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Original

EFECTOS DE LA EDAD CRONOLÓGICA EN LA PUNTUACIÓN DEL FUNCTIONAL MOVEMENT SCREEN^{TM} EN PREADOLESCENTES: ESTUDIO DE COHORTE

CHRONOLOGICAL AGE EFFECTS ON FUCTIONAL MOVEMENT SCREEN^{TM} SCORE IN PREADOLESCENTS: A COHORT STUDY

Alonso-Aubin, D. A.[1]; Rodrigo-Mallorca, D.[2]; Gómez, C.[3]; Chulvi-Medrano, I.[2].

[1]*Wingsport, Madrid, Spain*

[2] *Facultad de Ciencias de la Actividad Física y el Deporte. Universidad de Valencia. Spain*

[3]*Grupo de Investigación Fisioterapia y readaptación al deporte. Departamento de Fisioterapia. Universidad Católica San Antonio de Murcia. Spain*

Correspondence to:
Iván Chulvi Medrano
Facultad de Ciencias de la Actividad Física y el Deporte.
Universidad de Valencia
C/Gascó Oliag 3, 46010. Valencia-Spain
Tel. 677 222 952
Email ivan.chulvi@uv.es

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editor@journalshr.com

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RESUMEN

Introducción: Existe una alta prevalencia de “analfabetismo motriz” en la población pediátrica. Esta situación puede provocar una influencia negativa en la cantidad y la calidad de actividad física, así como el consiguiente desarrollo de condición física. La calidad del movimiento puede ser conocida aplicando el Functional Movement Screen (FMS^{TM}). Sin embargo, hay pocos estudios que hayan utilizado el FMS^{TM} en población preadolescente.

Objetivo: Así, el objetivo de este estudio fue examinar las puntuaciones obtenidas en el FMS^{TM} en subgrupos de preadolescentes.

Metodología: Las pruebas del FMS^{TM} fueron administradas de acuerdo a los procedimientos estándar que consisten en siete movimientos y las puntuaciones (0-3) de cada ejercicio fueron registradas en 213 preadolescentes (13.47±1.9 años). La muestra fue dividida en cuartiles por edad para ser analizada [(Q1 N = 53, de 0 a 11.79 años); (Q2 N = 54, de 11.79 a 13.59 años); (Q3 N = 53, de 13.59 a 14.91 años); (Q4 N = 53 más de 14 años).

Resultados: Existen diferencias en la puntuación final entre Q1 vs Q3 y Q1 vs Q4 ($p<0.05$). En la prueba *in line lunge* las diferencias de puntuación obtenidas por Q4 son mayores Q1 (-0.58, $p\leq 0.001$) y Q2 (-0.65, $p\leq 0.001$). En la prueba *trunk stability* Q4 obtiene una puntuación mayor que Q1 (-0.88; $p\leq 0.001$). En la prueba *leg raising*, Q1 obtiene una puntuación menor que Q4 (-0.45; $p\leq 0.05$).

Conclusiones: La edad cronológica puede influir en la habilidad del movimiento y las puntuaciones de los test *in line lunge, trunk stability y leg raising* en preadolescentes. Además, Q4 puntúa mejor que Q1 y esto puede estar asociado con el estado madurativo.

Palabras clave: fuerza, alfabetismo motriz, maduración, rango de movimiento, fitness pediátrico

ABSTRACT

Introduction: There is a high prevalence of "motor illiteracy" among the pediatric population. This situation can exert a negative influence on the amount and quality of physical activity, as well as the development of subsequent physical condition. The quality of movement can be known by applying the Functional Movement Screen (FMS^{TM}). However, there are few studies using FMS^{TM} in preadolescent population.

Objective: Therefore, the objective of the present study was to examine the scores obtained with the FMS^{TM} by subgroups in preadolescents.

Methods: FMS^{TM} was administered according to standard procedures which consist in seven movements and scores (0-3) of each exercise were recorded in 213 preadolescents (13.47±1.9 years). The sample was divided by quartiles of age for analysis [(Q1 N = 53, from 0 to 11.79 years); (Q2 N = 54, from 11.79 to 13.59 years); (Q3 N = 53, from 13.59 to 14.91 years); (Q4 N = 53 over 14 years old).

