

Estimation of cardiorespiratory fitness in adolescents with the 9-minute run/walk test

Aptidão cardiorrespiratória em adolescentes estimada pelo teste de corrida e/ou caminhada de 9 minutos

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Abstract – The aim of this study was to analyze estimation of cardiorespiratory fitness (CRF) in adolescents aged 10 to 12 years by means of the 9-minute run/walk test. A total of 115 adolescents (61 boys and 54 girls) took part in the study. Mean age was 12.2 ± 0.9 and 12.1 ± 0.7 years, body mass 47.5 ± 13.6 and 45.0 ± 13.2 kg, height 150.9 ± 7.7 and 150.4 ± 7.3 cm, and VO_2 peak 49.9 ± 9.5 and 42.2 ± 7.4 mL/kg/min in boys and girls respectively. The subjects performed a maximal treadmill test and a 9-minute run/walk field test (9-minute test). The relationship between VO_2 and the 9-minute test was analyzed by Pearson's correlation coefficient. The difference between the proportions of adolescents who met health criteria and agreement between the CRF cutoff points proposed in the Physical Best and Fitnessgram batteries was analyzed with McNemar's test and the Kappa statistic respectively. The significance level was set at 5%. There was moderate correlation ($r=0.64$) between the 9-minute test and directly measured VO_2 peak in the sample as a whole. Gender-stratified analysis showed higher correlation in boys ($r=0.59$) than in girls ($r=0.43$). There were significant differences between the tested cutoff points ($P<0.001$) and weak agreement (Kappa = 0.19) in relation to CRF. These findings suggest that the 9-minute test appears to be a valid indicator of CRF in adolescents between the ages of 10 and 12. However, care should be taken when choosing cutoff points for classification of cardiorespiratory fitness.

Key words: Adolescents; Cardiorespiratory fitness; Cutoff points; Field test.

Resumo – Analisar a estimativa da aptidão cardiorrespiratória (ACR) em adolescentes de 10 a 12 anos a partir da aplicação do teste de corrida e/ou caminhada de 9 minutos. Participaram 115 adolescentes (61 rapazes e 54 moças), idade média de $12,2(0,9)$ e $12,1(0,7)$ anos, massa corporal $47,5(13,6)$ e $45,0(13,2)$ kg, estatura $150,9(7,7)$ e $150,4(7,3)$ cm e VO_2 pico $49,9(9,5)$ e $42,2(7,4)$ mL/kg/min em rapazes e moças, respectivamente. Os sujeitos realizaram um teste máximo na esteira e um teste de campo de corrida e/ou caminhada de 9 minutos (9 min). A relação entre o VO_2 e o teste 9 min foi analisada pelo coeficiente de correlação de Pearson. A diferença entre as proporções dos adolescentes que atenderam os critérios de saúde e a concordância entre os pontos de corte propostos pelo Physical Best e o Fitnessgram para a ACR foi analisada com o teste de McNemar e o índice Kappa, respectivamente, com significância de 5%. O teste de 9 min demonstrou uma correlação moderada ($r=0,64$) com o VO_2 pico mensurado diretamente, para ambos os sexos, e de forma estratificada, apresentou maiores valores nos meninos ($r=0,59$) em relação às meninas ($r=0,43$). Os pontos de corte apresentaram diferenças em sua classificação ($P<0,001$) e uma fraca concordância (Kappa=0,19) em relação a classificação da ACR. Os resultados apontam que o teste de 9 min parece ser um indicador válido da ACR de adolescentes de 10 a 12 anos, contudo, deve-se ter cautela na escolha dos pontos de corte para a classificação desse componente.

Palavras-chave: Adolescentes; Aptidão cardiorrespiratória; Teste de campo; Pontos de corte.

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INTRODUCTION

In recent years, some studies have shown that cardiorespiratory fitness (CRF) is associated with health outcomes in children and adolescents, with satisfactory CRF being related to low levels of central and overall obesity, healthy cardiovascular parameters, and low metabolic scores^{1,2}.

For collection of information on CRF, maximal oxygen uptake (VO_2max) has long been considered one of the key indicators of aerobic power in children and adolescents^{3,4}. VO_2max can be determined directly by graded exercise testing (ergospirometry), which provides a highly valid measurement of this parameter⁵. However, this technique requires expensive equipment and expert examiners and testing sessions are very time-consuming, which makes its use infeasible for population studies.

