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Original Article

PREDICTION OF CARDIORESPIRATORY FITNESS IN THE BRAZILIAN POPULATION AGED 20 TO 59 YEARS: A NON-EXERCISE MODEL APPROACH WITH SELF-REPORTED VARIABLES

ESTIMATIVA DA APTIDÃO CARDIORRESPIRATÓRIA DA POPULAÇÃO BRASILEIRA DE 20 A 59 ANOS: ABORDAGEM POR MEIO DE MODELO SEM EXERCÍCIO COM VARIÁVEIS AUTO-RELATADAS

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RESUMO
Diferentemente de outras variáveis mais comuns relacionadas à saúde, a aptidão cardiorrespiratória (ACR) não é medida constantemente na população em geral. Sua omissão caracteriza numa perda de informação relevante. Com isso os objetivos do presente estudo foram: a) caracterizar a ACR da população brasileira de 20 a 59 anos, desenvolvendo valores normativos através de uma equação para estimar o consumo máximo de oxigênio ($VO_{2Máx}$) sem a realização de exercícios; e b) verificar a associação de menores níveis de ACR com a prevalência de doenças crônicas. Ao todo, 32.531 indivíduos compuseram a amostra oriunda da Pesquisa Nacional de Saúde (PNS-IBGE-2013). Apenas variáveis auto-relatadas foram incluídas a partir da equação de Wier et al. (2006): sexo, idade, nível de atividade física e Índice de Massa Corporal. A média de $VO_{2Máx}$ foi estimada como 44,6; 39,3; 34,8 e 30,6 ml/kg/min (homens) e 34,5; 29,6; 25,4 e 21,1 ml/kg/min (mulheres) com idades 20-29; 30-39; 40-49 e 50-59. Os valores de percentil 20 e 80 foram estabelecidos como os extremos de muito baixa e muito alta ACR. A baixa aptidão demonstrou significativamente 33% maiores chances de prevalência de doença cardiovascular, 89% de diabetes mellitus e 67% de hipertensão arterial independentemente de sexo, idade, e presença de obesidade, o que parece corroborar a qualidade da equação utilizada.
Palavras-chave: Aptidão Física; Valores de referência; Exercício; Fatores de Risco.

ABSTRACT
Unlike other more common health-related variables, cardiorespiratory fitness (CRF) is not frequently measured in the general population. This omission characterizes a loss of relevant information. Thus, the objectives of the present study were: a) to characterize the CRF of the Brazilian population aged 20 to 59 years and to develop normative values using a non-exercise equation for predicting maximal oxygen uptake (VO_{2max}), and b) to verify the association between lower levels of CRF and the prevalence of chronic diseases. A total of 32,531 individuals from the National Health Survey (NHS-IBGE-2013) composed the sample. Only self-reported variables were included in the equation of Wier et al. (2006): sex, age, physical activity level, and body mass index. The mean predicted VO_{2max} was 44.6, 39.3, 34.8 and 30.6 ml/kg/min for men, and 34.5, 29.6, 25.4 and 21.1 ml/kg/min for women aged 20-29, 30-39, 40-49 and 50-59 years, respectively. The 20th and 80th percentiles were established as the extremes (very low and very high CRF). Participants with low fitness had a 33% higher chance of cardiovascular disease, an 89% higher chance of diabetes mellitus, and a 67% higher chance of hypertension, regardless of sex, age and presence of obesity, which seem to corroborate the quality of the equation.
Keywords: Physical Fitness; Reference Values; Exercise; Risk Factors.

Introduction

Physical fitness can be defined as the capacity to perform physical effort without compromising the biological, psychological or social health of an individual[1]. One of the components of physical fitness is cardiorespiratory fitness (CRF), which can be expressed as maximal oxygen uptake (VO_{2max})[1]. Low levels of CRF are directly associated with a higher risk of developing cardiovascular diseases and of premature death, regardless of the association with other common risk factors[2-8]. In addition, CRF is a better predictor of cardiovascular disease risk than other more frequently studied factors such as obesity, arterial hypertension, smoking, and dislipidemias[6, 9,10].

Unlike other more common health-related variables, CRF is not frequently measured in the general population[11,12]. This omission characterizes a loss of relevant information on health status. Indeed, there is consensus that decisions related to the choice of variables to be included in a population study are intimately related to the feasibility and certainly to the cost of methods used for measurement. Consequently, more easily measurable variables are usually included, such as body weight, blood pressure, and blood glucose, cholesterol and triglyceride levels, variables commonly used in routine assessments[12]. Easier instruments for measuring CRF may contribute very important information to public health[13,14].

