Functional movement screen differences between male and female young judokas athletes

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

Marco A. García-Luna [ABCDE], Juan M. Cortell-Tormo [ABCD], Juan A. Valero-Cotillas [BC], Miguel García-Jaén [ABC]

University of Alicante, Alicante, Spain

Received: 25 March 2020; **Accepted:** 27 April 2020; **Published online:** 20 May 2020

AoBID: 13453

Abstract

Background and Study Aim: The Functional Movement Screen (FMS) test has been used in different sports to identify the alterations and asymmetries in the basic movement patterns of the athletes, although it has not been analysed as widely in children population, and even less in judo. The cognitive objective of this study was knowledge about the basic motor competence and the risk of injury in children practicing judo through the evaluation of fundamental movement patterns using the FMS test, and to establish a comparison between genders.

Material and Methods: Thirty young judokas (16 girls and 14 boys) participated in the study (mean ±SD; age: 13.93 ±0.96 years old; weight: 58.60 ±11.32 kg; height: 162.67 ±9.60 cm; BMI: 22.29 ±2.77 kg/m²). The performance of each participant was digitally recorded by two cameras, one in each plane (frontal and sagittal), and was later analysed jointly by two evaluators who are experts in the use of FMS.

Results: The girls obtained higher scores on the sum of the seven tests, compared to boys (16.00 ±1.79 vs. 13.57 ±2.59; p = 0.005). In particular, girls scored significantly better than boys in the deep squat, the rotary stability and the active straight leg raise tasks (p<0.05). The boys scored statistically significantly higher than girls in the trunk stability push up task (p<0.05).

Conclusions: The girls scored higher on most tasks, indicating better fundamental movement patterns. In addition, most girls scored above 14 points, while most boys scored at or below 14 points, which may indicate decreased motor competence and increased risk of injury in boys.

Keywords: children • motor competences • motor skills • quality of movement • sex differences

Conflict of interest: Authors have declared that no competing interest exists

Ethical approval: The study was approved by the local Ethics Committee

Provenance & peer review: Not commissioned; externally peer-reviewed

Source of support: Departmental sources

Author's address: Juan M. Cortell-Tormo; University of Alicante, Area of Physical Education and Sport, Campus de San Vicente del Raspeig, s/n, 03690, San Vicente del Raspeig, Alicante, Spain; email: jm.cortell@ua.es

Performance – *noun* the level at which a player or athlete is carrying out their activity, either in relation to others or in relation to personal goals or standards [30].

Physical activity – *noun* exercise and general movement that a person carries out as part of their day [30].

Motor skills – *plural noun* the ability of a person to make movements to achieve a goal, with stages including processing the information in the brain, transmitting neural signals and coordinating the relevant muscles to achieve the desired effect [30].

Training session – *noun* a period of time during which an athlete trains, either alone, with a trainer or with their team [30].

Motor competence – Authors of the conception stand out in the general sense three types of activities within a 24 hours routine in human life: everyday routine activities, work activities (in this professional sport), leisure-time activities. They emphasize that "Today, most of the work procedures require a combination of physical, intellectual, psychological and social competences. The requirements in regard to the motor (psychomotor) domain have shifted mostly from gross-motor to fi ne-motor activities. This is also due developments characterized by the phenomena of automation, technology, and computers" [31, p. 34]. Consequence of this attempt is distinguishing four elements structure of motor competence: sensory abilities (visual-, auditive-, tactile-, kinaesthetic abilities), motor abilities – condition (endurance, fl exibility, strength, speed), motor abilities – coordination (balance, motor combination, skill, reaction speed), body experience (body scheme: orientation, size estimation, knowledge; body image: consciousness, boundary, attitude) [31, see also p. 32].

INTRODUCTION

Judo is a martial art which has its origin in Japan, and comes from another Japanese martial art, jiu-jitsu. This was created by Jigoro Kano (1860-1938) in 1882 founding the first school of judo in history, which was called *the Kodokan*. Jigoro Kano had practiced jiu-jitsu for many years of his life and decided to create his own style based on movements of other martial arts. Thus, judo is known as the "way of softness" because of the syllables that form its name "ju" (soft, flexible, subtle) and "do" (way, path, track).

This is regulated by the International Judo Federation, which was created in 1951, and which organized the first World Championship 3 years later in Tokyo (Japan). As for its incursion in the Olympic Games, in 1964 it was part of the exhibition sports program in the Tokyo Games, but it was not until 1972 in the Munich Olympics when it became part of the Olympic Program of the IOC (International Olympic Committee), although it was only in the male category. It was not until 1992 in the Barcelona Games that the women's category was added.