One alternative method of CRF assessment is field testing, which has among its main advantages low operating cost, ease of administration, possibility of mass assessment of a large number of subjects simultaneously, and administration of the test in the specific setting of the subject's daily routine⁶. The most common field tests for assessment of CRF in children and adolescents include the one-mile run/walk test⁷, the 9-minute run/walk test⁷ and the 20-meter shuttle run (multistage fitness test)⁸.

In Brazil, one of the field tests most widely used for assessment of CRF in children and adolescents is the 9-minute run/walk test⁹⁻¹². This test has been used as an adaptation of the 12-minute Cooper test⁷ for children under the age of 12, and is also used in Brazil and internationally as an alternative to motor test batteries for CRF assessment^{6,13,14}.

On the other hand, despite the various advantages of field tests, some variables are hard to control during their administration, such as overload, which, in the 9-minute test, is determined by subjective control of intensity; environmental factors (temperature and humidity); and motivation. Furthermore, as field tests provide an estimate of CRF rather than a direct measurement, errors in measurement and assessment may be greater⁶.

Furthermore, as CRF is closely associated with health risk factors since childhood and adolescence, investigation of field tests that may be effective tools for assessment and classification of CRF in this population is particularly important. However, few studies have assessed the validity of the 9-minute run/walk test or agreement between CRF classification as determined by direct measurement of VO_2 versus that estimated by the 9-minute test, using classification schemes suggested by fitness test batteries¹⁴, particularly in Brazilian children and adolescents.

In view of this research gap, the present study sought to assess estimation of cardiorespiratory fitness (CRF) in adolescents aged 10 to 12 years with the 9-minute run/walk test and analyze agreement between the Physical Best and Fitnessgram cutoff points for CRF.

METHODS

Subjects

The sample comprised 115 adolescents, 61 male (median age, 12.25±0.9 years) and 54 female (12.06±0.7 years), who attended an educational facility in Londrina, Paraná, Brazil. The criteria for inclusion were age within the predefined range and enrollment in the public school at which the study was to be conducted. The criteria for exclusion were presence of any temporary or permanent physical conditions that would preclude participation in the test battery and failure of parents or guardians to provide written informed consent.

Subjects and their parents or guardians were informed of the objective of the study and the procedures involved and provided written informed consent. The project was approved by the Universidade Estadual de Londrina Research Ethics Committee (CEPE/UEL 202/07), in accordance with National Health Council Resolution no. 196/96 on human subject research.

Anthropometry

Body mass were measured with Urano PS 180 digital scales (resolution 0.1 kg), and height, with a wall-mounted stadiometer (resolution 0.1 cm), according to the protocol described by Gordon et al.¹⁵. All measurements were obtained with subjects barefoot and wearing only light clothes. Height and body mass measurements were used to calculate the body mass index (BMI), using the equation $BMI = \text{body mass (kg)}/\text{height (m)}^2$.

Direct Measurement of VO_2

Oxygen uptake (VO_2) was measured directly by means of open-circuit spirometry during a progressive maximal treadmill test. The test began with a 3-minute warm-up 6 km/h and a 0% grade. After the warm-up period, grade was increased to 1% and speed was increased by 1 km/h per minute until the end of the test. Grade remained constant at 1%.

This protocol had previously been tested in a pilot study of adolescents with the same profile and age range, who reached maximum exertion between 8 and 12 minutes, as has been recommended for measurement of aerobic power indicators in young populations¹⁶.

During the test, VO_2 was measured using a K4b2 mobile ergo spirometer (Cosmed, Rome, Italy), which provided information on respiratory parameters with each breath, recording mean measurements every 15 seconds. The oxygen and carbon dioxide analyzers were calibrated according to manufacturer recommendations before each day of testing.

The following criteria were used to halt the test: a) voluntary exhaustion, as expressed by a request to end the test; b) achievement of target heart rate for age ($220 - \text{age}$); c) respiratory exchange ratio >1.1 ; d) detection of VO_2 plateau, as defined by an increase in VO_2 of $<2 \text{ ml/kg/min}$ after a change in stage. When subjects met one or more of these criteria, the test was halted and the highest VO_2 measured up to that point was recorded as VO_2 peak.

