with percentages and the level of significance was set at 5%.

RESULTS

Figure 1 shows a flow diagram regarding the eligibility, allocation, follow-up, and analysis of the participants. The baseline characteristics of the sample concerning race, educational level, marital status, age, BMI, waist circumference, and gestation number are provided in Tables 2 and 3. In the IPAQ questionnaire, all participants were classified as minimally active (5 or more days of moderate-intensity activity or walking for at least 30 minutes per day). The groups were homogeneous.

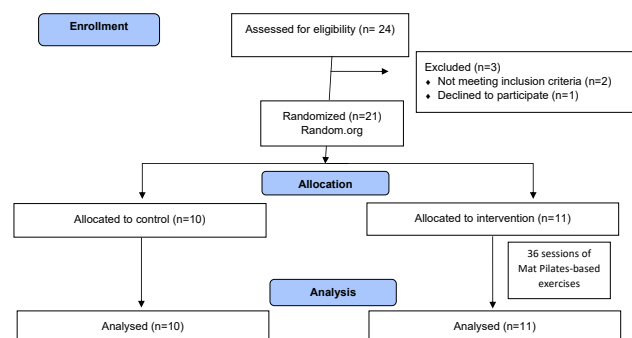


Figure 1: Flow diagram of participants

Table 2: Characterization of Control and Experimental Group participants

		Control %(n)	Experimental
Race	White	80% (8)	100% (11)
	Black	20% (2)	54.5% (6)
Educational level	High school incomplete	80% (8)	-
	High school complete	20% (2)	18.2% (2)
	University degree incomplete/complete	-	27.3 % (3)
Marital status	Married or cohabitant.	60% (6)	63.3% (7)
	Single. divorced or widows	40% (4)	36.6 (4)

Table 3: Anthropometric and clinical measures of Control and Experimental Groups

	Control (CG)	Experimental (EG) (p
Age(years)	54.3±3.1	55.3±4.0	0.716
Body mass index (kg/m²)	28.8 ±5.5	29.9 ±4.48	0.600
Abdominal circumference (cm)	95.1 ±12.2	97.6 ±9.85	0.605
Number of pregnancies	1.6± 0.69	1.8±0.4	0.605

Means with standard deviations (SD).

Outcomes

The pre-and post-intervention DRA values of the supraumbilical, umbilical, and infra-umbilical regions are described in Table 4. For the statistical interpretation of the data, comparisons between pre-intervention and post-intervention measurements in control and experimental groups were performed by the paired Wilcoxon test, revealing significant differences in the supraumbilical, umbilical, and infra umbilical measurements ($p < 0.05$) in the experimental group. Comparisons of pre-intervention and post-intervention measurements between the control group and the experimental group were performed with the Mann-Whitney test and revealed differences in the supra-umbilical, umbilical, and infra-umbilical regions ($p < 0.05$) in the post-intervention experimental group.

DISCUSSION

The results provide evidence that DRA was significantly reduced in the supra umbilical, umbilical, and infra umbilical regions after 36 sessions of mat Pilates compared with that in the control group. No studies are currently available regarding DRA in climacteric women.

DRA occurs frequently during pregnancy and regresses spontaneously after childbirth in most women. However, diastase was found in 33% of women 12 months after delivery²³. Bo et al. found no difference between vaginal delivery and cesarean section about DRA²⁴. In the present study, the samples were also homogeneous and did not differ in terms of parity. Spitznagle et al.³ were the first authors to document that more than 50% of menopausal women presented DRA, suggesting that if DRA is not treated surgically or through exercise throughout life, it may persist due to changes in the elasticity of connective tissue during the aging process. Therefore, DRA should be investigated beyond the gestational and postpartum periods.

Sarcopenia (i.e., loss of skeletal muscle mass and strength) is accelerated in women around the time of menopause²⁵. Pilates promotes muscle strengthening¹⁰ and has been proven to be a popular,

acceptable, and effective treatment approach in older women²⁶. In addition, it has been proposed that resistance training induces adaptations to contractile and passive muscle components including collagen synthesis²⁷. The abdominal muscles play a key role in posture, trunk stability, pelvic and respiratory function, trunk movements such as flexion, stretching, and rotation, and support of the abdominal viscera, and the presence of DRA compromises these functions²⁸. Some studies have observed a reduction in DRA when women engaged in exercises directed toward activation of the transversus abdominis muscle^{22,29}. Activation of the transversus abdominis muscle helps recruit abdominal rectus fibers, thus improving the integrity of the linea alba, and increasing force generation, allowing efficient load transfer and torque production²⁸. Pilates exercise has been proven to be effective in improving trunk strength, muscle strength, and postural control^{30,31}.

