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Effects of a non-randomized educational intervention on knowledge, postural habits and trunk muscle endurance related to back health: A 6-month follow-up study

Vicente Miñana-Signes[1,2,] *, Manuel Monfort-Pañego[1]

[1] Body Languages Didactics Department. Academic Unit of Physical Education. Teacher Training Faculty. University of Valencia. Av. dels Tarongers, 4, 46022, Valencia. Spain.
[2] IES Ferrer i Guàrdia, Valencia, Spain.

* Correspondence: (VM-S) vicente.minana@uv.es ORCID ID nº 0000-0003-2114-1294
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Abstract: Low back pain (LBP) prevalence in children and adolescents is high during their lives. School-based interventions have reported effectiveness on back health. The study aimed to determine the effect of an educational back-health intervention on knowledge, postural habits and trunk muscle endurance regarding low back pain prevention for a group of 12 to 13-year-old students using a 6-month follow-up. A non-randomized experimental design. Three groups of 1st-grade secondary school students were selected. A control group (CG), and two experimental groups (EG1 and EG2) who participated in a back-health educational program (BHEP); only one of the experimental groups was given a follow-up learning contract (EG2). Assessments were performed at three different time points: before the intervention (baseline), after (post-test) and 6 months after (follow-up). The level of general knowledge of the experimental groups improved after the intervention. The level of postural habits improved in EG1 and EG2 compared to the CG after the follow-up period (p < .001 in both). A lower percentage of problems in the lumbar area in EG2 was observed after the 6-month follow-up. Teaching students to take care of their spines seems to have positive effects concerning knowledge, postural habits, and back health.

Keywords: adolescents, secondary school, back health, back pain, intervention, Physical Education.

1. Introduction

Low back pain (LBP) prevalence in children and adolescents is high during their lives (Hwang, Louie, Phillips, An, & Samartzis, 2019), with the average being 39.9% (Calvo-Muñoz, Gómez-Conesa, & Sánchez-Meca, 2013). In Spain, the last study on a sample of 1,500 adolescents aged between 12 and 18 from the Valencian Community detected a 44.5% prevalence of low back pain; this being higher in girls

(50.3%) than in boys (38.9%) (Miñana-Signes & Monfort-Pañego, 2015a).

Schoolchildren are exposed to several risk factors: low frequency of physical activities, insufficient strength in the trunk musculature, hamstring shortening, restriction in lateral flexion and hip range of motion, limited lumbar lordosis, psychosocial factors, extended periods in sedentary activities such as screen habits (cell phone, television, computer, tablet and videogames), carrying heavy backpacks improperly, and staying in a sitting position for long periods on inadequate furniture (Rosa et al., 2017; Sadler, Spink, Ho, De Jonge, & Chuter, 2017; Trevelyan & Legg, 2006).

Knowledge of health risks and benefits creates the precondition for change. If people lack knowledge about how their lifestyle habits affect their health, they are not likely to change these detrimental habits (Bandura, 2004). Currently, it is known that knowledge regarding components of physical fitness, certain physical activities and principles of training (Brusseau, Kulinna, & Cothran, 2011) is very poor, as is back health knowledge (Akbari-Chehrehbargh, Tavafian, & Montazeri, 2020).

The necessity of providing students with appropriate knowledge, skills and attitudes to lead to personal well-being is a goal of both Physical Education teachers (Demetriou, Sudeck, Thiel, & Hoener, 2015) and the entire educational community (Powell & Graham, 2017). Knowledge is a determining factor for the development of physical competences (Lloyd, Colley, & Tremblay, 2010).

With regard to postural habits, it is believed that volitional habits are influenced by corresponding knowledge (Brynteson & Adams, 1993). Moreover, it has been shown that back health interventions which provide knowledge increase proper postural habits in schoolchildren (Dullien, Grifka, & Jansen, 2018; Habybabady et al., 2012; Miñana-Signes, Monfort-Pañego, & Valiente, 2021). Although, knowledge per se is probably not enough to change habits (Ennis, 2007), it could be considered as the first step in the establishment of healthy habits (Keating, 2003).

Regarding muscle endurance, levels of the endurance trunk musculature may be an indicator of the level of back health in students in the 1st year of secondary school. Students with inadequate endurance of the trunk muscles showed poor back health (Miñana-Signes & Monfort-Pañego, 2020). Female dance students with LBP exhibited lower levels of endurance than students without pain (Swain & Redding, 2014). Some controlled and randomized studies (Ahlqwist, Hagman, Kjellby-Wendt, & Beckung, 2008; Jones, Stratton, Reilly, & Unnithan, 2007) related an improvement in the resistance of the trunk flexor and extensor muscles with the reduction of LBP in adolescents.

It is urgent to transfer all this knowledge to the educational context, the place where young people are trained, using effective physical activity interventions through multicomponent models (ecological teaching models), as an important part of solving health problems and the well-being of future citizens (Naylor et al., 2015). However, currently, research into back health education in the school setting has not received much attention (Bettany-Saltikov et al., 2019) and, as far as we know, guidelines to support teachers' interventions do not exist.

A recent review study of randomized controlled trials on back health interventions in school setting found that only six studies attended these criterion (Miñana-Signes et al., 2021). All of them addressed some of these contents: knowledge, postural habits and muscular endurance (Dullien et al., 2018; Habybabady et al., 2012; Hill & Keating, 2015; Vidal et al., 2011; Vidal et al., 2013). Nevertheless, none of them used student-centred methods to teach these contents along with ecological teaching models. Using these models, recent studies have shown that learning contracts can help the teacher to involve students and families in applying the classroom contents to their homes, helping students to develop self-directedness and start taking charge of their own learning (Castillo, Felip, Quintana, & Tort, 2014; Greenwood & McCabe, 2008).

For these reasons, the purpose of this research was to determine the effect of an educational back-health intervention on knowledge, postural habits and trunk muscle endurance related to low back pain prevention for a group of 12 to 13-year-old students, with and without a parents' contract, using a 6-month follow-up.

It was hypothesized that questionnaire and field test scores of the pupils who followed the program would remain significantly higher than in the control group in the short and long-term. It is also hypothesized that following a learning contract, during a 6-month follow-up period after participating in an educational back health intervention, could help to maintain the improvements in knowledge, habits, muscle endurance and LBP perception.

2. Materials and Methods

The study followed a non-randomized experimental design with a baseline-post-test and a follow-up 6 months after the intervention. Two experimental groups (EG1 and EG2) and one control group (CG) were studied.

Subjects —The study took place in the city of Valencia (Spain), which had a total population of 26,590 1st-grade secondary school (SS) students (target group) during the 2017-2018 school year. This age group was selected because non-specific LBP onset prevalence starts in 10–14 year old according to the literature (Leboeuf-Yde & Kyvik, 1998; Miñana-Signes & Monfort-Pañego, 2015a). The initial sample was made up of a total of 196 participants from two public schools chosen based on a convenience factor. The final sample consisted of 113 (57.6%) adolescents who finished the whole process (baseline, post-test and follow-up) with a 95% confidence level and a margin of error of ±9.2%. Individual randomization in school-setting intervention studies is usually not possible, hence study groups instead of individuals were randomized (Kim & Shin, 2014). There were a total of nine natural 1st-grade class-groups, six from one school and 3 from the other, which were distributed into three study groups (EG1, EG2 and CG) in each SS. The control group (CG) consisted of 22 (19.5%) participants who followed the provided program in their Physical Education lessons, it was never about back health content. Experimental group 1 (EG1), 36 (31.9%) participants, had to participate in a back-health educational program (BHEP); and experimental group 2 (EG2), 55 (48.9%) participants, had to participate in a BHEP plus a follow-up learning contract. The study flow is shown in Figure 1.

