Original Article

Movement quality evaluation through the functional movement screen in 12- and 13-year-old secondary-school adolescents

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ABSTRACT

Introduction: The achievement of an optimal level of functional parameters by schoolchildren is essential to acquire appropriate motor competence to perform any sport or daily-life activity without difficulty. Objective: The objective of the study was to evaluate the quality of movement in adolescents using the Functional Movement Screen Test (FMS). Method: 35 schoolchildren between 12 and 13 years old (24 girls and 11 boys) participated in this cross-sectional, descriptive and comparative study. The FMS battery test, consisting of seven tasks of specific movement patterns (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raises, trunk stability push-up, rotary stability), was applied to evaluate the quality of movement. Results: Girls presented better quality of movement than boys, with an average global score of 16 points, compared to 15 of boys, without significant differences between them. In both girls and boys, the stability variable (hurdle step) showed the highest scores, while the in-line lunge was the test that presented the worst values. After the hurdle step, girls presented the highest values in rotary stability, while boys did in trunk stability. Conclusions: In general, the adolescents presented an acceptable level of movement quality, but would require compensatory exercises to reduce certain imbalances and asymmetries found. **Keywords:** Physical education; Movement patterns; Motor competence.

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INTRODUCTION

Physical Education (PE) programmes in secondary school (SS) contain very diverse contents, including but not limited to corporal expression, sports fundamentals, strength and conditioning, sport activity in nature, etc. All of them require that students have a minimum level of physical fitness and coordination skills in order to approach the proposed learning tasks with some warranty (García-Cantó, 2010; García-Jaén, Pérez, Cortell-Tormo, Valero, Anta, 2018). The contents become increasingly complex as school years increase. Consequently, it is important that students possess a certain level of basic movements patterns in order to tackle them properly.

According to Ruiz-Pérez (2000), it is important that schoolchildren possess some motor competence to be able to perform the motor tasks proposed by the PE teacher. The lack thereof may produce demotivation, a negative self-concept of themselves or even make them dislike physical activity due to their lack of competence.

The PE teacher's task is to propose motor challenges that students are able to complete and, to do so, previous analysis of the context where they will be performed is essential. It is also key to evaluate the students' motor competence and movement quality prior to designing any programme (Ruiz-Pérez, 2000). By doing so, the PE teacher will be able to determine the starting level of their students and to propose tasks that mean a challenge, but are attainable, leading to improvement and not to frustration. The latter could hinder adherence to physical activity (PA), this being one of the biggest problems in Spanish school population (Roman, Serra-Majem, Ribas-Barba, Pérez-Rodrigo, & Aranceta, 2008).

Some of these studies concluded that adolescents do not comply with the minimum physical activity recommendations by the World Health Organization (WHO) (60 minutes of physical activity per day, mostly aerobic, of moderate to vigorous intensity) (Mielgo-Ayuso et al., 2016).

Besides, considering that bad practice may lead to discomfort or pathologies (musculoskeletal, cardiovascular…), it is logical to think that PE can be a major tool to allow adolescents to do some physical activity and to try to correct movement deficiencies.

Several studies have confirmed that various test batteries have been applied within the PE programmes in order to assess physical fitness in secondary school students (Valdés &Yanci, 2016; Gioscia, Beretervide, Bermúdez, & Quagliatta, 2017). The majority of tests measure the basic components of fitness (cardiovascular endurance, flexibility and strength). Nevertheless, tests to assess qualitative motor aspects, such as coordination, agility, balance, etc., as well as movement quality, are less common.

Therefore, the aim of the present study was to evaluate several qualitative aspects related with the global quality of fundamental movement patterns in these adolescents.

One of the most exhaustive batteries to assess global movement quality found in the literature was the Functional Movement Screen (FMS), composed of seven tasks of specific movement patterns related with mobility, stability and balance to detect the presence or absence of bilateral imbalances of the body segments involved (Cook, Burton & Hogenboom, 2006a; 2006b). This is a simple and quantifiable method to evaluate fundamental movement patterns, able to establish profiles and to make comparisons among classmates or different sport modalities (Fernández, Figueroa, Garcés, Montalva, Núñez, Illares, 2017). Not only does the battery consist of simple, not time-consuming tests, which do not need much space or a lot or complex material, but its reliability is also excellent, according to the recent meta-analysis conducted by Bonazza, Smuin, Onks, Silvis and Dhawan (2017).