The practice of judo has been increasing exponentially throughout the years in most countries, currently counting in Spain with 105,206 federated licenses [1]. This has been due, not only to the recreational content inherent in its practice, but also to its great physical and psychosocial benefits – especially by practicing it at an early age – on body composition, strength, endurance, motor skills, cognitive performance, life satisfaction and a better behaviour and socialization [2-7]. Children need a minimum of motor skills to achieve sporting and psychosocial success, without which they may become demotivated and even abandon the practice of sports [8, 9]. This is of great importance, since these negative motor experiences of the child can affect their own self-concept, posing a risk of distancing themselves from sports practice in the future adolescent and adult [10, 11].

Although different test batteries have been applied in order to predict and evaluate physical condition, motor aptitude and level of motor competence and skills, they have generally focused on their quantitative analysis, leaving aside the qualitative aspects [12, 13]. In this respect, the *Functional Movement Screen* test™ (FMS) has been consolidated as a valid system for assessing the quality of global movement based on the evaluation of the individual's fundamental movement patterns [14, 15]. Furthermore, these authors state that FMS test is useful for describing the basic motor competence of the individual, as well as for identifying his limitations and asymmetries in basic functional movements at any age [16, 17].

This test consists of seven tasks which challenge the subject's motor control, challenging mobility, stability and balance by executing specific and fundamental patterns of movement. These seven tasks are intended to highlight both bilateral imbalances and the mobility-stability capacity of each body segment. Furthermore, according to a recent meta-analysis it seems that FMS has an excellent reliability inter and intra evaluators [18]. This meta-analysis also proposes this test as a predictor of musculoskeletal injuries suggesting that scores less than or equal to 14 points would indicate a significant increase in the probability of injury compared to those who obtain higher scores [18, 19-21].

So far, most research has used the FMS test in adult, active, male and/or female populations. However, its use in children and/or teenagers is not very extended, and even less in the field of Judo. Moreover, there is hardly any comparison of scores between genders, which could elucidate different lines of research. So, on the one hand, there is a need to measure the quality of global movement and the fundamental movement patterns in children and/or adolescents in order to know their motor competence. On the other hand, given the established gender differences in relation to muscle activation and strength, motor control, core stability, and injury ratios between males and females, it is interesting if these could be evidenced by performing the FMS test in judokas.

Therefore, the objective of this study was knowledge about the basic motor competence and the risk of injury in children practicing judo through the evaluation of fundamental movement patterns using the FMS test, and to establish a comparison between genders.

MATERIAL AND METHODS

Participants

A sample selected for convenience of 30 athletes (16 girls, 14 boys) in the beginner (under-14), youth (under-15) and junior (under-16) categories, belonging to a judo club (Chidaoba Judo Club/Athletes'

School; Alicante, Spain) participated in this study (mean ±SD; age: 13.93 ±0.96 years old; weight: 58.60 ±11.32 kg; height: 162.67 ±9.60 cm; BMI: 22.29 ±2.77 kg/m^2) – more details Table 1.

All had over 5 years of training experience and a national competitive level. Their training was generalised and they performed the same number of training sessions per week (3-4 days/week), also with similar contents. To be included in the study, participants had to have no suffered no musculoskeletal injuries in the last six months and did not have to have any vestibular, visual or balance problems. The participants' legal guardians signed an informed consent form outlining the purpose of the research and the methods and procedures used.

All the protocols complied with the Helsinki Declaration.

Instruments

The anthropometric data of weight and height were obtained through the use of a digital scale (Avery Ltd. Model 3306 ABV) and a portable stadiometer (Holtain Ltd.). The following materials were used to carry out the different tasks that make up the FMS test battery: a 1.22 m plastic stick, two 0.61 m plastic sticks, a 2x6 cm wooden plank, adhesive tape, tape measure, and some cones. In addition, two high definition cameras with 4K recording technology were used to record the execution of the exercises from the frontal and sagittal planes.

Procedures

The evaluations were performed individually, with only one test per practitioner. The FMS test consists of seven movements or tasks –and three pain clarification test–, which are listed below: (1) deep squat; (2) hurdle step; (3) in-line lunge; (4) shoulder mobility; (5) active straight leg raise; (6) trunk stability push-up; and (7) rotary stability. In five of the seven tasks (all except the deep squat and trunk stability push-up), the performance of both the left and right sides of the body must be evaluated. The participants completed five minutes of directed warm-up, consisting of basic dynamic mobility exercises, before the execution of the exercises. Participants were given verbal instructions for each exercise following the description guidelines proposed by Cook et al. [22]. Each participant can make three attempts of each task, being three points the maximum score of each exercise, and therefore 21 points the maximum score that a person can obtain in the FMS test.