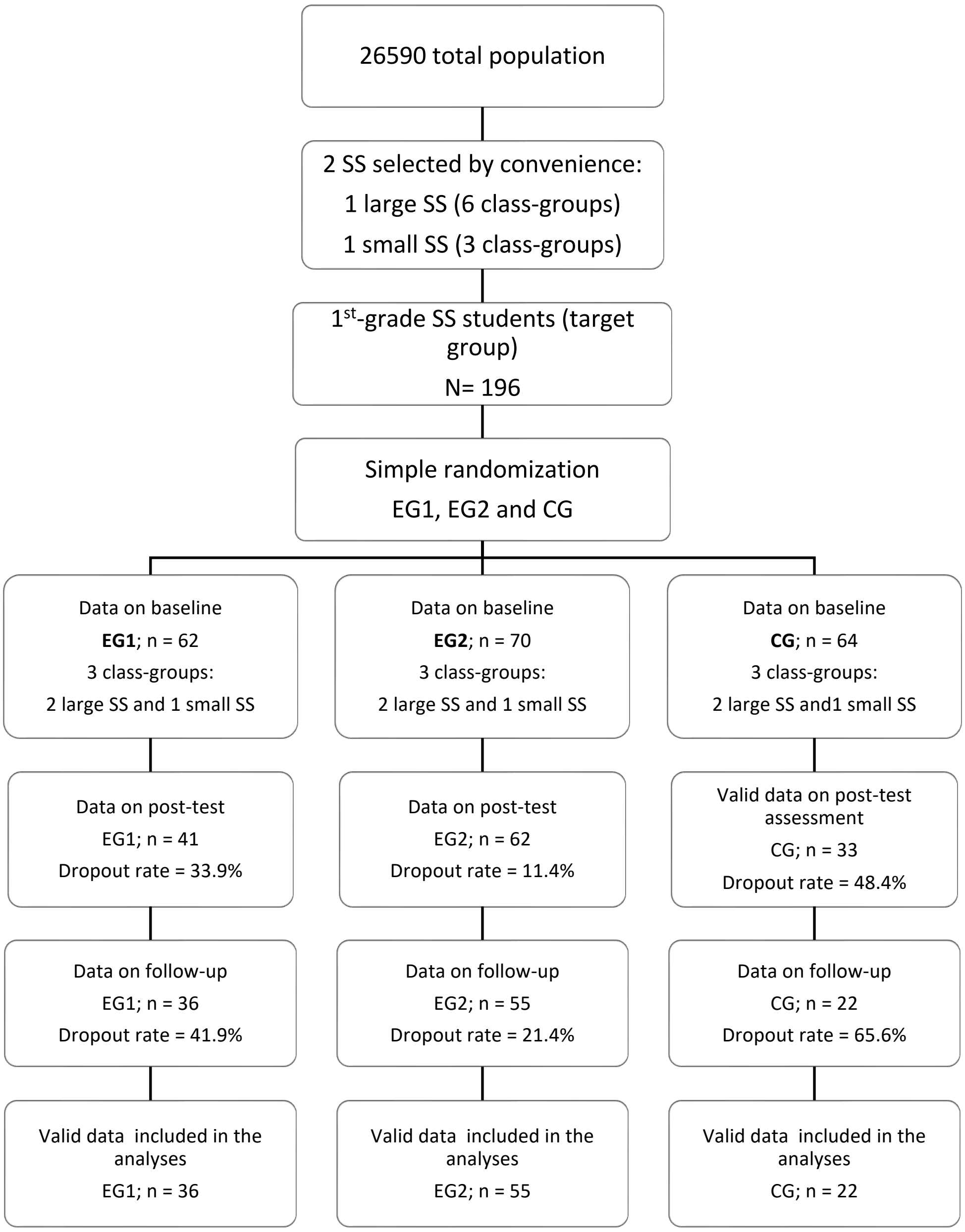

Figure 1 Study flow. EG1: experimental group one; EG2: experimental group two; CG: control group; SS: secondary school.

Ethical clearance —All the participants voluntarily participated in the study. The management of the centres, the class tutors, and the parents were informed about the study in writing and expressed their consent. The study also was accepted by the Ethics Committee in experimental research of the University of Valencia on September 6, 2017, registration number H1509086047576.

Selection criteria —The inclusion criteria followed were that the participants must be between 12 and 13 years of age and be attending the 1st-grade of secondary school education from two high schools in the city of Valencia.

The exclusion criteria were: not having returned the informed consent signed by the parents; having missed the intervention program more than twice, or not participated due to illness or disability, and not having completed all the questionnaires or field camp tests in the three registration times.

Instruments —Socio-demographic data was collected at the beginning of the administered questionnaires. Questions were asked regarding gender, age, the perception of health status and smoking. Anthropometric measurements were self-reported. The height and weight of young adults can be used to calculate BMI for weight classification purposes (Olfert et al., 2018). BMI was calculated using weight/height^2.

Nordic questionnaire: The back health of the participants was determined by the Nordic questionnaire on LBP (Kuorinka et al., 1987). It includes questions related to the duration of back pain symptoms over time, such as lifetime prevalence, during the last week, as well as in different situations. It may allow us to screen for musculoskeletal disorders in participants. The original questionnaire was used but only the questions related to the prevalence of low back pain were taken into account for the analysis. The questions used to discover the prevalence and provide the screening groups were: 1) Have you ever had problems (pain, felt unwell, discomfort) in the lower back unrelated to a stroke or menstrual pain? (Lifetime prevalence asked at baseline); 2) Have you had problems with your lower back at any time over the last 7 days? (Point prevalence asked at three different time points); 3) Have you had problems with your lower back after the intervention? (Period prevalence asked at follow-up). This questionnaire has been validated in several languages (de Barros & Alexandre, 2003).

Health questionnaire on back care knowledge concerning physical activities in daily life for adolescents (HEBACAKNOW-DL): This is a validated questionnaire (Monfort-Pañego et al., 2016) with a single construct that aims to discover the level of knowledge participants have about health and back care during daily activities. It is made up of 24 multiple-choice questions with four possible options, only one of them being correct. The score scale was from 0 to 10 points.

Health questionnaire on back care knowledge concerning practice physical activity and exercise for adolescents (HEBACAKNOW-PAE): This is a validated questionnaire (Miñana-Signes & Monfort-Pañego, 2015b) which aims to measure the degree of knowledge that young people have about health and back care related to activity and physical exercise. This questionnaire is made up of 13 multiple-choice questions with three possible options, only one of them being correct. The score scale is between -5 and 10 points.

Questionnaire on back-health-related postural habits in daily activities for adolescents (BEHALVES): This is a validated questionnaire (Monfort-Pañego & Miñana-Signes, 2020) whose scores report on the level of health of postural habits in daily life. It is made up of 31 questions, the scores of which function as a single construct. The score registered responses to a 4-point Likert scale (Never, Hardly ever, Almost always, and Always).

Field test measurements. To measure the endurance of the trunk muscle (CORE), 3 field tests were carried out before the intervention. The score scale ranged from 0 to 540 points (the sum of the three tests from 0 to 180 seconds for each test). The participants were instructed to maintain the positions as long as possible. After 3 minutes, the test ended. The tests were developed in the order explained here.

The isometric endurance of the trunk flexor muscle was evaluated by the prone forearm plank test (Strand, Hjelm, Shoepe, & Fajardo, 2014). Following a brief technique demonstration, and detailed instructions, the participants were tested individually. The test procedures were as follows: the participants assumed the forearm plank position with their elbows in contact with the ground, in such a way that the humerus formed a perpendicular line to the horizontal plane, directly beneath the shoulders. Their forearms were in neutral position and their hands were directly in front of their elbows. The participants assumed a rigid anatomical body position so that only their forearms and toes supported the body. This position is characterized by a phalangeal extension, neutral ankle position, knee and hip extension and neutral spinal position.

