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The Effect of Pilates Method in Scholar's Trunk Strength and Hamstring Flexibility: Gender Differences

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Abstract**—**Musculoskeletal injuries in school children could be reduced improving trunk strength and hamstring flexibility. Low levels of trunk muscle strength and hamstring flexibility may result in acute and musculoskeletal chronic diseases. The Pilates Method can be appropriate to improve these physical condition attributes and has been rarely employed by this social group. On the other hand**,** it has been shown that trunk strength and flexibility are different between genders**,** but there is no evidence about the effect of exercise programs designed to improve both items in school children. Therefore the objective of this study was to measure the effect of a six-week Pilates-based exercise program in 14 year old school children trunk strength and hamstring flexibility, establishing differences in gender. The sample was composed of 57 students divided into experimental group (EG; n=30) and control group (CG; n=27). Bench Trunk Curl test (BTC), Sörensen test and Toe-touch test (TT) were used to measure dynamic muscular resistance in trunk flexion, isometric strength in trunk extension and hamstring flexibility, respectively. EG utilized the Pilates exercise program during six-weeks (2 days/week, 55minutes/session). After this period of training, EG improved trunk strength and hamstring flexibility significantly but there were no significant differences within CG. Although boys were better in BTC test and girls were better in TT test, there were no significant differences between them.

Keywords**—**Teens, school, trunk muscular resistance, intervention, physical performance, abdominal, back.

I. Introduction

THE importance of keeping optimal trunk strength and hamstring flexibility levels are related to its effect on functional stability. Low levels of both attributes have been associated with increased risk of musculoskeletal injury [1], [2]. On the contrary, maintaining optimal levels may help prevent several spine disorders [3] and back pain, and improve the ability to maintain correct posture for long periods of time and athletic performance [4]. Physical fitness, including strength, resistance and flexibility, on the one hand is moderately determined by genes and is different between genders [5], [6] on the other it is likely to be modified by physical activity. Specifically, the importance of these exercise programs in schools is due to this period of growth is the most important in life, given that it is the moment that most of the growth and development of the body occurs, and they start to strengthen the habits and customs that build the lifestyle [7], [8]. Therefore, different authors recommend developing specific exercise programs to enhance these physical qualities. However, only two research studies implement programs to improve muscular resistance of trunk flexor [9], [10], one implement a program to improve muscular resistance of the trunk extensors [9] and eight specific programs to improve hamstring flexibility [11]-[18].

The Pilates Method (PM) is a physical technique based on the whole body strength, flexibility, balance, and coordination work [19], [20]. However little research on its effects in adults are found [21]-[24] and absent in school. In addition, the development of strength and flexibility are different between genders, and their levels in our sedentary society are unhealthy [25], [26].

Our objective was to measure the effect of a six-week Pilates based exercise program in 14 year-old school children's trunk strength and hamstring flexibility, establishing differences in gender.

II. Methodology

A. Participant

The sample composed of 57 school children from a secondary school in Murcia (Spain). Participation criteria for each student included: parental consent; free of musculoskeletal, neurological, cardiac, metabolic or rheumatic conditions; actively participating in the physical education sessions and regular evaluations; and not to miss more than one session of the Pilates program (attendance of 91,66%). The sample was divided into two groups, exercise group (EG, n=30) and control group (CG; n=27). Their characteristics are showed in Table I.

TABLE I
Sample Characteristics (Mean±SD)

		CG (n=27)	EG (n=30)
Age (years)		14 ±0,0	14,23±0,6
Gender	Male	55,56%	56,67%
	Female	44,44%	43,33%
Weight (kg)		67,59±14,2	64,74±12,5
Height (cm)		167,8±7,7	166±8,3
BMD (kg/m^2)		23,94±4,4	23,40±3,6

CG = Control Group; EG = Experimental Group; Kg = Kilogram; Cm = Centimeters; BMD= Body Mass Index.

B. Materials

Before the tests were carried out and with the aim of establishing evaluator's reliability, a double-blind assessment with 30 subjects was developed. The intraclass correlation index obtained in all tests was over 95. All trials were performed two times in a two-week interval.

