Original Article

Cardiorespiratory Fitness of a Brazilian Regional Sample Distributed in Different Tables

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Abstract

Background: **Most classification tables of cardiorespiratory fitness (CRF) used in clinical practice are international and have not been validated for the Brazilian population. That can result in important discrepancies when that classification is extrapolated to our population.**

Objective: **To assess the use of major CRF tables available in a Brazilian population sample of the Central High Plan of the state of Rio Grande do Sul (RS).**

Methods: **This study assessed the retrospective data of 2,930 individuals, living in 36 cities of the Central High Plan of the state of RS, and considered the following: presence of risk factors for cardiovascular disease and estimated maximum oxygen consumption (VO_{2peak}) values obtained through exercise test with Bruce protocol. To classify CRF, the individuals were distributed according to sex, inserted in their respective age groups in the Cooper, American Heart Association (AHA) and Universidade Federal de São Paulo (Unifesp) tables, and classified according to their VO_{2peak}.**

Results: **Women had lower VO_{2peak} values as compared with those of men (23.5 ± 8.5 vs. 31.7 ± 10.8 mL.kg-1.min^{-1}, $p < 0.001$). Considering both sexes, VO_{2peak} showed an inverse and moderate correlation with age ($R = -0.48$, $p < 0.001$). An important discrepancy in the CRF classification levels was observed between the tables, ranging from 49% (Cooper x AHA) to 75% (Unifesp x AHA).**

Conclusion: **Our findings indicate important discrepancy in the CRF classification levels of the tables assessed. Future studies could assess whether international tables could be used for the Brazilian population and populations of different regions of Brazil. (Arq Bras Cardiol 2012;99(3):811-817)**

Keywords: **Physical fitness; oxygen consumption; urban population; exercise test; classification.**

Introduction

The body of evidence correlating low cardiorespiratory fitness (CRF) with an increase in cardiovascular morbidity and mortality is very robust[1-4]. That association does not depend on the presence of other risk factors, providing important diagnostic and prognostic data[5].

The CRF level, assessed by use of maximum or peak oxygen consumption (VO_{2peak}), can be measured through the analysis of expired gases, a direct measure considered the reference standard, or can be estimated in a conventional exercise test (ET) using ergometry. Currently, the existing standardizations for conventional ET allow comparisons between individuals, the Bruce protocol being widely used for adults[6-8].

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Cardiorespiratory fitness can be classified by use of different tables, according to age, sex and VO_{2peak}[4]. However, those tables can vary significantly[7-9], which can be a confounding factor in the search for accuracy in classifying individuals. It is worth noting that the most used tables for CRF classification are that by Cooper[9] and that of the American Heart Association (AHA)[10]. The table of the Center of Physical Activity and Sports Medicine of the Universidade Federal de São Paulo (Unifesp)[11], genuinely Brazilian, is rarely used. Thus, this study aimed at assessing the existence of equivalence among those CRF classification tables (Cooper[9], AHA[10] and Unifesp[11]), having estimated VO_{2peak} as the base for comparison, and assessing individuals from a Brazilian regional sample.

Materials and Methods

Data were collected from 2,930 individuals, living in 36 cities of the Central High Plan of the state of Rio Grande do Sul, assessed at the Instituto de Cardiologia de Cruz Alta (ICCA), in the state of Rio Grande do Sul, Brazil, from 2002 to 2009. Based on the medical records from the ICCA, the following data were stored in a database: age (years); sex; history of diabetes; hypercholesterolemia; hypertriglyceridemia; systemic arterial hypertension; smoking; alcohol abuse; sedentary lifestyle; stress level; and presence of coronary artery disease (CAD). The following parameters were measured: body mass (kg), by use of a precision scale (Cauduro LTDA, model BB for 150 kg); height (cm), by use of a graded ruler in centimeters; and abdominal circumference (AC), by use of a measuring tape at the level of the navel[13]. Body mass index (BMI: weight/height^2) was calculated according to the World Health Organization recommendations[12].

