Nutrición Hospitalaria

Nutr Hosp. 2015;31(2):875-882
ISSN 0212-1611 • CODEN NUHOEQ
S.V.R. 318

## Original / *Deporte y ejercicio*

# Validity and reliability of the 1/4 mile run-walk test in physically active children and adolescents

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**Abstract**

**We investigated the criterion-related validity and the reliability of the 1/4 mile run-walk test (MRWT) in children and adolescents. A total of 86 children (n=42 girls) completed a maximal graded treadmill test using a gas analyzer and the 1/4MRW test. We investigated the test-retest reliability of the 1/4MRWT in a different group of children and adolescents (n=995, n=418 girls). The 1/4MRWT time, sex, and BMI significantly contributed to predict measured $VO_{2peak}$ ($R^2$= 0.32). There was no systematic bias in the cross-validation group (P>0.1). The root mean sum of squared errors (RMSE) and the percentage error were 6.9 ml/kg/min and 17.7%, respectively, and the accurate prediction (i.e. the percentage of estimations within ±4.5 ml/kg/min of $VO_{2peak}$) was 48.8%. The reliability analysis showed that the mean inter-trial difference ranged from 0.6 seconds in children aged 6-11 years to 1.3 seconds in adolescents aged 12-17 years (all P<0.001). In conclusion, the present study shows that the criterion-related validity of the 1/4MRW test is relatively low in the sample of children and adolescents studied. Beside the statistical significance, the reliability of the 1/4MRWT was considered acceptable, i.e. mean difference between tests ranged from half second to one second.**

(*Nutr Hosp*. 2015;31:875-882)

**DOI:10.3305/nh.2015.31.2.7789**

Key words: *1/4 mile run-walk test. Cardiorespiratory fitness. Validity. Reliability. Children. Adolescents.*

**VALIDEZ Y FIABILIDAD DEL TEST DE CORRER-CAMINAR 1/4 DE MILLA EN NIÑOS Y ADOLESCENTES FÍSICAMENTE ACTIVOS**

**Resumen**

**El objetivo del presente estudio fue analizar la validez de criterio y la fiabilidad del test de correr-caminar 1/4 de milla en jóvenes. Participaron un total de 86 jóvenes (42 niñas). Los participantes realizaron un test máximo en tapiz rodante para determinar el consumo de oxígeno pico ($VO_{2pico}$), así como el test de correr-caminar 1/4 de milla. La fiabilidad test-retest se estudió en un grupo distinto de jóvenes (n=995, n=418 niñas). El tiemplo empleado en realizar el test de correr-caminar 1/4 de milla, el sexo, y el índice de masa corporal contribuyeron de forma significativa a predecir el $VO_{2pico}$ ($R^2$= 0.32). No se observó diferencia sistemática en el grupo de cross-validación (P>0.1). La suma de los errores al cuadrado fue de 6.9 ml/kg/min y el porcentaje de error fue del 17.7%. El porcentaje de estimaciones entre un ±4.5 ml/kg/min del $VO_{2pico}$ fue del 58.8%. El análisis de fiabilidad mostró que la diferencia entre test osciló entre 0.6 segundos en niños de 6-11 años a 1.3 segundo en adolescentes de 12-17 años (todos P<0.001). En conclusión, el presente estudio muestra que la validez de criterio del test de correr-caminar 1/4 de milla es baja en los jóvenes estudiados. La fiabilidad fue sin embargo aceptable.**

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Palabras clave: *Test de correr-caminar 1/4 de milla. Capacidad aeróbica. Validez de criterio. Fiabilidad. Niños. Adolescentes.*

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Recibido: 15-VII-2014.
Aceptado: 16-VIII-2014.

## Funding

The study was funded by Centro Andaluz de Medicina del Deporte, Junta de Andalucía, Orden 4/02/05, BOJA nº 37 (Ref. JA-CTD2005-01) and the Spanish Ministry of Science and Innovation (RYC-2010-05957, RYC-2011-09011).