The qualification criteria are as follows: (i) three points if the person is able to perform the movement by meeting all the established criteria without the need to apply any compensation; (ii) two points if the person is able to perform the movement without the need to apply compensations, but without meeting all the established criteria; (iii) one point if the individual is able to perform the movement, but without meeting all the established criteria and with the assistance of a support or compensation; and (iv) zero points if the person is unable to complete the exercise and/or feels pain while performing the exercise. In the movements that involve unilateral exercises, the left and right extremities are independently evaluated, taking as a reference the lowest score in the calculation of the total score of the test. The clarification test for pain were scored as positive (having pain) or negative (not having pain) depending on whether they were painful for the participant. If the person has pain during movement, he or she automatically obtains a zero point score on that test, regardless of the score obtained previously [14].

The performance of each participant was digitally recorded from different movement planes and was later analysed jointly by two evaluators with at least two years of experience in the use of FMS [23].

Table 1. Descriptive data of the participants differentiated by gender (mean ±SD).

Variable	Total	Girls	Boys
	n = 30	n = 16	n = 14
Age (years)	13.93 ±0.96	13.50 ±1.07	14.43 ± 0.54
Weight (kg)	58.60 ±11.32	50.91 ±4.54	67.39 ± 10.30
Height (cm)	162.67 ±9.60	154.50 ±6.71	169.86 ±4.03
BMI (kg/m^2)	22.29 ±2.77	21.38 ±2.08	23.33 ±3.25

Statistical analysis

The descriptive data of the study (age, weight, height and BMI) are shown as the mean and standard deviation (±). The normality of the sample was checked by the Shapiro-Wilk test. Since the assumption of normality was met, t-test was used to check for differences between genders. The size of the effect was calculated by the Cohen's d, by means of the formula:

$$d = t\sqrt{\frac{n_1+n_2}{n_1 n_2}}$$

All the analyses were performed using Statistical Package for the Social Sciences, ver.25 (Chicago, USA). A value of $p < 0.05$ was established to determine statistical significance.

RESULTS

Figure 1 shows in a descriptive way the result obtained, in percentage values, for the total of the sample in each of the seven tasks. The tasks in which the highest proportion of three-points score were obtained were the active straight leg raise task (80% left; 87% right; 73% total) and trunk stability push-up task (67%). Deep squat (53%), hurdle step (47% left; 67% right; 53% total), in-line lunge (87% left; 60% right; 60% total), shoulder mobility (47% left; 33% right; 60% total) and rotary stability (80% left; 87% right; 73% total) were the tasks in which the two-point score was mostly achieved. There were no tasks in which scores of one point were obtained for the most part, and no tasks were given a score of zero points. All three pain clarification test were negative in all participants.

Figure 2 shows, in percentage values, the results obtained divided by gender, for each of the seven tasks. Girls had a statistically significant higher total score on the FMS test than boys (16.00 ±1.79 vs. 13.57 ±2.59; p = 0.005).

The results show that 75% of girls (n = 12) and 28.57% of boys (n = 4) scored above 14 points, while 25% of girls (n = 4) and 71,43% of boys (n = 10) scored equal to or below 14 points (Figure 3).

Girls in particular scored statistically significantly higher than boys in the deep squat, the rotary stability (both sides and total) and the

