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Original/*Deporte y ejercicio*

Test-retest reliability of a field-based physical fitness assessment for children aged 3-6 years

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Abstract

Objective: **the present study aims to determine the test-retest reliability of the Fitness Test Battery in children aged 3-6 years.**

Methods: **a total of 553 children voluntarily participated in the current study; all children were aged 3 to 6 years. Demographic characteristics reveal that 274 children were male (age: 4.63 ± 0.94 years old, Body max index [BMI] = 16.30 ± 2.07 kg/m^2), and 279 were female (age 4.70 ± 0.97 years old, BMI = 16.28 ± 2.09 kg/m^2), and they were selected from 8 schools in southern Spain. All selected tests for the Fitness Test Battery, except the 10 x 20 metres (m) test that was designed ad hoc for this study, have been used in previous studies and are focused on testing basic components of physical condition and motor development such as endurance, strength, speed, reaction time and balance (10 x 20 m, Standing Broad Jump, 20 m running speed, Ruler drop test and Balance).**

Results: **the results obtained in this study indicate that the Fitness Test Battery has obtained adequate reliability parameters, and is able to discriminate with age among the different tests in healthy children between 3 and 6 years old. The tests used were safe, easy to perform, very acceptable and understandable by children.**

Conclusion: **the Fitness Test Battery is a valid, reliable and easy to assess the physical fitness of pre-schoolers children.**

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Key words: *Physical fitness. Children. Preschool. Validation. Test.*

FIABILIDAD TEST-RETEST DE UNA BATERÍA DE EVALUACIÓN DE LA CONDICIÓN FÍSICO-MOTORA EN NIÑOS DE 3 A 6 AÑOS

Resumen

Objetivo: **el presente estudio tiene como objetivo determinar la fiabilidad test-retest de una batería de evaluación de la condición física en niños de 3-6 años.**

Método: **un total de 553 niños participaron voluntariamente en el estudio; todos los niños tenían entre 3 a 6 años. Las características demográficas revelan que 274 eran niños (edad: 4.63 ± 0.94 años, índice de masa corporal [IMC]= 16.30 ± 2.07 kg/m^2), y 279 eran niñas (edad 4.70 ± 0.97 años, IMC = 16.28 ± 2.09 kg/m^2), que fueron seleccionados de entre 8 escuelas en el sur de España. Todas las pruebas incluidas en la batería, con excepción de la prueba de 10 x 20 metros (m), que fue diseñada *ad hoc* para este estudio, se han utilizado en estudios anteriores y se centraron en los componentes básicos de la condición físico-motora, como la resistencia, la fuerza, la velocidad, el tiempo de reacción y el equilibrio.**

Resultados: **los resultados obtenidos en este estudio indican que la batería de condición física para preescolares ha obtenido parámetros de fiabilidad test-retest adecuados y es capaz de discriminar según la edad entre las diferentes pruebas en niños sanos de 3 a 6 años.**

Conclusión: **la batería de condición física para preescolares diseñada en este estudio es un instrumento válido, fiable y fácil de emplear para evaluar la condición física de los niños en edad preescolar. Las pruebas utilizadas eran seguras, fáciles de realizar, muy aceptables y comprensibles para los niños.**

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Palabras clave: *Condición física. Niños. Preescolar. Validación. Test.*

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Introduction

The importance of physical activity for health is well known and research has noted both physical and psychological benefits when children participate in physical activity[1,2]. Fitness, adiposity and body fat distribution during childhood have shown a high correlation with cardiovascular health in adulthood[3]. Additionally, fitness level is a potent biomarker of health from an early age[4]. Furthermore, the relationship between physical activity practice and fitness has been widely studied, even at early ages. Bürgi et al. (2011)[5] indicate that in preschool children, the level of physical activity is associated with improvements in heart abilities and aerobic capacity, being a determinant of cardiovascular risk. Likewise, high levels of aerobic performance and motor coordination are strong predictors of physical activity during childhood[6]. Therefore, early childhood should be targeted as a critical time to promote healthy lifestyle behaviours, especially, sedentary behaviours[7].