Results: There are differences in the final score between Q1 vs Q3 and Q1 vs Q4 ($p <0.05$). In the in line lunge the score differences obtained by Q4 are higher than Q1 (-0.58, $p\leq 0.001$) and Q2 (-0.65, $p\leq 0.001$). In trunk stability Q4 gets a score higher than Q1 (-0.88) ($p\leq 0.001$). In leg raising, Q1 scored lower ($p <0.05$) than Q4 (-0.45).

Conclusions: Chronological age can influence the ability to move and the scores on in line lunge, trunk stability and leg raising tests in preadolescents. In addition, Q4 scores better than Q1 and could be associated with the maturational status.

Keywords: strength; physical literacy; maturation; range of movement; youth fitness

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INTRODUCTION

During the transition from childhood to adolescence, there are changes in the growth, development and maturation of children (Malina et al., 2004). These biological processes are heterochronous with great inter-individual variability (Jakovljevic et al., 2016).
Through this transition physical activity has been considered an enhancing factor for the acquisition of motor skills and physical abilities (Faigenbaum et al., 2019; R. S. Lloyd et al., 2015) as a factor for the phenomenon of motor illiteracy, which describes the lack of confidence, motivation, competence, and knowledge to move proficiently in a variety of physical activities (Faigenbaum & Rebullido, 2018).
Strength and conditioning programs in pediatric stages should be adjusted to the needs and specific situations of each subject and prescribe exercises knowing the difference between chronological and biological age (Lloyd et al., 2016). The maturation stage can suppose a big difference on physical and motor capacities in consequence it must be considered a stage of special awareness for motor learning (Lloyd et al., 2016; Myer et al., 2015). Current recommendations for physical activity include developing motor skills which may help to facilitate exercise initiation and maintenance throughout childhood and being critical for promoting physical activity and other positive health trajectories across the lifespan (Frith and Loprinzi, 2019; Hulteen et al., 2018; Francesco and Greco, 2017). Integrated neuromuscular training is defined as the combination of activities that involves physical capabilities and motor control activities (Faigenbaum et al., 2018, 2019; Faigenbaum & Rebullido, 2018; Myer et al., 2015), and is related with the ability of fundamental movements (locomotor skills, goal control skills and stability skills) and with levels of physical activity (Holfelder & Schott, 2014).
The physical literacy is an essential component of youth training thus, due to the needs to improve motor patterns, it is important to establish an initial evaluation according to the maturational state of the subject. There is an emergent need of validated instruments that may be employed to evaluate fundamental and functional movement abilities of young children (Barnett et al., 2016; Plowman et al., 2014) The Functional Movement Screen (FMS^{TM}) evaluates trunk stability, range of motion, motion quality and symmetry during the performance of basic functional movement and has been stablished as an economic, practical and valid too (Cook et al., 2006, 2014; Kraus et al., 2014; Lubans et al., 2010). The FMS^{TM} presents acceptable levels of reliability among evaluators and intra-evaluators that allow it to be a detection tool for the development of exercise programs focused on the prevention of injuries, rehabilitation and improvement of sports performance (Cook et al., 2006, 2014; Kraus et al., 2014; Lubans et al., 2010). There are few studies that have included a pediatric sample stratified by quartiles of age to check whether the chronological age affects the FMS^{TM} score. Recently, it has been identified that age can influence the movement capacity evaluated with the FMS^{TM} and in particular on the inline, trunk stability and leg raising test in children under 14 years of age, possibly due to the influence of the maturational state (Portas et al., 2016). Because motor competence is enormously important in adolescent physical development and there is a great paucity of studies that assess the quality of movement, this study represents a novelty in this field. Therefore, the objective of this study is to determine if age can influence the FMS^{TM} score by age subgroups in healthy and active preadolescents. We hypothesize that the older the age, the higher the values in the FMS^{TM}.

We present the following article in accordance with the STROBE reporting checklist (Von Elm et al., 2008) (Appendix 1).