The endurance of the inclining muscle, or lateral flexors of the trunk, was evaluated using the dominant side bridge test (McGill, Childs, & Liebenson, 1999). This test consisted of participants lying on an exercise mat (thickness 2.5cm) on their dominant side with their legs extended and with their top foot placed in front of their lower foot on the mat for support. The participants were instructed to support themselves lifting their hips off the mat to maintain a straight line over their full-body length and support themselves on one elbow and their feet. Their uninvolved arm was held across the chest with their hand placed on the opposite shoulder.

The modified Biering-Sorensen test (Biering-Sorensen, 1984) was used to evaluate the endurance of the trunk extensor muscle. Participants lay prone with their lower body supported on the test bed at the ankles, knees and hips, and their upper body extended over one end of the edge of the test bench. Two companions held the participant's body rather than using belts on a traditional wooden gym bench. The test bench surface was approximately 25cm above the surface of the floor. The participants rested their upper bodies on the floor before the exertion. At the beginning of the exertion, their upper limbs were held across the chest with their hands resting on their opposite shoulders, and their upper body was lifted off the floor until the upper torso was horizontal to the floor.

Intervention —Back Health Education program: The intervention with the two experimental groups (EG1 and EG2) took place over a four-week period (November 2017). There were eight sessions, each one lasting 55 minutes, which occurred during the physical education classes. The control group (CG) followed the normal Physical Education class program.

The intervention was based on the guidelines of the Valencian Community Secondary Education curriculum, as well as previous scientific studies on the subject (Miñana-Signes, Monfort-Pañego, & Rosaleny-Maiques, 2019).

The sessions and contents of the back-health education programme were as follows:

1st session: Introduction and explanation of basic knowledge. Slides were used which showed: the anatomy and functions of the back; the most common pathologies of the spine; correct and incorrect postural habits; proper physical exercise for back health, and the principles of a healthy back.

2nd session: Postural awareness. Exercises on the schema and body image and strength.

3rd session: Practice of daily postural habits around a circuit. The habits worked on were: sitting, lifting objects, transporting objects, sleeping, writing, sweeping, brushing teeth, using a mobile phone, carrying a backpack, etc.

4th- 5th sessions: Group Relays. Relay races to collect cards on correct and incorrect daily postural habits (4th session) and physical exercise postures (5th session), as well as classifying them into good and bad (cooperative games).

6th session: Static and dynamic balancing. Strength games. Static and dynamic balancing games were carried out in pairs. Balancing exercises on one leg, and the Y balance test were practiced.

7th session: CORE and sports. Exercises to work the CORE muscle.

8th session: Synthesis and reinforcement session. Repeating the most important activities.

This intervention was carried out by a trained Physical Education teacher (PET). The PET used a variety of teaching styles (Mosston, 1966), but was specifically encouraged to use methodologies which are more focused on student-centreed processes (Mascolo, 2009). The proposed activities allowed the PET to act as a facilitator, guide and a co-learner, encouraging the participants to take responsibility for learning, while modelling learning processes and providing opportunities to develop learning skills (Wohlfarth et al., 2008).

Back Health learning contract: The contract consisted of applying 12 postural habits learned in the intervention in the students' daily lives (sitting, standing, lying down, carrying a backpack, lifting weight, etc.), and following a list of 12 exercises to strengthen the trunk muscle (front plank, lateral plank, hip raise, quadruped arm/leg raise, dead bug, crunch, front plank with leg raise, reverse plank, oblique crunch), as well as stretching (standing hamstring stretch, cat and camel, psoas stretch) for 20 minutes, 2 days a week. The contract detailed and explained each of the habits and exercises to be followed weekly.

Procedure —Questionnaires and field tests. The outcomes were collected through different assessment sessions, one for questionnaires and another for field tests. The experimental (EG1 and EG2) and control groups were assessed at three different time points: before the intervention (baseline), after the intervention (post-test) and 6 months after the intervention (follow-up). All the tests were carried out during Physical Education classes. A researcher, who was teacher, was required to guide the completion of the questionnaires, and five trained researchers (from the Teacher Training Faculty) were required to carried out the field tests.

The protocol guidelines for completing the questionnaires were as follows: A) The students were asked to go to the computer room. B) Each student had a computer with an internet connection set up. C) The supervisor briefly and clearly explained what the questionnaire consisted of. D) The URL to access Google Forms was provided. E) Immediate individual feedback was provided if there had been a critical error. F) Routine individual feedback was provided for self-improvement. G) Group comments were offered to focus efforts on improving the data collection process.

The protocol guidelines common to all the field tests were as follows: A) The researcher began by explaining that the participants had to maintain a static position for as long as possible and provided them with verbal cues to enable them to get into the correct, valid position to start the test. When the participants were in the correct position, the researcher started both the test and the chronometer. B) The test ended when: (1) the participant became tired or voluntarily stopped the test; (2) the participant could not maintain the proper position; (3) the participant warned of adverse effects of the test (e.g. a headache, dizziness, a pain not associated with fatigue, etc.); (4) the researcher noticed signs indicative of adverse effects on the student, or (5) the student maintained the position for 180 seconds, the maximum duration of the tests. C) Each student had to take the test 3 times with a 3-minute rest between repetitions; however, those participants who managed to maintain the position for three minutes were not required to do the test again. E) The breaks between tests were also 3 minutes. The longest time achieved in any of the three repetitions was recorded as the level of endurance.

The field test evaluations were performed by five previously trained independent evaluators (Ev1, Ev2, Ev3, Ev4 and Ev5), with each participant (10 students) being evaluated ten times over four days, twice by each evaluator. On the first day, there were two successive evaluations (Measures 1 and 2) by two evaluators (Ev1 and Ev2). The second day there were three successive evaluations (Measures 3, 4 and 5) by the last three evaluators (Ev3, Ev4 and Ev5). After a seven-day interval, the students were re-evaluated (Measures 6 and 7) by two evaluators (Ev1 and Ev2). And on the last day, the students were re-evaluated (Measures 8, 9 and 10) by three evaluators (Ev3, Ev4 and Ev5). The evaluators were research staff who received 4 hours training on the field test, which consisted of postural control, technical execution, analysis and evaluation (Chaturvedi & Shweta, 2015).

Learning contract: After the intervention program in the school had finished, we wanted to study the effects of a learning contract over a 6-month follow-up (EG2) to see if learning was maintained over a longer period after the educational intervention when a learning contract was used. This contract consisted of an agreement established between a student and the teacher. In our case, it also involved the students' parents. Therefore, a contract was delivered to each student that both the students themselves and their parents had to sign. The learning contract was monitored by the PET, via a meeting held in the PE class at the end of each month, where the participants reflected on its implementation.

Statistical analysis —The data analysis was carried out using SPSS® IBM® software, r. 26. The level of significance was set at 5%.

Firstly, quality control measures were carried out: double-checking data entry for errors, logical checks, pre-filling information and setting constraints on answer ranges. Intrarater and interrater agreement were determined by evaluating the ICC (intraclass correlation coefficient) for continuous data, according to Landis and Koch (1977). The Shapiro-Wilk test assessed the normality of distributions. One-way analysis of variance (ANOVA) tests were carried out to study group differences at baseline. The significance of the association between nominal data (gender) and LBP prevalence was established by the chi-square ($\chi 2$). Cochran's Q test was used to study the evolution of the groups over time in nominal data (students with LBP and students without LBP). The McNemar test was applied to compare the differences between pair nominal data (students with LBP and students without LBP and gender groups) obtained at different times.

The level of general knowledge variable was obtained by averaging between the two knowledge questionnaires (HEBACAKNOW-DL and HEBACAKNOW-PAE). The level of postural habits was the mean of the Likert-4 scale. The level of trunk muscle endurance (CORE) was obtained by the summation of the time of the three field tests (Miñana-Signes & Monfort-Pañego, 2020). The evolution of outcomes (general knowledge, postural habits and CORE) was explored using generalized linear model-analysis of variance for repeated measures (GLM-ANOVA-RM) with time (baseline, post-test, 6-month follow-up) as the dependent (within-subjects) variable and condition (CG, EG1 and EG2), gender and self-reported low back pain as the independent (between-subjects) variables, in order to evaluate fourth-way-interaction effects. The following assumptions were tested: (a) Independence of observations, (b) normality, and (c) sphericity. Post hoc tests using the Bonferroni correction were performed as needed. Effect sizes presented are partial eta squared, η_p^2, which were selected to facilitate comparison of effect sizes across similar studies with different designs (Cohen, 1973).