In spite of being a very commonly used battery in adult populations (Díaz, Salazar & Morera, 2013; Hammes, Aus der Fünten, Bizzini & Meyer, 2016), its application in school contexts, either primary or secondary school, is not very widespread (Anderson, Neumann & Bliven, 2015; Abraham, Sannasi & Nair, 2015; García-Jaén, et al., 2018).

Consequently, in the present study, we have decided to apply it in the first year of secondary school, since we deem it important to assess the global movement quality in these adolescents in order to determine their motor competence before the beginning of any intervention programme.

More specifically, the main aim of this study was to assess the global movement quality based on fundamental movement patterns through the application of the Functional Movement Screen to school adolescents between 12 and 13 years old of both sexes. By doing so, mobility, balance, stability and postural control would be determined in these schoolchildren from the first year of secondary school.

METHODS

Participants

A convenience sample of 35 students (24 girls and 11 boys) was selected from the first year of secondary school of IES Veleta de Granada high school. The inclusion criteria were: not to present any psychological or physical disability that could affect the results during the FMS test battery execution, not to present any visual or vestibular impairments that could compromise balance, and not to have suffered any muscle or joint injury during the previous school year. Furthermore, competing athletes were excluded, since they could have better physical fitness and motor skills due to their training. The participants' legal guardians were requested to sign an informed consent prior to the study, where the aims of the study were explained, as well as the procedure to be followed. Table 1 shows the characteristics of the sample divided by sex.

Table 1. Sample characteristics.

	Boys (n=11)	Girls (n=24)	Total (n=35)
Age (years)	12.45 (.52)	12.08 (.28)	12.20 (.41)
Body weight (kg)	47.04 (8.71)	48.93 (2.02)	48.34 (5.01)
Height (m)	1.54 (0.55)	1.58 (.025)	1.57 (.04)
BMI	19.68 (3.15)	19.59 (.48)	19.62 (1.76)

Design and Instruments

An observational, descriptive, cross-sectional study was conducted. The instrument used to evaluate the movement quality was the FMS test, created by Gray Cook and Lee Burton in 1998. It is a battery composed of seven tests with three aims: to evaluate the fundamental movement patterns, to detect asymmetries and to assess motor control (Dorrel, Long, Shaffer & Myer, 2015).

The tests included in the FMS battery are the following:

1. Overhead squat;
2. Hurdle step;
3. In-line lunge;
4. Shoulder mobility;

5. Active straight leg raises;
6. Trunk stability push-up;
7. Rotary stability.

The following material was used in order to conduct the test battery: one 1.22-m dowel, two 0.61-m dowels, one 2x6-cm wooden board, one inelastic measuring tape and two 4K high-definition cameras to film the exercise execution from the frontal and sagittal planes.

Procedure

Prior to data collection, authorisation to conduct the study was obtained from the high school. The students participated voluntarily and were selected during PE class, after explaining the study in the presence of their main teacher, specifying the confidentiality and anonymity of the data. All measurements were performed in March of the school year 2018/2019 during PE hours.

The assessments were performed individually. Every test of the FMS battery was performed three times, following the order and guidelines established by Cook (2010) and described below (see Figure 1).

