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original article

Cardiorespiratory fitness and physical activity level in adolescents

Aptidão cardiorrespiratória e nível de atividade física em adolescentes

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Abstract – More objective methods to detect inactive adolescents may help identify young people that are vulnerable to obesity and other chronic diseases. The objective of this study was to examine the association between classifications obtained with the cardiorespiratory fitness test and physical activity level in adolescents, as well as the agreement between tertiles and z-score distribution of the variables generated with these methods (distance covered and total physical activity score). A cross-sectional study was conducted using a random sample of 639 adolescents (61% girls) aged 12 to 19 years (mean age of 16 ± 1.8 and categorized into two age groups: 12-13 and 14-19 years), from public schools in Niterói, Rio de Janeiro, Brazil. Cardiorespiratory fitness was assessed by a 9-min run/walk test (T9) and physical activity level by the International Physical Activity Questionnaire (IPAQ). The chi-square test (or Fisher's exact test) and Kruskal-Wallis test were applied for the evaluation of associations, and the weighted kappa coefficient and intraclass correlation coefficient were used to investigate agreement between variables. A level of significance of $p<0.05$ was adopted. A significant association between the classifications obtained with the two methods was only observed for adolescents aged ≥ 14 years. However, there was agreement between the variables generated with the two methods in both age groups. The median distance covered in the T9 increased according to tertiles of total physical activity score. An association between the classifications obtained with the IPAQ and T9 was only found for older adolescents. However, the continuous variables and variables categorized into tertiles generated with the methods were associated and showed agreement in both age groups.

Key words: Adolescents; Fitness; Motor activity.

Resumo – *Métodos mais objetivos para identificar adolescentes inativos podem auxiliar na identificação de jovens vulneráveis à obesidade e outras doenças crônicas. O objetivo do estudo foi examinar a associação entre as classificações obtidas pelo teste de aptidão cardiorrespiratória e o nível de atividade física, bem como a concordância entre os tercis e a distribuição em z escore das variáveis geradas a partir destes métodos (metros percorridos e escore total de atividade física), em adolescentes. Estudo transversal com amostra probabilística composta por 639 adolescentes (61% meninas), entre 12 e 19 anos (idade média de 16 anos ± 1,8 e categorizados em duas faixas etárias: 12 a 14 e 15 a 19 anos), de escolas públicas de Niterói-RJ. A aptidão cardiorrespiratória foi estimada pelo teste de corrida e caminhada de 9 minutos -T9 e o nível de atividade física pelo International Physical Activity Questionnaire -IPAQ. Para avaliação de associações, foram utilizados os testes Qui quadrado (ou teste de Fisher) e Kruskal Wallis e para concordância o coeficiente Kappa ponderado (Kp) e coeficiente de correlação intraclasse (CCI). Adotou-se $p<0,05$ para significância estatística. Observou-se associação significativa entre as classificações obtidas pelos dois métodos apenas para os adolescentes com idade igual ou maior que 14 anos, mas houve concordância entre as variáveis geradas a partir dos mesmos para as duas faixas etárias. As medianas de metros percorridos em T9 aumentaram de acordo com os tercis de escore total de atividade física. A associação entre as classificações obtidas com base nos métodos IPAQ e T9 foram observadas apenas para os adolescentes com mais idade. Todavia, as variáveis contínuas e categorizadas em tercis, geradas a partir dos métodos, associaram-se e apresentaram concordância para ambas as faixas etárias.*

Palavras-chave: *Adolescentes; Aptidão física; Atividade motora.*

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INTRODUCTION

Physical inactivity has been associated with an increase of obesity in all age groups[1]. The prevalence of physical inactivity among Brazilian adolescents ranges from 39% to 93%, depending on the study design, criterion used for the classification of physical inactivity, and assessment instruments used[2]. The International Physical Activity Questionnaire (IPAQ) is commonly used for the assessment of physical activity level in epidemiological studies involving adolescents due to its practicality and the possibility of comparison of the results between international studies[3,4]. However, like all self-report instruments, this questionnaire has some limitations related to the capacity of adolescents to recall, interpret and quantify the physical activities performed[5,6].

