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ORIGINAL ARTICLE

Low agreement between the *fitnessgram* criterion references for adolescents

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Abstract
Objective: To analyze the association and agreement of *fitnessgram* reference criteria (RC) for cardiorespiratory fitness, body mass index (BMI) and strength in youth.
Methods: The study included 781 youth, 386 females, aged 10 to 18 years of Londrina-PR. It were performed cardiorespiratory fitness and muscular strength tests and was calculated body mass index. The association between the tests was analyzed using Poisson regression to obtain prevalence ratio (PR) and confidence intervals of 95%, while agreement of the reference criteria was tested by Kappa index.
Results: Significant associations were found between cardiorespiratory fitness and BMI (PR=1,49, 1,27-1,75), muscle strength and BMI (PR=1,55, 1,17-2,08), cardiorespiratory fitness and muscle strength (PR=1,81, 1,47-2,24). The agreement between reference criteria ranged from weak to fair, 48.8% (k=0.05, *p*=0.10) for cardiorespiratory fitness and BMI, 52.9% (k=0.09, *p*=0.001) for muscle strength and BMI and 38.4% (k=0.22, *p*<0.001) for cardiorespiratory fitness and muscle strength.
Conclusions: Although RC for cardiorespiratory fitness, muscle strength and BMI are associated, the agreement between them ranged from weak to fair. To evaluate health related physical fitness it is suggest the execution of all tests, since each test has specific characteristics.

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PALAVRAS-CHAVE
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Sobrepeso

Baixa concordância entre os critérios de referência da *fitnessgram* para adolescentes

Resumo

Objetivo: Analisar a associação e a concordância dos critérios de referência (CR) da *fitnessgram* para aptidão a cardiorrespiratória, índice de massa corporal (IMC) e força em jovens.

Métodos: Participaram do estudo 781 jovens, 386 do sexo feminino, idade entre 10 a 18 anos da cidade de Londrina-PR. Foram realizados testes de aptidão cardiorrespiratória, força muscular e calculado o IMC. A associação entre os testes foi analisada por meio da regressão de *Poisson* para se obter a razão de prevalência (RP) e os respectivos intervalos de confiança de 95%, enquanto que a concordância dos critérios foi realizada utilizando o índice *Kappa*.

Resultados: Foram encontradas associações significativas entre a aptidão cardiorrespiratória e IMC (RP=1,49, 1,27-1,75), força muscular e IMC (RP=1,55, 1,17-2,08), aptidão cardiorrespiratória e força muscular (RP=1,81, 1,47-2,24). A concordância entre o atendimento dos CR variou de fraca a razoável, sendo de 48,8% (k=0,05; p=0,10) para aptidão cardiorrespiratória e IMC, 52,9% (k=0,09; p=0,001) para a força muscular e IMC e 38,4% (k=0,22; p<0,001) para a aptidão cardiorrespiratória e força muscular.

Conclusões: Apesar de os CR para a aptidão cardiorrespiratória, IMC e força muscular estarem associados, a concordância encontrada entre eles variou de fraca a razoável. Para avaliar a aptidão física relacionada à saúde recomenda-se a aplicação de todos os testes, uma vez que cada teste possui características específicas.

Introduction

Physical fitness can be defined as the condition that allows the subject to perform physical effort, being divided into health-related physical fitness and athletic performance. The components of health-related physical fitness are cardiorespiratory fitness, muscular strength, flexibility, and body composition.

Cardiometabolic and mental health risk factors in adolescents are associated with cardiorespiratory fitness,[1,2] overweigth[3,4] and muscular strength,[5,6] and obesity also has an association with musculoskeletal pain.[7] Criterion-referenced standards (CRS) were developed to diagnose adolescents who may be at risk associated with health-related low physical fitness, with the most recent being the *fitnessgram* test battery.[8] CRS are values (cutoffs) that must be achieved, or exceeded, in order to have desirable health status.

In adolescents, the association between different components of physical fitness has been previously demonstrated. There is a positive association that varies from moderate to high, between muscle strength, velocity and agility.[9] Similarly, cardiorespiratory fitness is positively related, mildly to moderately, with strength and velocity.[10] On the other hand, there is an inverse association between body mass index (BMI) and cardiopulmonary fitness, strength, velocity and agility.[11]

Recently, Dumith et al.[12] demonstrated that performances at several tests of muscle strength, velocity, agility and cardiorespiratory fitness are strongly correlated, whereas BMI is only correlated with the tests that require body mass support or propulsion. It is hypothesized that because there is a strong association between the physical fitness components, possibly a single test can represent the individual's physical performance, thus preventing the need for a battery of comprehensive tests, which would result in less time spent to apply the measures, and increasing the convenience to analyze the health-related physical fitness.[12]