The individuals underwent ET according to the following indications of local general clinicians and cardiologists: diagnosis of myocardial ischemia; assessment of invasive and medicamentous therapies; assessment of arrhythmias; and assessment of physical fitness and exercise prescription. The ET was interrupted in the presence of limiting symptoms, maximum heart rate, or any abnormality during its execution.

The VO_{2peak} values were obtained by use of treadmill stress test with Bruce protocol. The VO_{2peak} was estimated based on the formulae used in the ErgoPC program, according to the method established in the Brazilian Society of Cardiology guidelines[14]. All data were collected by one single examiner. This study was approved by the Ethics Committee on Research in Human Beings of the Universidade de Cruz Alta (Unicruz) (protocol 003/09).

To classify the CRF, the subjects were distributed according to sex, and inserted in the age groups of the Cooper[9], AHA[10] and Unifesp[11] tables. Then, the percentage distribution of the individuals was analyzed at each level of the different tables. Finally, the CRF levels were compared between the three tables. Table 1 shows the classification criteria of the tables[9-11].

The results were shown as relative and absolute frequencies for categorical variables, and as mean and standard deviation for continuous variables. The variables were compared by use of the chi-square test for proportions and the *t* test for means. Pearson correlation coefficient was used to assess the correlations between the variables age and VO_{2peak}. The differences between the groups were considered significant when $p \leq 0.05$.

Results

This study sample comprised 2,930 individuals, 1,765 (60%) were of the female sex, and 96%, white. Their age ranged from 13 to 91 years (mean, 54 ± 14 years). Men were younger (52 ± 14 *vs.* 54 ± 13 years, $p = 0.001$) and had greater body mass (85 ± 15 *vs.* 69 ± 14 kg, $p < 0.001$), BMI (28 ± 5 *vs.* 27 ± 5 kg/m^2, $p < 0.001$), and AC (103 ± 13 *vs.* 94 ± 13 cm, $p < 0.001$) as compared with women. Table 2 shows the distribution of individuals according to the presence of risk factors.

As expected, women had lower VO_{2peak} values than men (23.5 ± 8.5 *vs.* 31.7 ± 10.8 mL.kg^{-1}.min^{-1}, $p < 0.001$). The VO_{2peak} showed an inverse and moderate correlation with age for both sexes ($R = -0.48$, $p < 0.001$). Table 3 shows the mean VO_{2peak} values according to the age groups. For both sexes, the VO_{2peak} percentage progressively decreased as age increased.

Figure 1 shows the percentage of women (1.A) and men (1.B) distributed according to the different tables studied.

Table 4 compares the percentage and number of individuals in each CRF classification level of the three tables assessed. An important disagreement is observed among the CRF levels of each table (Cooper *vs.* AHA= 49%; UNIFESP *vs.* AHA= 75%; and Cooper *vs.* UNIFESP 56%). Other comparisons are shown in Table 4.

Discussion

This study is the first to compare the distribution of CRF levels in a Brazilian regional sample regarding the three CRF classification tables used in Brazil. Our findings indicate relevant discrepancies among the Cooper, AHA and Unifesp CRF classification tables.

Most CRF classification tables have originated in other countries. Thus, ethnical and social differences regarding the Brazilian population might interfere in the CRF classification. In addition, it is worth noting that the different methods used to obtain VO_{2peak}, as well as the criteria used for CRF classification and different ages might have contributed to the disagreeing results found in our study.

In addition, the external validity of data collected in other countries or from small samples should be tested in Brazilian individuals, because pure and simple extrapolation might lead to rough errors[15]. It is worth noting that both Neto et al.[16] and Negrão[17] have already called attention to the generalization of reference parameters regarding the evaluation of CRF. Another important point in this study relates to the wide age range of the participants (13 to 91 years). The enrollment of individuals from a wide age range and the large sample enabled a comparative CRF analysis with other similar studies.