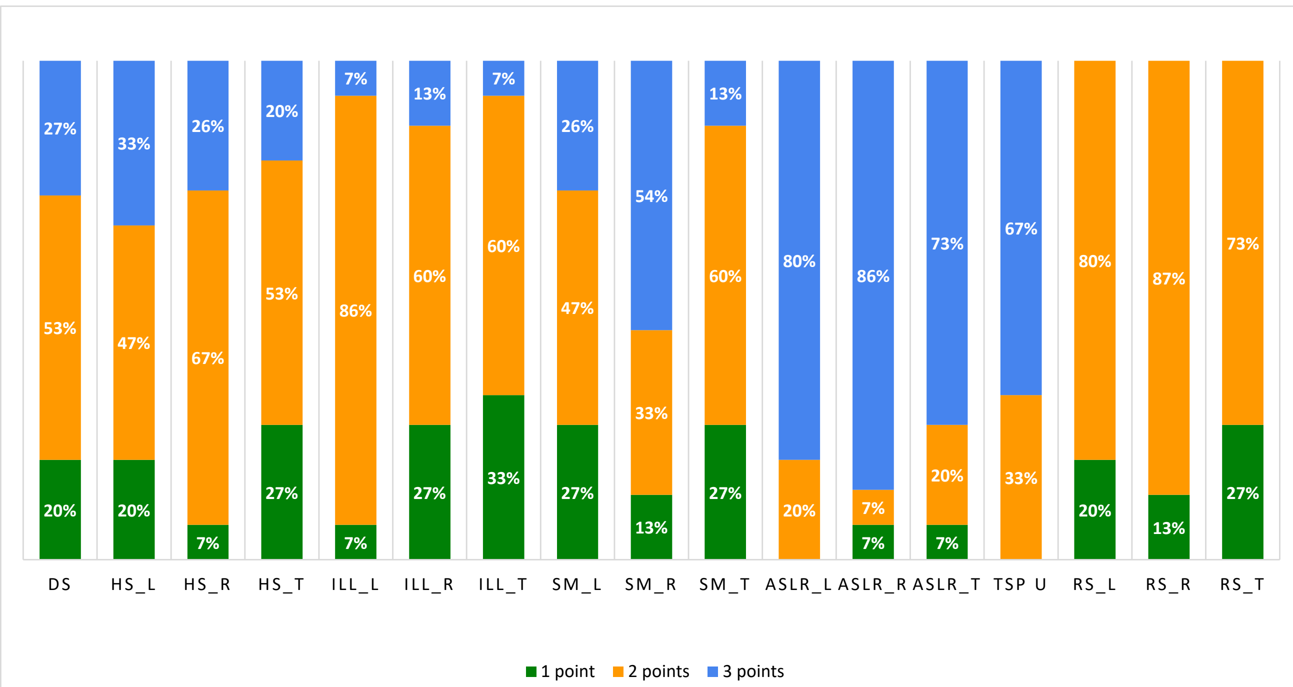

Figure 1. Percentage score obtained by the total sample for each of the 7 tasks of the FMS test.

DS: deep squat; *HS_L:* left hurdle step; *HS_R:* right hurdle step; *HS_T:* total hurdle step; *ILL_L:* left in-line lunge; *ILL_R:* right in-line lunge; *ILL_T:* total in-line lunge; *SM_L:* left shoulder mobility; *SM_R:* right shoulder mobility; *SM_T:* total shoulder mobility; *ASLR_L:* left active straight leg raise; *ASLR_R:* right active straight leg raise; *ASLR_T:* total active straight leg raise; *TSPU:* trunk stability push-up; *RS_L:* left rotary stability; *RS_R:* right rotary stability; *RS_T:* total rotary stability.

