Original Article

The conditioning of the trunk muscles and back health in Physical Education

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ABSTRACT

Background. The search for scientific arguments for the inclusion of back health as a fundamental aspect in the contents of physical conditioning for health in Physical Education (PE) in schools has led us to search for the relationship between the resistance of trunk musculature and non-specific low back pain in 1st year compulsory secondary education (CSE) students. Methods. Three tests were used: the front bridge (FB) test, the dominant side bridge (SB) test, and the modified Biering-Sorensen test (BS). The Nordic questionnaire was used to assess back health. Results. The prevalence of low back pain in boys was 58.3% (n = 42), while in girls it was 52.7% (n = 39) with no statistically significant differences. In the general sample, the students who had lower levels of muscular resistance of the trunk were associated with poor back health, while the students with better results were associated with good back health values. Conclusions. The resistance levels of the trunk musculature can be associated with the level of back health in 1st year CSE students. At these ages there are no large differences in the level of core resistance strength between sexes thus facilitating inclusive work in PE.

Keywords: Muscular endurance; Core; Non-specific low back pain; Secondary education; Health education.

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INTRODUCTION

Back health is a major problem for citizens, health systems and social welfare systems. This implies indirect economic costs recognized by the United Nations and the World Health Organization through their support for the Bone and Joint Decade 2000-2010 (Woolf, 2000).

Currently, it is estimated that the prevalence of non-specific low back pain (NSLBP) in children and adolescents over the course of their lives is high, and may vary between 7% and 72% (Jeffries, Milanese, & Grimmer-Somers, 2007), the average being 39.9% (Calvo-Muñoz, Gómez-Conesa, & Sánchez-Meca, 2013). It has been reported that between the ages of 10 and 14, from the end of the primary education stage to the beginning of compulsory secondary education, the prevalence of LBP increases significantly (Fairbank, Pynsent, Van Poortvliet, & Phillips, 1984; Korovessis, Koureas, & Papazisis, 2004; Leboeuf-Yde & Kyvik, 1998). However, there are few studies on the adolescent population (Miñana-Signes, Monfort-Pañego, & Rosaleny-Maiques, 2019), most of the works on the prevention and treatment of back problems have been directed towards the study of the adult population, with very few dealing with back health in children and young people (Miñana-Signes, 2017).

In the Valencian Community, a study carried out with a sample of 1500 secondary and high school students aged between 12 and 18, showed a prevalence of LBP over the course of their lives of 44.5%, and an LBP prevalence of 36.9%. at age 13 Girls recorded a significantly higher level of LBP (50.3%) than boys (38.9%) (Miñana-Signes & Monfort-Pañego, 2015).

Research does not indicate that the causes of these back problems are related to the weakness of the trunk musculature, nor are they due to problems in the development of its stabilizing function. An inadequate level of strength of the back stabilizing muscles could be considered as a risk factor for LBP in the school population (Salminen, Erkintalo, Laine, & Pentti, 1995). Spinal instability, induced by a weakness of the musculature, causes an imbalance in the osteo-articular system that could trigger the appearance of low back pain (Sjolie & Ljunggren, 2001). Several papers found associations between a low level of strength and the development of LBP in children and adolescents (Astfalck, O'Sullivan, Straker, & Smith, 2010; Bernard et al., 2008; Bo Andersen, Wedderkopp, & Leboeuf-Yde, 2006; Johnson, Mbada, Akosile, & Agbeja, 2009; Johnson, Olubusola Esther et al., 2011; Jones, Stratton, Reilly, & Unnithan, 2005; Lee et al., 1999; Mulhearn & George, 1999; Salminen et al., 1995; Sjolie & Ljunggren, 2001) Controlled and random studies (Ahlqwist, Hagman, Kjellby-Wendt, & Beckung, 2008; Jones, Stratton, Reilly, & Unnithan, 2007) related an improvement in the resistance of the flexor and extensor muscles of the trunk with the reduction of LBP in adolescents, and consequently there were positive effects on the back health of the participants.

Exercise programs for the development of trunk stability are indicated as appropriate means for the prevention of back problems and the improvement of functional capacity and motor performance (Borghuis, Hof, & Lemmink, 2008). These are common in the field of physical education, and in sports medicine, fitness and amateur and professional sports. Allen, Hannon, Burns, & Williams (2014) studied the effects of a simple routine for conditioning core (central) musculature in school-age children using tests such as dynamic trunk extension in parallel Roman chair, prone plank, side plank, and static and dynamic stretching. The results suggested that it might be useful for children and adolescents to carry out high-intensity dynamic core exercises during the warm-up phase of Physical Education classes to improve the strength and endurance of the trunk musculature.