3. Results

3.1 Intraobserver and interobserver reliability

Excellent intraobserver and interobserver agreement were achieved for the standardized method of measuring the level of trunk muscle endurance. Interobserver agreement was ICC ≥ .98 (95% CI: .998-1) and intraobserver reliability was ICC ≥ .98 (95% CI: .994-1), both for the three proves and CORE.

3.2 Normality of distributions

The Shapiro-Wilk tests showed that the data, the general knowledge questionnaire (HEBACAKNOW-DL), the specific one (HEBACAKNOW-PAE), the postural habits (BEHALVES), and the average score of the three field tests (CORE), followed a normal distribution for both groups of girls and boys in the CG, EG1 and EG2 with $p > .05$.

3.3 Descriptive analysis

It was observed (Table 1) that the values of age, weight, height, and BMI were similar for all the participants in EG1, EG2, and the CG in the baseline of the study.

3.4 Generalized linear model- analysis of variance for repeated measures

The Box's test indicated that covariance matrices equality is assumed, Box's M= 68.3, F (45, 3349.3) = .1.1, p = .366. Mauchly's test showed the absence of sphericity in the post-test, W=.824, $\chi 2$ (2) = 13.14, $p < .001$. Therefore, Greenhouse–Geisser ε (ε = .85), was calculated.

3.5 Within-subject analyses/ tests per main effect and interaction

The GLM-ANOVA-RM showed significance for the time variable (baseline, post-test and 6-month follow-up) and time x condition (EG1, EG2, CG) interaction effects as a within-subject factor regarding general knowledge, posture habits and CORE (Table 2). However, other fourth-way interactions (Time x gender, time x self-reported LBP, time x condition x gender, time x condition x self-reported LBP, time x gender x self-reported LBP and time x condition x gender x self-reported LBP) showed no significance.

The significance of the time x condition interaction in the study of within-subject effects leads us to ignore the main effects and analyse simple effects. Descriptive data for the different within-subject measures and pairwise comparisons can be found in Table 2. See Figures 2, 3 and 4 for graphical representations of these results.

3.6 Between-subject analyses/ Interactions with between-subject variables

The between-subjects results showed no significance for the four-way-interaction effects (gender, self-reported LBP, condition x gender, condition x self-reported LBP, gender x self-reported LBP and condition x gender x self-reported LBP) except for the condition variable regarding general knowledge and postural habits and for the self-reported LBP variable regarding postural habits (Table 2).

Once we found statistically significant results, and in order to determine where our differences truly came from, we applied the Bonferroni post hoc test (Table 2).

3.7 Effects of the intervention on low back pain

Regarding the problems in non-specific LBP at baseline, no significant differences were observed between groups. A lifetime prevalence of LBP between 44%- 58%, and a last week prevalence of LBP between 16%-33% in the total sample, by gender and by study groups was observed. In general, the girls showed slightly higher frequencies.

At post-test, all the groups showed better levels of back health (participants without LBP) from a descriptive point of view, but with no significant differences. The EG2 was the only group who showed significant results in flow-up with respect to baseline and post-test (Table 3). These results should be interpreted with caution since although the total sample in the three-time intervals was the same. However, most important missing values were found in the Nordic lumbar pain questionnaire during baseline time. The loss percentage was 58% EG1, 20% EG2 and 18% CG in this period. While in the post-test and follow-up all the participants (n = 113) answered the questions, in the baseline many missing values were found (n = 82).

In the follow-up, EG2 was the group that decreased most in the last week prevalence of LBP with respect to the baseline and post-test, showing significant differences. However, the control group also registered less prevalence of LBP in the post-test and follow-up with respect to the baseline, although without any significant differences (Table 3).

Table 1 Baseline sample characteristics of the three groups.

	EG1			EG2			CG			One-way ANOVA	
Variable	**n**	**⚜**	**SD**	**n**	**⚜**	**SD**	**n**	**⚜**	**SD**	**F**	***p***
Age (years)											
Girls	21	12.29	.561	30	12.00	.263	8	12.25	.707	2.684	.077
Boys	15	12.13	.352	25	12.08	.277	14	12.43	.756	2.657	.080
Total	36			55			22				
Weight (Kg)											
Girls	19	49.94	9.119	29	47.02	7.702	8	50.19	10.113	.844	.436
Boys	15	48.81	10.456	25	47.89	8.813	13	46.39	14.010	.179	.836
Total	34			54			21				
Height (cm)											
Girls	20	1.57	.090	27	1.59	.051	8	1.62	.043	1.606	.211
Boys	15	1.55	.078	25	1.57	.088	13	1.58	.112	.355	.703
Total	35			54			21				
Body mass index (kg/m^2)											
Girls	18	19.64	2.409	27	18.05	4.581	8	18.98	2.779	1.003	.374
Boys	15	20.17	3.259	25	19.32	2.695	12	19.13	3.708	.476	.624
Total	33			52			20				

EG1: experimental group one; EG2: experimental group two; CG: control group; n: frequency; ⚜: mean; SD: standard deviation; F: Snedecor F; *p*: level of critical significance.

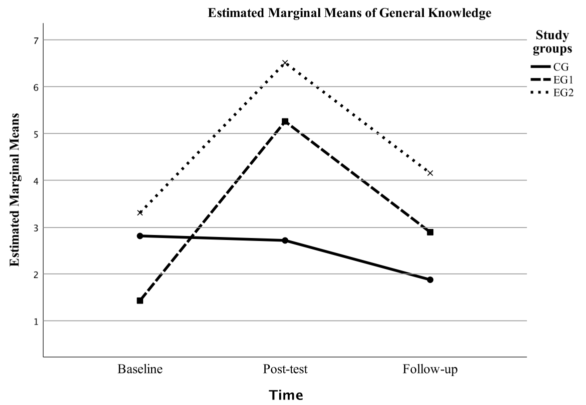

Figure 2 Graphical representation of General Knowledge results.

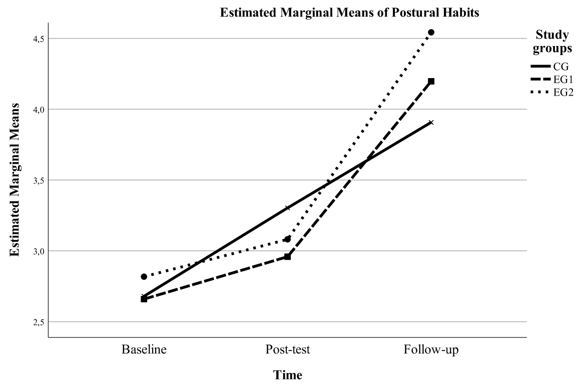

Figure 3 Graphical representation of Postural Behavior results.

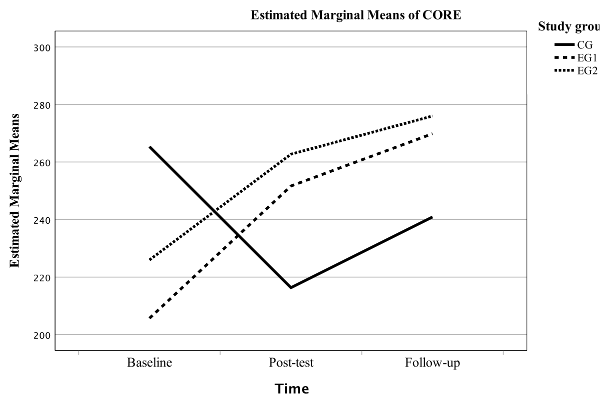

Figure 4 Graphical representation of CORE results.