Different test batteries have been designed and validated in order to assess the fitness level in young and older people (e.g., ALPHA, EUROFIT, FITNESSGRAM,)[8,9,10] However, these are usually inadequate to determine fitness in children 3-6 years old because of the difficulty participants at this age have with following strict instructions. Furthermore, the physical fitness test typically analyses only physiological components, such as muscle strength or endurance capacity, that are tested with more or less advanced technological equipment in controlled laboratory settings. In addition, laboratory tests are expensive and require highly trained experimenters; thus, they are not feasible for use with large groups of participants[11]. At the moment, there is insufficient information about reliability and validity of fitness tests in pre-schoolers children[12]. Valid and reliable measures of physical fitness of preschool children are necessary to investigate the relationship between physical fitness and health in this population[12,13,14]. To date, just a few studies[5,15] have focused on analysing the physical abilities and fitness level of children aged 3-6 years.

Taking into account the above information, a reliable test battery that leads to testing the fitness level of preschool children in a large population is needed. Therefore, the aims of this study are: i) to determine the test-retest reliability of the Fitness Test Battery and ii) to determine the feasibility of this battery in children 3-6 years in discriminating performance with age.

Method

Participants

In this study, a total of 553 children aged 3 to 6 years voluntarily participated. Demographic characteristics reveal that 274 children were male (age: 4.63 ± 0.94 years old, Body max index [BMI] = 16.30 ± 2.07 kg/m^2), and 279 were female (age 4.70 ± 0.97 years old, BMI = 16.28 ± 2.09 kg/m^2), and they were selected from 8 schools in southern Spain. Inclusion criteria included schooling in early childhood and being free from physical and/or intellectual disabilities. Parents voluntarily signed an informed consent form for the participation of their children in this study. The study was completed in accordance with the norms of The Declaration of Helsinki (2013 version) and following the directives of the European Union on Good Clinical Practice (111/3976/88 of July, 1990), as specified in the Spanish legal framework for human clinical research (Royal Decree 561/1993 on clinical essays). The study was approved by the Ethics Committee of the University of Jaen (Jaen, Spain).

Materials and testing

All selected tests for the Fitness Test Battery, except the 10x20 metres (m) test that was designed ad hoc for this study, have been used in previous studies[8,9,10,11,16,17] and are focused on testing basic components of physical condition and motor development such as endurance, strength, speed, reaction time and balance. The test battery is designed to reduce the cognitive component of the tests and more easily sustains children's motivation to participate.

Cardiorespiratory endurance was assessed using the 10x20m test, inspired by the spatial structure of the Léger test[18] and based on the guidelines of the Spanish Athletics Federation (RFEA) for participants at this age in endurance efforts. The test design took into account that the rules were very simple and the test had a playful motivation. Materials required include a tape measure to mark the distances of the runway (20m), 2 boxes, 5 balloons, and a stopwatch. It is a 20-m shuttle test, in which participants have to move five balloons from a box –A, located in an extreme- to other box –B, located in the opposite extreme-. The total distance covered is 200m, timed to the signal "Go" until the participant deposits the last balloon. It does not matter if the balloon does not enter into the box. If during the moving the balloon is dropped, the participants must take it and carry on moving. Supervisors should indicate to the participants that the balloon must be caught with both hands. The test allows running and walking. Only one attempt is allowed. The result is recorded in seconds with one decimal. The test score was the running time, a longer time indicating a poorer performance. As a test for convergent validity with 10x20m, the 6-minute walk test (6MWT) has been used (as gold standard). The 6MWT originally designed for adults, measures aerobic endurance evaluated by the maximum distance covered on flat ground for 6 minutes following a standard protocol. In healthy children and adolescents, this test has been validated and standardised in international studies[19,20]. To analyze the reaction time (RT) the Ruler Drop Test (RDT)[16], which aims to measure the RT and eye-hand coordination, was used. A rule of 50-60 centimetres (cm) long was used. The RDT was repeated three times with each hand, it taking the average score of each hand. The average of each hand and the average of both hands were used for the subsequent statistical analysis. The RT conversion (in seconds) is performed using the formula for a body in free fall under the influence of gravity ($d = ½gt2$). The test score was the running time, a longer time indicating a poorer performance. As for the balance assessment, the Stork Balance Stand Test[21] was used. Two attempts were made with both legs and the best results (s) were scored, averaging the results of both legs. The test score was the runtime, a longer time indicating a better performance. To measure explosive lower body strength, the standing broad jump test was used[8]. The test was performed twice and the best score was recorded in centimetres. The test score was the distance reached, a lower distance indicating a poorer performance. The sprint test was performed using a distance of 20m on a flat, hard, non-slip surface[11]. Two attempts were made for the test and the best time was recorded (in seconds). The test score was the running time, a longer time indicating a poorer performance.