METHODS

Participants

In this cross-sectional cohort study, active preadolescents aged 10-15 years were recruited to participate voluntarily in this study (mean ± SD; age: 13.47 ± 1.97; height: 1.61 ± 0.12; body mass: 56.40 ± 16.61; body mass index: 21.34 ± 4.56). The study was carried out in a several rugby clubs in the city of Madrid. The recruitment period began in August 2019. The assessment period extended from September 2019 to February 2020. The study was approved by the Instituto Valenciano de Postgrado (IVP-0015-2020). Participants were excluded from the study by an expert physical therapist if they had any musculoskeletal disorder or injury that impede participation in the correct execution of the test. All participants were asked about the number of days in the past week that they spent a total of at least 60 minutes participating in any physical activity that increased heart rate or breathing rate hard some of the time considered active.

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They must response at least 5 days per week in order to be considered active (Borrud et al., 2014). In the same questionnaire it was included a question about previous experience in systematic resistance training and in FMS^{TM} test. Sample should not have experience in any systematic resistance training in the last 6 months and none had previous experience in making the FMS^{TM} battery. Included subjects were divided for analysis in quartiles of age: [(Q1 N = 53, from 0 to 11,79 years); (Q2 N = 54, from 11,79 to 13,59 years); (Q3 N = 53, from 13,59 to 14.91 years); (Q4 N = 53, over 14 years old). Descriptive analysis of the groups can be found in table 1. Informed consent was administered and signed by parents of all participants before the start of the data collection. The research was approved by local Ethics Committee.

Table 1. Descriptive analysis of the subjects

	All	Group Q1	Group Q2	Group Q3	Group Q4
N	213	53	54	53	53
age (years ± SD)	13.47 (1.97)	10.96 (0.67)	12.75 (0.57)	14.14 (0.38)	16.05 (0.89)
weight (kg ± SD)	56.40 (16.61)	41.96 (9.67)	54.27 (13.83)	65.80 (17.76)	63.59 (12.66)
height (m ± SD)	1.61 (0.12)	1.49 (0.07)	1.58 (0.09)	1.69 (0.08)	1.67 (0.11)

Procedures

In this cross-sectional study, a pediatric sample performed the FMS^{TM} in order to report the possible influence of age in FMS^{TM} scores. The FMS^{TM} battery includes seven tests and three clearing exams: deep squat, hurdle step (right and left), active straight leg raise (right and left), rotary stability (right and left) and spinal flexion pain test (clearing exam); in-line lunge (right and left), trunk stability push-up and back extension pain test (clearing exam); shoulder mobility (right and left) and shoulder pain test (clearing exam). The tests are evaluated using an ordinal scale (0-3) (Cook et al., 2006, 2014; Lubans et al., 2010): 0=pain during the movement; 1=participant is unable to execute the correct movement, 2=participant executes the movement with compensations; and 3: participant executes correct movement without pain or compensations. The maximum total score is 21 points.

Evaluators (n=2) had more than five years of experience on applying FMS^{TM} (Cook et al., 2006, 2014; Lubans et al., 2010). Assessment and scoring procedures were followed respecting FMS^{TM} guidelines.

Forty-eight hours before the FMS^{TM} assessment, each participant was invited to the first session that included the anthropometrical measuring and a detailed explanation and familiarization of the FMS^{TM} battery test with its execution. They were advised to wear comfortable clothes to carry out the test battery. In the assessment session, after a standardized warm-up consisting of light jogging around rugby field and dynamic mobility, each participant performed the seven FMS^{TM} exercises following standardized instructions. A random number generating software was used to randomly assigned the order of the sub-tests for each participant (free software www.randomizer.org.). Execution was assessed by a conditioning specialist with experience in the application of the FMS^{TM}.

Statistical analysis

Data analysis was performed using the statistics package SPSS® v20 for MacOs (SPSS Inc., Chicago, IL, with license from the University of Valencia). Data are shown as mean ± SD (standard deviation). Normality and homogeneity of distributions were verified using the Kolmogorov-Smirnov and Levene tests. The sample was divided into quartiles for comparison: first quartile (Q1), second quartile (Q2), third quartile (Q3) and fourth quartile (Q4). Comparative study between quartiles was carried out for each sub test using a t-test for related samples and Cohen's d to compare the effect size (ES) between groups. A one-way repeated measures analysis of variance (ANOVA) was used to assess the effect of the quartile in the FMS^{TM} results using eta-squared to compare the effect size. The level of significance was set at <0.05.

RESULTS

In the comparison of the effect of the group factor (table 2) in the different tests of the FMS^{TM} we found the following significant differences in line lunge (p=0.001; ES=0.09), leg raising (p=0.01; ES=0.05), trunk stability (p=0.001; ES=0.16), rotary stability

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(p=0.01; ES=0.05) y FMS™ total score (p=0.001; ES=0.08).