4. Discussion

The main purpose of this study was to determine the effect of an educational back-health intervention on knowledge, postural habits and trunk muscle endurance regarding low back pain prevention for a group of 12 to 13-year-old students using a 6-month follow-up. The research showed that offering a BHEP could have a positive effect on knowledge, postural habits, and the perception of LBP in the experimental groups (EG1 and EG2) compared to the control group, although the improvement in the perception of LBP was only significative for the group with follow-up learning contract (EG2). Furthermore, it is known that multicomponent intervention programmes utilizing knowledge, postural awareness, postural habits, balancing exercises, strength and stretching exercise contents are the most widely used to address back health problems in students (Bettany-Saltikov et al., 2019; Michaleff et al., 2014; Steele, Dawson, & Hiller, 2006).

Regarding the level of general knowledge, and in line with our first hypothesis, the children who participated in the programme scored higher than the control group, who did not follow the program, when tested after the intervention and after 6 months. The evolution of the level of general knowledge was very clear and statistically significant. The two experimental groups improved their knowledge immediately after the intervention, and they maintained this level of knowledge, although they obtained slightly lower results in the follow-up, similar to other studies (Cardon, De Bourdeaudhuij, & De Clercq, 2002; Miñana-Signes et al., 2019). EG2, who followed a learning contract at home, registered the highest scores in knowledge at follow-up, ratifying the second hypothesis.

Table 2 Mixed between-within subject GLM-ANOVA to compare the effect of condition and self-reported LBP (as between-subject factor), and time and time vs condition (as a within-subject factor) on general knowledge, postural behavior and CORE scores; along with Bonferroni test for post hoc pairwise comparisons based on mean differences (95% CI).

Variable (score range)	Descriptive statistics: Group	Time	⚜ (SD)	ANOVA RM: Effects	F(df)	Effect size (η_p^2)	Bonferroni test for post hoc pairwise comparisons: Post-test				
KNOW (0-10)		Baseline	2.6±1.6				Comparison	⊚ I-J	SE	*p*	95% CI
	EG1	Post-test[a]	5.6±1.5	**Time**	49.8*** (2, 138)	.42	EG2- EG1	.8	.3	.028	.1- 1.6
		Follow-up	3.0±1.2				EG2- CG	3.53	.4	<.001	2.6- 4.4
		Baseline	3.3±1.4				EG1- CG	2.7	.4	<.001	1.7- 3.7
	EG2	Post-test[a]	6.4±1.5	**Time x condition**	10.4*** (4, 138)	.23	**Follow-up**				
		Follow-up	4.2±1.5				Comparison	⊚ I-J	SE	*p*	95% CI
		Baseline	2.8±1.2				EG2- EG1	1.2	.3	<.001	.5- 1.9
	CG	Post-test[a]	2.9±1.2	**Condition**	17.9*** (2, 69)	.34	EG2- CG	2.8	.3	<.001	2.0- 3.6
		Follow-up	1.4±1.2				EG1- CG	1.6	.4	<.001	.7- 2.5
PB (1-4)		Baseline	2.8±.2				**Post-test**				
	EG1	Post-test[a]	3.0±.3	**Time**	167.9*** (2, 138)	.71	Comparison	⊚ I-J	SE	*p*	95% CI
		Follow-up	4.5±.5				EG2- EG1	.1	.07	1.000	-.1- .3
		Baseline	2.8±.3	**Time x condition**	5.1** (4, 138)	.13	EG2- CG	-.1	.1	.451	-.4- .1
	EG2	Post-test[a]	3.1±.3				EG1- CG	-.2	.1	.120	-.4- .0
		Follow-up	4.6± .4	**Condition**	4.0* (2, 69)	.11	**Follow-up**				
		Baseline	2.7±.3				EG2- EG1	.1	.1	1.000	-.2-.3
	CG	Post-test[a]	3.2±.3	**Self-reported LBP**	4.4* (1, 69)	.06	EG2- CG	.6	.1	<.001	.3- .9
		Follow-up	4.0± 5				EG1- CG	.5	.1	<.001	.2- .8
CORE (0-560)		Baseline	217.5±93.1				**Post-test**				
	EG1	Post-test[a]	268.5±95.4	**Time**	3.8*** (2, 138)	.05	Comparison	⊚ I-J	SE	*p*	95% CI
		Follow-up	279.1±116.8				EG2- EG1	13.4	23.0	1.000	-42.4- 69.3
		Baseline	240.9±96.0				EG2- CG	63.4	27.0	.062	-2.3- 129.1
	EG2	Post-test[a]	281.9±117.8	**Time x condition**	4.0** (4, 138)	.10	EG1- CG	50.0	29.0	.3	-20.5- 120.50
		Follow-up	293.9±110.1				**Follow-up**				
		Baseline	254.0±97.3				EG2- EG1	14.8	23.8	1.000	-43.1- 72.7
	CG	Post-test[a]	221.2±97.6				EG2- CG	32.0	28.0	.767	-36.1- 100.1
		Follow-up	268.1±102.4				EG1- CG	17.2	30.0	1.000	-55.8- 90.2

EG1: experimental group one n= 36; EG2: experimental group two n= 55; CG: control group n= 20; ⊚: mean; SD: standard deviation; GLM-ANOVA RM: generalized linear model- analysis of variance for repeated measures; F: Snedecor F (and degrees of freedom); η_p^2: partial eta squared; KNOW: level of general knowledge; PB: level of postural behavior; CORE: level of trunk muscle endurance. Post-test a: Mauchly's test showed absence of sphericity in the post-test, therefore, Greenhouse–Geisser was calculated; SE: standard error; p: level of significance; 95% CI: confidence interval. *$p < .03$, **$p < .005$, ***$p < .001$

Table 3 Level of LBP prevalence in the last week according to sex and study groups.

	EG1				EG2				CG				χ2 test		
	No LBP		LBP		No LBP		LBP		No LBP		LBP				
Baseline	**n**	**%**	**N**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**χ2**	**gl**	***p***
Girls	6	66.7	3	33.3	19	67.9	9	32.1	5	71.4	2	28.6	.045	2	.978
Boys	5	83.3	1	16.7	16	76.2	5	23.8	9	81.8	2	18.2	.220	2	.896
Total	11	73.3	4	26.7	35	71.4	14	28.6	14	77.8	4	22.2	1.204	1	.273
Post-test	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**χ2**	**gl**	***p***
Girls	19	90.5	2	9.5	23	76.7	7	23.3	7	87.5	1	12.5	1.804	2	.496
Boys	14	93.3	1	6.7	17	68.0	8	32.0	12	85.7	2	14.3	4.141	2	.126
Total	33	91.7	3	8.3	40	72.7	15	27.3	19	86.4	3	13.6	.218	1	.640
Follow-up	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**χ2**	**gl**	***p***
Girls	20	95.2	1	4.8	27	90.0	3	10.0	7	87.5	1	12.5	.630	2	.730
Boys	14	93.3	1	6.7	23	92.0	2	8.0	12	85.7	2	14.3	.588	2	.760
Total	34	94.4	2	5.6	50	90.9	5	9.1	19	86.4	3	13.6	.022	1	.883
Cochran's Q test (Q p)	4.000		.135		10.111		.006		.500		.779				
McNemar test	**n**		***p***		**n**		***p***		**n**		***p***				
Post-baseline	15		.500		49		1.000		18		1.000				
Follow-baseline	15		.500		49		.022		18		1.000				
Follow-post	36		1.000		55		.006		22		1.000				

EG1: experimental group one; EG2: experimental group two; CG: control group; LBP: low back pain; n: frequency; %: percentage of prevalence of LBP or without LBP; χ2: chi-square contrast statistic; gl: degrees of freedom; *p*: level of critical significance; Q: Cochran's Q statistic. Bold numbers: Statistically significant differences.