To better understand the association between the different tests to assess adolescents' health-related physical fitness and the possibility of using a single test as their indicator, one must assess whether there is an agreement between the CRS of the respective tests. The health-related physical fitness test battery – *fitnessgram*[8] – underwent alterations (in 2010) in its cutoffs, according to age and gender. In the scientific literature there is already some information about the agreement between the CRS for flexibility,[13] cardiorespiratory fitness,[14] strength[15] and BMI.[16]

Although the correlation between the health-related physical fitness components has already been demonstrated, the association of the adolescents' classification between different components has yet to be analyzed. This analysis, as well as the agreement between the CRS, can provide information that either supports or not the hypothesis of evaluation of several components of health-related physical fitness based on a single test. Thus, the aim of this study was to analyze the association and the agreement between the CRS of the *fitnessgram* battery for cardiorespiratory fitness, BMI and strength in adolescents.

Method

This is a cross-sectional study, which is part of a project entitled "Influence of the Physical Education Program on Adolescent Health," carried out in public schools in the city of Londrina, state of Paraná, Brazil, between April and July 2012. The method for sample selection was probabilistic, using two clusters (school and classroom) and stratified by city region (north, south, east, west and central) and gender, performed in two stages. First, one school from each city region was randomly selected, and in each school a number of students proportional to the number of students in the region was used, using the full classrooms.

The study was approved by the Ethics Committee on Research with Human Subjects of Universidade Estadual de Londrina (CEP: 312/2011), according to Resolution 196/96 of the National Health Council. Students' parents or guardians that allowed their children to participate in the study signed the free and informed consent form, which explained all procedures to be performed and gave contact information to have any doubts clarified.

The required sample size calculation had as parameters the population of 55,475 students, the prevalence of meeting the health criteria for health-related physical fitness of 50%,[17] confidence interval of 95% and a sampling error of 5%. A minimum number of 382 students would be required. The design effect of two-stage sampling was added, due to the use of clusters in the sampling, and a possible sample loss of 20% was added. Inclusion criteria were: age between 10 and 18 years, being enrolled in public state schools, attending physical education classes and having no physical/orthopedic limitations that would prevent the implementation of the study's procedures.

A total of 965 adolescents were analyzed; however, the study included only 781, as only adolescents who performed the tests in full and answered the questionnaire on socioeconomic status had their data analyzed. Sample loss was 23.5%. All procedures were performed at the school where the student was enrolled, in the morning or afternoon, during school hours. Students were instructed not to perform any strenuous physical exertion or change their daily routine on the day before and on the day of data collection.

A socioeconomic questionnaire was applied, and anthropometric measurements and two physical tests were performed. The questionnaire was completed in class, whereas anthropometric measurements and physical tests were performed on the sports field of the school on the same day. All measurements were performed following this order: anthropometry, elbow flexion test and then the cardiorespiratory fitness test.

The adolescents in this study were grouped according to their socioeconomic status. The latter was estimated using the "Economic Classification Criteria of Brazil",[18] which establishes classifications for socioeconomic status according to the mean family income estimate: A1 (R$11,480), A2 (R$8,295), B1 (R$4,754), B2 (R$2,656), C1 (R$1,459), C2 (R$962), D (R$680) and E (R$415). For data analysis, the adolescents were grouped into high (A1-B1), middle (B2-C2) and low socioeconomic class (D and E).

Height was measured with a stadiometer with a 1 mm precision, with the help of a marker. Body mass was measured on a digital scale, with a precision of 100 g. BMI was calculated using the equation Body weight (kg)/height $(m)^2$. Aerobic fitness was estimated by the Shuttle-run test (20 m).[19] Muscle strength was measured with elbow flexion test. The CRS adopted for BMI, cardiorespiratory fitness and muscle strength were those proposed by *fitnessgram*.[8] These classify adolescents according to age and sex, in the following categories: 1) does not meet the CRS – high risk; 2) does not meet the CRS –some risk; 3) meets the criteria-healthy fitness zone.

Initially, the data were analyzed using descriptive statistics – absolute and relative frequency. The chi-square (x^2) test was used to verify the association between the results. The variables that showed association ($p \leq 0.05$) in the x^2 test were included in the Poisson regression model with robust adjustment of variance to estimate the prevalence ratio (PR) and respective confidence intervals of 95%. As the analyzed outcomes had prevalence >10%, we decided to use the robust adjustment of variance to obtain a more precise confidence interval. Variables were adjusted for age, gender and socioeconomic status, considering a significance of 5%. The Kappa (κ) index was used to analyze the agreement of the CRS, as well as the relative agreement of classification of individuals between tests. *Kappa* values were interpreted according to Landis & Coch:[20] <0=poor; 0-0.20=weak; 0.21-0.40=fair; 0.41-0.60=moderate; 0.61-0.80=substantial; 0.81-1.00 almost perfect.