## Introduction

Cardiorespiratory fitness is a direct marker of physiological status and reflects the overall capacity of the cardiovascular and respiratory systems to supply oxygen during sustained physical activity, as well as the ability to carry out prolonged exercise (Taylor, Buskirk, & Henschel, 1955). The maximal oxygen (or peak) consumption ($VO_{2peak}$) attained during a graded maximal exercise is considered to be an objective measure of the cardiorespiratory fitness performance (Taylor et al., 1955). Cardiorespiratory fitness is associated with lower cardiovascular disease risk factors, with a better quality of life and positive health in both healthy and diseased young people (Ortega, Ruiz, Castillo, & Sjostrom, 2008). Furthermore, higher levels of cardiorespiratory fitness in childhood and adolescence are associated with a healthier cardiovascular profile later in life (Ruiz et al., 2009).

Laboratory tests provide an accurate and reliable measurement of $VO_{2peak}$, however, they are not feasible when a large number of subjects need to be measured in a short period of time, which is the case in the school setting. To deal with these problems, a number of field tests (~10) have been developed to assess cardiorespiratory fitness (Castro-Pinero et al., 2010), being the running-walking field tests the most popular (Castro-Pinero et al., 2010; Olds, Tomkinson, Leger, & Cazorla, 2006; Ruiz et al., 2009).

There is no consensus regarding the appropriate length of the field based run-walk test in young people to estimate $VO_{2peak}$. It was suggested that the test should be at least 550 meters long (Cureton, Boileau, Lohman, & Misner, 1977; Disch, Frankiewicz, & Jackson, 1975), whereas others recommended that the tests should have a distance of at least one mile (1,609 meters) (Disch et al., 1975; Jackson & Coleman, 1976). Several studies assessed the criterion-related validity of the 1 mile run-walk test (1MRWT) (Castro-Pinero, Mora, Gonzalez-Montesinos, Sjostrom, & Ruiz, 2009; Cureton, Sloniger, Black, McCormack, & Rowe, 1997; Cureton, Sloniger, O'Bannon, Black, & McCormack, 1995; Rowland, Kline, Goff, Martel, & Ferrone, 1999) and 1/2MRW (Castro-Pinero, Ortega, Mora, Sjostrom, & Ruiz, 2009; Fernhall et al., 1998) tests in children and adolescents and observed that the test time explains a small proportion of the $VO_{2peak}$ variance in children and adolescents, suggesting that other variables might also influence $VO_{2peak}$ in young people.

The 1/4MRWT (~402.25 meters) is included in several fitness test batteries as a suitable test to assess cardiorespiratory fitness in 6-7 years old children (The President´s Council on Physical Fitness and Sport) and in young people (*Amateur Athletic Union. Physical Fitness Test Manual. Bloomington, In Franks, D.B. YMCA Youth Fitness Test manual* 1989; "China's National Sports and Physical Education Committee. The national fitness testing methods. Beijing, VA: Author," 1990; Sport, Accessed September 28, 2009). This test consists of completing 1/4 mile as quickly as possible (either running or/and walking). Due to the relatively short distance, the 1/4MRWT is likely to reduce the influence of psychological (e.g. willingness to accept the strenuous effort, motivation and monotonous), factors that are known to affect performance in young people (Castro-Pinero, Mora, et al., 2009; Castro-Pinero, Ortega, et al., 2009; Cureton et al., 1995; Fernhall et al., 1998). In addition, it is possible that the influence of these variables on the performance is lower when the test is shorter mainly due to the possibility of better regulating the pacing strategy. The 1/4MRWT can be performed in a relatively short period of time, which is important from a feasibility point of view.

The aim of the present study was to investigate the criterion-related validity of the 1/4MRWT in physically active children and adolescents. For this purpose, we developed and cross-validated a regression equation in children and adolescents. To our knowledge, the reliability of the 1/4MRWT in children and adolescents has not been examined; therefore, we studied the reliability of the test in a separate group of children and adolescents.

## Methods

### *Participants*

The present study comprised a total of 86 (44 boys and 42 girls) healthy and physically active children and adolescents aged 8 to 17.9 years (from Cádiz, South of Spain). Of those, 79 participants were swimmers and reported a training regimen of 5 days per week, 2 hours per day (~4000 meters per session) plus one day of competition during the weekend; 3 participants were enrolled in basketball teams, and 4 in football teams with a training regimen of 4-5 days per week, 1.5-2 hours per day. Most of them competed at a national level. All the children were of Caucasian (Spanish) descent for ≥2 generations. The cohort was randomly divided into either validation (n=43) or a cross-validation (n=43) group. The t-test revealed no significant difference between the two groups in any of the study variables (all $P>0.05$).