Procedure

After obtaining the appropriate permits in schools and informed parental consent, we proceeded to the application of the test battery. In two separate sessions, 48 hours apart, a team of researchers previously trained in conducting the different test evaluated the children. During the first testing session, RDT, the standing broad jump test, the balance test and 6MWT were performed. Two-days later, during the second testing session, the 20m and 10x20m test were performed. Prior to conducting the tests, children performed a typical warm-up, consisting of five minutes of low-intensity running, and five minutes of general exercises (i.e., high skipping, leg flexions, lateral running, front and behind arm rotation, and sprints) and the research team conducted a demonstration. The children also performed some executions of the familiarization in RT, balance and horizontal jump. Each child was assessed individually. A week later a retest in every single fitness test was conducted with a sample of 90 children. The children were motivated and encouraged at all times to execute the tests.

Statistical Analysis

Data were analysed using SPSS, v.19.0 for Windows (SPSS Inc, Chicago, USA) and the significance level was set at $p<0.05$. The data are shown in descriptive statistics for mean and standard deviation (SD). Reliability analysis was performed using intraclass correlation coefficients (ICC) in the pretest-posttest and Bland-Altman graphs study. The convergent validity was performed by Pearson's correlation. Differences between genders and age groups were analysed using analysis of variance (ANOVA). Moreover, in the sprint test inter-observer reliability was calculated using ICC. Finally, a Pearson correlation analysis was performed between the different tests in this battery.

Results

Table I shows the descriptive statistics and ICC tests for all pre- and post-tests. In the 10x20m test, an ICC equal to 0.969 (95% confidence interval (CI)= 0.953-0.979) was achieved. The Bland-Altman graphic showed limits of agreement (2 SD) of 10.9 and -11.4s with the mean of the differences= -0.21 ± 5.60 s (Figure 1). Regarding the convergent validity between the 10x20m test and 6MWT, a Pearson correlation coefficient of $r = -0.657$, ($p <0.001$) was obtained. As for the RDT, an ICC equal to 0.744 (95% CI= 0.836-0.602) was obtained, the Bland-Altman graphic showed limits of agreement (2 SD) of 13.8 and -13.6cm, and the mean of the differences was equal to 0.10 ± 6.87cm. Regarding the balance test, an ICC equal to 0.995 (95% CI = 0.997-0.992) was achieved; the Bland-Alt-

Table I
Descriptive statistics and ICC of Fitness Test Battery.

	Test Mean (SD) n=90	*Retest Mean (SD) n=90*	*ICC*	*95% Confidence Interval*
10x20m (s)	83.11 (16.64)	83.31 (15.48)	0.969	0.953-0.979
Ruler drop test (cm)	37.98 (7.75)	37.87 (7.49)	0.744	0.602-0.836
Balance (s)	9.67 (8.65)	10.15 (8.45)	0.995	0.992-0.997
Standing broad jump (cm)	76.53 (20.20)	74.56 (21.12)	0.913	0.866-0.943
20m running speed (s)	5.77 (1.12)	5.78 (1.17)	0.942	0.911-0.962

SD (standard deviation).