The existence of a positive association between cardiorespiratory fitness and physical activity level is well established in the literature[7], suggesting cardiorespiratory fitness to be a proxy of the level of physical activity. Cardiorespiratory fitness can be estimated by practical field tests that permit to evaluate a large number of subjects over a short period of time[8,9]. The 9-minute run/walk test (T9) has been applied in epidemiological studies conducted in Brazil[10-12] and in other countries[12-14], since it is a valid, reproducible, objective and low-cost test. The T9 is also one of the methods indicated for the evaluation of cardiorespiratory fitness in schoolchildren by the Brazilian Sports Project (Projeto Esporte Brasil)[8]. An association of unsatisfactory performance in this test with obesity and comorbidities has been observed in adolescents[10,13,14].

In view of the possibility that a cardiorespiratory fitness test such as the T9 could have broad applicability for health risk assessment in the school environment and since it is less prone to the limitations inherent to questionnaires in general[15], the question is whether the results obtained with this test are correlated with the physical activity levels obtained by the IPAQ. The hypothesis is that young people who regularly perform some type of physical activity detected by the IPAQ show a better performance in the T9, covering a greater distance within the same period of time, than inactive youngsters.

The objective of the present study was to examine the association between classifications obtained with the cardiorespiratory fitness test and physical activity level in adolescents, as well as the agreement between tertiles and z-score distribution of the variables generated with these methods.

METHODOLOGICAL PROCEDURES

This was a cross-sectional study involving a random sample of students aged 12 to 19 years, who were enrolled from 6th grade in elementary school to 3rd year of high school in 13 of the 34 public state schools in Niterói, Rio de Janeiro, Brazil. These schools participated in a larger study whose main objective was to evaluate the progression of excess weight and obesity

among adolescents, comparing two cross-sectional studies conducted in 2003 and 2008/2009.

The data analyzed in this article were obtained from the second study and were collected between May 2008 and April 2009. The 13 participating school were same as those randomly selected for the 2003 study in order to favor the purpose of comparability of the baseline study. The planning of sample selection for the baseline study has been described in detail by Barros *et al.*[16] and Bagni *et al.*[17].

Among the 928 eligible student who regular attended the 34 classes selected at the schools during the period of data collection (excluding students with physical disabilities that would impair anthropometric assessment and pregnant adolescents), IPAQ and T9 data were obtained for 639 students who comprised the sample of the present study. The students voluntarily participated in the study and were included after they or their legal guardian, in the case of adolescents younger than 18 years, had signed the free informed consent form.

The baseline study from which this study was derived was approved by the Ethics Committee of Instituto de Pediatria e Puericultura Martagão Gesteira on April 11, 2008 (Protocol No. 27/08).

Cardiorespiratory fitness was evaluated by the T9 according to the protocol of Gaya and Silva[8]. The test was applied to groups with a maximum number of six adolescents at a time. The perimeter of the track was previously marked, respecting a distance of 50 m for each lap. The test was conducted on the school sports court or on the space destined for physical education classes, on a plane and covered ground, so that the adolescents would not have to perform the test under adverse conditions of temperature and rain. The students were guided by a trained team of three examiners coordinated by a physical education professional. The adolescents were instructed to run the longest distance possible over a period of 9 minutes counted with a stopwatch, avoiding peak velocities intercalated with long walks[8]. The adolescents were classified into six categories according to the distance covered: very weak, weak, reasonable, good, very good, and excellent[8]. For some statistical analyses, the categories "reasonable" and "weak" were grouped. Additionally, the distance covered was analyzed as a continuous variable, in meters[8], as z-score distribution, and categorized into tertiles.

The short form of the IPAQ validated in Brazil for adolescents older than 14 years was administered by interview[18]. Although validated only for adolescents older than 14 years, in this study the IPAQ was applied to the whole sample as done in other studies designed to evaluate the agreement between this questionnaire and cardiorespiratory fitness tests in European adolescents[19, 20]. This was due to the curiosity in investigating the applicability of this questionnaire in a context that differed from that of the validation study (different region in Brazil). However, in view of this limitation, the analyses were stratified according to age group (< 14 and ≥ 14 years).

The IPAQ consists of eight open questions that permit to estimate the time spent per week on different domains of physical activity (walking and

physical effort of moderate and vigorous intensities) and physical inactivity (sitting). The adolescents were classified into five categories according to the frequency and duration of the activities evaluated (very active, active, irregularly active A, irregularly active B, and sedentary)[21].

The IPAQ data can also be used to estimate a score expressed as metabolic equivalent of task (MET)[22,23], in minutes per week, facilitating the comparison with continuous variables obtained with instruments such as accelerometers and physical fitness measures[24]. In this study, a total physical activity score was created based on this criterion to report the continuous data of physical activity.