9-Minute Run/Walk Test (9-minute test)

The 9-minute run/walk test took place on a standard 400 m track. Subjects were instructed to cover the greatest possible distance over the 9-minute test period and to keep a steady pace, whether walking, jogging, or running. After the end of the 9-minute period, subjects were instructed to keep walking so as to aid the recovery process.

Distance was measured by the number of laps around the track, adding extra distance as required. A trained examiner was in charge of measuring and recording the distance covered by each subject.

Classification of Cardiorespiratory Fitness

Directly measured VO_2 values were classified according to the recent Fitnessgram cutoff points¹⁷, with subjects being classified as *meeting* or *not meeting* CRF criteria.

For the 9-minute test, total distance in meters (9-minute distance) was used as the CRF indicator. Classification was based on suggested Physical Best cutoff points¹⁴, adapted to the 9-minute test.

Statistical Analysis

The *Kolmogorov–Smirnov* test for normality revealed that all variables were normally distributed, except for age, body mass, and BMI. Sample variables were expressed as median and interquartile range. U Mann - Whitney test was used for between-gender comparison descriptive variables.

Pearson's linear correlation coefficient was used to test for correlation between VO_2 peak and 9-minute distance. McNemar's test was used to analyze differences between the proportion of adolescents in each CRF classification according to cutoff points, and the kappa statistic was used to test for agreement between proportions. The significance level was set at 5% and all analyses were carried out in the SPSS 17.0 environment.

RESULTS

The sample profile, stratified by gender, is described in Table 1. The only statistically significant differences were in distance on the 9-minute test and VO_2 peak, which were both higher in males.

Table 1. General sample profile according to gender, Londrina, 2010. Values expressed as median (interquartile range).

	Males (n=61)	Females (n=54)	Overall (n=115)
Age (years)	12.2 (0.9)	12.1 (0.9)	12.2 (0.8)
Body mass (kg)	44.4 (14.8)	42.7 (14.2)	43.5 (15.0)
Height (cm)	150.0 (8.8)	150.3 (9.9)	150.0 (9.0)
BMI (kg/m ²)	20.0 (6.0)	18.9 (5.4)	19.3 (6.0)
9-minute distance (m)	1385.0 (360.0)	1169.0 (244.0) *	1280.0 (355.0)
VO_2 peak (ml/kg ⁻¹ .min ⁻¹)	50.5 (13.7)	42.31 (9.1) *	46.1 (14.1)

* $P < 0.05$

Figure 1 represents the correlation between VO_2 peak and 9-minute distance. There was moderate correlation¹⁹ ($r=0.64$) between these two variables, explained by 40% of shared variance, for the overall sample. When analysis was stratified by gender, the correlation was found to be stronger among males ($r=0.59$) than females ($r=0.43$).

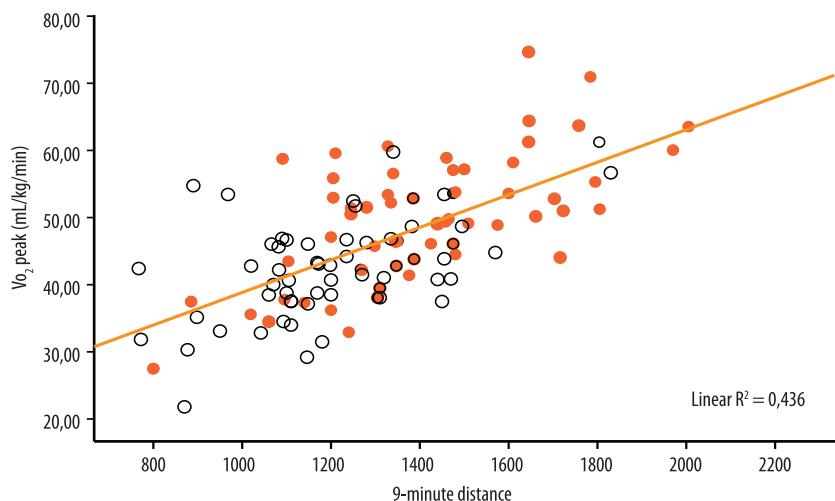


Figure 1. Relation between VO_2 peak and run/walk 9-minute distance. White circles: female, orange circles: male.

Agreement between VO_2 peak-based and 9-minute distance-based CRF classifications is shown in Table 2. McNemar's test showed differences between the two methods, and the kappa statistic revealed only weak (0.19) agreement between the tested cutoff points.