This makes us think that a learning contract could be an interesting didactic resource to involve students in classroom activities when they are out of school and to consolidate learnings. Contracts formalize and ensure the gradual release of responsibility, which is often talked about but less-than-frequently practiced.

On the other hand, it should be noted that very low levels of knowledge concerning back health were found in the participants before the application of the intervention programme, as mentioned in the introduction, and as can be seen in other studies (Akbari-Chehrehbargh et al., 2020; Mendez & Gomez-Conesa, 2001). Appropriate knowledge is an important factor in leading to personal well-being (Demetriou et al., 2015) and develop physical competences (Lloyd et al., 2010). Numerous studies have carried out intervention programmes concerning back health education in the school setting to improve knowledge in schoolchildren (Dullien et al., 2018; Habybabady et al., 2012; Hill & Keating, 2015; Kovacs et al., 2011; Vidal et al., 2011; Vidal et al., 2013). However, knowledge per se is probably not enough to change habits (Ennis, 2007). Knowledge could be considered as the first step in the establishment of healthy habits (Keating, 2003).

Regarding daily postural habits, all the groups improved their level of postural habits, showing a significant longitudinal evolution. However, the pairwise comparisons of the follow-up indicated no statistically significative differences between the experimental groups (Table 2), partially refuting the second hypothesis. Based on these results, back health programmes for schoolchildren can be seen to be an efficient way to improve the students' knowledge, a determining factor in changing postural habits (Keating et al., 2009) as already mentioned. A learning contract could help children retain part of the knowledge. However, it seems that postural habits require more time to be assimilated.

A longitudinal improvement was observed in the trunk muscle endurance test; however, the pairwise comparisons did not find statistically significative differences. The best muscle endurance score was obtained by EG2 in the follow-up.. Other works showed that it is possible to improve the endurance of the trunk muscle in a safe and fun way at school (Miñana-Signes et al., 2019; Vera-García et al., 2005; Vera-García et al., 2005). Analyzing the effect of a core training programme between adolescents, males obtained greater effects in perceived effort than females, but women got a greater effect in posture (Aparicio-Sarmiento, Gómez-Carmona, Martínez-Romero, Gamonales, & Sainz de Baranda, 2021). This makes us think that working on endurance during Physical Education classes, under teacher supervision, could be more efficient, although more studies are required to continue contributing knowledge. On the other hand, we must bear in mind that trunk muscle endurance was approached in a playful and educational way, and not as a specific training plan.

Regarding the problems with non-specific LBP at baseline, we observed an elevated lifetime prevalence of LBP (42%-52%) and LBP over the last week (16%-33%) similar to other studies (Jeffries, Milanese, & Grimmer-Somers, 2007; Miñana-Signes & Monfort-Pañego, 2015a). In general, the girls showed slightly higher frequencies (Kovacs et al., 2003). We can report that EG2, who followed a learning contract for 6 months after participating in the educational back health intervention, registered significant differences with respect to the prevalence of LBP at baseline in the last week, partially verifying the second hypothesis. School-based interventions seems to report effectiveness related to back health (Michaleff et al., 2014); however, some current evidence suggests that educative interventions do not appear to prevent LBP (Dullien et al., 2018; Steffens et al., 2016).

In general, these results, which should be taken with caution, suggest that back health should be taught in school, and that schools must be taken advantage of due to their great potential (Balague, Nordin, Dutoit, & Waldburger, 1996; Rosa et al., 2017). The fact that many students have experienced back pain at some point in their lives must be a reason for us to inform and educate about back health in schools. Schools are a good agent to reach personal well-being (Powell & Graham, 2017). Moreover, students spend long hours in the centres sitting (Cardon, De Clercq, De Bourdeaudhuij, & Breithecker, 2004), therefore, all teachers are responsible for their students' back health. In addition, it is known that bringing about changes in people's health requires interdisciplinary and multidisciplinary interventions (Hall & Weaver, 2001; Ponte, Gross, Milliman-Richard, & Lacey, 2010). As future lines of research, we understand that more comprehensive longitudinal intervention studies are needed to study the effects of educational programs aimed at primary and secondary education. Besides, it would be interesting to study quality of life as in other works (Balague et al., 2012; Fontecha et al., 2011; Pellise et al., 2009), where the authors demonstrated that the onset of back pain was mainly linked to psychosocial and family issues.

Limitations —As limitations, it should be noted that we lost many participants during the process because there were a lot of tests to be done over several days, and many participants could not complete them all. Because of the size of the sample, and the type of study design, our results cannot be generalized or transferred directly, but the results show the trend. In the present study, there were intervention and control groups in both centres, which could increase the risk bias or extend the contamination (Keogh-Brown et al., 2007). Cluster-randomized groups could not be allocated, so the schools suggested using natural reference groups instead. Furthermore, self-reported data may be a limitation because an adolescent's selective memory may, or may not, be reliable when remembering low back pain experiences which occurred sometime in the past. Besides, in this study, the variable physical activity habits and participation in back health programs out of the school context were not taken into account.

5. Practical Applications.

Any school, be it primary or secondary, can develop an intervention program (didactic unit) like the one presented here via the appropriate adaptation of its Physical Education classes. Knowledge concerning back health could be efficiently attained following an intervention. On the other hand, postural habits, and the endurance of the trunk muscle, require more time and follow-up to assimilate and improve. Over time, it has been observed that this could help improve back pain problems in students. Based on our results, and the literature, what we are in fact studying is the effectiveness of an educational centre project on back health through a social ecological model (McLeroy, Bibeau, Steckler, & Glanz, 1988). Both individual and social environmental factors could contribute to a change in behaviour and make for a more powerful intervention.

6. Conclusions

The results showed that knowledge concerning back-care and postural habits was significantly improved through the program. Furthermore, students who performed a BHEP and followed a learning contract for 6 months reduced the perception of low back pain. Randomized studies using validated and uniform instruments are required.

Supplementary Materials: The following are available online at http://eurjhm.com/index.php/eurjhm, Figure S1: Study flow. EG1: experimental group one; EG2: experimental group two; CG: control group; SS: secondary school, Figure S2: Graphical representation of General Knowledge results, Figure S3: Graphical representation of Postural Behavior results, Figure S4: Graphical representation of CORE results, Table S5: Baseline sample characteristics of the three groups, Table S6: Mixed between-within subject GLM-ANOVA to compare the effect of condition and self-reported LBP (as between-subject factor), and time and time vs condition (as a within-subject factor) on general knowledge, postural behavior and CORE scores; along with Bonferroni test for post hoc pairwise comparisons based on mean differences (95% CI)., Table S7: Level of LBP prevalence in the last week according to sex and study groups.

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References

Ahlqwist, A., Hagman, M., Kjellby-Wendt, G., & Beckung, E. (2008). Physical therapy treatment of back complaints on children and adolescents. Spine, 33(20), 721. doi:10.1097/BRS.0b013e318182c347

Akbari-Chehrehbargh, Z., Tavafian, S. S., & Montazeri, A. (2020). Effectiveness of a theory-based back care intervention on spine-related behavior among pupils: A school-based randomised controlled trial (T-bak study). BMC Public Health, 20, 1-15. doi:rg/10.1186/s12889-020-08566-z

Aparicio-Sarmiento, A., Gómez-Carmona, C. D., Martínez-Romero, M. T., Gamonales, J. M., & Sainz de Baranda, P. (2021). Efecto de una unidad didáctica formativa de fortalecimiento del tronco en educación física sobre el esfuerzo percibido y la técnica. Journal of Sport & Health Research, 13(2), 195-210.