The total physical activity score was calculated by multiplying the METs of each type of activity by the minutes spent per week[22]. The volume of each type of activity was calculated by weighting its energy requirements: walking, 3.3 METs; moderate activity, 4.0 METs; vigorous activity, 8.0 METs. The sum of products obtained for each type of physical activity gave origin to the total physical activity score (walking + moderate physical activity + vigorous physical activity = total physical activity score)[22]. Values of less than 10 minutes of physical activity per day were not included in the calculation and were re-coded to "zero', since scientific evidence indicates that physical activity sessions of less than 10 minutes do not permit to achieve health benefits[22]. Cases in which the total physical activity score exceeded 960 minutes (16 hours per day) were considered outliers and were excluded from the analysis[22]. The total physical activity score was analyzed as a continuous variable expressed as MET-minutes/week and as z-score distribution, and was categorized into tertiles for analysis of the agreement and association with the variables generated with the T9, as suggested by Ottevaere *et al.*[20].

Statistical analysis was performed using the Statistical Package for the Social Sciences 19.0 (SPSS, Inc., Chicago, USA). The classification of the adolescents based on the two methods is reported according to gender and age group (12 to 13 years and 14 to 19 years) and the comparative analysis between methods is stratified only by age group. Associations were analyzed using the chi-square or Fisher's exact test (categorical variables) and the Kruskal-Wallis test (for comparison of the median distance covered in the T9 according to tertile of total physical activity score). For the analysis of agreement, the weighted kappa coefficient (Kw) was used according to the classification criteria of Landis and Koch[24] for categorical variables, and the intraclass correlation coefficient (ICC) for continuous variables. A level of significance of $p<0.05$ was adopted in all analyses.

RESULTS

Among the 928 eligible students who regularly attended school during the data collection period, 639 participated in all assessments necessary for the study, corresponding to a response rate of 68.8%. Losses were due to general refusal to participate in the study (n=101), lack of authorization by

the responsible person (n=64), absence at school on the day of data collection (n=37), lack of physical activity or cardiorespiratory fitness data due to refusal (n=81), or illness impairing the participation in physical activities at the time of the study (n=6). No difference in the distribution by age group was observed between participants and non-participants (12 to 13 years: 18.7% *vs* 18.3%; 14 to 19 years: 81.3% *vs* 81.7%, p=0.64), but there was a difference in the distribution by gender (boys: 39.1% *vs* 56.7%; girls: 60.9% *vs* 43.3%, p<0.001).

More than 90% of the adolescents were classified as "very weak", "weak" and "reasonable" by the T9, without a significant difference between genders, but with a higher proportion of adolescents younger than 14 years in the category "very weak" and a higher proportion of adolescents older than 14 years in the categories "weak" and "reasonable" (p<0.05) (Table 1). Application of the IPAQ showed a higher proportion of adolescents classified as "active" and "very active" (about 60%), without a significant difference between genders or age groups (Table 1).

Table 1. Prevalence and 95% confidence interval (95%CI) of the classification of cardiorespiratory fitness by the T9 and physical activity level by the IPAQ, stratified by gender and age group.

T9	Gender		Age group	
	Boys (n = 250) % (95%CI)	Girls (n = 389) % (95%CI)	12-13 years (n = 119) % (95%CI)	14-19 years (n = 520) % (95%CI)
Excellent	1.5 (0.0-3.2)	0.9 (0.1-2.4)	1.7 (-0.8-2.5)	0.8 (0.2-2.0)
Very good	0.8 (0.4-1.1)	1.1 (-0.1-1.6)	0	1.3 (0.2-2.0)
Good	6.9 (3.0-8.9)	6.1 (3.8-8.6)	4.2 (1.6-10.1)	6.5 (4.0-8.2)
Reasonable	14.2 (11.7.4-29.6)	16.3 (15.9-28.1)	11.8 (9.0-12.4)	17.3 (15.2-21.8)[a]
Weak	33.3 (31.9-47.5)	34.9 (33.3-42.9)	30.3 (26.9-31.3)	35.2 (34.6-40.8)[a]
Very weak	43.3 (36.2-48.5)	39.9 (35.7-45.5)	52.1 (46.5-64.4)	38.8 (33.9-42.2)[a]
p-value	0.69*		0.01*	
IPAQ	Gender		Age group	
	Boys (n = 250) % (95%CI)	Girls (n = 389) % (95%CI)	12-13 years (n = 119) % (95%CI)	14-19 years (n = 520) % (95%CI)
Very active	14.1 (9.8-18.3)	14.6 (11.2-18.0)	12.6 (6.8-18.4)	14.8 (11.8-17.7)
Active	46.8 (40.7-52.8)	45.1 (40.3-49.9)	44.1 (35.4-52.8)	46.1 (42.0-50.2)
Irreg. A	26.2 (20.9-31.6)	29.8 (25.4-34.2)	27.6 (19.7-35.3)	28.6 (24.9-32.4)
Irreg. B	10.6 (7.0-14.4)	9.8 (6.9-12.6)	14.2 (8.0-20.2)	9.2 (6.7-11.6)
Sedentary	2.3 (0.4-4.0)	0.7 (-0.0-1.5)	1.6 (-0.6-3.8)	1.3 (0.3-2.2)
p-value	0.41**		0.54**	