Despite knowledge of the importance of CRF, few population-based studies were able to estimate it[15], and no studies have so far evaluated CRF in a representative sample of the Brazilian population. Therefore, the objective of the present study was to characterize CRF in the Brazilian population aged 20 to 59 years and to develop normative values using a non-exercise equation for predicting VO_{2max}. In addition, the association of lower levels of CRF with the prevalence of cardiovascular diseases, systemic arterial hypertension and diabetes was evaluated.

Methods

The present study was conducted using data from the 2013 National Health Survey (NHS). The NHS was an initiative of the Ministry of Health and is part of the Integrated Household Survey System (SIPD in the Portuguese acronym) of the Brazilian Institute of Geography and Statistics (IBGE)[16]. The research was carried out through a household survey. The target population of the NHS were adults (older than 18 years) residing exclusively in Brazil. Exceptions were individuals located in special sectors such as military quarters, military bases, shelters, camps, boats, penitentiaries, penal colonies, jails, asylums, orphanages, convents, and hospitals.

The present study was carried out considering the macroregions of Brazil and geographical disaggregation. The idea of the sampling process was to obtain a representative sample. The instruments used and the sampling process are described in the official report of the survey[16].

The study was approved by the National Research Ethics Committee (CONEP) under approval number 328.159, on 26 June 2013, and was conducted in accordance with Resolution 466 of the National Health Council from 12 December 2012. All subjects received detailed information about the study and agreed to participate by signing the free informed consent form.

The method used for predicting CRF was developed from the non-exercise equation of Wier et al.[17], which contained the following data: sex, age, body mass index (BMI), and physical activity level evaluated by the Physical Activity Rating (PA-R) scale[18]. The prediction equation was as follows:

$$\text{Predicted } VO_{2max} = 57.402+[1.396*(\text{PA-R})]-[0.372*(\text{age in years})]-[0.683*(\text{BMI})]+[8.596*(F=0, M=1)]$$

where F = female and M = male.

The inclusion criteria for determination of the final sample were: subjects of both sexes aged between 20 and 59 years (due to the low validity of the equation for older adults and young people); individuals who had reported some information about physical activity level and those with self-reported weight and height (for the calculation of BMI). The final sample consisted of 32,531 individuals.

The participation in physical activity was extracted from a questionnaire consisting of questions about the frequency and duration of physical activity in different domains. Physical activity scores were developed for each domain by multiplying the weekly frequency by the duration on the days when the activity was performed. The following domains were evaluated: leisure, transportation, occupational, and household. This instrument follows the model of the questionnaire applied by the Surveillance System for Risk and Protective Factors for Chronic Diseases by Telephone Survey (Vigitel).

The data were coded for the PA-R scale by attributing a value that ranged from 0 to 10, which corresponded to the type, volume and intensity of the physical activity reported. According to the PA-R score, occupational and transportation physical activity received values of 0 to 3 and leisure-time physical activity of 0 to 10. The highest value attributed to any of the physical activity domains was considered the final PA-R score. Adaptations of the PA-R based on other questionnaires are common in the literature and the following scores are generally used as a reference for the classification of physical activity level: 0 to 2, inactive; 3 and 4, low level; 5, moderate level; 6, high level; ≥ 7, very high level[12].

The distribution of predicted CRF was analyzed considering sex and age group (decade of life). For the classification of CRF level, the values were divided into deciles. The following cut-off points were adopted: 20th percentile, very low fitness; ≤ 40th percentile, low fitness; ≤ 60th percentile, moderate fitness; ≤ 80th percentile, high fitness, and > 80th percentile, very high fitness, according to the 2010 recommendations of the American College of Sports Medicine (ACSM)[19].

The values were categorized into quintiles, with the extremes being classified as low and high fitness and intermediate quintiles as moderate. Logistic regression analysis was used to compare the odds of a history of hypertension, diabetes and cardiovascular diseases at the different CRF levels, with the highest quintile being used as the reference. The indicators of hypertension, diabetes and cardiovascular diseases were based on self-reports. Logistic regression yielded crude and adjusted odds ratios. Adjustments were made considering age, sex, and the presence of obesity (BMI > 29.99).

The Stata for Windows 12.0 software was used for all analyses and a level of significance of p≤0.05 was established.

Results

The characteristics of the sample are shown in Table 1.