A comprehensive verbal description of the nature and purpose of the study was given to the children, adolescents, their parents and teachers. This information was also sent to parents or children supervisors by regular mail and written consents from parents, children and adolescents were requested and obtained. The criteria for inclusion were: no personal history of cardiovascular or metabolic disease, any muscular or skeletal injuries, and medication at the time of the study and pregnancy. The study was approved by the Review Committee for Research Involving Human Subjects of our university.

*Procedures*

Participants performed the 1/4MRW test and a maximal graded exercise test on a motor driven treadmill in random order within a 2-week period. Participants were asked (i) to avoid vigorous physical exercise for 48 hours before the tests, so they were asked to skip physical training 2 days before the tests (ii) to avoid heavy meal at least for the last 4-5 hours before the tests, (iii) to do not drink coffee, tea or stimulating soft drinks like coca-cola at least 1 hour before testing.

Participants were randomly assigned into either validation (n=43) or a cross-validation (n=43) group. The analysis of t-test revealed no significant difference between the two groups in all the study variables (Table I).

1/4 mile run-walk test

Participants were instructed and encouraged to complete the distance of 1/4 mile as quickly as possible.

**Table I**
*Characteristics of the study participants.*

| | *Girls* | | *Boys* | | *All* | | *P** |
|---|---|---|---|---|---|---|---|
| *Validation group, n* | *21* | | *22* | | *43* | | |
| Age (years) | 11.0 | (3.1) | 11.1 | (3.4) | 11.1 | (3.2) | |
| Weight (kg) | 40.4 | (12.0) | 45.4 | (16.7) | 42.9 | (14.7) | |
| Height (cm) | 147 | (15) | 151 | (21) | 148.9 | (18) | |
| Body mass index (kg/m$^2$) | 18.3 | (2.6) | 19.2 | (2.8) | 18.7 | (2.7) | |
| Laboratory test | | | | | | | |
| Measured $VO_{2peak}$ (ml/kg/min) | 53.2 | (5.7) | 60.2 | (9.6) | 56.7 | (8.6) | |
| Time to exhaustion (min) | 9.6 | (1.3) | 10.3 | (1.8) | 10.0 | (1.6) | |
| Maximal speed (km/hr) | 13.5 | (1.8) | 14.1 | (2.4) | 13.8 | (2.1) | |
| Ventilation (l/min) | 71.1 | (22.0) | 83.2 | (33.0) | 77.3 | (28.5) | |
| RER | 1.2 | (0.1) | 1.2 | (0.1) | 1.2 | (0.1) | |
| Heart rate (bpm) | 200 | (5) | 200 | (5) | 200 | (5) | |
| 1/4MRWT | | | | | | | |
| Time (seconds) | 118.4 | (23.0) | 103.7 | (23.4) | 110.9 | (24.1) | |
| Maximal speed (km/hr) | 12.7 | (2.4) | 14.6 | (3.2) | 13.7 | (3.0) | |
| Estimated $VO_{2peak}$ (ml/kg/min) | 53.2 | (4.2) | 60.2 | (3.6) | 56.7 | (5.2) | |
| *Cross-validation group, n* | *21* | | *22* | | *43* | | |
| Age (years) | 11.2 | (3.6) | 11.0 | (3.4) | 11.1 | (3.4) | 0.974 |
| Weight (kg) | 41.7 | (12.4) | 44.0 | (16.9) | 42.9 | (14.7) | 0.980 |
| Height (cm) | 149 | (18) | 150 | (22) | 150 | (20) | 0.878 |
| Body mass index (kg/m$^2$) | 18.4 | (2.6) | 18.6 | (2.6) | 18.5 | (2.6) | 0.673 |
| Laboratory test | | | | | | | |
| Measured $VO_{2peak}$ (ml/kg/min) | 54.0 | (7.6) | 61.3 | (8.6) | 57.7 | (8.8) | 0.606 |
| Time to exhaustion (min) | 9.5 | (1.2) | 10.6 | (1.7) | 10.0 | (1.5) | 0.846 |
| Maximal speed (km/hr) | 13.5 | (2.0) | 14.5 | (2.5) | 14.0 | (2.3) | 0.697 |
| Ventilation (l/min) | 72.7 | (22.1) | 81.9 | (33.2) | 77.4 | (28.4) | 0.985 |
| RER | 1.2 | (0.1) | 1.2 | (0.1) | 1.2 | (0.1) | 0.812 |
| Heart rate (bpm) | 201 | (5) | 200 | (5) | 201 | (5) | 0.833 |
| 1/4MRW test | | | | | | | |
| Time (seconds) | 117.6 | (21.1) | 104.1 | (25.8) | 110.7 | (24.3) | 0.972 |
| Maximal speed (km/hr) | 12.8 | (2.7) | 14.7 | (3.5) | 13.8 | (3.2) | 0.907 |
| Estimated $VO_{2peak}$ (ml/kg/min) | 53.3 | (3.9) | 60.6 | (3.5) | 57.0 | (5.2) | 0.828 |