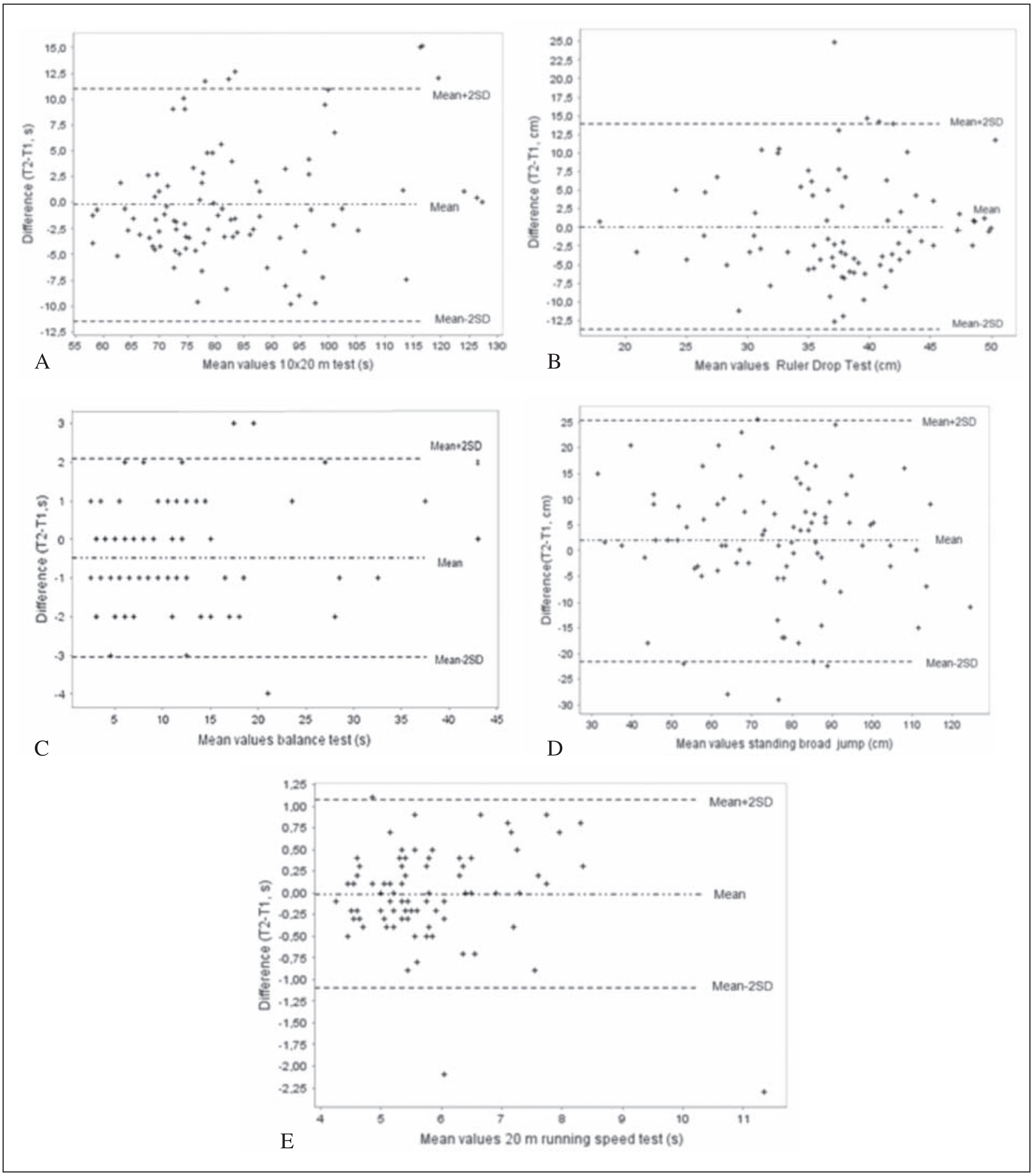

Fig. 1.—Bland-Altman graph 10x20m (A), RDT (B), balance test (C), standing broad jump (D) 20m running speed (E) pre-test/post-test.

man graphic showed limits of agreement (2 SD) of 2.09 and -3.03s, and the average of the differences was -0.47±1.28s. Concerning the standing broad jump test, an ICC= 0.913 (95% CI= 0.943-0.866) was obtained; the Bland-Altman graphic showed limits of agreement (2 SD) of 25.4 and -21.4cm, the mean differences were ± 1.96±11.72cm. Finally, as for the 20m sprint test, an ICC = 0.942 (95% CI= 0.962-0.911) was achieved and the Bland-Altman graphic showed limits of agreement (2 SD) of 1.06 and -1.09s; the average differences were -0.01±0.54s. The inter-observer agreement in the sprint test shows an ICC equal to 0.991 (95% CI= 0.987-0.994).

Table II shows the results of the battery Fitness Test Battery considering gender and age. The boys show higher scores on the standing broad jump than girls ($p=0.019$). Taking age group into account, a significant improvement ($p<0.001$) was observed in all tests with growth. Table III shows the results of the Pearson correlation analysis between the test battery and age; significant correlations between all tests with each other, and between each test with age, were found.

Discussion

In this study, the main goal was to describe a new test battery aimed at quantifying fitness level and motor development in children ages 3 to 6 years. The Fitness Test Battery has obtained adequate reliability parameters in the different tests performed. All tests were conducted without any incident and were appropriate for pre-schoolers children.

Moreover, a primary purpose of this study was that the test battery should be easy to perform and should not require complex technical equipment. In this regard, this test battery is designed to let us test large groups of children, and monitoring fitness levels and motor development of children over time. The evaluation of the acute response to physical activity is an important clinical tool as it provides an examination of the respiratory, cardiac and metabolic systems[20].

