

Functional improvements after a pilates program in adolescents with a history of back pain: A randomised controlled trial



Noelia González-Gálvez^a, Pablo J. Marcos-Pardo^a, María Carrasco-Poyatos^{b,*}

^a Department of Physical Activity and Sport Sciences, Universidad Católica San Antonio de Murcia, Campus de los Jerónimos, 30107, Guadalupe, Murcia, Spain

^b Department of Education, Research Center in Health and Public Administration, Universidad de Almería, Carretera Sacramento s/n, 04120, La Cañada de San Urbano, Almería, Spain

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ABSTRACT

Background: and purpose. Trunk endurance and extensibility are the main physical condition factors related to back pain. The goal was to analyse the effectiveness of a 6-week Pilates programme on trunk endurance and extensibility in adolescents with a history of back pain, determining the influence of sex.

Materials and methods: Fifty-two students with a history of back pain were randomly assigned to the Pilates group (PG; n = 26) or the control group (CG; n = 26). Trunk flexion (BTC test) and extension (SOR test), and hamstring extensibility (TT test) were measured.

Results: PG improved significantly BTC, SOR, and TT test. Statistical differences ($p = 0.005$) were found between the PG and the CG for the SOR test.

Conclusion: The Pilates programme enhanced trunk endurance and extensibility in adolescents with a history of back pain. Trunk flexor endurance was better in the PG. Results were not influenced by sex.

1. Introduction

The prevalence of back pain among schoolchildren aged 9–19 years is growing across the world [1], and it is now similar to that of the adult population (33.6%–40.8%) [1–4]. Back pain during the adolescent years is a precursor to chronic back pain in adulthood [4,5], and it is the first cause of disability in the world [6]. In addition, gender is a factor that has a bearing on pain. Among adolescents, females have a higher prevalence of back pain (38.9%–44.5%) than males (35%–36.8%) [2,3].

There are three fitness factors that are mainly associated with back pain: mobility of the hip and lumbar region in the sagittal plane, trunk muscular endurance, and frontal and lateral flexions of the spine. Several studies have associated back pain with low trunk flexor [5,7] and extensor [8] endurance as well as hamstring extensibility in adolescents [7–9]. In addition, it has been shown that trunk endurance and extensibility are different between sexes and are moderately determined by genes [5,7,8,10].

The Pilates method has been demonstrated to be an effective physical technique for reducing back pain [11]. This technique focuses on body conditioning by stretching and strengthening muscles to improve flexibility, muscular endurance, strength, coordination, and balance [12]. Among exercises, Pilates is unique because it begins with an

activation of the deep abdominal and lumbar muscles (abdominal transverse, internal oblique, and lumbar multifidus) [13], and this musculature is especially related to trunk stability [14].

In this regard, most of the studies evaluating the influence of the Pilates method on trunk strength and flexibility have been focused on adults with back pain or a history of back pain [15–18]. Only two studies [19,20] have assessed the effect of the Pilates method on the trunk strength and flexibility of healthy adolescents, and only one has compared the results by gender [20]. Therefore, it is relevant to implement this physical technique on adolescents with a history of back pain and to determine the differences between genders, in order to improve their functionality and quality of life.

Following the results of previous studies, the purpose of the present study is to analyse the effectiveness of a 6-week programme on trunk endurance and extensibility in adolescents with a history of back pain, while determining the influence of sex.

2. Materials and methods

2.1. Design

The present research was a 6-week randomised controlled trial in which adolescents with a history of back pain were randomly assigned

* Corresponding author.

E-mail addresses: ngonzalez@ucam.edu (N. González-Gálvez), pmarcos@ucam.edu (P.J. Marcos-Pardo), carrasco@ual.es (M. Carrasco-Poyatos).

to a Pilates group (PG; $n = 26$) or a control group (CG; $n = 26$). The trial design followed CONSORT guidelines and was registered with [ClinicalTrials.gov](https://clinicaltrials.gov) (identifier: NCT03609554; available from <https://clinicaltrials.gov/ct2/results?cond=&term=NCT03609554&cntry=&state=&city=&dist=>).