Values are means (standard deviation).
RER, indicates respiratory exchange ratio; 1/4MRWT, 1/4 mile run/walk test.
*P for validation vs. cross-validation differences.

Walking was permitted if the participant could not keep running. Tests were performed by groups of 10-15 individuals on a 200 m track laid-out on the schools playing field. The time to complete the test was recorded to the nearest second. One week prior to the tests, all the participants received comprehensive instructions about the test, after which they practised it once. All tests were conducted by the same investigators and at the same time of day for each participant (between 10:00 and 13:30 h).

Maximal Treadmill GTX

Participants also performed a graded maximal treadmill test (Eric Jaeger, GmbH & Co, Wurzburg, Germany). The test started with a 3-min warm-up at 4 km/h, at 3% grade for children aged 6-10 years, and at 6 km/h for children aged 11 years or older. The grade was maintained at 3% throughout the test. The speed was increased 1 km/h every minute until volitional exhaustion. The test was finished when the participant was unable to continue despite verbal encouragement (Docherty, 1996).

Heart rate was recorded every 5 seconds throughout the test using a JECg 12 Channel electrocardiograph (Eric Jaeger, GmbH & Co, Wurzburg, Germany) which in turn was averaged over a 15-second period. Oxygen consumption was measured via open circuit spirometry using an automated gas analyser (Oxycon Delta Version 4.3, Eric Jaeger, GmbH & Co, Wurzburg, Germany). Before each test was conducted, the oxygen and carbon dioxide analysers were calibrated according to the manufacturer's instructions. This consisted of performing a room air calibration and a reference gas calibration using 15.03 % oxygen and 5.042 % carbon dioxide. The flow turbine (Triple V, Erich Jaeger) was calibrated using a 3-litre 5530 series calibration syringe (Hans-Rudolph, Kansas City, USA). Gas and volume calibration was repeated until the difference between two consecutive calibrations was less than 1%. This device has been shown to be valid and reliable (Macfarlane, 2001). Measures were recorded breath-by-breath, and means for each were recorded for 15-second periods. During each test, a gel seal was used to help prevent air leaks from the paediatric facemasks. The highest $VO_2$ recorded during the test was denoted as $VO_{2peak}$, and it was confirmed when maximal heart rate was no more than 15 beats per minute below age-predicted maximal heart rate (220-age), and respiratory exchange ratio (RER) was higher than 1.

One week prior to the tests, all the participants received comprehensive instructions of the test, after which a familiarization session took place. All the participants completed the test satisfactorily. The participants were encouraged to keep running as long as possible throughout the course of both the field and lab tests.

Body mass index

Body mass and stature were measured with physical education clothing (shorts and T-shirts) and barefoot. Height was assessed to the nearest 0.1 cm using a stadiometer (Holtain LTd, Crymmych, Pembs, United Kingdom). Body mass was measured to the nearest 0.1 kg using a Seca scale. Instruments were calibrated following manufacturer's instruction to ensure acceptable accuracy. Body mass index (BMI) was calculated as body mass/stature squared ($kg/m^2$).