Table 1. Characteristics of the sample

Characteristic	Mean (95% CI)	
	Men (n=15,015)	**Women (n=17,516)**
Age (years)	37.2 (36.9-37.5)	38.2 (37.8-38.5)
Height (cm)	1.72 (1.72-1.72)	1.61 (1.61-1.61)
Body weight (kg)	78.2 (77.8-78.6)	67.5 (67.1-67.8)
Body mass index (kg/m^2)	26.3 (26.2-26.5)	26.1 (26.0-26.3)
PA-R score	2.94 (2.88-3.00)	1.99 (1.94-2.04)

Source: The authors

A total of 32,531 individuals composed the sample (Table 1). The mean predicted VO_{2max} of men was 44.6, 39.3, 34.8 and 30.6 ml/kg/min for the age groups of 20-29, 30-39, 40-49 and 50-59 years, respectively. For women, these values were 34.5, 29.6, 25.4 and 21.1

ml/kg/min for the same age groups. The 20th and 80th percentiles were established as very low and very high fitness. The overall mean VO_{2max} considering all ages was 37.7 ml/kg/min for men and 28.1 ml/kg/min for women. These data are presented in Tables 2 and 3.

Table 2. Mean and selected percentiles of predicted VO_{2max} (ml/kg/minute) according to age for men between 20 and 59 years. National Health Survey, 2013 (n=15,015)

		All ages	**20-29 years**	**30-39 years**	**40-49 years**	**50-59 years**
	n	15,015	3,647	4,507	3,849	3,012
	Mean	37.7	44.6	39.3	34.8	30.6
	p value[b]			< 0.001		
Percentile	10th	28.9	38.4	33.2	28.9	24.8
	95% CI	28.7-29.0	38.0-38.6	33.0-33.5	28.6-29.1	24.5-25.1
	20th	31.6	40.3	35.3	31.1	26.9
	95% CI	31.5-31.8	40.1-40.5	35.1-35.5	30.9-31.3	26.7-27.1
	30th	33.8	42.0	36.8	32.4	28.4
	95% CI	33.6-33.9	41.8-42.2	36.7-37.0	32.2-32.6	28.2-28.6
	40th	35.7	43.3	38.1	33.6	29.5
	95% CI	35.5-35.8	43.1-43.6	37.9-38.3	33.4-33.8	29.4-29.7
	50th	37.5	44.6	39.4	34.9	30.7
	95% CI	37.3-37.6	44.4-44.8	39.2-39.5	34.7-35.1	30.4-30.9
	60th	39.4	45.8	40.6	36.0	31.7
	95% CI	39.3-39.6	45.6-46.0	40.4-40.8	35.9-36.2	31.6-31.9
	70th	41.4	47.1	41.9	37.1	32.9
	95% CI	41.3-41.6	46.9-47.3	41.7-42.1	36.9-37.3	32.7-33.1
	80th	43.7	48.8	43.4	38.5	34.2
	95% CI	43.6-43.9	48.5-49.0	43.2-43.6	38.3-38.7	34.0-34.4
	90th	46.7	51.0	45.5	40.4	35.9
	95% CI	46.5-46.9	50.7-51.2	45.2-45.8	40.2-40.8	35.7-36.2

Note: VO_{2max} = maximal oxygen uptake, n = number of subjects, CI = confidence interval.
Source: The authors

Table 3. Mean and selected percentiles of predicted VO_{2max} (ml/kg/minute) according to age for women between 20 and 59 years. National Health Survey, 2013 (n=17,516)

		All ages	20-29 years	30-39 years	40-49 years	50-59 years
	n	17,516	4,554	5,661	4,202	3,099
	Mean	28.1	34.5	29.6	25.4	21.1
	p value[b]			< 0.001		
Percentile	10th	19.7	22.2	23.6	19.4	15.1
	95% CI	19.5-19.9	27.9-28.5	23.4-23.9	19.1-19.8	14.9-15.4
	20th	22.6	30.5	25.9	21.6	17.4
	95% CI	22.5-22.8	30.3-30.7	25.7-26.1	21.4-21.9	17.1-17.6
	30th	24.8	32.0	27.5	23.1	19.0
	95% CI	24.6-24.9	31.8-32.1	27.3-27.6	22.9-23.2	18.7-19.2
	40th	26.7	33.1	28.6	24.4	20.1
	95% CI	26.6-26.8	32.9-33.3	28.5-28.7	24.2-24.5	19.9-20.3
	50th	28.4	34.2	29.8	25.5	21.4
	95% CI	28.3-28.6	34.1-34.4	29.7-30.0	25.3-25.7	21.2-21.6
	60th	30.2	35.2	30.9	26.7	22.4
	95% CI	30.0-30.3	35.1-35.4	30.7-31.0	26.5-26.9	22.3-22.6
	70th	31.9	36.3	32	27.8	23.6
	95% CI	31.8-32.0	36.2-36.5	31.9-32.1	27.7-28.0	23.4-23.7
	80th	33.8	37.7	33.3	29.1	24.8
	95% CI	33.7-34.0	37.6-37.9	33.1-33.5	29.0-29.3	24.6-25.0
	90th	36.4	39.7	35.2	30.9	26.6
	95% CI	36.2-36.6	39.5-39.9	35.0-35.4	30.7-31.2	26.4-26.8

Note: VO_{2max} = maximal oxygen uptake, n = number of subjects, CI = confidence interval.
Source: The authors

As can be seen in Table 4, a lower classification of CRF significantly increased the chances of having cardiovascular diseases, diabetes mellitus and systemic arterial hypertension (crude and adjusted odds ratios).