Balague, F., Ferrer, M., Rajmil, L., Pont Acuna, A., Pellise, F., & Cedraschi, C. (2012). Assessing the association between low back pain, quality of life, and life events as reported by schoolchildren in a population-based study. European Journal of Pediatrics, 171(3), 507-514. doi:10.1007/s00431-011-1596-1

Balague, F., Nordin, M., Dutoit, G., & Waldburger, M. (1996). Primary prevention, education, and low back pain among school children. Bulletin (Hospital for Joint Diseases (New York, N.Y.)), 55(3), 130-134.

Bandura, A. (2004). Health promotion by social cognitive means. Health Education & Behavior, 31(2), 143-164. doi:10.1177/1090198104263660

Bettany-Saltikov, J., Kandasamy, G., Van Schaik, P., McSherry, R., Hogg, J., Whittaker, V., . . . Racero, G. A. (2019). School-based education programmes for improving knowledge of back health, ergonomics and postural behaviour of school children aged 4–18: A systematic review. Campbell Systematic Reviews, 15(1-2), 1-11. doi:10.1002/cl2.1014

Biering-Sorensen, F. (1984). Physical measurements as risk indicators for low-back trouble over a one-year period. Spine, 9(2), 106-119.

Brusseau, T. A., Kulinna, P. H., & Cothran, D. J. (2011). Health and physical activity content

knowledge of pima children. The Physical Educator,
Brynteson, P., & Adams, T. M. (1993). The effects of conceptually based physical education programs on attitudes and exercise habits of college alumni after 2 to 11 years of follow-up. Research Quarterly for Exercise and Sport, 64(2), 208-212. doi:10.1080/02701367.1993.10608798
Calvo-Muñoz, I., Gómez-Conesa, A., & Sánchez-Meca, J. (2013). Prevalence of low back pain in children and adolescents: A meta-analysis. BMC Pediatrics, 13, 14-14. doi:10.1186/1471-2431-13-14; 10.1186/1471-2431-13-14
Cardon, G., De Clercq, D., De Bourdeaudhuij, I., & Breithecker, D. (2004). Sitting habits in elementary schoolchildren: A traditional versus a "moving school". Patient Education and Counseling, 54(2), 133-142. doi:10.1016/S0738-3991(03)00215-5
Cardon, G., De Bourdeaudhuij, I., & De Clercq, D. (2002). Knowledge and perceptions about back education among elementary school students, teachers, and parents in belgium. Journal of School Health, 72(3), 100-106. doi:10.1111/j.1746-1561.2002.tb06524.x
Castillo, J., Felip, N., Quintana, A., & Tort, A. (2014). ¿ Hay lugar para las familias en la educación secundaria? percepciones y propuestas para una transformación del programa institucional de los centros educativos. Profesorado. Revista De Currículum Y Formación De Profesorado, 18(2)
Chaturvedi, S., & Shweta, R. C. (2015). Evaluation of inter-rater agreement and inter-rater reliability for observational data: An overview of concepts and methods. Journal of the Indian Academy of Applied Psychology, 41(3), 20-27.
Cohen, J. (1973). Eta-squared and partial eta-squared in fixed factor ANOVA designs. Educational and Psychological Measurement, 33(1), 107-112. doi:rg/10.1177/001316447303300111
de Barros, E. N., & Alexandre, N. M. (2003). Cross-cultural adaptation of the nordic musculoskeletal questionnaire. International Nursing Review, 50(2), 101-108. doi:rg/10.1046/j.1466-7657.2003.00188.x
Demetriou, Y., Sudeck, G., Thiel, A., & Hoener, O. (2015). The effects of school-based physical activity interventions on students' health-related fitness knowledge: A systematic review. Educational Research Review, 16, 19-40. doi:rg/10.1016/j.edurev.2015.07.002
Dullien, S., Grifka, J., & Jansen, P. (2018). Cluster-randomized, controlled evaluation of a teacher led multi factorial school based back education program for 10 to 12-year old children. BMC Pediatrics, 18(1), 1-10.
Ennis, C. D. (2007). 2006 CH McCloy research lecture: Defining learning as conceptual change in physical education and physical activity settings. Research Quarterly for Exercise and Sport, 78(3), 138-150. doi:rg/10.1080/02701367.2007.10599411
Fontecha, C. G., Balague, F., Pellise, F., Rajmil, L., Aguirre, M., Pasarin, M., . . . Ferrer, M. (2011). Low back pain in adolescents: Is quality of life poorer in those seeking medical attention? Spine, 36(17), 1154. doi:10.1097/BRS.0b013e318203ed5b
Greenwood, S. C., & McCabe, P. P. (2008). How learning contracts motivate students. Middle School Journal, 39(5), 13-22.
Habybabady, R. H., Ansari-Moghaddam, A., Mirzaei, R., Mohammadi, M., Rakhshani, M., & Khammar, A. (2012). Efficacy and impact of back care education on knowledge and behaviour of elementary schoolchildren. JPMA.the Journal of the Pakistan Medical Association, 62(6), 580-584.
Hall, P., & Weaver, L. (2001). Interdisciplinary education and teamwork: A long and winding road. Medical Education, 35(9), 867-875.
Hill, J. J., & Keating, J. L. (2015). Daily exercises and education for preventing low back pain in children: Cluster randomized controlled trial. Physical Therapy, 95(4), 507-516. doi:10.2522/ptj.20140273 [doi]
Hwang, J., Louie, P. K., Phillips, F. M., An, H. S., & Samartzis, D. (2019). Low back pain in children: A rising concern. Eur Spine J, 28(2), 211. doi:rg/10.1007/s00586-018-5844-1
Jeffries, L. J., Milanese, S. F., & Grimmer-Somers, K. A. (2007). Epidemiology of adolescent spinal pain: A systematic overview of the research literature. Spine, 32(23), 2630-2637. doi:10.1097/BRS.0b013e318158d70b
Jones, M., Stratton, G., Reilly, T., & Unnithan, V. (2007). The efficacy of exercise as an intervention to treat recurrent nonspecific low back pain in adolescents. Pediatric Exercise Science, 19(3), 349-359.
Keating, X. D. (2003). The current often implemented fitness tests in physical education programs: Problems and future directions. Quest, 55(2), 141-160. doi:10.1080/00336297.2003.10491796
Keating, X. D., Harrison, L., Chen, L., Xiang, P., Lambdin, D. D., Dauenhauer, B., . . . Pinero,

J. C. (2009). An analysis of research on student health-related fitness knowledge in K-16 physical education programs. Journal of Teaching in Physical Education, 28(3), 333-349.

Keogh-Brown, M. R., Bachmann, M. O., Shepstone, L., Hewitt, C., Howe, A., Ramsay, C. R., . . . Miles, S. (2007). Contamination in trials of educational interventions. Health Technolology Assessment, 11(43) doi:10.3310/hta11430

Kim, J., & Shin, W. (2014). How to do random allocation (randomization). Clinics in Orthopedic Surgery, 6(1), 103-109.

Kovacs, F., Gestoso, M., Gil del Real, M. T., Lopez, J., Mufraggi, N., & Mendez, J. I. (2003). Risk factors for non-specific low back pain in schoolchildren and their parents: A population based study. Pain, 103(3), 259-268.

Kovacs, F., Oliver-Frontera, M., Plana, M. N., Royuela, A., Muriel, A., Gestoso, M., & and the Spanish Back Pain Research Network. (2011). Improving schoolchildren's knowledge of methods for the prevention and management of low back pain: A cluster randomized controlled trial. Spine, 36(8), 505. doi:10.1097/BRS.0b013e3181dccebc

Kuorinka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sørensen, F., Andersson, G., & Jørgensen, K. (1987). Standardised nordic questionnaires for the analysis of musculoskeletal symptoms. Applied Ergonomics, 18(3), 233-237. doi:10.1016/0003-6870(87)90010-X

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. Biometrics, , 159-174.

Leboeuf-Yde, C., & Kyvik, K. O. (1998). At what age does low back pain become a common problem? A study of 29,424 individuals aged 12-41 years. Spine, 23(2), 228-234.