Originally, the 10x20m test was created to analyse cardiorespiratory fitness, which has obtained a high temporal reliability (test-retest), thus this test has been shown to be safe, easy to perform and highly acceptable for use with children. At the same time, the 10x20m test significantly correlates with age and it can be a test for monitoring the development of cardiorespiratory fitness in children of this age as the time taken is reduced with age, with no significant differences between genders, thus similar to the increase in 6 minute walk test (6MWT) in preschool children[22].

The results obtained in this study showed that RT decreases with age of the children; a previous study reported similar findings[23]. Similarly, the RDT shows adequate reliability; other studies have also shown reliability and validity of the RDT test in young adults[24,25]. Ruiz, Mata and Jimenez (2005)[26] and Raynor (1998)[27] indicate that the RT is a very interesting measure as it shows the ability of the neuromuscular system to respond quickly to the demands of the envi-

Table II
Results the Fitness Test Battery considering gender and age.

	Total Mean (SD)	*Boy Mean (SD) n=274*	*Girl Mean (SD) n=279*	*p-value*	*3 years n=173 Mean (SD)*	*4 years n=148 Mean (SD)*	*5 years n=149 Mean (SD)*	*6 years n=83 Mean (SD)*	*p-value*
10x20m (s)	94.35 (20.61)	94.53 (20.72)	94.18 (20.54)	0.842	109.18 (21.58)[a]	93.53 (15.90)[b]	87.19 (16.41)[c]	78.73 (12.44)[d]	<0.001
Ruler drop test (s)	0.27 (0.03)	0.27 (0.03)	0.27 (0.03)	0.083	0.28 (0.03)[a]	0.27 (0.03)[b.]	0.26 (0.02)[c]	0.26 (0.03)[c]	<0.001
Balance (s)	7.09 (7.18)	7.37 (7.78)	6.82 (6.55)	0.377	3.99 (3.06)[a]	6.06 (5.51)[b]	9.47 (8.88)[c]	11.03 (9.05)[c]	<0.001
Standing broad jump (cm)	70.01 (25.11)	72.54 (26.25)	67.51 (23.72)	0.019	51.90 (19.18)[a]	66.39 (20.58)[b]	81.93 (21.11)[c]	91.36 (21.78)[d]	<0.001
20m running speed (s)	6.30 (1.08)	6.23 (1.08)	6.37 (1.08)	0.122	7.14 (1.00)[a]	6.32 (0.97)[b]	5.73 (0.69)[c]	5.59 (0.84)[c]	<0.001

SD (standard deviation). Post-hoc analysis (Bonferroni): Different letter subscript indicates significant differences (p<0.05) between age groups.

Table III
Pearson correlation between the tests.

	Age	*10x20 m*	*Ruler drop test*	*Balance*	*Standing broad jump*	*20m running speed*
Age	1	-0.510**	-0.307**	0.391**	0.594**	-0.566**
10x20m		1	0.164**	-0.343**	-0.443**	0.523**
Ruler drop test			1	-0.241**	-0.307**	0.257**
Balance				1	0.381**	-0.313**
Standing broad jump					1	-0.508**
20m running speed						1

**p<0.01.

ronment and thus indicates increases in RT in people with developmental problems in motor coordination. Regarding balance, standing broad jump and sprint, equally suitable reliability values were obtained and association with the age of participants; results are consistent with Zhou et al. (2014)[28] in pre-schoolers children.

All tests correlated significantly with age suggesting that the Fitness Test Battery can be used with children aged 3-6 years. According to gender differences, only the standing broad jump test shows significant differences in children with higher values.

The most important limitation of this study was that it is limited to samples of 3- to 6-year-old Spanish children. Larger samples in each age group are essential for establishing age and gender specific norms. Nevertheless, to the best researchers´ knowledge, this is the first study that provides the reliability of a fitness test battery for preschool children.

Conclusions

The results obtained in this study indicate that the Fitness Test Battery has obtained adequate test-retest reliability parameters, and was able to discriminate, using age, among the different tests in healthy children between 3 and 6 years old. The tests used were safe, easy to perform, very acceptable and understandable by children. From a practical standpoint, the Fitness Test Battery is a valid, reliable and easy to assess the physical fitness of pre-schoolers children. Consequently, teachers, coaches, trainers and other staff working with children of these ages can use this test battery despite not having a large variety of materials and technological resources.

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