Table 2. Agreement between CRF classifications derived from direct VO_2 peak measurement or 9-minute distance (m).

VO_2 peak (Fitnessgram ¹⁷)	9-minute distance (Physical Best ¹⁴)		P	Kappa
	Meeting (n - %)	Not meeting (n - %)		
Boys				
Meeting (n - %)	24.6(15)	57.4(35)	<0.01	0.13
Not meeting (n - %)	0.0 (0)	18.0(11)		
Girls				
Meeting (n - %)	24.1 (13)	38.9(21)	<0.01	0.28
Not meeting (n - %)	1.9 (1)	35.2 (19)		
Overall				
Meeting (n - %)	24.3(28)	48.7 (56)	< 0.001	0.19
Not meeting (n - %)	0.9(1)	26.1 (30)		

DISCUSSION

In our study, estimation of CRF by the 9-minute run/walk test consisted of comparative analysis of the indicators of fitness provided by a field test (distance covered on the 9-minute test) versus the criterion or “gold measure” measurement (direct VO_2 measurement), a research topic which is still little explored in pediatric populations.

The 9-minute test correlated moderately ($r=0.64$) with directly measured VO_2 values in our sample. Drinkard et al.¹⁹, in a study of obese ado-

lescents between the ages of 12 and 17, also found moderate correlation ($r=0.63$) between the 9-minute test and VO_2 values measured directly during a cycle ergometer test.

Analysis of the validity of fixed-duration field tests reveals weak to moderate validity in young subjects, as shown in the present study and in previous investigations of the 12-minute run/walk test ($r=0.72$)¹⁹ and the 6-minute walk test²⁰.

Sub-analysis of the validity of the 9-minute test by gender revealed differences, with higher validity in male subjects ($r=0.59$) as compared to female subjects ($r=0.43$); in males, the test explained 35% of results, versus 18% of results in female subjects. This is consistent with the results reported in previous studies of other field tests for estimation of CRF, which showed superior validity in male subjects²¹⁻²³.

Careful interpretation of this analysis of the validity of the 9-minute test is warranted, as analysis based solely on the 9-minute distance does not permit comparison between VO_2 peak values and absolute VO_2 values measured during the test itself. Most field tests for assessment of CRF in pediatric subjects are based on a mathematical model that enables conversion of test results (whether expressed as time or as distance) into predicted VO_2 peak values. Currently, there is no regression equation that permits conversion of the 9-minute distance into predicted VO_2 peak values. Such a mathematical model might lead to adjustments in test validity, as was the case with the 20-minute shuttle run, the validity of which was higher when predicted by the Léger et al. equation than when calculated from test duration ($r=0.73$ vs. $r=0.69$ respectively)²¹.

Once the 9-minute test has been identified as a reliable indicator of cardiovascular fitness in children and adolescents, an important step is to ascertain its ability to evaluate existing CRF levels through reference standards.

Therefore, this study sought to assess agreement between CRF classification based on cutoff points established in the literature. We detected significant differences in estimated CRF levels between the two tested classification schemes, as shown by McNemar's test, and only weak agreement between the two schemes, as expressed by the kappa statistic (0.19).

The low validity of test estimates and weak agreement between CRF classifications in this study may often have been attributable to intrinsic factors, such as subject and rater motivation both on the running track and in the lab environment, as well as extrinsic factors and variables such as weather and run/walk speed during the field test.

The limitations of this study included the narrow age range of the sample and the small number of participants, as well as the lack of more robust analysis of estimates derived from the 9-minute test, as it still does not have VO_2 peak values as its final outcome. However, it bears stressing that studies of this nature are still rare in the literature; in fact, this was the first study to assess the validity of the 9-minute test.

CONCLUSION

We conclude that, in this sample of adolescents, there was moderate correlation between 9-minute test estimates and directly measured VO_2 , with superior correlation in boys as compared to girls.

CRF classification of adolescents on the basis of Fitnessgram cutoff points for directly measured VO_2 differed from that based on 9-minute test estimates and Physical Best cutoff points. Furthermore, there was weak correlation between cutoff points.

Therefore, caution is warranted when interpreting the results of the 9-minute field test as an indicator of the cardiorespiratory component in school children and on classification of CRF levels, due to the risk of divergences in CRF classification of adolescents with the characteristics of this study sample depending on the CRF indicator used.

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