2.2. Participants

A total of 176 students were contacted. The participants were students in grades 2 to 4 from Ginés Pérez Chirinos secondary school in Murcia (Spain). The inclusion criteria were (a) history of back pain in the past year and (b) physically active in school physical education sessions. The exclusion criteria were (a) presenting any musculoskeletal, neurological, cardiological, metabolic, or rheumatic alteration at the moment of the measure and (b) missing more than one session of the programme. History of back pain in the past year was defined as having back pain during the past year that hampered or limited activities at school or during leisure time for more than 3 months. All parents and/or guardians signed an informed consent, and the study was approved by the Scientific and Ethical Committee of the institution.

2.3. Interventions

The PG received a Pilates exercise program implemented over 6 weeks, with 2 sessions/week (55 min/session). Adolescents assigned to the CG did not receive any structured exercise programme but attended their usual physical education sessions.

The Pilates programme was developed at school and was conducted by the physical education teacher, who was certified in Pilates training. The Pilates programme began at the basic level, incorporating more difficult principles and exercises gradually. The sessions were divided into the warm-up, the main part, and the cool down. The warm up was 7 min long (12.73%). It concentrated on basic Pilates exercises involving the principal regions of the body (spine flexions, extensions, and rotations; hip flexions, extensions, and rotations; and shoulder abductions, adductions, and rotations). The cool down was 7 min long (12.73%) and concentrated on stretching exercises and flexibility. The main part was 41 min long (74.54%).

The Pilates method exercise protocol is described in Table 1, following the example used in Patti et al. [21]. During the first 6 sessions, the main parts were based on proper breathing and integration of the principles of the Pilates method. A repertoire of basic exercises was used (the hundred, half roll-up, one-leg kick and double-leg kicks, swimming, shoulder bridge, hip lift, hip lift with abdominal preparation, rolling like a ball, leg stretching, double-leg stretching, one-leg circles, mid-back bending). In the following 4 sessions, the teacher developed basic to intermediate exercises and incorporated the concept of correct placement (criss-cross, double-leg circles, front support, lateral support, the seal, swimmer, superman, cat stretch, the hundred, half roll-up, shoulder bridge, and two-leg stretching). The last two sessions served to consolidate all the knowledge acquired, and participants practiced the variety of exercises learned. Additional materials were not used to implement the exercises. Representation of the exercises is provided in Fig. 1.

The CG received their typical physical education session. They performed endurance and strengthening exercises based on running, strength circuits, plyometrics, or sport/cooperation games.

The adolescents did not participate in any other physical activity or rehabilitation program during the intervention.

2.4. Outcomes

Body mass was measured using a SECA 762 scale (SECA, Germany) and height using a GPM anthropometer (Siber-Hegner, Switzerland). Body mass index (BMI) was calculated with the Quetelet index formula ($BMI = \text{weight [kg]} / \text{height [m]}^2$).

The bench trunk curl (BTC) test was used to evaluate trunk flexor endurance. This test was chosen because of its safety; it protects the back and isolates the abdominal musculature in contrast to other isometric tests, avoiding hip flexor muscle involvement. Its reliability and validity have been demonstrated in other studies (women: $R = 0.94$; men: $R = 0.88$) [22], showing a moderate correlation with the Cybex trunk extension flexion machine ($r = 0.50$) [22], and it was used in previous investigations with school populations [20,23,24]. The subject was placed in a supine position with the legs on top of a chair 46 cm in height. The knees and hips remained at a 90° angle. The arms were crossed over the chest, with each hand grasping the elbow of the opposite arm. The subject performed a curl of the trunk so that the forearm touched the front of the thigh and finished the movement by touching the scapula again to the ground. The subject repeated this movement for 120 s to ensure the endurance quality of the test. A specific cadence was not set. The number of complete cycles was annotated [22].