The exercises of mat Pilates include core activation, including the pelvic floor muscles³². Co-activation of the abdominal muscles and the muscles of the pelvic floor has been investigated in detail by researchers^{33,34}, and because of this synergism, the abdominal muscle function associated with DRA will affect the performance of the pelvic muscles³. However, one study showed that women with DRA during gestational and postpartum periods did not have a higher prevalence of urinary incontinence or pelvic organ prolapse compared to the control group³⁵. Mesquita et al.³⁶ evaluated the effectiveness of abdominal exercises and pelvic exercises in DRA performed six and 18 hours postpartum with measurements taken before and after 18 hours of intervention. The intervention group had a mean decrease in DRA width of 0.44 cm (13%) compared with the control group, which had a mean decrease in DRA width of 0.17 cm (5%) and did not engage in physical activity. Furthermore, Walton et al.³⁷ determined whether a significant difference existed between a six-week experimental core stability plank program and a traditional supine exercise program in reducing DRA in nine postpartum women and concluded that both the traditional and experimental groups showed significant reductions in DRA measurements.

Table 4: Diastasis Recti Abdominis values (cm) of supraumbilical, umbilical, and infra umbilical measures of the control (CG) and experimental (EG) groups pre- and post-intervention of 36 sessions.

	Pre intervention	Pos's intervention	p
DRA –Supraumbilical Control (CG)	2.12(1.25-3.02)	2.17(1.38-3.24)	0.280
DRA –Supraumbilical Experimental (EG)	2.82 (0.50-3.21)	0.89(0.10-1.12)	0.004*
p (control x experimental) (CGxEG)	0.438	0.000**	
DRA – Umbilical Control (CG)	3.08(2.35-4.41)	3.12(2.54-4.45)	0.059
DRA – Umbilical Experimental (EG)	3.08(1.39-4.73)	1.08(0.84-1.54)	0.003*
p (control x experimental) (CGxEG)	0.805	0.000**	
DRA – Infraumbilical Control (CG)	2.94(1.45-3.19)	1.66(0.11-3.38)	>0.999
DRA – Infraumbilical Experimental (EG)	1.75 (1.44-3.13)	0.76(0.28-1.03)	0.003*
p (control x experimental) (CGxEG)	0.170	0.017*	

Values expressed in median (minimum-maximum). DRA – Diastasis Recti Abdominis. * $p < 0.05$; ** $p < 0.001$

Although DRA is a common clinical problem, little is known about its prevention or treatment³⁸. Regarding DRA prevention, Benjamin's review concluded that compared with non-exercising groups in two studies^{22,39}, prenatal exercise reduced the presence of DRA by 35%, with the results revealing that for every three pregnant women treated with exercise, one woman would be prevented from developing DRA³⁸. Gluppe et al.⁸ evaluated the effect of a 16-week postpartum exercise program on the prevalence of DRA immediately after cessation of the intervention and at a 12-month postpartum follow-up. Unlike our study, the exercise protocol was designed to strengthen the pelvic floor muscles, but the program also contained strengthening exercises for the abdominal, back, arm, and thigh muscles, stretching, and relaxation. The authors concluded that the exercise program did not reduce the prevalence of diastasis⁸.

Some challenges in studying DRA include the lack of standardization among studies regarding reference points for measurements, the instruments used for measurements⁴⁰, and the reference values for diagnosis.

The exact location for measurement is also controversial; however, measurements 4.5 cm above and below the umbilical scar are most common in recent works³⁵. The greatest lack of consensus concerns the criteria used to diagnose DRA. Distances vary between 2.5 cm⁴ and 3 cm (consider two fingers)³⁵ and one study²¹ specified different values for each region depending on age; below 45 years of age, 1.0 cm in the supra umbilical region, 2.7 cm in the umbilical region and 0.9 cm in the infraumbilical region constitute the diagnostic criteria, and above 45 years of age, the values change to 1.5 cm in the supra umbilical region, 2.7 cm in the umbilical region, and 1.4 cm in the infraumbilical region.

Limitations and strengths

The present study demonstrates the effectiveness of mat Pilates exercises in reducing DRA in climacteric women.

The strengths of the study are the randomized and blinded design, the sample size calculation, the homogeneity among the groups, the inclusion criterion of only women with DRA, the high adherence of the participants, and the objective measurements of the inter-rectus abdominal distance performed by only one trained and blinded evaluator with a digital caliper, which is considered the gold standard measurement tool in the absence of ultrasonography⁴⁰.

As a limitation, although the sample was defined after sample size calculation, further trials with larger sample sizes and different nationalities are required to confirm and generalize our results. Moreover, the inter-rectus abdominal distance should be measured using ultrasound as it is considered a reliable method when performed by trained and experienced personnel⁴⁰.

We found only one study³ in the databases reporting DRA in menopausal women and several related articles regarding DRA in the gestational and postpartum periods, thus limiting comparisons with the literature. The result of the current study refers to the long-term consequences of DRA and is not only restricted to the postpartum period.

Recommendations for clinical practice

This study may primarily serve physiotherapists who collaborate with climacteric women and seek conservative alternative exercises for the treatment of DRA.

Conclusion

Our study is the first to provide evidence that DRA declined significantly after performing exercises based on the Mat Pilates method. Further studies might broaden the focus on extending follow-up periods to evaluate whether the changes observed in the current study indicate recovery in the long term. Therefore, physiotherapists can use these exercises for climacteric women in clinical practice.

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