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All tests were implemented by the same evaluator. They were performed without previous warming up and with the participants barefooted.

1. Height and Weight

Height and weight were measured using a Seca 220 medical scale with a measuring rod.

2. Bench Trunk-Curl Test (BTC)

This test was used to measure abdominal muscle resistance [27]. The participants laid on a supine position with the legs resting on a 0.46 cm high chair. Hip and knees were bent at 90º. The arms were crossed over the chest and hands were holding the opposite arm's elbow (Fig. 1). In this position, the participant was asked to perform a trunk curl, touching the front part of the tight with the forearm (Fig. 2). Then, the movement should be finished going back to the floor, touching it with the scapula. This cycle should be conducted by the participant as many repetitions as possible during 120 seconds. The number of complete cycles was registered.

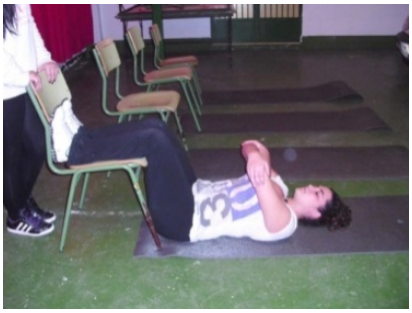

Fig. 1 BTC Test. Starting position

Fig. 2 BTC Test. Final position

3. Sörensen Test

This test was used to measure isometric trunk extensor muscles strength [28].

The participant laid down in a prone position over an examining table with the arms folded across the back. An assistant helped to hold the lower body against the examining table. The participant was asked to maintain the upper body in a horizontal position, aligning the upper edge of the iliac crests with the edge of the table, until they could not hold the position any longer. The test should be stopped at 240 seconds (Fig. 3).

Fig. 3 Sörensen Test

4. Toe-Touch Test (TT)

This test measures hamstring flexibility. To perform the test, the participant stood over a box with knees and feet shoulder width apart. They performed a maximal trunk flexion without bending the knees and with arms and palms outstretched over the ruler of the box (Fig. 4). The zero-point was in line with the edge of the box. Values above the zero-point were considered negative, while those below it were positive. All measures were registered in centimeters (cm). We consider normal values those higher or equal to -5 cm. Values between -5 cm and -12 cm were considered as having hamstring shortness type I, and values lower than -12 cm where considered having hamstring shortening type II [29].

Fig. 4 Toe-touch test

C. Exercise Program

Exercise program based on Pilates Method was developed for the EG during six-weeks. Two sessions per week of 55 minutes each were performed [30]. It was integrated on physical education sessions. The control group continued with their regular PE sessions. All children attended at least 91.66% of the sessions, so that no more than one day was missed by any of the students.

The Physical Education teacher conducted the PM sessions. Prior to the PM program beginning several appointments were arranged in order to determine the exercises that would be

performed during the sessions and to ensure their correct implementation.

Participants started working at a basic level and gradually more complex exercises were incorporated. Sessions were divided into warm-up, main activity and cool down. The main activity had a total duration of 41 minutes, accounting for 74.54% of the session, representing the bulk of the PM exercises. The first six-sessions were an introduction for breathing methods, integration the PM principles and a repertoire of basic exercises (supine spine twist, hundred, abdominal preparation or half roll-up, one and double leg kick, swimming, shoulder bridge, half flexion back sitting, hip raise, hip raise with abdominal reparation, rolling like a ball, one leg stretch, double leg stretch, one leg circles and sidekick over extended arm). The following four-sessions included basic-intermediate exercises and the concept of a correct segmental placement was developed. The last two sessions were useful to consolidate the acquired knowledge and all learned exercises were put into practice.

The cooling-down had seven-minute duration, focusing on stretching and flexibility exercises.

D.Data Analysis

After confirming all variables had a normal distribution, we carried out a descriptive analysis. A t-test for paired samples was used to determine possible changes between groups. To establish correlations between different variables from each group, the Pearson's r correlation coefficient were used. The t-test for independent samples was employed to determine differences in the same variable between groups. The statistical analysis was performed with the software SPSS 15.0 for Windows. The significance level was set at $p < 0.05$.