Isometric trunk extension endurance was measured using the Sorensen (SOR) test. Its validity (global result: $r = 0.685$; iliocostalis lumborum pars thoracis: $r = 0.710$) [25] and reliability (intraclass correlation coefficient [ICC] = 0.860) [23] have been established in previous studies. It was also used in previous research with adolescents [20,26,27]. This test was chosen to ensure the isolation of the trunk extensor musculature, in contrast to other dynamic tests [28,29]. Moreover, taking into account the stability of the adolescent's spine, the endurance-strength measurement is more adequate than the maximum or explosive trunk strength [30]. The subject was placed in a prone position on the examination table with the superior border of the iliac crests aligned with the edge of the table. The lower part of the body was held by an auxiliary. With arms crossed behind the back, the subject was asked to keep the upper part of the body in a horizontal position until he or she could no longer support the position. The total number of seconds was annotated [23].

The toe-touch (TT) test was used to evaluate hamstring extensibility. The TT test was selected instead of the sit-and-reach test because there is a high correlation between them ($r = 0.96$) [31], and researchers considered the TT test easier to administer. It also has high intraobserver (0.89–0.99) and interobserver reliability [32,33]. The participants stood on the measuring drawer, with knees extended and feet placed shoulder-width apart. The subject performed the maximum flexion of the trunk without knee flexion, with the arms and palms extended over the drawer rule. The zero of the rule coincided with the surface of the drawer. Values that were above the surface of the drawer were considered negative, and those that remained below were positive. The record was scored in centimetres. Values between -5 cm and -12 cm were categorized as hamstring shortness type I (moderate decrease in hamstring extensibility), and values lower than -12 cm were categorized as hamstring shortening type II (high decrease in ischium extensibility) [34].

Every test was conducted by the same examiners in a single session, either in the pre- or in the posttest. These tests were performed without a previous warm-up, between 10:00 and 14:00 h, with bare feet and at random. The laboratory temperature was standardized at 24°C . There was a 5-min rest between measures. To establish the reliability of the examiners before the measurement, a double-blind study was performed using the assessment protocol with 30 participants, and an ICC higher than 95% coefficient interval was obtained.

2.5. Sample size and power

Calculations to establish the sample size were performed using Rstudio 3.15.0 software. The significance level was set at $\alpha = 0.05$. According to the standard deviation established for the SOR test in previous studies [20,26,27] and an estimated error of 4 s, a valid sample size for a confidence interval of 95% was 50. A total of 52 students completed the trial. The final sample size for each group in our

Table 1
Pilates method exercises.

Exercise	Time, min	Repetitions	Objectives and hints
Warming up: breathing exercise, mobilization pelvis and principal joints	10		Pelvis retroversion and anteversion, raquis flexion, extension, rotation and tilt, mobilization of the joint
The hundred	5	2 sets × 50 reps with 2 min of recovery between sets	Strengthening the abdominals, torso stability, and breathing cycle
Half roll-up	5	2 sets × 12 reps with 2 min of recovery between sets	Strengthening the abdominals and torso stability
One-leg stretch	5	2 sets × 12 reps with 2 min of recovery between sets	Strengthening the abdominals, torso stability, mobilization of the hip, and hamstring flexibility
Two-leg stretch	5	2 sets × 12 reps with 2 min of recovery between sets	Strengthening the abdominals, torso stability, neck strengthening, mobilization of the hip, and hamstring flexibility
One-leg kick	5	2 sets × 6 reps (each leg) with 2 min of recovery between sets	Back and glute muscle strengthening and breathing cycle
Double-leg kicks	5	2 sets × 12 reps with 2 min of recovery between sets	Back and glute muscle strengthening and breathing cycle
Swimming	5	3 sets × 15 s with 1 min of recovery between sets	Back muscle strengthening and breathing cycle
Shoulder bridge	5	3 sets × 5 reps with 1 min of recovery between sets	Back muscle strengthening, spine mobilization, hamstring flexibility
Hip lift	5	2 sets × 6 reps with 2 min of recovery between sets	Strengthening the abdominals, torso stability, neck strengthening
Hip lift with half roll-up	5	2 sets × 6 reps with 2 min of recovery between sets	Strengthening the abdominals, torso stability, neck strengthening
The seal	5	2 sets × 5 reps with 1 min of recovery between sets	Abdominal muscle strengthening and self-massage of the spine
One-leg circle	5	2 sets × 5 reps (each leg) with 2 min of recovery between sets	Abdominal muscle strengthening and hamstring flexibility
Double-leg circle	5	2 sets × 5 reps with 2 min of recovery between sets	Abdominal muscle strengthening and hamstring flexibility
Roll like a ball	5	2 sets × 5 reps with 1 min of recovery between sets	Abdominal muscle strengthening and self-massage of the spine
Criss-cross	5	2 sets × 12 reps with 2 min of recovery between sets	Strengthening the abdominals, torso stability, neck strengthening, mobilization of the hip, and hamstring flexibility
Front support	5	3 sets × 20 s with 1 min of recovery between sets	Strengthening the abdominals and back muscle, torso stability, and breathing cycle
Lateral support	5	2 sets × 20 s (each side) with 1 min of recovery between sets	Strengthening the abdominals and back muscle, torso stability, and breathing cycle
Superman	5	3 sets × 15 s (each side) with 1 min of recovery between sets	Strengthening the abdominals and back muscle, torso stability, balance, and breathing cycle
Cat stretch	3	5 reps	Stretching back muscle and relaxing
Mid-back bending	3	5 reps	Stretching back and hamstring muscle and relaxing
Breathing exercise and relax: breathing exercise, mobilization pelvis and principal joints	5		Recovery of the initial status