On the other hand, and in order to enhance abdominal muscles through safe, fun exercises, it was shown that motor games can produce levels of electrical activity equal to or greater than those achieved using traditional, more monotonous abdominal exercises (Vera-García, et al., 2005). Exercises involving doing wheelbarrows, roly polies, the tunnel, chicken fights and the hula-hoop turned out to be an effective educational resource for conditioning abdominal muscles (Vera-García, et al., 2005b; Vera-García, et al., 2005).

All these studies are aimed at assessing the effectiveness of conditioning programs for prevention; however, few studies focus on the relationship between the strength of the trunk muscles and back health. There are studies that analysed the resistance levels of the trunk muscles and revealed no significant differences between a group of healthy adolescents and a group with lumbar problems (Balague, Damidot, Nordin, Parnianpour, & Waldburger, 1993; Bernard, et al., 2011; Feldman, Shrier, Rossignol, & Abenhaim, 2001; Merati, Negrini, Carabalona, Margonato, & Veicsteinas, 2004). The need to associate back health to the fact of having a suitable condition of the trunk stabilizing musculature leads us to consider the objective of this study, to evaluate the level of resistance of the trunk musculature with central stability exercises in a sample of adolescents in their first year of compulsory secondary education (CSE) and its relationship with low back pain.

MATERIAL AND METHODS

Study design

The research is based on a cross-observational study design, using a convenience sample.

Participants

The study population (N = 26590) was made up of 1st year CSE students from the city of Valencia during the 2017-2018 school year. Specifically, the field tests were collected during the month of October 2017.

The initial sample consisted of a total of 196 1st year compulsory secondary education (CSE) students from two secondary schools (SS) in Valencia. 140 students attended secondary school No. 1 (the large one) and 56 students attended SS No. 2 (the smaller one)

In the end, 168 (85.71%) students participated with a confidence level of 95% and a margin of error of ± 7.5%. A total of 127 students from SS nº1 and 41 from SS nº2. The average age of the students was 12.16 (SD = 0.474). With regard to gender, 86 girls (51.2%) and 82 boys (48.8%) participated.

Selection criteria

1st year CSE adolescent students aged between 12 and 13 from two secondary schools in the city of Valencia were selected.

The exclusion criteria were not returning the consent form signed by their parents. Not attending on the day when the field tests or written test (Nordic questionnaire) took place. Having some form of impairment which made it impossible to do the test as indicated in the protocol.

Measures

Nordic or low back pain questionnaire

This is a questionnaire that includes 10 questions about low back pain (its duration and symptoms) in adolescents (Kuorinka et al., 1987). Using it, students are classified into two groups, one made up of subjects

without low back pain and the other of those with low back pain. The questionnaire includes a drawing indicating where the lower back is, and asks questions such as, have you ever had problems (pain, unease, discomfort) in the lower back unrelated to a blow or menstrual pain? (lifetime prevalence of low back pain). Thus, the lifetime prevalence of low back pain was defined as the proportion of the sample that had experienced an episode at some time in their life. It is a solid, widely-used instrument with high reliability and reproducibility, and it has been validated in other languages (de Barros & Alexandre, 2003).

Field test

Trunk muscle strength tests, which measure the retention time of a specific posture, are often used as tools for assessing trunk function (Allen et al., 2014).

To obtain the resistance level of the trunk or core musculature, 3 tests were used. The normal protocol for these tests consisted of:

- The researcher explaining to the students that they had to statically maintain a position for as long as possible, while providing them with verbal guidelines in order to get into the correct, valid position to start the test. When the student was in the correct position, the investigator started the test and the stopwatch.
- The test ended when: (1) the participant got tired or voluntarily stopped the test; (2) the participant could not maintain the correct position; (3) the participant mentioned some adverse effects of the test (for example a headache, dizziness, pain not associated with fatigue, etc.), or (4) the investigator noticed signs indicative of adverse effects on the student.
- The maximum duration of the tests was 180 seconds. After this time, the test ended.
- Repetitions. Each student had to take the test 3 times, with a 3-minute break between repetitions.
- There were also 3-minute breaks between tests.