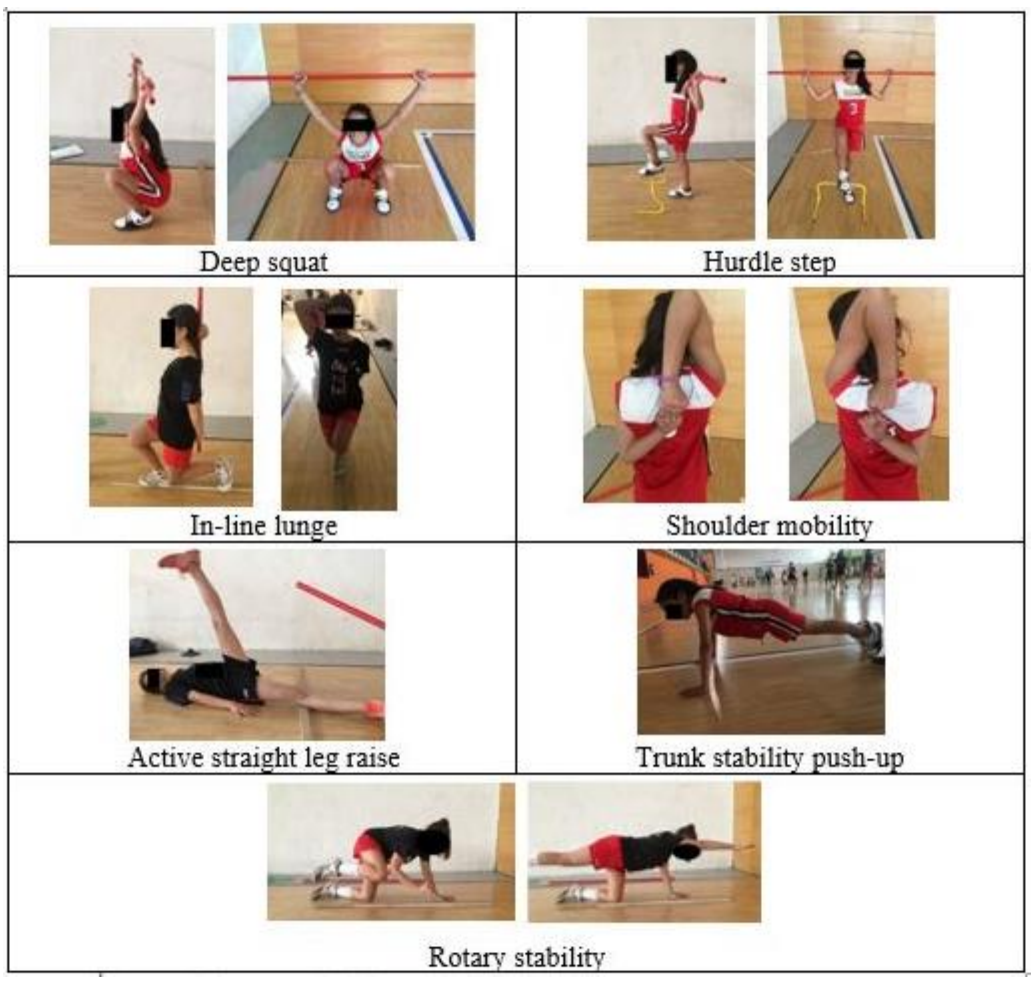

Figure 1. Images of all battery tests.

Overhead squat
Place your feet approximately shoulder-width apart and the toes pointing forward.
Adjust your hands on the dowel and hold it overhead, keeping your shoulders and elbows flexed.
Press the dowel overhead.
Descend slowly into a squat position, keeping the heels on the floor, the trunk straight, and the dowel maximally pressed overhead.
Hold the position for one second before returning to the starting position.

Hurdle step
Place your feet together and align your toes touching the base of the 2x6 board.
Hold the dowel with both hands across the shoulders below the neck.
While keeping a straight position, raise your right leg and keep your foot in line with your ankle, knee and hip.
Touch the ground with your heel and return to the starting position while keeping your foot in line with your ankle, knee and hip.

In-line lunge
Place the dowel behind your back touching your head, thoracic spine, and sacrum (low back).
Your right hand should be grasping the dowel at the cervical spine. The left hand grasps the dowel at the lumbar spine.
Step on the 2x6-cm board with a flat foot and place your toe at the starting mark.
Place your left heel at the measuring mark of the tibialis insertion. The feet must stay flat with the toes of both feet pointing at the front.
Keep a straight position, so that the dowel stays in contact with your head, thoracic spine and the upper gluteus. Lower to a lunge position, so that the right knee touches the 2x6 board behind the left heel.
Return to the starting position.

Shoulder mobility
Place your feet together and leave your arms relaxed along your body.
Make a fist with each hand, placing the thumb inside the fist.
Place one fist above your head and move it as far as possible down your back. At the same time, raise the other fist as far as possible along your back.

Active straight leg raises
Lie supine with the back part of your knees touching the 2x6 board and your toes pointing up.
Place your arms along your body with your palms facing down.
Lift the toes of your right foot towards your shin keeping your knee extended and the back of your knee in contact with the 2x6 board. Lift the right leg as high as possible.