min = minutes; rep = repetitions; sec = seconds.

study (PG = 26, CG = 26) provides a power of 94% if between and within a variance of 1.

2.6. Randomisation and blinding

A simple randomisation method (Microsoft Excel 2016) was used to allocate participants to the PG or CG. The research staff distributed participants into groups following the initial evaluation order. Because of the difficulty of blinding participants in the exercise trials, only research staff performing the assessment and statistical analysis were blinded to the group assignment.

2.7. Statistical methods

Statistical analysis was performed using the statistical package SPSS 21.0 for Windows. After analysing the normality of variables (Kolmogorov-Smirnov test), one-way analysis of variance was used to analyse the pretest measures. The post hoc test was evaluated for statistical significance (Bonferroni test for parametric and Mann-Whitney *U* test for nonparametric variables). The repeated-measures analysis of covariance was adopted to investigate the interaction between groups and time following three dependent variables: the BTC test, SOR test, and TT test. Sex was included as a covariable. An error of $p \leq 0.05$ was established.

3. Results

A total of 122 students did not meet the inclusion criteria. Therefore, 54 students were enrolled in the study. One participant in each group was not followed up.

Therefore, a total of 52 adolescents participated in the analysis. Fig. 2 illustrates the protocol distribution. The PG group had 100% attendance. Characteristics of the sample at baseline are shown in Table 2. There were significant changes for the BTC, SOR, and TT test in the PG at the end of the intervention, accompanied by nearly perfect, very large, and large effect sizes, respectively (Table 3). There were significant differences between groups (PG/CG) in the BTC test. There was no significant influence of sex in the interaction between groups for the BTC, SOR, and TT test. These results are shown in Table 4. The data set is available at <http://hdl.handle.net/10835/6112>.

4. Discussion

In the present study, there were significant improvements in trunk flexor and extensor endurance and hamstring extensibility in the group of adolescents with a history of back pain who practiced Pilates for 6 weeks. Moreover, the PG was better regarding trunk flexor endurance than the CG. Sex had no influence on the results.