Lloyd, M., Colley, R. C., & Tremblay, M. S. (2010). Advancing the debate on 'fitness testing'for children: Perhaps we're riding the wrong animal. Pediatric Exercise Science, 22(2), 176-182. doi:rg/10.1123/pes.22.2.176

Mascolo, M. F. (2009). Beyond student-centered and teacher-centered pedagogy: Teaching and learning as guided participation. Pedagogy and the Human Sciences, 1(1), 3-27.

McGill, S. M., Childs, A., & Liebenson, C. (1999). Endurance times for low back stabilization exercises: Clinical targets for testing and training from a normal database. Archives of Physical Medicine and Rehabilitation, 80(8), 941-944.

McLeroy, K. R., Bibeau, D., Steckler, A., & Glanz, K. (1988). An ecological perspective on health promotion programs. Health Education Quarterly, 15(4), 351-377.

Mendez, F. J., & Gomez-Conesa, A. (2001). Postural hygiene program to prevent low back pain. Spine, 26(11), 1280-1286.

Michaleff, Z. A., Kamper, S. J., Maher, C. G., Evans, R., Broderick, C., & Henschke, N. (2014). Low back pain in children and adolescents: A systematic review and meta-analysis evaluating the effectiveness of conservative interventions. European Spine Journal : Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society, 23(10), 2046-2058. doi:10.1007/s00586-014-3461-1 [doi]

Miñana-Signes, V., & Monfort-Pañego, M. (2015a). Back health in adolescents between 12-18 years of the valencian community, spain: Prevalence and consequences. J Spine, 4(237), 2. doi:rg/10.4172/2165-7939.1000237

Miñana-Signes, V., & Monfort-Pañego, M. (2015b). Design and validation of a health questionnaire about knowledge for health and back care related to the practice of physical activity and exercise for adolescents: COSACUES-AEF. Journal of Spine, 2015

Miñana-Signes, V., Monfort-Pañego, M., & Rosaleny-Maiques, S. (2019). Improvement of knowledge and postural habits after an educational intervention program in school students. Journal of Human Sport and Exercise, 14(1) doi:10.14198/jhse.2019.141.04

Miñana-Signes, V., & Monfort-Pañego, M. (2020). The conditioning of the trunk muscles and back health in physical education.

Miñana-Signes, V., Monfort-Pañego, M., & Valiente, J. (2021). Teaching back health in the school setting: A systematic review of randomized controlled trials doi:10.3390/ijerph18030979

Monfort-Pañego, M., & Miñana-Signes, V. (2020). Psychometric study and content validity of a questionnaire to assess back-health-related postural habits in daily activities. Measurement in Physical Education and Exercise Science, , 1-10. doi:rg/10.1080/1091367X.2020.1784899

Monfort-Pañego, M., Molina-García, J., Miñana-Signes, V., Bosch-Biviá, A. H., Gómez-López, A., & Munguía-Izquierdo, D. (2016).

Development and psychometric evaluation of a health questionnaire on back care knowledge in daily life physical activities for adolescent students. European Spine Journal, , 1-6. doi:rg/10.1007/s00586-016-4627-9

Mosston, M. (1966). Teaching physical education: From command to discovery MacMillan Publishing Company.

Naylor, P., Nettlefold, L., Race, D., Hoy, C., Ashe, M. C., Higgins, J. W., & McKay, H. A. (2015). Implementation of school based physical activity interventions: A systematic review. Preventive Medicine, 72, 95-115.

Olfert, M. D., Barr, M. L., Charlier, C. M., Famodu, O. A., Zhou, W., Mathews, A. E., . . . Colby, S. E. (2018). Self-reported vs. measured height, weight, and BMI in young adults. International Journal of Environmental Research and Public Health, 15(10), 2216.

Pellise, F., Balague, F., Rajmil, L., Cedraschi, C., Aguirre, M., Fontecha, C. G., . . . Ferrer, M. (2009). Prevalence of low back pain and its effect on health-related quality of life in adolescents. Archives of Pediatrics & Adolescent Medicine, 163(1), 65-71. doi:10.1001/archpediatrics.2008.512

Ponte, P. R., Gross, A. H., Milliman-Richard, Y. J., & Lacey, K. (2010). Interdisciplinary teamwork and collaboration an essential element of a positive practice environment. Annual Review of Nursing Research, 28(1), 159-189.

Powell, M. A., & Graham, A. (2017). Wellbeing in schools: Examining the policy–practice nexus. The Australian Educational Researcher, 44(2), 213-231. doi:10.1007/s13384-016-0222-7

Rosa, B. N. d., Furlanetto, T. S., Noll, M., Sedrez, J. A., Schmit, E. F. D., & Candotti, C. T. (2017). 4-year longitudinal study of the assessment of body posture, back pain, postural and life habits of schoolchildren. Motricidade, 13(4), 3-12.

Sadler, S. G., Spink, M. J., Ho, A., De Jonge, X. J., & Chuter, V. H. (2017). Restriction in lateral bending range of motion, lumbar lordosis, and hamstring flexibility predicts the development of low back pain: A systematic review of prospective cohort studies. BMC Musculoskeletal Disorders, 18(179), 1-15. doi:10.1186/s12891-017-1534-0

Steele, E. J., Dawson, A. P., & Hiller, J. E. (2006). School-based interventions for spinal pain: A systematic review. Spine, 31(2), 226-233. doi:10.1097/01.brs.0000195158.00680.0d

Steffens, D., Maher, C. G., Pereira, L. S., Stevens, M. L., Oliveira, V. C., Chapple, M., . . . Hancock, M. J. (2016). Prevention of low back pain: A systematic review and meta-analysis. JAMA Internal Medicine, 176(2), 199-208.

Strand, S. L., Hjelm, J., Shoepe, T. C., & Fajardo, M. A. (2014). Norms for an isometric muscle endurance test. Journal of Human Kinetics, 40(1), 93-102.

Swain, C., & Redding, E. (2014). Trunk muscle endurance and low back pain in female dance students. Journal of Dance Medicine & Science, 18(2), 62-66. doi:10.12678/1089-313X.18.2.62

Trevelyan, F. C., & Legg, S. J. (2006). Back pain in school children—Where to from here? Applied Ergonomics, 37(1), 45-54. doi:10.1016/j.apergo.2004.02.008

Vera-García, F. J., Arroyo Fenoll, N., López Elvira, J. L., Alonso Roque, J. I., Flores-Parodi, B., & Sarti, M. A. (2005). Eficacia de cuatro juegos motores para el acondicionamiento de los músculos del abdomen. Motricidad.European Journal of Human Movement 14, 79, 91

Vera-García, F. J., Roque, J. I. A., Fenoll, N. A., Martínez, M. J. S., Elvira, J. L. L., & Flores-Parodi, B. (2005). Juegos motores: Una alternativa para fortalecer los músculos del abdomen. Apunts: Educación Física Y Deportes, (79), 80-85.

Vidal, J., Borras, P. A., Ortega, F. B., Cantallops, J., Ponseti, X., & Palou, P. (2011). Effects of postural education on daily habits in children. International Journal of Sports Medicine, 32(4), 303-308. doi:10.1055/s-0030-1270469

Vidal, J., Borras, P. A., Ponseti, F. J., Cantallops, J., Ortega, F. B., & Palou, P. (2013). Effects of a postural education program on school backpack habits related to low back pain in children. European Spine Journal : Official Publication of the European Spine Society, the European Spinal Deformity Society, and the European Section of the Cervical Spine Research Society, 22(4), 782-787. doi:10.1007/s00586-012-2558-7; 10.1007/s00586-012-2558-7

Wohlfarth, D., Sheras, D., Bennett, J. L., Simon, B., Pimentel, J. H., & Gabel, L. E. (2008). Student perceptions of learner-centered teaching. Insight: A Journal of Scholarly Teaching, 3, 67-74.