The isometric resistance of the trunk flexor muscle was evaluated by means of the front bridge test or "*prone forearm plank test*" (Strand, Hjelm, Shoepe y Fajardo, 2014). The resistance of the inclined muscle or the lateral flexors of the trunk was evaluated by the dominant lateral bridge test (McGill, Childs y Liebenson, 1999). The modified Biering-Sorensen test (Biering-Sorensen, 1984) was used to assess the resistance of the trunk extensor muscle. Modified means that the original Biering-Sørensen test was used with small variations, e.g., the participant's body was held by two other participants rather than the belts used on a traditional wooden gym bench.

The resistance level of the trunk or core musculature was calculated by adding the scores, in seconds, obtained in the three tests (Imai & Kaneoka, 2016).

Procedures

The questionnaires and the field test were carried out during physical education classes. Five researchers were needed to perform the field test.

All students voluntarily participated in the study. The heads of the centres and the parents were informed about the study in writing and gave their consent. The study was also accepted by the Ethics Committee in experimental research from the University of Valencia.

Analysis

Data analysis was performed using the SPSS® IBM® software, r. 24. First, for the analysis of the study sample, a descriptive analysis was carried out, calculating the mean, standard deviation and median of the

quantitative variables, as well as the frequency and percentage of the qualitative variables. The intraclass correlation coefficient was used to study the reliability of the use of the tests by the researchers. To study the equivalence of the groups in the quantitative variables, the Mann-Whitney test was applied for two independent samples. The chi-square test was applied to analyse the relationship of the group with the qualitative variables (LBP). The level of significance for all comparisons was set at 5%.

RESULTS

Descriptive analysis

Based on the analysis of the descriptive statistics, it was seen that the characteristics of age, weight, height, BMI, perception of health status and smoking were similar for all participants.

Back health levels

Regarding lower back problems, it was noted that the frequency was slightly higher in boys (58.3; n = 42) than in girls (52.7; n = 39) but with no statistically significant differences.

Intra-observer and inter-observer reliability

An excellent intra-observer and inter-observer agreement was achieved for the standardized method of measuring the level of muscular endurance of the trunk. The agreement between evaluators was ICC = .998 (95% CI: .994 - .999). All the evaluators had an inter-evaluator reliability classified as excellent (ICC > .95).

Descriptive analysis of the resistance level of the trunk musculature

After the analysis of the three field tests on the level of resistance of the trunk musculature, it was noted that the test which provided the best results was the Biering-Sorensen test (trunk extensor muscles), the second best test was the front bridge test (trunk flexor muscles), and in third place was the lateral bridge test (trunk lateral flexor muscles) for both girls and boys (Table 1).

As can be seen in Tables 1 and 2, boys generally recorded higher muscle resistance scores than girls; however, statistically significant differences were only observed in the lateral bridge test (Table 2).

Relationship between the level of back health and the field tests

In the general sample (n = 146), without separating the sample based on gender, the students without back problems had better resistance strength results than the students with low back pain, showing statistically significant differences in all field tests (Table 3)

In Table 4, it can be seen that there was a statistically significant difference between all the scores of the trunk muscle strength test and the prevalence of lumbar pain throughout life (low back pain), with the exception of the BS test for the boys. In all the field tests, the group of girls and the group of boys with no lumbar problems obtained better muscular- resistance scores than the students with low back pain (Table 4).

Table 1. Descriptive data and percentiles on the level of muscular resistance of the trunk for the different genders.

		FB	SB	BS	CORE
Girls	N	86	86	86	86
	X	56.16	33.45	93.20	208.73
	SD	30.298	16.558	49.154	96.969
	Percentiles				
	10	25.70	14.47	33.50	108.00
	20	31.80	18.00	56.00	133.00
	30	38.03	21.40	63.10	149.00
	40	46.40	26.80	69.60	176.00
	50	51.25	32.67	78.50	201.50
	60	56.00	35.13	100.70	224.80
	70	66.83	40.55	114.80	250.80
	80	72.50	47.43	130.00	276.00
	90	95.10	56.40	180.00	321.60
Boys	N	82	82	82	82
	X	65.110	43.64	99.81	231.26
	SD	35.776	22.414	50.890	96.873
	Percentiles				
	10	27.97	18.85	40.30	126.30
	20	39.00	26.20	58.40	144.20
	30	45.00	30.97	73.90	162.80
	40	49.47	34.10	82.20	189.40
	50	54.50	38.92	95.00	206.50
	60	59.80	43.00	113.40	245.80
	70	74.23	48.05	138.50	278.20
	80	94.40	64.30	164.00	305.80
	90	108.70	75.18	180.00	374.10

N: sample size; X: average; SD: standard deviation; FB: front bridge test; SB: side bridge test; BS: Biering-Sorensen test; CORE: sum of the three field tests.