The significant improvements in trunk flexor and extensor

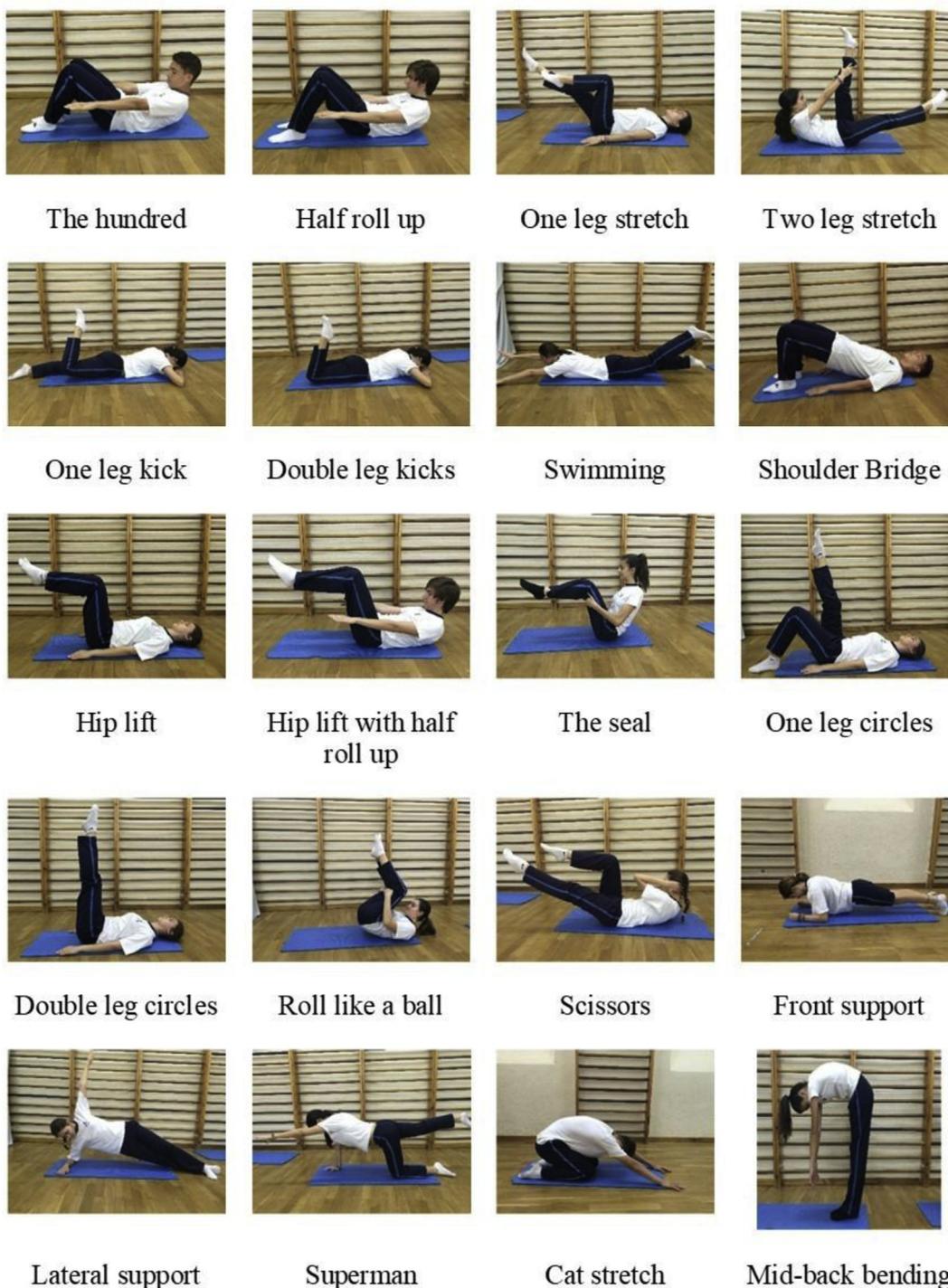


Fig. 1. Pilates Method exercises.

endurance found in the PG were accompanied by a nearly perfect effect size in the BTC test ($ES = 0.93$), a high effect size in the SOR test ($ES = 0.67$), and a moderate effect size in the TT test ($ES = 0.49$). This highlights the stronger effect of Pilates exercises on trunk muscle endurance than on muscle flexibility. This is also accordance with Pilates principles, which are centred principally on the activation of trunk stabilizer muscles to prepare the body to develop every routine exercise [35]. Nevertheless, the range or motion produced in Pilates exercises is also effective in improving hamstring extensibility.