T9: 9-minute walk/run test; IPAQ: International Physical Activity Questionnaire; Irreg. A: irregularly active A; Irreg. B: irregularly active B. *Fisher's exact test; **chi-square test. a Significant differences between age groups in the same category (p<0.05, Fisher's exact test).

Considering the difference in the number of categories between tests (six in T9 and five in IPAQ), the T9 categories "reasonable" and "weak" were grouped in the association analysis of the results obtained with the

two methods (Table 2). This analysis was only stratified by age group since no significant differences between genders were observed as shown in Table 1. An association was only found for adolescents older than 14 years (p=0.016) (Table 2).

Table 2. Association between the frequencies (%) of classification of cardiorespiratory fitness by the 9-minute run/walk test (T9) and physical activity level by the IPAQ.

		12-13 years (n = 119)				
		IPAQ				
		Very active	Active	Irreg. A	Irreg. B	Sedentary
T9	Excellent	0	0	0	0	0
	Very good	0	0	3.3	0	0
	Good	0	5.6	6.7	11.1	0
	Reasonable and weak[1]	40	44.4	33.3	22.2	50
	Very weak	60	50	56.7	66.7	50
	Total	100	100	100	100	100
		14-19 years* (n = 520)				
		IPAQ				
		Very active	Active	Irreg. A	Irreg. B	Sedentary
T9	Excellent	1.2	2.1	0	0	0
	Very good	3.7	0.4	1.3	0	0
	Good	7.3	6.4	6.7	2.1	0
	Reasonable and weak[1]	59.8	57.7	49.3	39.6	16.7
	Very weak	28.0	33.3	42.7	58.3	83.3
	Total	100	100	100	100	100

T9: 9-minute walk/run test; IPAQ: International Physical Activity Questionnaire; Irreg. A: irregularly active A; Irreg. B: irregularly active B; [1]grouped categories. *p<0.05 (chi-square test).

The ICC for total physical activity score and distance ran in the T9 distributed in z-scores were 0.61 (95%CI 0.47-0.72) for adolescents < 14 years and 0.43 (95%CI 0.35-0.50) for adolescents ≥ 14 years (p<0.05) (data not shown in the table).

Analysis of agreement between tertiles of the distance covered in the T9 and total physical activity score in MET-minutes/week revealed Kw values of 0.65 (95%CI 0.52-0.79) for adolescents < 14 years and of 0,47 (95%CI 0.39-0.55) for adolescents ≥ 14 years. Absolute agreement was 68% for younger adolescents and 59% for older adolescents (Table 3).

An increase (p<0.001) in the median distance covered in the T9 was observed according to tertiles of total physical activity score in both adolescents < 14 years (1^{st} = 31.4; 2^{nd} = 72; 3^{rd} = 78.1) and adolescents ≥ 14 years (1^{st} = 142.2; 2^{nd} = 242.3; 3^{rd} = 301.6) (data not shown in the table).

Table 3. Agreement between tertiles of distance covered in the 9-minute run/walk test and total physical activity score according to age group.

T9	12-13 years				14-19 years			
	Score			Total	Score			Total
	1st	2nd	3rd		1st	2nd	3rd	
1º	44	5	4	53	82	15	6	103
2º	10	14	5	29	35	97	34	166
3º	0	9	12	21	32	63	87	182
Total	54	28	21	103	149	175	127	451

T9: 9-minute run/walk test; Score: total physical activity score; 1st: first tertile; 2nd: second tertile; 3rd: third tertile.