Trunk stability push-up
Assume a prone position with the arms extended and the hands placed shoulder-width apart.
Pull your thumbs downwards in line with your forehead (boys) or chin (girls).
Raise your knees and elbows from the ground while keeping your legs together.
Try to keep your trunk straight and lift your body as a unit to a push-up position.

Rotary stability
Start on your hands and knees on the 2x6 board, so that your hands are below your shoulders and your knees below your hips.

Your thumbs, knees and toes must be in contact with the 2x6 board sides and the toes must be pointing at your shins.
Extend one hand to the front and the opposite leg to the back at the same time, as if you were flying.
Then, without touching the ground, touch one elbow with the opposite knee over the 2x6 board.
Return to the extended position.
Return to the starting position.

In five of the seven tests (all except the deep squat and the trunk stability push-up), the performance of both left and right sides was assessed. The participants completed a 5-minute guided warm up before the exercise execution, consisting of basic exercises of dynamic mobility. The participants were provided with verbal instructions of every exercise following the description guidelines suggested by Cook (2010) and described above. They were allowed to perform three attempts per exercise and the best was saved. When the participant was able to perform the movement without any problem in the first attempt, there was no need to repeat it.

The maximum score is three points per exercise, 21 points being, therefore, the maximum score one can obtain in the test. The score per exercise is:

- Three points when the person completes the movement meeting all the established criteria, without any compensation;
- Two points if the person is able to complete the movement but must compensate once or more times, and not meeting all the established criteria;
- One point if the person is unable to complete the movement;
- Zero points if the person cannot complete the exercise and/or they complete it but feel pain during the execution (Cook, et al., 2006a).

In the exercises involving unilateral movements, left and right sides were assessed independently, taking the lowest score for the calculation of the total test score.

The pain clearing tests were graded as positive (presence of pain) or negative (absence of pain) depending on whether the student felt pain or not. If a person had pain during the movement, that test was then automatically scored with zero points, regardless of the score previously obtained (Cook, et al., 2006a).

Each participant's execution was filmed digitally from different movement planes and it was then jointly analysed by two ratters with previous experience using FMS (Anderson, Neumann, & Huxel Bliven, 2015).

Statistical analysis

All the analyses were conducted using SPSS v 22.0 (Inc. Chicago Il USA). Descriptive statistics were conducted for the scores obtained in every test (mean and standard deviation) and the percentage of each score was calculated for the whole sample as well as divided by sex. The data normality and homoscedasticity were determined through the Kolmogorov-Smirnov and Levine tests, respectively. Given that part of the values obtained from the FMS did not follow a normal distribution based on the levels of Sex and BMI variables, a non-parametric analysis was applied. The independent sample comparison was performed through Kruskal-Wallis and Mann-Whitney U tests.

RESULTS

Table 2 shows the descriptive statistics of the scores obtained in each of the seven FMS tests divided by sex. Overall, the scores achieved by both sexes in every test were similar, girls having scored slightly lower in the in-line lunge and trunk stability tests and boys in the active straight left leg raise and rotary stability to the right.

Table 2. Scores obtained by the students in the different FMS tests divided by sex.

	Boys (n=11)	Girls (n=24)	Total (n=35)
Deep squat	2.27 ± .467	2.25 ± .442	2.26 ± .443
Hurdle step	2.64 ± .505	2.92 ± .282	2.83 ± .382
In-line lunge	2.36 ± .505	1.71 ± .464	1.91 ± .562
Right shoulder mobility	2.45 ± .688	2.83 ± .381	2.71 ± .519
Left shoulder mobility	2.09 ± .701	2.50 ± .511	2.37 ± .598
Active straight leg raise- right	2.36 ± .505	2.33 ± .565	2.34 ± .539
Active straight leg raise- left	1.73 ± .647	2 ± .590	1.91 ± .612
Trunk stability	2.55 ± .522	1.96 ± .751	2.14 ± .733
Rotatory stability- right	1.91 ± .701	2.88 ± .338	2.57 ± .655
Rotatory stability- left	2 ± .632	2.63 ± .495	2.43 ± .608

The results obtained by the whole sample in each of the seven tests are shown, in percentages, in Table 3. For girls, it is noteworthy that the only test where none of them obtained 3 points was the in-line lunge. By contrast, in every test there was at least one boy who obtained 3 points. Regarding laterality, both boys and girls obtained higher percentages for the right than left side, what could mean an asymmetry in arms and legs.