The results obtained for the different FMS™ tests in the groups and the group effect can be found in Table 2.

Table 2. FMS™ battery results by groups effect

	Group Q1	Group Q2	Group Q3	Group Q4	diff	Squared eta
Deep Squat (points ± SD)	1.87 (0.65)	2.09 (0.76)	2.08 (0.76)	2.23 (0.75)		0.03
Hurdle Step (points ± SD)	1.79 (0.69)	1.87 (0.78)	2.02 (0.97)	1.92 (0.81)		0.01
In Line Lunge (points ± SD)	1.87 (0.68)	1.80 (0.88)	2.15 (0.86)	2.45 (0.75)	***	0.097
Shoulder Mobility (points ± SD)	2.66 (0.65)	2.41 (0.84)	2.53 (0.70)	2.55 (0.75)		0.015
Leg Raising (points ± SD)	2.06 (0.72)	2.17 (0.80)	2.28 (0.63)	2.51 (0.67)	**	0.054
Trunk Stability (points ± SD)	1.74 (0.79)	2.04 (0.85)	2.40 (0.82)	2.62 (0.56)	***	0.167
Rotary Stability (points ± SD)	2.08 (0.73)	2.11 (0.69)	2.51 (0.58)	2.26 (0.88)	**	0.053
Total Score (points ± SD)	14.06 (3.04)	14.48 (3.94)	15.96 (3.47)	16.55 (2.87)	***	0.087

diff: differences; *:p<0.05; **:p<0.01; ***:p<0.001

In the comparisons between groups (table 3), the differences in "in line lunge were (Q1 vs Q4: p=0.001; ES=-1.57; Q2 vs Q4: p=0.001; ES=-1.22), leg raising (Q1 vs Q4: p=0.01; ES=-1.24), trunk stability (Q1 vs Q3: p=0.001; ES=-1.25; Q1 vs Q4: p=0.001; ES=-2.15; Q2 vs Q4: p=0.001; ES=-1.69), rotary stability (Q1 vs Q3: p=0.01; ES=-1.77; Q2 vs Q3: p=0.05; ES=-1.85) and FMS™ total score (Q1 vs Q3: p=0.05; ES=9.16; Q1 vs Q4: p=0.001; ES=-8.45; Q2 vs Q4: p=0.01; ES=-9.62).

Table 3. Comparisons between groups and effect size

Group	Subgroup	Deep Squat (points)		Hurdle Step (points)		In Line Lunge (points)		Shoulder Mobility (points)	
		diff	D-Cohen	diff	D-Cohen	diff	D-Cohen	diff	D-Cohen
Q1	Q2		-1.1		-0.76		-0.44		-0.58
	Q3		-1.08		-0.64		-0.92		-1.1
	Q4		-1.3		-0.78	***	-1.57		-0.99
Q2	Q3		-0.65		-0.44		-0.68		-0.89
	Q4		-0.85		-0.56	***	-1.22		-0.81
Q3	Q4		-0.87		-0.15		-0.89		-1,00

Group	Subgroup	Leg Raising (points)		Trunk Stability (points)		Rotary Stability (points)		Total Score (points)	
		diff	D-Cohen	diff	D-Cohen	diff	D-Cohen	diff	D-Cohen
Q1	Q2		-0.81		-0.76		-0.9		9.91
	Q3		-1.33	***	-1.25	**	-1.77	*	9.16
	Q4	**	-1.24	***	-2.15		-1.04	***	8.45
Q2	Q3		-1.03		-0.85	*	-1.85		10.17
	Q4		-0.95	***	-1.69		-1.08	**	9.62
Q3	Q4		-1.23		-1.41		-0.94		10.74

diff: differences; *:p<0.05; **:p<0.01; ***:p<0.001

DISCUSSION

The objective of the present study was to analyze the ability of movement in preadolescents grouped at different ages with the scores obtained using the FMS™. The main finding is the existence of differences in the scores obtained in the ability to move: test in-line, trunk stability and leg raising in preadolescents. The oldest quartile scores better than the subjects of the youngest quartile. Although the factor that generates this influence has not been evaluated, biological maturation and the status of previous physical activity may be an indicator. the quality of motor work will improve other aspects such as cognitive(van der Fels et al., 2015), motor confidence (Logan, Robinson, Wilson, & Lucas, 2012) and subsequent motor skills (Lloyd, Saunders, Travis, Bremer, & Tremblay, Mark, 2014; Logan, Ross, Chee, Stodden, & Robinson, 2018)