Each CRF classification table has its particularities as follows: the Cooper table used individuals over the age of 13 years, regardless of their level of physical activity[9]; the AHA table encompassed individuals aged between 20 and 69 years, with either a sedentary lifestyle or not[10]; and the Unifesp table selected only individuals aged between 20 and 59 years with a sedentary lifestyle[11]. Of the 2,930 individuals studied, 100% were allocated to the Cooper table, 85% (2,480) to the AHA table, and 65% (1,913) to the Unifesp table, which had the greatest rate of exclusion.

When measuring functional capacity, CRF can be obtained by use of different methods. To collect that information, conventional ET on a treadmill was performed with the Bruce protocol, which has been widely used for youngsters and adults, being the most commonly used in Brazilian health services[6,18]. However, Cooper has used the length of stay in the Balke treadmill protocol[19]. The Unifesp table used the curve adjustment for VO_{2peak} *vs.* age[11], and the direct measure through expired gas analysis. However, independently of measuring VO_{2peak} directly or indirectly, the major aspect for an accurate analysis lies in the specificity of the measures performed[9,19].

Assessing the VO_{2peak} variation per decade, a more expressive drop occurred as the individuals' age increased, for both sexes, a regular and inverse correlation between age and VO_{2peak} being observed ($r = -0.48$). It is worth noting the striking similarity of that value with that of the study by Jae et al.[20] performed with direct measurement of expired gases

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Table 1 – Cardiorespiratory fitness classification levels of women and men according to Cooper, AHA and Unifesp, based on VO_{2peak}

WOMEN	Age (years)	13-19	20-29	30-39	40-49	50-59	60-69	60+
Table	Category				VO_2 values mL(kg.min)$^{-1}$			
Cooper	Very poor	<25.0	<23.6	<22.8	<21.0	<20.2		<17.5
AHA	Very weak		<24	<20	<17	<15	<13	
Unifesp	Very weak		<30	<29	<25	<25		
Cooper	Poor	25.0–30.9	23.6–28.9	22.8–26.9	21.0–24.4	20.2–22.7		17.5–20.1
AHA	Weak		24–30	20–27	17–23	15–20	13-17	
Unifesp	Weak		30–34	29–33	25–29	25–29		
Cooper	Regular	31.0–34.9	29.0–32.9	27.0–31.4	24.5–28.9	22.8–26.9		20.2–24.4
AHA	Regular		31–37	28–33	24–30	21–27	18–23	
Unifesp	Regular		35–36	34–35	30–32	30–32		
Cooper	Good	35.0–38.9	33.0–36.9	31.5–35.6	29.0–32.8	27.0–31.4		24.5–30.2
AHA	Good		38–48	34–44	31–41	28–37	24–34	
Unifesp	Good		37–41	36–38	33–34	33–34		
Cooper	Excellent	39.0–41.9	37.0–40.9	35.7–40.0	32.9–36.9	31.5–35.7		30.3–31.4
AHA	Excellent		>49	>45	>42	>38	>35	
Unifesp	Excellent		>41	>38	>34	>34		
Cooper	Superior	>42.0	>41.0	>40.1	>37.0	>35.8		>31.5
MEN	**Age (years)**	**13-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60- 69**	**60+**
Table	Category				VO_2 values mL(kg.min)$^{-1}$			
Cooper	Very poor	<35.0	<33.0	<31.5	<30.2	<26.1		<20.5
AHA	Very weak		<25	<23	<20	<18	<16	
UNIFESP	Very weak		<36	<34	<30	<27		
Cooper	Poor	35.0–38.3	33.0–36.4	31.5–35.4	30.2–33.5	26.1–30.9		20.5–26.0
AHA	Weak		25-33	23–30	20–26	18–24	16–22	
Unifesp	Weak		36–42	34–38	30–33	27–31		
Cooper	Regular	38.4–45.1	36.5–42.4	35.5–40.9	33.6–38.9	31.0–35.7		26.1–32.2
AHA	Regular		34–42	31–38	27–35	25–33	23–30	
Unifesp	Regular		43–45	39–41	34–35	32–34		
Cooper	Good	45.2–50.9	42.5–46.4	41.0–44.9	39.0–43.7	35.8–40.9		32.3–36.4
AHA	Good		43–52	39–48	36–44	34–42		
Unifesp	Good		46–49	42–45	36–39	35–38	31–40	
Cooper	Excellent	51.0–55.9	46.5–52.4	45.0–49.4	43.8–48.0	41.0–45.3		36.5–44.2
AHA	Excellent		>53	>49	>45	>43	>41	
Unifesp	Excellent		>49	>45	>39	>38		
Cooper	Superior	>56.0	>52.5	>49.5	>48.1	>45.4		>44.3