Table 4. Crude and adjusted odds ratio (OR) for cardiovascular diseases, diabetes and hypertension

Disease	Crude OR	95% CI	Adjusted OR*	95% CI
Cardiovascular diseases				
Moderate	1.13	0.93-1.37	0.98	0.80-1.19
Low	1.79	1.45-2.21	1.33	1.01-1.74
Diabetes mellitus				
Moderate	1.82	1.51-2.19	1.32	1.09-1.61
Low	3.82	3.15-4.64	1.89	1.49-2.40
Systemic arterial hypertension				
Moderate	1.19	1.76-2.13	1.30	1.18-1.45
Low	4.40	3.87-4.97	1.67	1.47-1.90

Note: *Adjusted for obesity, age, and sex. CI = confidence interval.
Source: The authors

The odds of reporting cardiovascular diseases were 33% for low CRF, and the odds of having diabetes mellitus and hypertension were 32% and 89% and 30% and 67% for moderate and low levels, respectively.

Discussion

The results of the present study describe the distribution of CRF levels among men and women aged 20-59 years, divided into decades, in a national sample of the Brazilian population. All data were self-reported and obtained from the 2013 NHS of IBGE.

For comparison with other national studies, the study of Herdy and Caixeta[20] is probably the best to be used. These authors evaluated the results of 2,837 cardiopulmonary exercise tests performed in the south of the country. For example, the mean VO_{2max} values found here (Table 2) for men are consistent with the range established as regular by Herdy and Caixeta[20]: 15-34 years: 37.9-48.1; 35-54 years: 32.4-43.1; 55-64 years: 28.2-33.5. In contrast, the values obtained for women seemed to be slightly lower: 15-34 years: 30.5-36.9; 35-54 years: 29.5-34.1; 55-64 years: 22.9-27.2. However, that study excluded obese, hypertensive, diabetic and dyslipidemic individuals as well as those taking any medication, a fact limiting its generalization capacity. Other attempts to characterize CRF of men and women were made in North American studies[21,22]; however, the samples used were never representative of the population.

It is known that CRF is an excellent predictor of chronic noncommunicable diseases[23]. Thus, the odds ratios were calculated considering values below the first quintile as low CRF levels and intermediate quintiles (>20th and <80th) as moderate levels in order to determine the probability of cardiovascular diseases, diabetes and systemic arterial hypertension. The findings suggest that low CRF levels increase by 33% the odds of a history of cardiovascular diseases.

Individuals with low CRF were 89% more likely to report a history of diabetes mellitus. These results agree with epidemiological studies evaluating the association between CRF level and diabetes. Loprinze and Pariser[24] estimated the CRF of individuals with diabetes and found that 51% of the population had moderate to low fitness levels. Another study analyzed the association between CRF and insulin resistance in Japanese men aged 40 to 79 years. The results showed an inverse association with insulin resistance indices in men with better CRF, thus supporting the power of CRF to predict the risk of developing diabetes [25].

With respect to low CRF and a history of systemic arterial hypertension, the risk was increased by 67%. No consensus exists in the literature regarding the association between CRF and pressure levels and the results are not always significant[26]. However, aerobic activities are known to influence CRF levels and to prevent the diagnosis of arterial hypertension[27].

The present study has some limitations, such as the use of self-reported data and the adequacy of the physical activity information reported in the PA-R. However, the fact that the equation used here has already been validated in national samples suggests a good generalization capacity[28]. In addition, the cross-sectional design of the study does not allow to establish causal relationships.

Conclusions

The results of the present study led us to conclude that the CRF of the adult Brazilian population can be characterized using a non-exercise approach to obtain relevant information on the health status of this population. These data may serve as a classification model of CRF in the Brazilian population. A low CRF was significantly associated with a higher probability of a history of chronic diseases such as cardiovascular disease, diabetes mellitus and systemic arterial hypertension, regardless of the influence of variables such as sex, age and body weight. These data corroborate the quality of the model used.

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