Therefore, Pilates exercises could be recommended for improving either muscle endurance or flexibility in adolescents with a history of

back pain. In this regard, the effects of practicing Pilates on these variables have been studied in adults with a history of back pain. Samples of adults 40–45 years of age and Pilates programmes of 6–16 weeks long (1–2 sessions/week, 45–60 min/session) [15–18] have been used. Along the same lines as the present study, improvements were found in trunk extensor endurance measured with an isokinetic dynamometer [16] and in hamstring extensibility measured with the seat-and-reach test [17], a goniometer [18], or the TT test [15]. This means that the Pilates method is a good physical strategy for improving trunk endurance and flexibility in people with a history of back pain, independent of age.

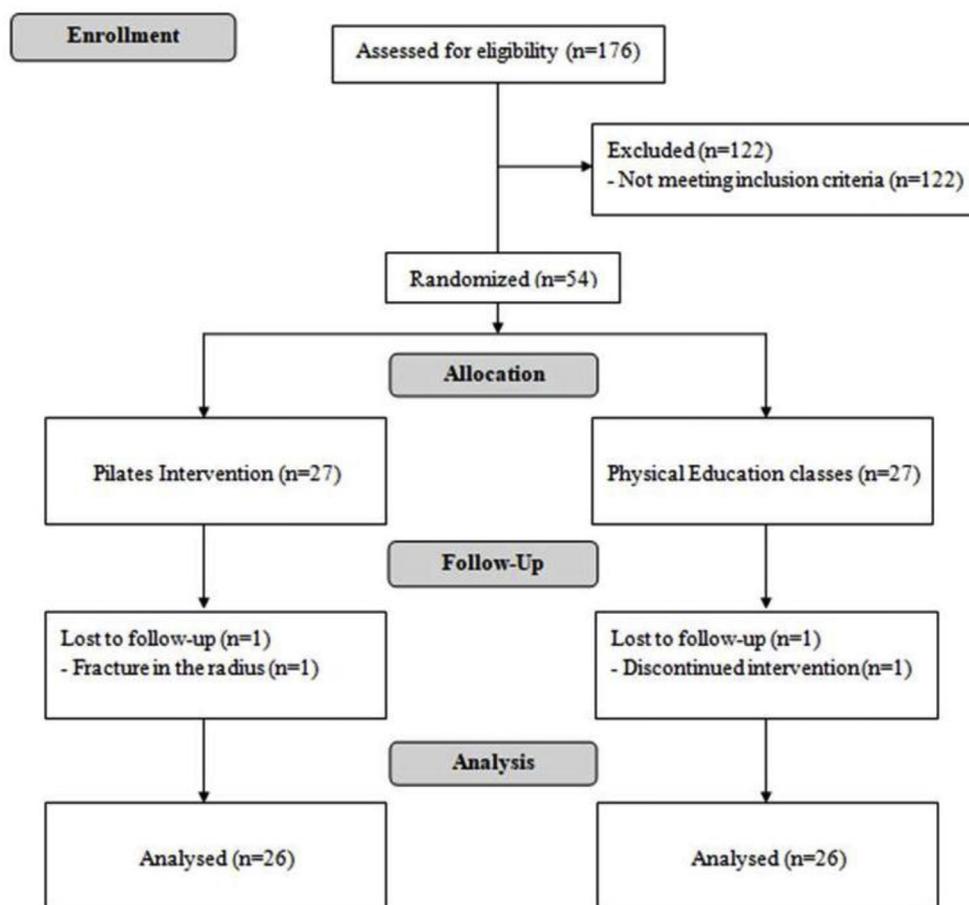


Fig. 2. CONSORT flow diagram.

Table 2
Characteristics at baseline.

Variable	Mean	SD	Min	Max
Age (years)	14.12	0.40	14.00	16.00
Height (cm)	166.85	8.00	152.00	186.00
Weight (kg)	66.09	13.30	44.70	105.00
BMI (kg/m ²)	23.66	4.00	17.03	32.77

SD = standard deviation; Min = minimum; Max = maximum; cm = centimeters; kg = kilograms; BMI = body mass index; kg/m² = kilograms divided by the square of the height in meters.

The statistical difference in trunk flexor endurance between the PG and the CG was also found in another study in which adults with a history of back pain participated in a 16-week exercise program and were measured with an isokinetic dynamometer [16]. However, in that article, there were also statistical differences in trunk extension

Table 3
Differences in pre- and posttest for the BTC, SOR, and TT tests on each group (PG and CG).