Source - Powers & Howley, 2000. Marins & Giannichi, 2003. Ghorayeb & Barros, 1999.

(r = -0.5). As expected, VO_{2peak} decreased as age increased, especially from 50 years onwards, decreasing regularly around 20% to 25% per decade, and this was much more evident in individuals over 60 years[7,8]. However, the small number of individuals allocated for the decades below 40 years might explain the irregular variation found among individuals aged between 13 and 39 years.

A study has reported that VO_{2peak} can decrease approximately 10% per decade in non-athletic individuals, this drop varying from 3% to 6% in individuals aged between 20 and 30 years[5]. That decline can reach 20% after the age of 60 years[21], being faster among men[15,22]. It is worth noting the similarity between those literature data and ours, taking in mind that our findings were obtained by use of indirect

Table 2 - Distribution of the 2,930 individuals studied according to the presence of cardiovascular risk factors

Risk factors	% (n)
Diabetes	6% (165)
Hypercholesterolemia	27% (805)
Hypertriglyceridemia	19% (561)
Hypertension	40% (1168)
Tobacco use	11% (326)
Alcohol abuse	6% (160)
Sedentary lifestyle	73% (2142)
Stress	76% (2238)
History of CAD	4% (118)
AC greater than recommended*	70% (2063)

*CAD – coronary artery disease; AC - abdominal circumference. * For women, AC > 80 cm; for men, AC > 94 cm. Source: Database of the Instituto de Cardiologia de Cruz Alta - RS.*

measure. In other words, VO_{2peak} variation with age seems to differ only slightly, independently of being performed with or without expired gas analysis.

Another aspect worthy of note was the elevated percentage of disagreement between the CRF levels in the three tables (Table 4). Marins and Giannichi[10] have reported that the use of different CRF classification tables would not interfere significantly in the results of the studies. However, we observed disagreement among the CRF levels of the three tables ranging from 43% to 86% for both sexes and in almost all CRF levels ($p < 0.001$).

The high disagreement found in our study within the same classification level can be partially explained by the different types of samples used to elaborate the tables. Thus, we investigated the samples used to elaborate the Cooper, AHA and Unifesp tables, and discovered that the Cooper table enrolled individuals from the North-American Air Force[19], differing from this study population, which included individuals with 133 different professions/occupations (not described in this study). It is worth noting that, we have found the description of neither the method nor the type of sample used to formulate the AHA table. Similarly, the occupation of the individuals assessed to elaborate the Unifesp table has not been described.

Table 3 - Distribution of the VO_{2peak} (Mean ± SD and percentage variation) of 2,930 individuals according to sex and age group

Sex	Age group	N (%)	M ± SD	% Variation	Sex	N (%)	M ± SD	% Variation
Women	13 to 19 years	15(8)	31.7 ± 10		Men	13(1)	41.9 ± 9	
	20 to 29 years	43(2)	32.2 ± 7	+1%		50(4)	39.4 ± 12	-6%
	30 to 39 years	178(10)	28.1 ± 8	-13%		161(14)	38.4 ± 9	-3%
	40 to 49 years	402(23)	26.5 ± 8	-6%		281(24)	36.0 ± 9	-6%
	50 to 59 years	512(29)	24.4 ± 7	-8%		286(25)	31.4 ± 9	-13%
	60 to 69 years	348(20)	20.5 ± 7	-16%		219(19)	26.6 ± 9	-15%
	70 years or +	267(15)	16.4 ± 7	-20%		155(13)	21.3 ± 8	-20%

Database of the Instituto de Cardiologia de Cruz Alta - RS.