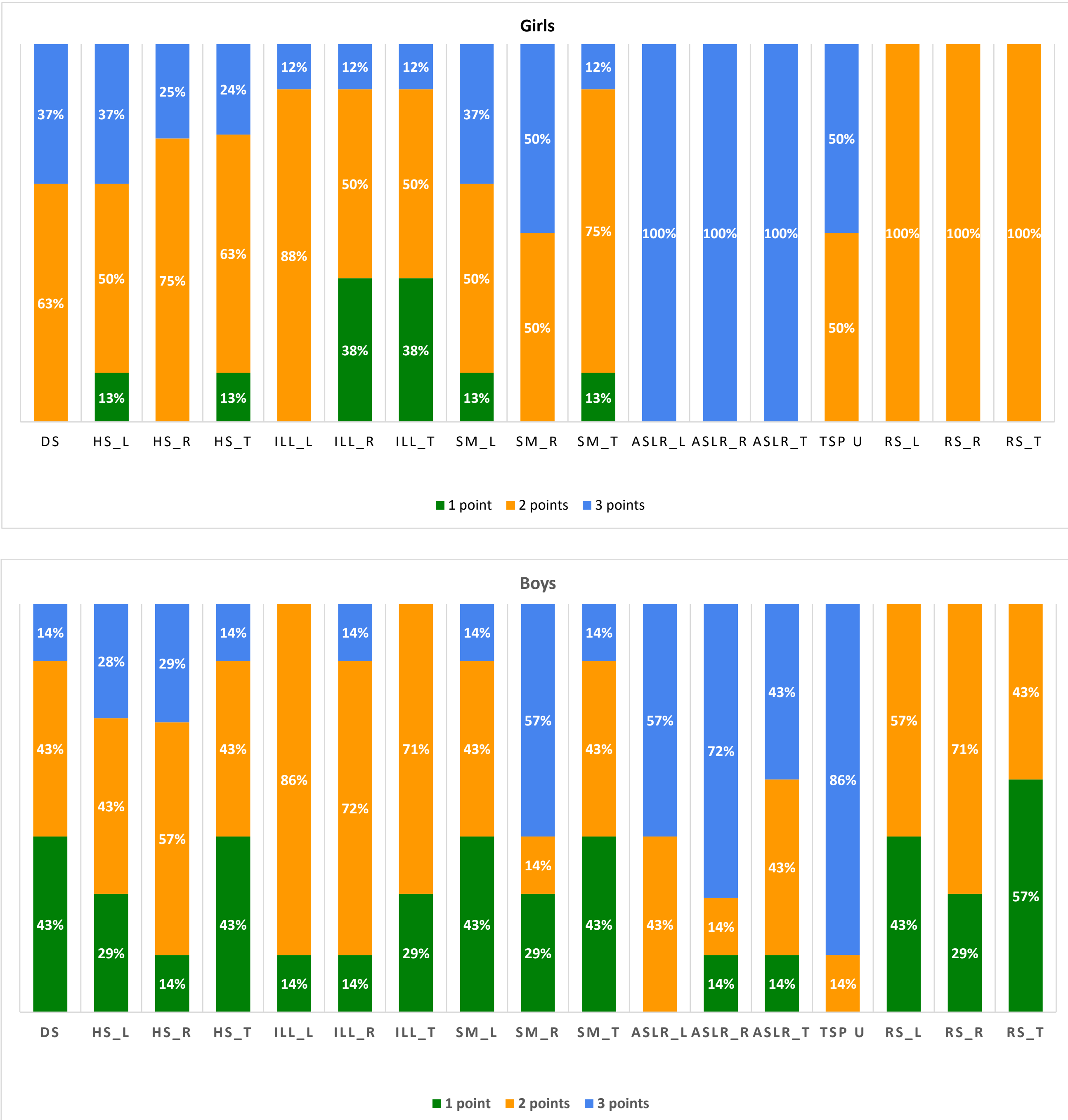

Figure 2. Percentage score obtained divided by gender for each of the 7 tasks of the FMS test.

DS: deep squat; *HS_L:* left hurdle step; *HS_R:* right hurdle step; *HS_T:* total hurdle step; *ILL_L:* left in-line lunge; *ILL_R:* right in-line lunge; *ILL_T:* total in-line lunge; *SM_L:* left shoulder mobility; *SM_R:* right shoulder mobility; *SM_T:* total shoulder mobility; *ASLR_L:* left active straight leg raise; *ASLR_R:* right active straight leg raise; *ASLR_T:* total active straight leg raise; *TSPU:* trunk stability push-up; *RS_L:* left rotary stability; *RS_R:* right rotary stability; *RS_T:* total rotary stability.

active straight leg raise (both sides and total) tasks ($p = 0.007$; $p<0.05$; $p<0.05$; respectively). In in-line lunge and shoulder mobility tasks only significant differences were found, surprisingly, in the left side ($p = 0.047$). The boys scored statistically significantly higher than girls in the trunk stability push up task ($p = 0.036$). In the rest of the exercises, no significant differences in the score between boys and girls were observed, but a tendency in favour of girls was

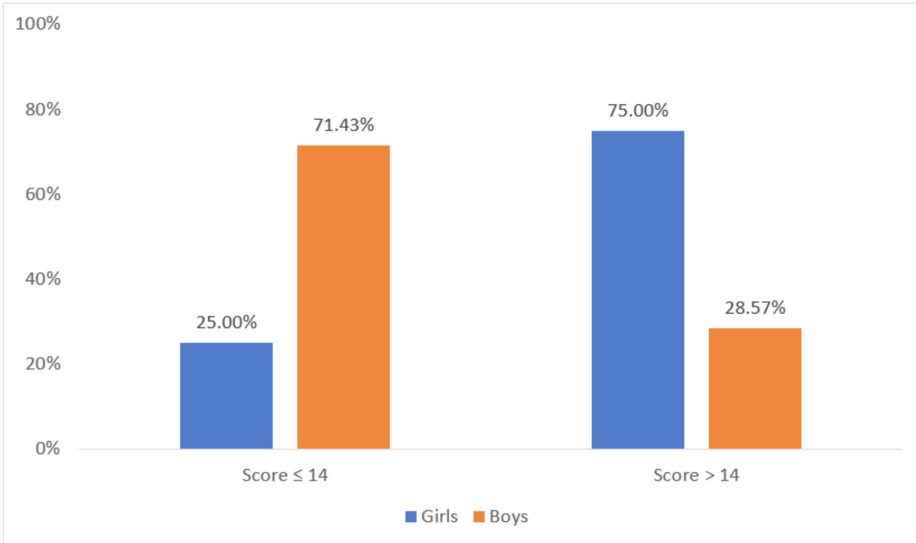

Figure 3. Percentage of participants by gender who scored below/equal to and above 14.

observed in most tasks. The active straight leg raise task in girls (3.00 ±0.00), and the trunk stability push up task in boys (2.86 ±0.38), were the tasks with the best scores in each gender. The worst average score is observed in the in-line lunge task in girls (1.71 ±0.71), and in the rotary stability task in boys (1.43 ±0.54) (Table 2).