Results

Sample characteristics are described in Table 1. The proportion of male (49.4%) and female (50.6%) adolescents was similar. Most (53.8%) were classified as middle socioeco-

Table 1 Characteristics of the sample.

Variable	n (%)
Gender	
Male	386 (49.4)
Female	395 (50.6)
Socioeconomic class	
High (A1-B1)	103 (13.2)
Middle (B2-C2)	420 (53.8)
Low (D and E)	258 (33.0)
BMI	
Meets CRS	586 (76.3)
Does not meet CRS	185 (23.7)
Cardiorespiratory Fitness	
Meets CRS	371 (47.5)
Does not meet CRS	410 (52.5)
Muscle strength	
Meets CRS	273 (35.0)
Does not meet CRS	508 (65.0)

CRS, Criterion-referenced standards; BMI, body mass index.

Table 2 Association between criterion-referenced standards (CRS) for cardiorespiratory fitness, muscle strength and BMI.

		MCRS, n (%)	Does not MCRS, n (%)	*p*
		Muscle strength		
BMI	MCRS	228 (38.3)	368 (61.7)	<0.001
	Does not MCRS	45 (24.3)	140 (75.7)	
BMI		*Cardiorespiratory fitness*		0.014
	MCRS	293 (49.2)	303 (50.8)	
	Does not MCRS	78 (42.2)	107 (57.8)	
Muscle strength		*Cardiorespiratory fitness*		<0.001
	MCRS	172 (63.0)	101 (37.0)	
	Does not MCRS	199 (39.2)	309 (60.8)	

BMI, body mass index; MCRS, meets the criterion-referenced standards.

Table 3 Multivariate analysis of the association between meeting the criterion-referenced standards (CRS) for cardiorespiratory fitness, muscle strength and BMI.

Analyzed criteria	PR (IC 95%)	Robust Variance	*p*
BMI *vs.* Cardiorespiratory fitness	1.49 (1.27-1.75)[a]	0.120	<0.001
BMI *vs.* Muscle strength	1.55 (1.17-2.08)[b]	0.228	0,002
Muscle strength *vs.* Cardiorespiratory fitness	1.81 (1.47-2.24)[c]	0.228	<0.001

PR, prevalence ratio adjusted for gender, age and socioeconomic class; 95%CI, 95% confidence interval.
[a] Wald Test=307.55, $p<0.001$.
[b] Wald Test=63.78, $p<0.001$.
[c] Wald Test=93.85, $p<0.001$.

nomic status, followed by low (33%). As for the cardiorespiratory fitness, 47.5% of the adolescents met the CRS, 76.3% met for BMI and 35% for muscle strength.

The results of the bivariate analysis (Table 2) indicate that positive associations were found between CRS for cardiorespiratory fitness (49,2 vs 42,2%), BMI and muscle strength (38,3 vs 24,3%), between those who met the CRS for the BMI. There was a greater proportion that met the CRS for cardiorespiratory fitness and muscle strength among those who met the CRS for BMI (63,0 vs 39,2%). Moreover, among all adolescents that met the CRS for cardiorespiratory fitness, there was a greater proportion that met the CRS for muscle strength (63,0 vs 39,2%).

As associations ($p<0.05$) were found between all the CRS (Table 2), all variables were included in the multivariate analysis, adjusted for gender, age and socioeconomic status (Table 3). After adjustment, prevalence ratios for meeting the CRS for cardiorespiratory fitness were found to be 49% higher in those that met the CRS for BMI, compared to those that did not. For the association between the CRS of BMI with muscle strength, individuals who met the CRS for BMI had a prevalence ratio 55% higher for meeting the CRS for muscle strength, when compared to those that did not meet the CRS for BMI. For the association between muscle strength and cardiorespiratory fitness, individuals who met the CRS for muscle strength had a prevalence ratio 81% higher of meeting the CRS for cardiorespiratory fitness, when compared to those who did not meet the CRS for strength.

As for the results of the agreement between meeting the CRS for the cardiorespiratory fitness tests and BMI, a value of k=0.05 was found, and relative agreement of 48.8%. For the correlation between the CRS for BMI with the muscular strength test, k=0.09, and relative agreement of 52.9%. The agreement of the CRS for muscle strength and cardiorespiratory fitness was κ=0.22, and the relative agreement was 38.4%. The agreements between the tests were classified as poor to fair.