*Statistical analyses*

All statistical analyses were performed with PASW (Predictive Analytics SoftWare, v. 18.0 SPSS Inc., Chicago, IL, USA). The data are presented as mean ± standard deviation (SD), unless otherwise stated. In the validation group, we conducted stepwise multiple regression analysis to build the equation to estimate $VO_{2peak}$ in children and adolescents aged 6-17 years. Age, sex, BMI, and 1/4MRWT time were initially included in the model. Additional analyses were performed including height and weight instead of BMI, or weight and height$^2$. Interaction terms (i.e. sex*1/4MRWT time and age*1/4MRWT time) were subsequently added to the model to investigate whether the patter of the association was different in boys and girls, or in children and adolescents. We repeated the models by adding additional interaction terms (i.e. BMI*1/4MRWT time, and sex*age*BMI*1/4MRWT time).

Bivariate correlations were used to examine the relationship between measured $VO_{2peak}$ and 1/4MRWT time, and between measured and estimated $VO_{2peak}$ in the cross-validation group. The developed equation to estimate $VO_{2peak}$ was assessed through a set of error measures including the root mean sum of squared errors (RMSE), the percentage error and the standard error of estimate (SEE) as detailed elsewhere (Castro-Pinero, Mora, et al., 2009; Castro-Pinero, Ortega, et al., 2009; Ruiz et al., 2008). These analyses were conducted in the cross-validation group. The mean difference, 95% confidence intervals of the difference, and the 95 % limits of agreement (mean difference ± 1.96 SD of the differences) were calculated. The difference between the measured and estimated $VO_{2peak}$ was calculated by means of ANOVA for repeated measures. Moreover, we also calculated the percentage of predicted and observed $VO_{2peak}$ values within ±4.5 ml/kg/min of estimated $VO_{2peak}$ (so called, accurate prediction). The value of ±4.5 ml/kg/min is an arbitrary predetermined range that has been used in college students (Dolgener, Hensley, Marsh, & Fjelstul, 1994) as well as in adults (Fenstermaker, Plowman, & Looney, 1992), and represents an acceptable $VO_{2peak}$ estimation.

We assessed the agreement between the measured and estimated $VO_{2peak}$ following the Bland and Altman method (J.M. Bland & Altman, 1986; J.M. Bland & Altman, 1995). We also examined the association between the difference and the magnitude of the measurement (i.e. heteroscedasticity) by conducting correlation analysis. The absolute difference (negative values were multiplied by -1) between the measured and estimated $VO_{2peak}$ was entered as dependent variable and the averaged value [(measured + estimated)/2] as independent variable.

To investigate the reliability of the 1/4MRWT, we compared the test and retest (hereafter called T1 and T2), carried out with one week interval, with ANOVA for repeated measures in a different study group (n=995, n=418 girls) of children and adolescents of a similar age than the group involved in the validation study (age range: 6-17 years, 11.04±3.3 years, n=418 girls). We conducted the analysis for the whole sample separately in girls and boys, as well as in children (aged 6-11 years) and adolescents (aged 12-17 years). We also calculated the inter-trial mean difference, as well as the RMSE, percentage error and SEE.

## Results

Table I displays the descriptive characteristics for the validation and cross-validation group by sex. The correlation coefficient between measured $VO_{2peak}$ and 1/4MRWT time was -0.65 (P=0.002) for the validation group, and -0.479 (P=0.001) for the cross-validation group. Maximal speed in the 1/4MRWT was similar to that achieved in the treadmill test in both the validation and cross-validation group (P=0.697 and 0.417, respectively) (Table I).

### *Validity: Regression equation computed in the validation group*

Table II shows the stepwise regression model estimating $VO_{2peak}$. The analyses showed that only the 1/4MRWT time, sex, and BMI were significantly associated with measured $VO_{2peak}$.

**Table II**
*Stepwise regression model estimating $VO_{2peak}$ from the 1/4 mile run/walk test (1/4MRWT) time (in seconds), sex, and body mass index (kg/m²) in the validation group*

| *Variable* | *Value* | *95% CI* | *P* |
|---|---|---|---|
| Intercept | 88.73 | 66.50 / 110.96 | <0.001 |
| Sex | 5.35 | 0.74 / 9.96 | 0.024 |
| Body mass index | -0.90 | -1.76 / -0.04 | 0.040 |
| 1/4 mile run/walk | -0.161 | -0.261 / -0.061 | 0.002 |
| R | | 0.61 | |
| $R^2$ | | 0.32 | |

Regression equation: -0.161 (1/4MRWT, in seconds) -0.9 (BMI, kg/m²) + 5.35 (sex, girls=0, boys=1) + 88.73.