DISCUSSION

The results of the study showed that in only two of the seven tasks most of the participants obtained the maximum score (active straight leg raise, and trunk stability push up). In the remaining tasks participants scored mostly with two (deep squat, hurdle step, in-line lunge, shoulder mobility and rotary stability). These results indicate differences in the basic motor competence of judoka children depending on the specific movement pattern assessed, and may therefore reveal possible limitations in mobility, stability, coordination and balance depending on the test assessed.

The FMS test was created to assess fundamental movement patterns and can indirectly measure certain intrinsic factors such as muscle activation and strength, neuromotor control, balance, flexibility and core stabilization ability [22]. These intrinsic factors, together with other extrinsic factors such as gender, age or the subject's level of maturity, can determine the child's level of basic motor competence and therefore influence his or her FMS test scores. This allows us to identify the possible limitations and asymmetries that the subject presents in the execution of fundamental movements that, ultimately, are carried out both in daily life in general and specifically in physical-sports activities [14, 15, 23, 24].

The main finding of our research came when we conducted the gender comparison among the Judokas participating in the study. The results showed that, in the sum of the seven tests of the FMS test, the girls obtained a statistically significant total score higher than the boys (16.00 ±1.79 vs. 13.57 ±2.59; $p = 0.005$). In particular, the girls scored significantly better than the boys in the deep squat, active straight leg raise and rotary stability tasks ($p = 0.007$; $p<0.05$; $p <0.05$; respectively). The boys, on the other hand, scored significantly higher in the trunk stability push up task ($p = 0.036$). In all these tasks, moderate and large effect sizes were found according to Rhea [25], considering the sample as leisure athletes. In the rest of the exercises, no significant differences in the overall score of the tasks according to gender were found. These findings are evidence that girls performed better overall on the FMS test than boys, indicating differences in the assessment of fundamental movement patterns and, therefore, differences in the level of motor competence of this group of Judokas. These findings may reveal and evidence deficits in functional movement capacity in children and an increased risk of injury while practicing Judo or any other physical activity. The factors contributing to this increased risk of injury could be related

Table 2. Comparison of the scores (mean and SD) in the different exercises of the FMS test by gender.

Variable	Girls (n = 16)	Boys (n = 14)	p value	Cohen's d
Deep squat	2.38 ±0.52	1.71 ±0.76	**0.007****	**1.07†**
Hurdle step (left)	2.25 ±0.71	2.00 ±0.82	0.359	0.34
Hurdle step (right)	2.25 ±0.46	2.14 ±0.69	0.604	0.19
Hurdle step (total)	2.13 ±0.64	1.71 ±0.76	0.106	0.61
In-line lunge (left)	2.13 ±0.35	1.86 ±0.38	**0.047***	0.76
In-line lunge (right)	1.75 ±0.71	2.00 ±0.58	0.285	0.40
In-line lunge (total)	1.75 ±0.71	1.71 ±0.49	0.871	0.06
Shoulder mobility (left)	2.25 ±0.71	1.71 ±0.76	**0.047***	0.76
Shoulder mobility (right)	2.50 ±0.54	2.29 ±0.95	0.447	0.28
Shoulder mobility (total)	2.13 ±0.64	1.86 ±0.90	0.233	0.45
Active straight leg raise (left)	3.00 ±0.00	2.57 ±0.54	**0.008****	**1.14†**
Active straight leg raise (right)	3.00 ±0.00	2.57 ±0.79	**0.031***	0.78
Active straight leg raise (total)	3.00 ±0.00	2.29 ±0.76	**0.003****	**1.35†**
Trunk stability push up	2.50 ±0.54	2.86 ±0.38	**0.036***	**0.81†**
Rotary stability (left)	2.00 ±0.00	1.57 ±0.54	**0.008****	**1.14†**
Rotary stability (right)	2.00 ±0.00	1.71 ±0.49	**0.040***	**0.83†**
Rotary stability (total)	2.00 ±0.00	1.43 ±0.54	**0.001****	**1.52††**

*p<0.05; **p<0.01
†0.80 <d <1.50 (moderate effect size); ††d>1.50 (large effect size)

to intrinsic factors (deficits in mobility, core stabilization and coordination and balance ability), as well as being related to extrinsic factors such as age, gender and the child's biological maturation process. Therefore, it could be suggested to include some specific exercises in the judokas' training for each of the detected needs, in order to minimize the differences between both sexes and decrease the possible risk of injury.