Table 3. Frequency (percentage) of every score obtained by the complete sample in each of the seven FMS tests.

FMS TESTS	Boys (n=11)			Girls (n=24)			Total (n=35)		
	1	2	3	1	2	3	1	2	3
Deep squat	0(0)	8(72.7)	3(27.3)	0(0)	18(75)	6(25)	0(0)	26(74.3)	9(25.7)
Hurdle step	0(0)	4(36.4)	7(63.6)	0(0)	2(8.3)	22(91.7)	0(0)	6(17.1)	29(82.9)
In-line lunge	0(0)	7(63.6)	4(36.4)	7(29.2)	17(70.8)	0(0)	7(20)	24(68.6)	4(11.4)
Right shoulder mobility	1(9.1)	4(36.4)	6(54.5)	0(0)	4(16.7)	20(83.3)	1(2.9)	8(22.9)	26(74.3)
Left shoulder mobility	2(18.2)	6(54.5)	3(27.3)	0(0)	12(50)	12(50)	2(5.7)	18(51.4)	15(42.9)
Active straight leg raise- right	0(0)	7(63.6)	4836.4)	1(4.2)	14(58.3)	9(37.5)	1(2.9)	21(60)	13(37.1)

Active straight leg raise-left	4(36.4)	6(54.5)	1(9.1)	4(16.7)	16(66.7)	2(16.7)	8(22.9)	22(62.9)	5(14.3)
Trunk stability	0(0)	5(45.5)	6(54.5)	7(29.2)	11(45.8)	6(25)	7(20)	16(45.7)	12(34.3)
Rotatory stability - right	3(27.3)	6(54.5)	2(18.2)	0(0)	3(12.5)	21(87.5)	3(8.6)	9(25.7)	23(65.7)
Rotatory stability-left	2(18.2)	7(63.6)	2(18.2)	0(0)	9(37.5)	15(62.5)	2(5.7)	16(45.7)	17(48.6)

Lastly, the information obtained from the FMS test revealed that the majority of the surveyed students showed acceptable movement quality values (Table 4).

Table 4. Frequency (percentage) of each item of the FMS questionnaire.

FMS Score	All N(%)	Girls N(%)	Boys N(%)
14	11(31.4)	6(25)	5(45.5)
15-20	24(68.6)	18(75)	6(54.5)
21	0(0)	0(0)	0(0)

Prior to conducting the comparative analysis, normality and homoscedasticity of the distributions was checked. Kolmogorov-Smirnov statistic revealed the absence of normality of the FMS variable based on the levels of BMI and sex variables (see Table 5).

Table 5. Normality test. Kolmogorov-Smirnov[a] statistic.

			Statistic	df	Sig
FMS	BMI	Slightly underweight	.253	3	.000
		Normal weight	.142	28	.153
	Sex	Male	.290	8	.047
		Female	.154	24	.144

[a]Lilliefors significance correction.

Table 6 shows the results of applying Levine statistic. The hypothesis that the variance was equal across groups was accepted in all cases.

Table 6. Test for homogeneity of variance. Levene statistic.

		Statistic	df1	df2	Sig.
FMS	BMI	-1.225	29	-1.35	.230
	Sex	.727	33	.511	.472

Kruskal-Wallis statistic did not yield significant differences in the FMS mean range (H(1)=.909, p=.340) based on sex or BMI variables (H(2)=4.201, p=.122) (see Figures 2 and 3).