The regression equation was: -0.161 (1/4MRWT, in seconds) -0.9 (BMI, kg/m²) + 5.35 (sex, girls=0, boys=1) + 88.73. Age was not significantly associated with measured $VO_{2peak}$ (P>0.1). Likewise, weight and height, or weight and height² did not significantly contribute to the model when entered separately instead of BMI (all P>0.1). We observed no significant sex*1/4MRWT time or age*1/4MRWT time, BMI*1/4MRWT time, and sex*age*BMI*1/4MRWT time interaction effect (all P>0.05). The correlation coefficient between measured $VO_{2peak}$ and estimated $VO_{2peak}$ from the regression equation was 0.613 (P<0.001) in the cross-validation group.

Table III shows the error assessment of the estimated $VO_{2peak}$ from the regression equation in the cross-validation group. The accurate prediction was 44.2% in the cross-validation group.

We observed no systematic bias between the measured $VO_{2peak}$ and the estimated $VO_{2peak}$ from the regression equation in the cross-validation group. The mean difference was 0.74 ml/kg/min (P=0.487) in the validation and cross-validation group. There was a positive association of the measured and estimated $VO_{2peak}$ difference with the measured and estimated $VO_{2peak}$ mean in the cross-validation group (r=0.339, P=0.026), indicating heteroscedasticity.

### *Reliability*

Inter-trial difference and measurement errors of the 1/4 mile run/walk test are shown in table IV. The analysis of ANOVA for repeated measures showed a mean inter-trial difference (all P<0.001) ranging from 0.6 seconds in children aged 6-11 years to 1.3 seconds in adolescents aged 12-17 years) (Table IV). In girls, mean inter-trial difference was 0.7 (P=0.001), whereas in boys was 1.1 (P<0.001). Percentage error was lower than 1% when the sample was analysed together, and range from 3% in boys to 4% in adolescents. SEE ranged from 3.4 seconds in boys to 6.5 in girls. When the sample was analysed together, SEE was 6.9 seconds.

**Table III**
*Error assessment of the estimated $VO_{2peak}$ from the regression equation in the cross-validation sample*

| | *Cross-validation (n=43)* |
|---|---|
| RMSE (ml/kg/min) | 6.7 |
| Error (%) | 20.7 |
| SEE (ml/kg/min) | 6.8 |
| Mean difference* / 95% CI (ml/kg/min) | 0.74 / 2.13 |
| Accurate prediction** | 44.2% |

RMSE, root mean squared errors; SEE, standard error of estimate; CI, confidence interval.
*Mean difference: measured $VO_{2peak}$ minus estimated $VO_{2peak}$.
**Percentage of estimated $VO_{2peak}$ values within ±4.5 ml/kg/min of the measured $VO_{2peak}$ value.

**Table IV**
*Inter-trial difference and measurement errors of the 1/4 mile run/walk test*

| | *All (n=995)* | | *Girls (n=418)* | | *Boys (n=577)* | | *Children (n=522)* | | *Adolescents (n=473)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| T1 (seconds)* | 106.2 | (22.8) | 112.8 | (19.5) | 101.3 | (23.8) | 120.6 | (18.7) | 90.2 | (14.9) |
| T2 (seconds)* | 105.2 | (23.1) | 112.1 | (19.7) | 100.2 | (24.1) | 120.0 | (18.6) | 88.9 | (15.2) |
| *Inter-trial difference* | | | | | | | | | | |
| T2-T1 (seconds)* | -0.9 | (3.8) | -0.7 | (4.3) | -1.1 | (3.4) | -0.6 | (3.6) | -1.3 | (4.1) |
| P | <0.001 | | 0.001 | | <0.001 | | <0.001 | | <0.001 | |
| *Measurement errors* | | | | | | | | | | |
| RMSE (seconds) | 0.7 | | 4.4 | | 3.6 | | 3.6 | | 4.3 | |
| Error (%) | 0.6 | | 3.9 | | 3.0 | | 3.2 | | 4.0 | |
| SEE (seconds) | 6.9 | | 6.5 | | 3.4 | | 3.6 | | 4.0 | |

*Values are means (standard deviation).
T2-T1 refers to Trial 2 minus Trial 1.
RMSE, root mean squared errors; SEE, standard error of estimate.