To the best of our knowledge, this is the first study to use the FMS test to evaluate the motor competence of children and adolescents in judo. Furthermore, it is the first study to make a gender comparison with the FMS test in this population, as well as to identify and evidence differences in test performance between girls and boys, both in the total score and in the score of some particular tests. Therefore, the comparison of our results with other findings in the related literature is limited. Other studies had already made gender comparisons, but in other populations, of different age and activity levels and physical condition, and with different results from our study. Anderson et al. [24] investigated gender differences in FMS test scores in 60 adolescent school children (31 boys and 29 girls) in secondary education (16 ±1.1 years), reporting that girls scored significantly lower than boys on the sum total of the seven tests (p = 0.004), and suggesting that they may therefore have lower motor competence and an increased risk of injury. Schneiders et al. [26] evaluated 209 active youths (108 girls and 101 boys, 21.9 ±3.7 years old) and found no significant gender differences in total FMS scores. In line with that study, Paszkewicz et al. [27] compared different static and functional tests among young athletes (11.45 ±1.98 years old) and reported that total FMS test scores increased significantly between those participants who were pre-pubertal and those who were post-pubertal, without finding significant differences in the comparison between girls and boys.

Another major finding of our study was that most Judoka girls (75%; n = 12), and only a small number of judoka boys (28.57%; n = 4) scored above 14 points, while 25% of girls (n = 4) and 71.43% of boys (n = 10) scored at or below 14 points. The scientific literature has suggested that a total score of 14 points or less is indicative of an increased risk of injury [18, 19-21]. If we apply this criterion to the results of our study, we can determine that most of the boys evaluated could be at increased risk of injury during judo or another physical activity, while the risk of injury in most of the girls evaluated would be presented as decreased risk. These findings, if confirmed in future studies assessing the basic motor competence of children in different sports, should be considered by any coach when analysing the environment and context in which to set and implement any motor task, and thus be able to detect deficiencies in the athlete's motor capacity, as well as pose motor challenges that help improve fundamental patterns of movement and restore optimal functional movement capacity, thereby improving their motor competence and decreasing their risk of injury [24]. However, it should be noted that recent studies have questioned the predictive value of this test in determining the risk of injury [28, 29], and that, in any case, this threshold of 14 points has not been established as valid for a population of children and adolescents, so that the real risk of injury is unknown and can only be inferred from previous research that has examined this issue in other population groups [18], so that our conclusions in this regard are limited.

With regard to other limitations of the study, it is worth noting that this research did not directly examine the intrinsic factors that can influence basic motor competence and the execution of fundamental movement patterns (muscle activity and strength, motor control, coordination, balance and core stability), so we can only speculate and infer the reasons why boys scored lower than girls, and relate it in a limited way to extrinsic factors such as age, activity and physical condition level, gender and the child's maturation process. However, although these intrinsic factors are not directly measured by the FMS test, it is generally accepted that the integration of all these intrinsic factors is required to successfully complete the various tests of the FMS test [16, 17]. It would be interesting for future research to explore possible relationships between FMS test scores and levels of muscle activation, motor control, coordination, balance and core stabilization. Also, more studies could be proposed to investigate possible relationships between levels of motor competence, measured by the FMS test, with self-perceived levels of physical fitness, physical activity and health-related quality of life, and to establish gender comparisons in children and adolescents.

CONCLUSIONS

The results showed that, in the sum of the seven tasks of the FMS test, the girls scored statistically significantly higher than the boys, scoring significantly better in the deep squat, active straight leg raise and rotary stability tasks. Boys, on the other hand, scored significantly higher on the trunk stability push up task. In the rest of the exercises, no significant differences in the score according to gender were observed. In addition, most of the girls and only a small number of the boys scored above 14 points. Therefore, most boys scored at or below 14 points, which may indicate reduced motor skills and increased risk of injury in boys. The results of the overall sample indicate differences in the basic motor competence of the children and adolescents in judokas depending on the specific movement pattern assessed, and may therefore reveal possible limitations in mobility, stability, coordination and balance depending on the test assessed.

REFERENCES

1. Spanish National Sports Council. Sports Statistics Yearbook, 2019 [accessed 2020 Jan 18]. Available from URL: http://www.culturaydeporte.gob.es/en/dam/jcr:dc406096-a312-4b9d-bd73-2830d0affb2d/anuario-de-estadisticas-deportivas-2019.pdf
2. Gleser J, Brown P. Judo principles and practices: applications to conflict-solving strategies in psychotherapy. Am J Psychother 1988; 42(3): 437-447
3. Sekulic D, Krstulovic S, Katic R et al. Judo training is more effective for fitness development than recreational sports for 7-year-old boys. Pediatr Exerc Sci 2006; 18(3): 329-338
4. Krstulović S, Kvesić M, Nurkić M. Judo training is more effective in fitness development than recreational sports in 7 year old girls. Facta Univ Ser Phys Educ Sport 2010; 8(1): 71-79
5. Fukuda DH, Stout JR, Burris PM et al. Judo for children and adolescents: benefits of combat sports. Strength Cond J 2011; 33(6): 60-63
6. Sterkowicz-Przybycień K, Klys A, Almansaba R. Educational judo benefits on the preschool children's behaviour. J Combat Sport Martial Arts 2014; 5: 23-26
7. Toskić D, Lilić L, Toskić L. The influence of a year long judo training program on the development of the motor skills of children. Act Phys Educ Sport 2014; 4(1): 55-58
8. Sánchez-Bañuelos F. La actividad física orientada hacia la salud. Madrid: Biblioteca Nueva; 1996 [in Spanish]
9. Ruiz-Pérez LM. Aprender a ser incompetente en educación física: un enfoque psicosocial. Apunt Educ física y Deport 2000; 60: 20-25 [in Spanish]
10. White SA. The perceived purposes of sport among male and female intercollegiate and recreational sport participants. Int J Sport Psychol 1995; 26(4): 490-502