Test	Group	Preintervention (Mean ± SD)	Postintervention (Mean ± SD)	p-Value	ES	Difference Post-Pre (Mean ± SD)	CI 95% (Mpost-Mpre)
BTC (rep)	PG (n = 26)	43.12 ± 20.46	62.69 ± 31.25	0.00005	0.93	19.57 ± 20.46	11.31; -27.83
	CG (n = 26)	54.92 ± 19.97	52.96 ± 19.15	0.409	0.10	1.96 ± 11.91	-6.77; 2.85
SOR (sec)	PG (n = 26)	106.08 ± 64.14	150.08 ± 67.78	0.01	0.67	44.00 ± 61.30	19.23; 68.77
	CG (n = 26)	128.94 ± 69.91	136.54 ± 74.43	0.396	0.11	8.11 ± 47.87	-11.22; 27.45
TT (cm)	PG (n = 26)	2.27 ± 7.12	5.85 ± 6.22	0.00002	0.49	3.57 ± 3.45	2.18; 4.97
	CG (n = 26)	-2.94 ± 7.32	-3.00 ± -8.47	0.93	0.01	0.06 ± 3.34	-1.29; 1.40

PG = Pilates group; CG = control group; MG = male gender; FG = female gender; BTC = bench trunk curl test; SOR = Sorensen test; TT = toe-touch test; rep = repetition; sec = seconds; cm = centimetres; ES = effect size; CI 95% = confidence interval; SD = standard deviation; Mpost-Mpre = mean of posttest minus mean of pretest.

Table 4
Differences between groups (PG and CG) for the BTC, SOR, and TT tests adjusted by sex.

Test	Group	Increment	F	p	ES	Difference PG-CG (Mean ± SD)	CI 95% (PG-CG)	Sex Effects			Group × Sex Effects		
								F	p	ES	F	p	ES
BTC (rep)	PG (n = 26)	19.57 ± 20.46	8.67	0.005	0.15	0.44 ± 0.15	0.14; 0.74	1.58	0.21	0.03	0.27	0.60	0.01
	CG (n = 26)	−1.96 ± 11.91											
SOR (sec)	PG (n = 26)	44.00 ± 61.31	0.48	0.49	0.01	13.54 ± 19.45	−25.53; 52.61	0.14	0.71	0.00	0.29	0.59	0.01
	CG (n = 26)	7.60 ± 47.87											
TT (cm)	PG (n = 26)	3.58 ± 3.45	3.46	0.069	0.06	0.16 ± 0.08	−0.01; 0.32	0.11	0.74	0.00	0.59	0.44	0.01
	CG (n = 26)	0.06 ± 3.33											

PG = Pilates group; CG = control group; MG = male gender; FG = female gender; BTC = bench trunk curl test; SOR = Sorensen test; TT = toe-touch test; rep = repetition; sec = seconds; cm = centimetres; p = signification; ES = effect size; CI 95% = confidence interval; SD = standard deviation; F = distribution.

The main point of the current study was to analyse the effects of Pilates in adolescents with a history of back pain, taking into account the influence of sex. However, the results should be considered in light of certain limitations. The small sample of 52 adolescents limits the capacity to extrapolate the results. Moreover, uneven distribution of males and females and the nonblinding of participants and intervention instructors affected the internal validity. The present research contributes relevant results regarding the adolescent population, and this analysis should lead to more research to confirm our findings.

5. Conclusion

This 6-week Pilates exercise programme is effective for improving trunk flexor and extensor endurance as well as hamstring extensibility in female and male adolescents with a history of back pain. These adolescents had better trunk flexor endurance than those who performed only the exercise of the physical education classes. Sex did not determine the test results in any group.

Recommendations for future research include increasing the sample size and including the variable sex in the randomisation to analyse differences between sexes. The influence of Pilates exercise programs in adolescents with back pain also needs to be assessed, because to our knowledge, it has not been demonstrated in this population.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ctcp.2019.01.006>.

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