## Discussion

In the present study we developed and cross-validated a new regression equation to estimate $VO_{2peak}$ from the 1/4MRWT time, sex, and BMI in healthy children and adolescents aged 6-17 years. We did not observe a systematic bias in the cross-validation group. To note is also that the 1/4MRWT time together with sex and BMI explained only a 32% of the $VO_{2peak}$ variance, suggesting that other variables such as genetics, running economy and behavioural factors (willingness to accept the strenuous effort, motivation and monotonousness) might share the 68% unexplained $VO_{2peak}$ variance. The percentage error was 20.7 in the cross-validation group, which together with the relatively low percentage of accurate prediction (44.2%) suggest that the criterion-related validity of the 1/4MRWT test to estimate $VO_{2peak}$ in children and adolescents is relatively low. We have recently conducted a criterion-related validity systematic review of field-based fitness tests in children and adolescents, and found no study examining the criterion-related validity of the 1/4MRWT test (Castro-Pinero et al., 2010).

The criterion-related validity of a test might be influenced by the fitness level of the participants (Dolgener et al., 1994; Hunt, George, Vehrs, Fisher, & Fellingham, 2000) so that the higher the fitness level the higher the validity of the test. Indeed, several studies showed that the 1MRW test seems to better estimate $VO_{2peak}$ in young individuals with high fitness level than in those with poor fitness level (Hunt et al., 2000; Larsen et al., 2002). In contrast, we showed a poor validity of the 1MRW and 1/2MRW tests in a group of fit children and adolescents (Castro-Pinero, Mora, et al., 2009; Castro-Pinero, Ortega, et al., 2009). In the present study, the participants were extremely active and had a relatively high $VO_{2peak}$ (53.6±6.6 and 60.7±9.0 ml/kg/min, for girls and boys, respectively). To note is also that most (90%) of the participants involved in the present study were swimmers, which may have influenced the results. Further studies should investigate whether the validity of the 1/4MRWT test is influenced by the fitness level and the type of sport that the participants regularly do.

The correlation coefficient between measured $VO_{2peak}$ and 1/4MRWT time observed in the present study concur with the figures reported in other validity studies using tests of similar nature, namely the 1/2MRW test (Castro-Pinero, Ortega, et al., 2009; Fernhall et al., 1998) or the 1MRW test (Castro-Pinero, Mora, et al., 2009; Cureton et al., 1995). The observed RMSE and percentage error is also similar to those shown in the 1/2MRW test (Castro-Pinero, Ortega, et al., 2009) and slightly lower than those reported in the 1MRW test (Castro-Pinero, Mora, et al., 2009) when using the Cureton's equation (Cureton et al., 1995).

The run/walk tests are not user-friendly tests, especially in young people, due to the difficulty to develop an appropriate pace. It is often the case that participants start too fast, so that they are unable to maintain their speed throughout the test. In contrast, they may start too slowly so that when they wish to increase their speed the test has already finished. These problems are more likely to occur in longer distance tests, such as the 1MRW test than in shorter ones. However, it might be that tests shorter than 550 meters long are not appropriate to estimate $VO_{2peak}$ (Cureton et al., 1977; Disch et al., 1975). Further studies are needed to better determine the most appropriate test length to estimate $VO_{2peak}$ in young people. Ideally, the distance should be as short as possible to avoid the previously mentioned problems related to (i) pacing strategy, and (ii) psychological (e.g. individual´s willingness to accept and endure the discomfort of strenuous effort, short attention, motivation, and interest span for monotonous task). On the other hand, the distance should be long enough