DISCUSSION

The hypothesis of this study was that young people performing some type of physical activity reported in the IPAQ would show a better performance in the T9. However, differences in the prevalence of each category were observed between methods. Whereas in the T9, most adolescents were classified as "reasonable", "weak" and "very weak", the IPAQ classified a higher proportion as "active" and "very active", irrespective of gender and age group.

The low prevalence of adolescents with "excellent", "very good" and "good" performance in the T9 is in agreement with another study using this test to evaluate cardiorespiratory fitness in Brazilian adolescents[12]. On the other hand, the results obtained with the IPAQ are also consistent with a study including students aged 13 to 20 years from a public school in Anápolis, Goiánia, in which about 65% of the adolescents were classified as "active" and "very active"[26]. However, in a study conducted in Canoas, Rio Grande do Sul, a higher proportion of adolescents were classified as irregularly active B (36.2%) and sedentary (29.3%)[27], in contrast to the present study and the study conducted in Anápolis.

The high prevalence of active adolescents identified by the IPAQ raises the hypothesis that this questionnaire tends to overestimate the level of physical activity in adolescents, since studies evaluating physical activity using other methods have shown a high prevalence of physical inactivity among Brazilian adolescents[2]. The need for correct interpretation of the questions that make up the questionnaire and memory to answer them may lead to errors when compared to more direct and objective assessment instruments of physical activity level[4]. Furthermore, problems with the interpretation and capacity to answer the questions may be more evident among students from public schools such as those studied here, since Brazil is below the world average in the main education tests[28].

The better association observed for adolescents older than 14 years may be explained by the fact that they are more prone to participate in structured (sports) activities or to be more sedentary, thus increasing the probability that these activities or practices are remembered more easily. In contrast, adolescents younger than 14 years are more frequently engaged in

spontaneous and outdoor activities that are more difficult to be evaluated by questionnaires[3]. Therefore, the T9 may be an alternative as a proxy of physical activity in younger subjects.

With respect to application of the T9, the lack of familiarization of the adolescents with the overload imposed by the test may have influenced the final result[7], underestimating cardiorespiratory fitness in the adolescents studied here. Also, the size of the ground, which followed the natural conditions of the school as suggested in the protocol of Gaya and Silva[8], may have influenced the total distance during the test in such as way that the smaller the course, the larger the number of turns performed, with a consequently shorter distance ran. The characteristics of the ground and environmental conditions of the place where the test is applied can compromise the performance of the subjects evaluated. However, in the present study, the recommendations of a plane and firm track without obstacles or debris that could interfere with the course of the subject were followed. Additionally, an attempt was made to standardize the time of the day when the test was applied for recording of environmental conditions, minimizing possible bias[28].

When tertiles of the variables generated with the two methods (total physical activity score and distance covered) were analyzed, the Kw values ranged from 0.47 to 0.65, indicating regular to good agreement, respectively. This analysis provided better agreement between methods than the association of the original categories of each test. These results indicate that adolescents, who report a higher level of activities in the IPAQ and consequently have a higher total physical activity score, would also show better performance in the T9. This fact is supported by the significant agreement between the z-score distribution of these variables, especially among younger adolescents.

The better results obtained for younger adolescents based on the analysis of continuous variables (total physical activity score and distance covered), in contrast to the results of association analysis according to category, are intriguing and deserve further investigation. The lack of validation of the IPAQ for Brazilian adolescents younger than 14 years[18] may explain these contradictory results, and the application of this instrument to this age group is a limitation of the present study. In this respect, additional validation studies using a gold standard and representative samples of the population of Brazilian adolescents should be conducted to better understand the relationship between these two constructs and to guide exercise prescription as a tool for health promotion[30]. The criteria used to determine the cut-off values that classify test performance should be reviewed and discussed as done in the studies of Bergmann *et al.*[10] and Paludo *et al.*[12].

CONCLUSIONS

An association between the categories of classification obtained with the IPAQ and T9 was only observed for older adults. However, continuous

variables transformed in z-score distribution and categorized into tertiles generated with the two methods were associated and showed agreement also among younger adolescents. Future studies investigating the association between the results obtained with the two methods and morbidities should clarify which method will be more effective for health risk assessment in adolescents.

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