The disparities in the classification of this study sample can be justified by the fact that there are great variations among the classification tables (values ranging from 0 to 12 $mL.kg^{-1}.min^{-1}$)[9-11] (Table 1). In addition, when analyzing the VO_{2peak} values used to establish each CRF level, the following different intervals were noted, hindering a better agreement between the same CRF levels: 3 to 7 $mL.kg^{-1}.min^{-1}$ in the Cooper table[9]; 4 to 10 $mL.kg^{-1}.min^{-1}$ in the AHA table[10]; and 1 to 6 $mL.kg^{-1}.min^{-1}$ in the Unifesp table[11]. Thus, for distributing our sample in the CRF levels, there was no consensus for most individuals classified according to Cooper, AHA and Unifesp. It is worth noting that the Unifesp table, from Brazilian origin, had the highest percentage of classification disparity between individuals.

As in most parts of Brazil, cardiology clinics and services do not routinely use expired gas analysis, but the indirect method, applying either the AHA classification or Cooper's classification, in addition to Bruce protocol. Thus, we considered performing this study important, because an individual can be classified differently depending on the table used by the ET examiner. This, by itself, can change the perception of the clinician and/or patient regarding physical fitness, especially for general physicians who are not used to work with ergometry and physical exercises.

The ET has been increasingly indicated for initial assessment or prescription and reprograming of physical exercises to both healthy individuals and those with cardiovascular risk factors, or even severe heart disease. Thus, knowing the existence of those discrepancies among the tables is necessary, justifying the clinical importance of this study.

According to the Brazilian Society of Cardiology III Guideline on Exercise Test, the ET is a procedure in which the individual undergoes a programed and individualized physical exertion, aiming at assessing clinical, hemodynamic, autonomic, electrical, metabolic and eventually ventilatory responses to exercise[23]. That assessment, according to that guideline, allows assessing functional capacity and aerobic capacity, prescribing exercise, and showing the patients and their families their actual physical conditions, providing data to attending physicians.