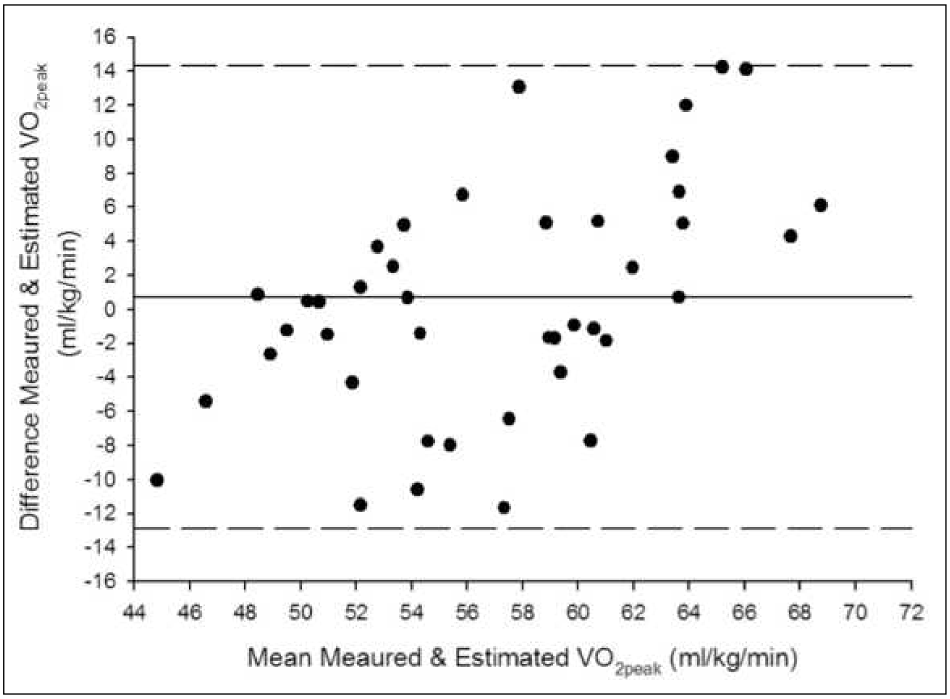


*Fig. 1.—Bland-Altman plot for the measured $VO_{2peak}$ and estimated $VO_{2peak}$ in the cross-validation sample in children and adolescents aged 6-17 years. Solid line represents the mean difference (bias) between measured and estimated $VO_{2peak}$. Upper and lower dashed lines represent the 95% limits of agreement (mean difference ± 1.96 SD of the difference).*

to enable a valid and accurate $VO_{2peak}$ estimation. In the current study, the accurate prediction, that is, the percentage of estimated $VO_{2peak}$ values within ±4.5 ml/kg/min of the measured $VO_{2peak}$ value was lower than 50%, which further support the idea that the validity of the 1/4MRWT is relatively low.

The results of the reliability study showed a mean inter-trial difference of ~1.0 second, which indicates that, overall, the 1/4MRWT can be considered reliable. To note is that the inter-trial difference was statistically different when analysed by sex or age, as well as when analysed the group together. The percentage error ranged from 0.6 when analysed the whole group to 4 in adolescents. One study examined the reliability of the 1/2MRWT in children and reported correlation coefficients ranging from 0.74 to 0.79 in boys, and from 0.47 to 0.77 in girls aged 5-9 years (Rikli, Petray, & Baumgartner, 1992). They also showed that the 1/2MRW test is more reliable than the 1MRW test in children aged 5-7 years (Rikli et al., 1992). In our study, the 1/4MRWT T1-T2 correlation coefficients were 0.986 when analysed the group together, 0.976 in girls, 0.990 in boys, 0.982 in children, and 0.964 in adolescents. We have recently conducted a reliability (Artero et al., 2010) systematic review of field-based fitness tests in children and adolescents and found no study analysing the reliability of the 1/4MRWT in young people.

Limitations of the present study include the lack of control for factors that are known to affect performance such as genetics, maturation, or running economy. Unfortunately, we did not measure heart rate during the 1/4MRWT, yet, the speed attained during the test was similar to that obtained in the treadmill test. The accurate prediction of 4.5 ml/kg/min is close to 10%, therefore its acceptability might be arguable. The well-controlled conditions of the validity study together with the relatively large number of participants involved in the reliability study are notable strengths of this study. We do not know whether the results of the present study apply to children and adolescents with lower activity patterns. Future studies should address this issue.

In conclusion, the present study shows that the criterion-related validity of the 1/4MRWT is low in the sample of children and adolescents studied. The reliability of the 1/4MRWT seems however acceptable due to the fact that the mean difference between tests ranged from half second to one second. The findings of this study suggest that despite the, *a priori*, advantages of the 1/4MRWT, such as reduced psychological stress, and the possibility of better regulating the pacing strategy compared with longer tests such as the 1MRWT or the 1/2MRW, the 1/4MRWT should not be used to estimate $VO_{2peak}$ in young very active people.

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