Discussion

The association between physical fitness components related to athletic performance such as strength, agility, velocity, cardiorespiratory fitness and BMI have been previously described in the literature.[9-12] However, the analysis of the association between the CRS for health-related physical fitness such as cardiorespiratory fitness, BMI and strength had not been described yet. In the present study, the analysis was carried out through categorical variables using the CRS. The results showed there is an association between the CRS for cardiorespiratory fitness, strength and BMI. However, there is an agreement that ranges from poor to fair for the concurrent CRS meeting.

There was a higher prevalence ratio (49%) of meeting the CRS for cardiorespiratory fitness among those meeting the CRS for BMI, indicating poorer performance on the cardiorespiratory fitness test in overweight individuals. This can be explained by the limitation that overweight adolescents have to increase cardiorespiratory demand required to move a larger body mass, as demonstrated by similar values of oxygen consumption at the lactate threshold and maximal effort when compared to normal weight adolescents.[21] Additionally, due to increased body mass, overweight adolescents have a higher metabolic burden, resulting in higher relative amount of oxygen consumed during submaximal exercise.[21]

A higher body mass caused by overweight may also explain the association between meeting the CRS for muscular strength and BMI, in which there was a higher prevalence ratio (55%) for meeting the CRS for muscle strength among those that met the CRS for BMI. The strength test used in the present study was the elbow flexion, which is influenced by both relative fat and body mass.[22] These results corroborate other studies that have demonstrated that overweight adolescents have worse performance on strength tests requiring body mass propulsion or support.[11,12]

For the association between muscle strength and cardiorespiratory fitness, the results indicated a higher proportion (81%) of meeting CRS for muscle strength among those meeting the CRS for cardiorespiratory fitness. The association has been found in other studies, however, the tests used were different and the variables were analyzed in a linear form.[10,12] In adults, it was demonstrated that the elbow flexion test is an indicator of maximum strength, body fat and maximal aerobic capacity,[23] although the mechanism responsible for these associations is yet to be known. In the present study, an aspect that may mediate the association between meeting the CRS for muscle strength and cardiorespiratory fitness is the adolescents' physical activity practice. Recently, Morrow et al.[24] demonstrated that adolescents that meet the recommended weekly physical activity level have a 3.1-fold higher odds ratio of meeting all CRS for cardiorespiratory fitness, BMI, muscle strength and flexibility, compared to the ones that do not meet the physical activity level recommendation. There is a possible cause-and-effect association between physical activity and performance at physical fitness tests.

In spite of the associations found between meeting the CRS for cardiorespiratory fitness, BMI and muscle strength, the agreement in meeting the test CRS was classified from poor to fair, ranging from 38.4 to 52.9%. This low agreement can be explained by the methods used in the preparation of the CRS. The validation of the *fitnessgram* CRS proposed for BMI aimed to identify adolescents that might be at risk based on the estimation of relative fat, obtained by measuring triceps+subscapular or triceps+calf skinfolds.[25] Regarding CRS for cardiorespiratory fitness, they were validated to identify adolescents at risk of developing metabolic syndrome, using as a parameter the direct analysis of maximum oxygen consumption.[26] Dissimilarly to BMI and cardiorespiratory fitness, a health-related outcome has not been established for strength tests yet, with the reporting of pain in the lumbar region being most widely used.[27]

One aspect to be considered when analyzing the correlation between the muscle strength test and cardiorespiratory fitness is the specificity of the tests in relation to the physical activities performed by adolescents. The performance in motor tests depends on the individual's level of physical activity,[24] and much of the accumulation of physical activity in adolescents comes from sports and active transport, predominantly aerobic tasks and performed mostly with the lower limbs. On the other hand, tasks that require upper limb strength and demand anaerobic energy, such as elbow flexion, are not commonly performed by adolescents, which may justify their poor performance in this test. In the present study, this can be observed due to the lower prevalence of meeting the CRS for muscle strength, when compared to cardiorespiratory fitness (35% vs 47.5%).

The results indicate that a single test should not be used as a general indicator of health-related physical fitness. Although cardiorespiratory fitness, muscle strength and BMI are associated, the agreement demonstrated by the tests when meeting the CRS showed to be unacceptable to support the hypothesis that one test can represent the health-related physical fitness of adolescents.

Although the association and agreement between different aspects of health-related physical fitness of adolescents were analyzed, the non-inclusion of health risk factors prevented the identification of which tests are better predictors of health in adolescents. Future studies should include adolescent health risk factors, a fact that will help to understand the choice of specific tests to estimate adolescent health-related physical fitness. However, the applicability of the findings is limited only to adolescents who can be submitted to the *fitnessgram* tests.

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Conflicts of interest

The authors declare no conflicts of interest.

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