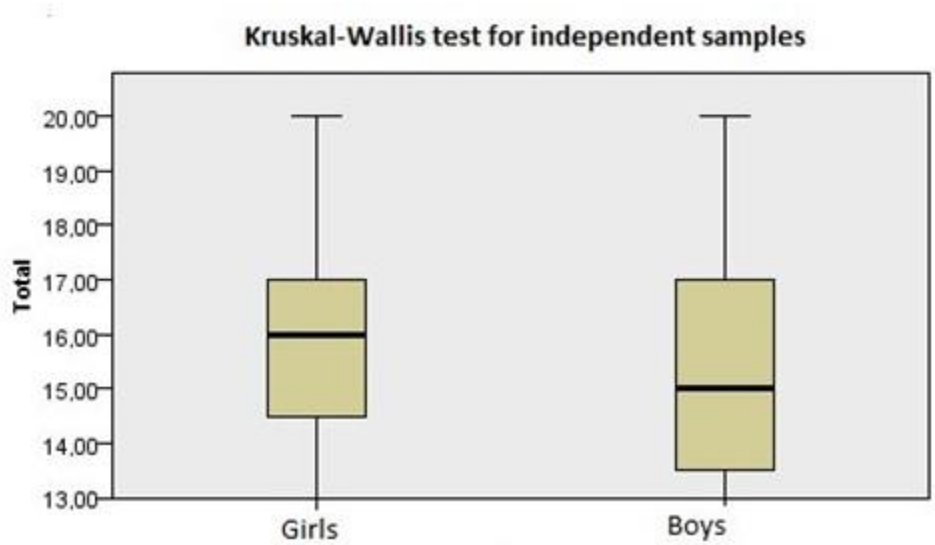

Figure 2. Observed differences in the FMS mean range between sexes.

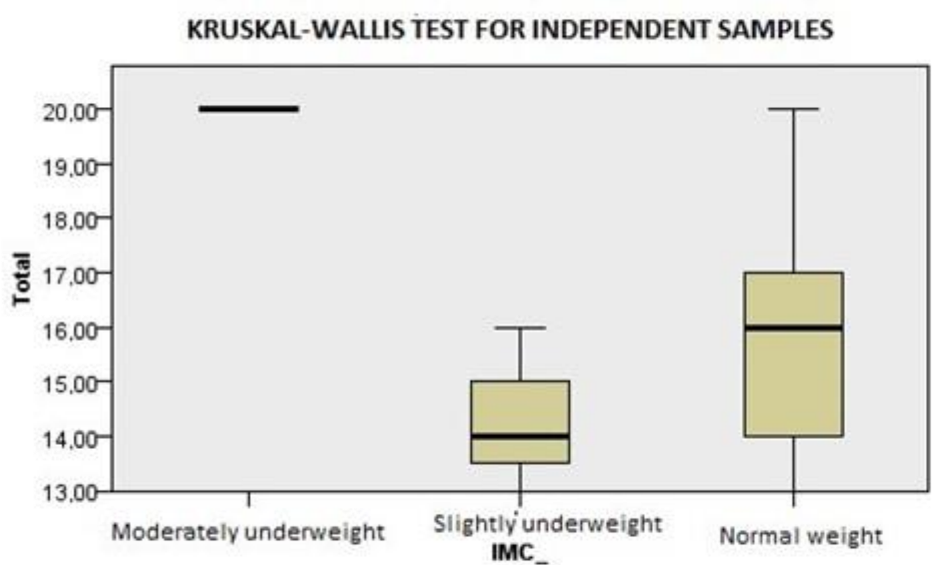

Figure 3. Observed differences in the FMS mean range among the different BMI levels.

Mann-Whitney U test for independent samples revealed statistically significant differences in the FMS mean range based on sex (U=105, p=.233). More specifically, boys presented significantly higher mean range than girls (20.45 and 16.88, respectively) (see Figure 4).