Table 2. Differences in the level of resistance of the trunk muscles between genders (Mann-Whitney test).

	Girls			**Boys**			**Mann-Whitney test**		
	N	ME	SD	N	ME	SD	U	Z	p
PF	86	51.52	30.298	82	54.50	35.776	3024.0	-1.593	.111
PL	86	32,67	16.558	82	38.92	22.414	2593.0	-2.961	**.003**
BS	86	78,50	49.154	82	90.00	50.890	3284.0	-0.769	.442
CORE	86	201.73	86.969	82	206.50	96,873	3098.0	-1.358	.174

N: sample size; ME: medium; SD: standard deviation; U: Mann-Whitney statistic; z: contrast statistic; p: level of critical significance; FB: front bridge test; SB: side bridge test; BS: Biering-Sorensen test; CORE: sum of the three field tests. Bold: statistically significant differences.

Table 3. Relationship between the prevalence of low back pain throughout life and the field tests in the general sample (Mann-Whitney test to study differences between groups).

		N	X	SD	Me	z p
FB	No	65	70.3564	32.80769	62.6667	-4.044
	Yes	81	52.0947	28.75833	47.5000	**0.000**
SB	No	65	44.3897	20.60010	42.3333	-3.190
	Yes	81	34.5988	18.92964	33.0000	**0.001**
BS	No	65	110.8179	51.61431	106.0000	-2.557
	Yes	81	87.5350	47.46480	78.0000	**0.011**
CORE	No	65	250.45	88.315	246.00	-3.684
	Yes	81	199.01	87.254	182.00	**0.000**

N: sample size; X: average; SD: standard deviation; ME: medium; z: Mann-Whitney test contrast statistic for two independent samples; p: level of critical significance; FB: front bridge test; SB: side bridge test; BS: Biering-Sorensen test; CORE: sum of the three field tests. ***Bold****: statistically significant differences.*

Table 4. Relationship between the prevalence of low back pain throughout life and the field tests by gender (Mann-Whitney test to study differences between groups).

		Girls					Boys				
		N	X	SD	Me	z p	N	X	SD	Me	z p
FB	No	35	67.93	31.876	64.33	-3.611	30	73.19	34.187	56.00	-2.119
	Yes	39	45.50	19.740	44.00	**0.000**	42	58.22	34.245	50.67	**0.034**
SB	No	35	39.63	18.250	36.33	-2.258	30	49.94	22.065	43.00	-2.450
	Yes	39	29.91	13.236	27.50	**0.024**	42	38.96	22.280	34.25	**0.014**
BS	No	35	112.23	51.192	106.50	-2.724	30	109.17	52.930	96.00	-0.876
	Yes	39	77.42	43.411	70.00	**0.006**	42	96.93	49.614	90.50	0.381
CORE	No	35	245.31	86.570	239.00	-3.210	30	256.43	91.419	253.50	-2.119
	Yes	39	180.74	74.657	173.00	**0.001**	42	215.98	95.274	199.00	**0.034**

N: sample size; X: average; SD: standard deviation; ME: medium; z: Mann-Whitney test contrast statistic for two independent samples; p: level of critical significance; FB: front bridge test; SB: side bridge test; BS: Biering-Sorensen test; CORE: sum of the three field tests. ***Bold****: statistically significant differences.*

DISCUSSION

Similar to other previous works (Ahlqwist et al., 2008; Geldhof et al., 2007) our study shows the relationship between the prevalence of back problems or the lack of back health and the level of conditioning of the trunk muscles. Hence, our results indicate that students with a history of poor back health obtained lower results in the different trunk musculature strength tests, both in general and based on gender (Tables 3 and 4). Although we cannot say that this indicates an explicit causal relationship, this association between the level of resistance of the trunk musculature and unspecific low back pain in a sample of adolescents from the 1st course of CSE indicates that it might be a priority to include aspects related to back health from the educational perspective for this age group.