11. Kerr R, Cote J, Hay J et al. Changing attitudes and expectations in a university setting: A case study. Phys Educ 1998; 55(3): 160-168

12. Gómez-Puerto JR, Berral de la Rosa CJ, Viana-Montaner BH et al. Valoración de la aptitud física en escolares. Arch Med del Deport 2002; 19(90): 273-282 [in Spanish]

13. Ruiz-Pérez LM, Navia-Manzano JA, Ruiz-Amengual A et al. Coordinación motriz y rendimiento académico en adolescentes. Retos 2016; 29: 86-89 [in Spanish]

14. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function – part 1. N Am J Sports Phys Ther 2006; 1(2): 62-72

15. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function – part 2. N Am J Sports Phys Ther 2006; 1(3): 132-139

16. Cook G, Burton L, Hoogenboom BJ et al. Functional movement screening: the use of fundamental movements as an assessment of function – part 1. Int J Sports Phys Ther 2014; 9(3): 396-409

17. Cook G, Burton L, Hoogenboom BJ et al. Functional movement screening: the use of fundamental movements as an assessment of function – part 2. Int J Sports Phys Ther 2014; 9(4): 549-563

18. Bonazza NA, Smuin D, Onks CA et al. Reliability, validity, and injury predictive value of the Functional Movement Screen: a systematic review and meta-analysis. Am J Sports Med 2017; 45(3): 725-732

19. Chorba RS, Chorba DJ, Bouillon LE et al. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. N Am J Sports Phys Ther 2010; 5(2): 47-54

20. O'Connor FG, Deuster PA, Davis J et al. Functional Movement Screening: predicting injuries in officer candidates. Med Sci Sport Exerc 2011; 43(12): 2224-2230

21. Kiesel KB, Butler RJ, Plisky PJ. Prediction of injury by limited and asymmetrical fundamental movement patterns in american football players. J Sport Rehabil 2014; 23(2): 88-94

22. Cook G, Burton L, Kiesel K et al. Movement. Functional movement systems: screening, assessment and corrective strategies. Santa Cruz: Lotus Publishing; 2010: 407

23. Kiesel K, Plisky P, Butler R. Functional movement test scores improve following a standardized off-season intervention program in professional football players. Scand J Med Sci Sports 2011; 21(2): 287-292

24. Anderson BE, Neumann ML, Huxel-Bliven KC. Functional Movement Screen differences between male and female secondary school athletes. J Strength Cond Res 2015; 29(4): 1098-1106

25. Rhea MR. Determining the magnitude of treatment effects in strength training research through the use of the effect size. J Strength Cond Res 2004; 18(4): 918-920

26. Schneiders AG, Davidsson A, Hörman E et al. Functional movement screen normative values in a young, active population. Int J Sports Phys Ther 2011; 6(2): 75-82

27. Paszkewicz JR, McCarty CW, Van Lunen BL. Comparison of functional and static evaluation tools among adolescent athletes. J Strength Cond Res 2013; 27(10): 2842-2850

28. Moran RW, Schneiders AG, Mason J et al. Do Functional Movement Screen (FMS) composite scores predict subsequent injury? A systematic review with meta-analysis. Br J Sports Med 2017; 51(23): 1661-1669

29. Newton F, McCall A, Ryan D et al. Functional Movement Screen (FMSTM) score does not predict injury in English Premier League youth academy football players. Sci Med Footb 2017; 1(2): 102-106

30. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006

31. Hagg H, Haag G. From physical fitness to motor competence: Aims – Content – Methods – Evaluation. Sports Sciences International. Berno: Peter Lang GmbH, Internationaler Verlag der Wissenschaften; 2000

32. Kalina RM, Barczyński BJ. From "physical fitness" through "motor competence" to the "possibility of action. Arch Budo 2008; 4: 106-109

Cite this article as: García-Luna MA, Cortell-Tormo JM, Valero-Cotillas JA et al. Functional movement screen differences between male and female young judokas athletes. Arch Budo 2020; 16: 119-127