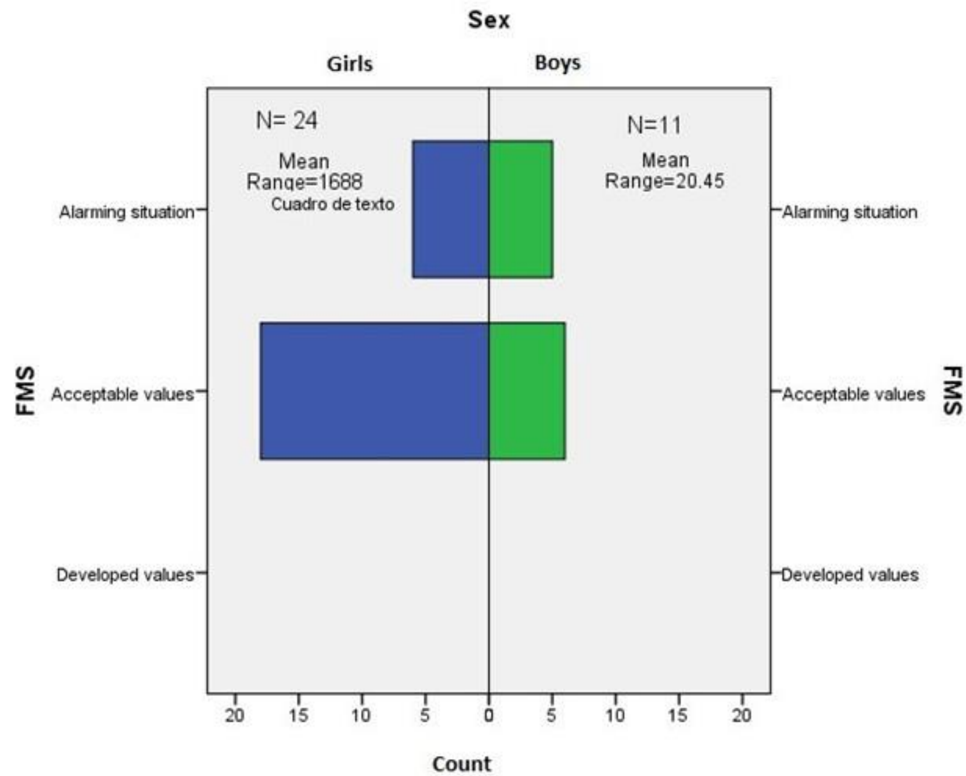

Figure 4. FMS mean range divided by participants' sex. Differences yielded by the Mann-Whitney U Test for independent samples.

DISCUSSION

The main aim of the present study was to assess global movement quality according to the fundamental movement patterns applying the Functional Movement Screen in adolescent students of both sexes aged between 12 and 13. The major findings revealed that girls presented better quality of movement than boys, with a mean global score of 16 points, compared to 15 of boys, with no significant differences between sexes.

In this regard, there is some controversy with previous studies. On one hand, these data agree with García-Jaén et al. (2018), who concluded that the global test score was higher in girls than in boys, as well as García-Pinillos et al. (2018), who established that sex does not seem to affect test performance. By contrast, the study by Anderson et al. (2015) contradicts the results obtained in the present research, since they did find significant differences in FMS scores between boys and girls, boys scoring actually higher. Nevertheless, it must be born in mind that the sample of this last study consisted of adolescents up to 17 years old, meaning greater biological maturation, which reflected in greater muscle strength and postural control in boys than in girls. This had not happened yet at the ages involved in our study.

The results of the FMS test showed that 75% of the girls (n=18) and 54.5% of the boys (n=6) scored above 14 points (acceptable level), while 25% of the girls (n=6) and 45% of the boys (n=5) scored 14 or under 14 points (low level or increased injury risk).

With regard to the specific goal of students' joint mobility, differences were observed in shoulder mobility (both right and left) and active straight left leg raise, where boys presented lower joint range of movement. Abraham et al. (2015) found significant differences in active straight right leg raise, boys scoring higher in this case. In our study, boys and girls scored very similar in this test, although there was only one score of 1 point, and it belonged to a girl.

According to the results obtained in the deep squat, the predominant value in boys and girls (more than 70%) was 2 points, followed by 3 points; no student scored 1 in this test. These results reveal that few students presented big deficiencies in this test, in contrast to other studies that reported significantly lower scores for girls, probably due to the lack of postural control and muscle strength (Anderson et al., 2015; Abraham et al. 2015; García-Pinillos et al. 2019).

Neither boys nor girls presented difficulties in the hurdle step (none of them scored 1), revealing the absence of muscle shortening or imbalances, which would appear when raising the lower limb. Girls obtained higher scores for the quality of this movement: 91.7% scored 3, compared to 63.6% of the boys.