Our results are in agreement with the study by Portas, Parkin, Roberts & Batterham in 2016, who found an increase of approximately 10% in the final score among children aged 11 to 14 years (Portas et al., 2016) According to the authors' conclusions, it is considered that the FMS may be invalid to assess the ability to move at an early age 14. The possible reason may be the non-specificity of the FMSTM in children (Liao et al., 2019; Mitchell et al., 2015; Wright et al., 2015) and therefore the application of the same scoring criteria as in adults. In this situation, it should be remembered that the child is not a small adult, and as previously stated, it should be noted that the use of the FMSTM may not be suitable for all age ranges. These differences can be attributed to differences in maturation processes (García-Jaén et al., 2018; Lloyd et al., 2015; Portas et al., 2016). Potential practical applications of the FMSTM test in pediatric population would be limited by procedures and technical checklist score oriented to adult performance.

The study has various limitations that must be explained when interpreting the results. First, the sample is small and the participants did not play a specific sport competitively. However, they were considered active because they performed at least 60 minutes of moderate to vigorous physical activity. In addition, subjects participated voluntary without a random sampling. Second, the maturation status of the sample was not evaluated. The difference between chronological and biological age may be a limitation. Third, the tests were not filmed and could not be analyzed more objectively using motion software. This type of analysis would allow quantifying anthropometric changes that could also influence the results of the battery. And finally, a higher number of females would have allowed us to make comparisons by sex.

CONCLUSIONS

The aim of the present study was to determine if age can influence the FMSTM score by age subgroups in healthy and active preadolescents. Based on our results, in preadolescents the oldest quartile scores better than the subjects in the youngest quartile in the test: in line, trunk stability and leg raising. These findings highlight the need to adapt the FMSTM to the pediatric population. Movement quality criteria should be broadened and greater caution should be exercised in the technical aspects during strength training sessions. For this reason it would recommended that these factors were responsible for expanding the checklist associated with the exercise execution (Faigenbaum & McFarland, 2016) and the test included in the FMSTM.

Future research is needed to evaluate the differences in performance according to maturation status and gender, including the recording of the tests to be able to analyze them later through software.

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APPENDIX 1. STROBE Statement- checklist of items that should be included in reports of observational studies.

Section/item	Item No	Recommendation	Reported on Page Number/Line Number	Reported on Section/Paragraph
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 5	Title
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 6 lines 42-73	Abstract
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 7, lines 87-91	Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 7, lines 149-153	Introduction
Methods				
Study design	4	Present key elements of study design early in the paper	Page 7, line 157	Methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 7,m lines 89-93	Methods
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Page 7, line 161	Methods
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 8, lines 123-140	Procedures
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 8 lines 204-213	Procedures
Bias	9	Describe any efforts to address potential sources of bias	Page 9, lines 251-267	Limitations
Study size	10	Explain how the study size was arrived at	NA	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	NA	NA
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 8 lines 236-242	Stadistical analysis
		(*b*) Describe any methods used to examine subgroups and interactions	Page 8 lines 242-252	Stadistical analysis
		(*c*) Explain how missing data were addressed	NA	NA
		(*d*) If applicable, explain how loss to follow-up was addressed	NA	NA
		(*e*) Describe any sensitivity analyses	NA	NA
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	NA	NA
		(b) Give reasons for non-participation at each stage	NA	NA
		(c) Consider use of a flow diagram	NA	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Pag 7, lines 86-89	Participants
		(b) Indicate number of participants with missing data for each variable of interest	NA	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	Table 2	Results
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA	NA
		(*b*) Report category boundaries when continuous variables were categorized	NA	NA
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA	NA
Discussion				
Key results	18	Summarise key results with reference to study objectives	Page 9 lines 289-292	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 9 lines 335-341	Discussion
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 10 lines 352-356	Conclusion
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 10 lines 356-360	Conclusion
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 10 lines 297-299	Acknowledge

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.