III. Results

In EG boys and girls improved significantly the mean scores in the three tests (Table II). Males improved their trunk strength (BTC test) 20,76 repetitions, and females 13,54 repetitions. Isometric trunk extension was enhanced 55,71 seconds in boys and 3,61 seconds in girls. Hamstring flexibility was improved 6,12 centimeters by boys and 6 centimeters by girls. However, no statistical differences between genders were observed.

CG participant results followed the same line, finding no statistical differences between genders in the tests. Moreover, there were no statistical improvements after 6 weeks.

IV. Discussion and Conclusions

Our results show that a six-week pilates exercise program is effective improving trunk strength and hamstring flexibility in adolescent. However, there were no gender differences.

Our findings are different from other specific six-week trunk strength and hamstring flexibility exercise programs in school children [9], [11]. Moreover, exercise programs with longer duration and frequency (32 weeks, 3 sessions/week) obtained similar [12] or lower results [13] compared to our study.

TABLE II
Result of Trunk Strength and Hamstring Flexibility in Pre- and Post-Test According to Group and Gender (Mean±SD)

	EG		CG	
	Boys	**Girls**	**Boys**	**Girls**
BTC				
Pre	71,07±38,4	41,58±19,1	65,36±38,2	38,00±16,3
Post	88,18±39,5*	61,92±30,6*	56,93±27,8	34,00±12,9
Sörensen				
Pre	144,20±69,8	152,69±72,5	149,50±54,3	115,83±32,3
Post	181,04±59,7*	184,89±63,4*	115,00±48,2	113,33±39,8
TT				
Pre	-2.19±8.5	4.62±9.9	-8.93±5.75	1.00±5.66
Post	1.19±8.14*	8.47±8.4*	-8.87±5.86	1.13±7.29

*Significant Differences Regarding Pre-Test (P< 0,01)

Mayorga et al. [10] and Moreira et al. [9] found a significant increase of 8% in adolescent abdominal muscle resistance after a six and eight weeks specific abdominal program, respectively. Despite the methodology similitude respecting our exercise program, we can say that Pilates brings better results in this abdominal resistance, as we obtained improvements of 34,03%.

With regard to isometric back strength, our results are still higher than Moreira et al. [9]. After their abdominal exercise program they found an isometric back strength improvement of 8%. Using the same test and applying a similar methodology, the Pilates Method showed a 35,03% improvement.

They are 8 studies assessing a program of IMF finding all positive results [9], [11]-[15], [17], [18].

Other specific hamstring flexibility exercise-based studies using similar tests (seat and reach, toe touch, 90/90 or EPR) have found different results. Improvements of 7 cm and 1,86 cm after 32 weeks of training [13], [17], and 2,7 cm and 3,4 cm after six-weeks of training [9], [11]. Our Pilates exercise program produced greater gains in hamstring flexibility than those previously described. But this fact may be due to the gender.

In our study, both boys and girls enhanced their trunk strength and hamstring flexibility after the Pilates exercise program. Boys showed higher abdominal scores in trunk flexion, and girls, higher hamstring flexibility before the Pilates program. However we can't assure these differences. With a higher sample, these results may be clarified.

We cannot make a comparison in this regard with the studies reviewed as these do not make a distinction between genders. However, it is described that gender influences physical condition [31]-[35]. Some studies show an improvement in the superior overall performance in women than in men after exercise programs, but this is usually due to the relatively higher initial level of men in the parameters of fitness. Males are generally closer to the maximum potential level.

Most studies have shown equal response of the exercise program over men and woman [36]. This similarity in the evolution in gender indicates that the PM could be a valid technique for application in school conditioning when subjects

are mixed and will be equally beneficial for both sexes. However more research may be necessary to compare our results.

V. Conclusions

After a six-week Pilates exercise program, adolescents improved significantly trunk strength and hamstring flexibility without gender differences.

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