The in-line lunge test evidenced postural control deficiencies in girls, since none of them achieved the maximum score, 70.8% obtained 2 points (they performed the exercise in an acceptable manner, with some compensation) and the rest, 29.2%, scored only 1 (they did not complete the movement correctly or they used several compensations to complete it). These results were caused by small imbalances and decreased postural control in segments of the upper and lower limb, in particular the trunk and knee. Our results are in line with Anderson et al. (2015) and Abraham et al. (2015), who reported significantly lower scores for girls than boys. Nonetheless, this disagrees with García-Pinillos et al. (2018) and García-Jaén et al. (2018), who reported better scores in the in-line lunge for girls than boys. However, the authors stated that this could be due to the age of the participants, primary school students (8.5 ± .5 years), not being therefore appropriate to compare and extrapolate the results to populations of different age, since biological maturation affects physical performance, muscle mass and intramuscular coordination. In our case, mean age was 12.2 years, which is higher than in the studies by García-Jaén et al. (2018) and García-Pinillos et al. (2018), but lower than in the studies by Anderson et al. (2015) and Abraham et al. (2015). Consequently, comparing the results to these studies allows only for an approximation, given that many and very fast anatomical, biological, physiological and motor changes occur at these ages, but not at the same age for every adolescent.

Given the weaknesses found in this test, complete training not only of the anterior muscles (abdominal wall and quadriceps), but also of the posterior and rotator muscles (hamstrings, gluteus medius, lower back, oblique muscles) is suggested. These muscles are essential for a correct posture and body balance in order to perform this test successfully.

In the trunk stability test, boys achieved higher scores than girls, in keeping with the studies by Anderson et al. (2015), Abraham et al. (2015) and García-Pinillos et al. (2019). However, in the present study, girls scored higher than boys in the rotary stability tests. Some boys scored 1 point, while all girls scored 2 or 3, the highest percentage corresponding to 3.

It can be concluded that the stability variable (hurdle step) presented the highest score in both girls and boys, girls showing greater postural control, since they scored 3 points in 91.7% of the cases. In the other trunk stability test (push up), opposite results were found: 54.5% of the boys scored 3 points, compared to 25% of the girls, who mostly scored 2 or even 1 in this test. This may be due to the greater general strength and postural control of boys in this test.

A noteworthy fact is that, in the tests performed on both sides (except the rotary stability test), both girls and boys scored higher on the right side, revealing a deficit in the use of the non-dominant side. Work on the different skills on both sides should be emphasised.

Lastly, it is important to highlight that, although no adolescent achieved 21 points (one boy and one girl reached 20 points), none of the participants scored 0 in any of the tests, i.e. none of them felt pain during test execution. This is a positive aspect of the research, meaning that the situation was not extreme in any case, although several movements would need work in order to improve the scores.

CONCLUSIONS

It can be concluded from this research that girls of a sample of students between 12 and 13 years old presented better quality of movement than boys, with a mean global score of 16 points, compared to 15 of boys.

In the shoulder mobility and active straight left leg raise tests, girls presented greater range of movement than boys. Similarly, girls achieved better scores in the rotary stability test.

Both sexes obtained similar scores in the deep squat and hurdle step tests (girls slightly higher than boys), while boys scored higher in the trunk stability test. Both groups obtained the lowest score in the in-line lunge test, boys scoring slightly higher than girls.

In those tests performed on both sides (left and right), girls and boys obtained higher scores on the right side, except boys in the rotary stability test, where they obtained similar results on both sides.

It is, therefore, concluded that both groups presented an acceptable level of movement quality, although compensatory exercises would still be needed in order to reduce imbalances and asymmetries.

Among the limitations of the study we must highlight its cross-sectional nature and the sample size. The results may vary with a larger number of adolescents, so they must be handled with caution. Moreover, the number of boys was considerably smaller than the number of girls, what may have affected the comparison between groups.

In future studies, it would be advisable to extend the sample to different ages, in order to determine the differences among school years. Besides, it would be interesting to take into account the after-school physical activity practice, including the type of activity and years of experience. This would allow us to determine whether a higher or lower score in the different tests is directly related with the practice of any sport modality or not.

Likewise, longitudinal studies along the school year are needed in order to examine the evolution of functional patterns along time, as well as to determine the relationships of these patterns with other variables of interest, such as anthropometric parameters (BMI, fat percentage, etc.), physical fitness level and health habits.

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DISCLOSURE STATEMENT

The authors declare no conflicts of interest.

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