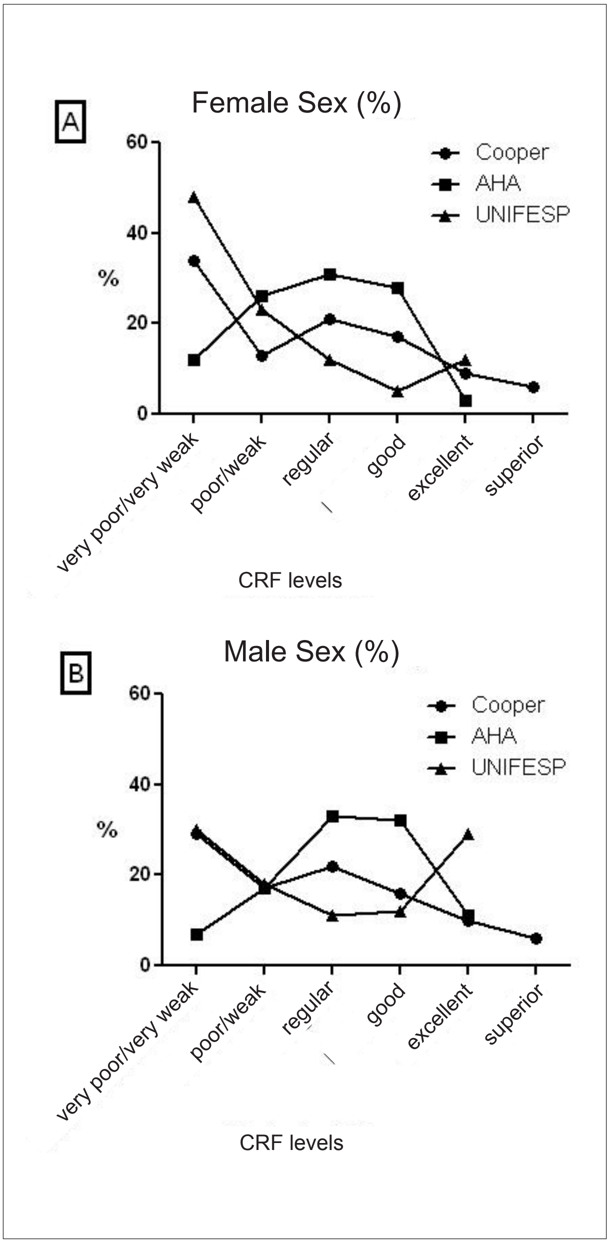

Figure 1 – *Levels of CRF of a Brazilian regional sample, distributed as percentage, according to the Cooper, AHA and Unifesp CRF classification tables. A: female sample; B: male sample.*

Briefly, the variation found among the three CRF classification tables points to the importance of developing classification tables specific for the Brazilian population, considering all ethnical, social and cultural differences[16,17,23], in the search for more careful attention at health care services in Brazil.

Limitations of the study

Although ET with expired gas analysis is considered the reference standard for assessing CRF, and the symptom-limited protocol is currently the most used in research services, in this study, VO_{2peak} was indirectly measured and with only the Bruce protocol, which was an important limitation[23].

However, most cardiology clinics and services use routinely the indirect method for measuring VO_2 concomitantly with the Bruce protocol. Thus, we believe that performing this study is reasonable, especially because, according to the Brazilian Society of Cardiology III Guideline on Exercise Test, the social reality of several municipalities should be considered[23].

Finally, based on data collection of other centers in several regions of Brazil also using the indirect VO_2 measurement and Bruce protocol, a better overview of CRF of Brazilians could be obtained, according to each regional subtype and closer to the cardiological clinical reality of the country[24].

Conclusion

Our findings show discrepancies in the CRF classifications originating from the Cooper, AHA and Unifesp tables. Future studies could investigate whether international tables can be applied to the Brazilian population and populations of different Brazilian regions. National CRF classification tables, contemplating the characteristics of the Brazilian population, should be validated.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any post-graduation program.

Table 4 – Comparison of the number and percentage of individuals of a Brazilian regional sample, allocated to each classification level of the AHA, Cooper and Unifesp tables

		AHA CRF				
		Very weak	Weak	Regular	Good	Excellent
	Total	255 (100%)	553 (100%)	791 (100%)	733 (100%)	148 (100%)
COOPER	Very poor	255 (100%)	385 (70%)	44 (6%)	0	0
	Poor	0	162 (29%)	212 (27%)	0	0
	Regular	0	6 (1%)	450 (57%)	101 (14%)	0
	Good	0	0	83 (10%)	354 (48%)	0
	Excellent	0	0	2 (1%)	226 (31%)	35 (24%)
	Superior	0	0	0	52 (7%)	113 (76%)
		AHA CRF				
		Very weak	Weak	Regular	Good	Excellent
	Total	178 (100%)	411 (100%)	629 (100%)	564 (100%)	131 (100%)
UNIFESP	Very weak	178 (100%)	408 (99%)	198 (31%)	1 (1%)	0
	Weak	0	3 (1%)	364 (58%)	36 (6%)	0
	Regular	0	0	65 (10%)	151 (27%)	0
	Good	0	0	2 (1%)	144 (25%)	0
	Very good	0	0	0	233 (41%)	131 (100%)
		UNIFESP CRF				
		Very weak	Weak	Regular	Good	Very good
	Total	784 (100%)	403 (100%)	216 (100%)	146 (100%)	364 (100%)
COOPER	Very poor	498 (63%)	0	0	0	0
	Poor	210 (27%)	77 (19%)	0	0	0
	Regular	76 (10%)	223 (55%)	70 (32%)	53 (36%)	0
	Good	0	103 (26%)	119 (55%)	39 (27%)	77 (21%)
	Excellent	0	0	27 (13%)	54 (37%)	146 (40%)
	Superior	0	0	0	0	141 (39%)

Database of the Instituto de Cardiologia de Cruz Alta - RS. For all variables $p < 0.001$.

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