In the analysis of the difference of the three resistance strength exercises that were carried out based on gender, it was seen that (Table 2), as in other studies (Imai & Kaneoka, 2016), the boys obtained the best results in the scores in the Biering-Sorensen test, the front bridge test and the side bridge test, and consequently in the core test. However, statistically significant differences were only observed in the lateral bridge test. This could be due to the development of strength in different genders and ages. Before puberty

(10-13 years of age), strength does not develop a great deal, and there are no large differences between boys and girls. It is during puberty, and into adolescence, when the most important physical changes (weight and height increase) occur, and with this the first differences between sexes (Beunen & Malina, 2008; O'Brien, Reeves, Baltzopoulos, Jones, & Maganaris, 2010). Another explanation could be that at these ages, both girls and boys maintain similar levels of sporting activity; however, it is during adolescence (14-18 years of age) that sports habits decrease (Currie, 2008; Roman, Serra-Majem, Ribas-Barba, Pérez-Rodrigo, & Aranceta, 2008). On the other hand, it should also be taken into account that, in general, it seems that boys have a physical self-concept and sporting competence superior to girls (Moreno, Cervelló, & Moreno, 2008) and this factor can influence the results of the tests.

As an example of the application of the most important results of this study, from the data obtained in the analysis of the relationship between the level of back health and the resistance of the stabilizing musculature (Table 3), we can determine the level of core musculature resistance in relation to a criterion of the level of back health in the general sample of the study and, in this way, establish measures that allow us to find out what level of resistance they have, how this relates to back health and how our students evolve through initiatives in the classroom. Since the data behaviour is not normal, we will take the values of the median for the different sexes according to their level of health (Table 4) and we will contrast them with the descriptive values of the intervals in Table 1. According to these results, and according to the data provided by the core test, which gives us a more global value of the resistance level, we can provide information on the health of our students' backs. In the case of the boys in our study we can say that those who attain a score of 250 points or higher (Table 4), which is in the 60-70% percentile or higher (Table 1), have good back health, while those who attain scores of 199 points or less (Table 4), in the 40-50% percentile or lower (Table 1), have poor back health. In the case of the girls in our study, the core test results necessary to achieve a score that indicates good back health should reach values equal to or greater than 239 points (Table 4), this score is similar to that obtained by the boys by a few percentiles, 60-70% (Table 1), while the values that indicate poor back health, 173 points or less (Table 4), are in a slightly lower percentile interval (30-40%) to that of the boys (Table 1).

It is necessary to investigate this issue in greater depth since, contrary to expectations, females with lower resistance scores than males are not at the same levels of risk as the males. However, it has been reported that girls have a higher prevalence of low back pain and this occurs earlier than in boys (Jeffries et al., 2007). From our study, what is clear in this regard is that girls need resistance results of the stabilizing muscles similar to those of boys in order to maintain a level that has been reported to provide a high probability of having a healthy back.

With this example, and the information that emerges from the proper use of these tests, we can present and reinforce in our students the use of the concept of trunk stability and provide them with a form of assessment and evaluation of the health status of their back. leading to addressing health intervention plans to improve their level of health through programs to improve the strength and endurance of the core musculature.

Limitations

There are some limitations in this study that must be taken into account for any practical application. The results of this study cannot be generalized to younger or older populations, and future research is needed on students from diverse geographic contexts, and ethnic and socioeconomic backgrounds. In addition, the initial physical condition of the selected sample, which is known to influence physical performance tests, (Faigenbaum et al., 2009) has not been taken into account. Finally, this study presents the usual limitations

of a cross-sectional study, since no causal relationships can be established between the variables that show statistically significant relationships.

Implications for practice

According to current evidence, exercise programs could be effective in preventing low back pain (Steffens et al., 2016) and improving back health. Physical education classes provide an accessible environment for children to participate in the development of core musculature on a weekly basis (Allen et al., 2014). However, addressing the problem of back health from an educational perspective requires an approach to the problem from a global disciplinary perspective. The problems of back health education will not be solved only through physical education classes, or through endurance tests. Knowledge of the complex problem of health education, of the body, its function and its correct use, as well as an awareness of the importance of active postural and life habits, as well as their acquisition for the development of autonomous and sustainable physical activity requires delving deeper, from a scientific and educational perspective, into the problem of education for back health.

CONCLUSIONS

Resistance levels of the trunk musculature may be an indicator of the level of back health in students in the 1st year of CSE. Students with inadequate strength-resistance of the trunk muscles have poor back health. At these ages, there are no major differences in the level of core resistance strength between the sexes, and this can facilitate inclusive work in Physical Education. To clarify these conclusions, it is necessary to develop and evaluate intervention programs on back health as well as to properly train teachers to address the problem, both during the last stage of primary education and throughout secondary education.

AUTHOR CONTRIBUTIONS

Both authors contributed substantially to the conception and design of the study, the analysis and interpretation. VM performed data collection. Both authors drafted or provided critical revision of the article and provided final approval of the version to publish.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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