

# CARDIORESPIRATORY FITNESS AND CARDIOMETABOLIC RISK FACTORS AMONG UNIVERSITY PROFESSORS



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APTIDÃO CARDIORRESPIRATÓRIA E FATORES DE RISCO CARDIOMETABÓLICO  
ENTRE PROFESSORES UNIVERSITÁRIOS

APTITUD CARDIORRESPIRATORIA Y FACTORES DE RIESGO CARDIOMETABÓLICO  
ENTRE PROFESORES UNIVERSITARIOS

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## ABSTRACT

**Introduction:** Cardiorespiratory fitness (CF) is associated with mortality and the development of cardiovascular disease, in addition to being related to work capacity. **Objectives:** This study aimed to verify the demographic, cardiometabolic and behavioral factors associated with CF in a representative sample of professors from a public university in Minas Gerais, Brazil. **Methods:** This is a cross-sectional study which evaluated, in addition to the CF, age, sex, glycemia, triglycerides, LDL and HDL cholesterol, C-reactive protein, body mass index (BMI), waist circumference, and physical activity (PA). The association between CF and cardiometabolic risk factors was estimated by logistic regression to obtain the odds ratios and respective confidence intervals (95%). **Results:** After adjustment, it was observed that professors with lower levels of CF were older, female, had higher BMI and a greater chance of being physically inactive. **Conclusion:** In general, the results show that the probability of low CF increases with the increase in BMI, in addition to the strong association with PA practice, which is a major focus of intervention measures aimed at improving workers health and their work capacity. **Level of Evidence III; Case control study.**

**Keywords:** Physical fitness; Motor activity; Body mass index; Occupational health.

## RESUMO

**Introdução:** A aptidão cardiorrespiratória (ApCr) está associada à mortalidade e ao desenvolvimento de doenças cardiovasculares, além de estar relacionada com a capacidade de trabalho. **Objetivos:** Este estudo objetivou verificar os fatores demográficos, cardiometabólicos e comportamentais associados à ApCr em uma amostra representativa de professores de uma universidade pública em Minas Gerais, Brasil. **Métodos:** Trata-se de um estudo seccional que avaliou, além da ApCr, idade, sexo, glicemia, triglicérides, colesterol LDL e HDL, proteína C-reativa, índice de massa corporal (IMC), circunferência da cintura e atividade física (AF). A associação entre ApCr e fatores de risco cardiometabólico foi estimada pela regressão logística, obtendo-se os valores de odds ratio e respectivos intervalos de confiança (95%). **Resultados:** Após ajustamento, observou-se que os professores com menores níveis de ApCr eram mais velhos, do sexo feminino, tinham maiores valores de IMC e maior chance de serem fisicamente inativos. **Conclusão:** Em geral, os resultados mostram que a probabilidade de baixa ApCr aumenta com a elevação do IMC, além da forte associação com a prática de AF, que constitui um importante foco das medidas de intervenção que visem a melhoria da saúde do trabalhador e de sua capacidade de trabalho. **Nível de Evidência III; Estudo de caso-controle.**

**Descritores:** Aptidão física; Atividade motora; Índice de massa corporal; Saúde do trabalhador.

## RESUMEN

**Introducción:** La aptitud cardiorrespiratoria (ApCr) está asociada a la mortalidad y al desarrollo de enfermedades cardiovasculares, además de estar relacionada a la capacidad de trabajo. **Objetivo:** Este estudio tuvo como objetivo verificar los factores demográficos, cardiometabólicos y comportamentales asociados a la ApCr en una muestra representativa de profesores de una universidad pública en Minas Gerais, Brasil. **Métodos:** Se trata de un estudio seccional que evaluó, además de la ApCr, edad, sexo, glucemia, triglicéridos, colesterol LDL y HDL, proteína C-reativa, índice de masa corporal (IMC), circunferencia de la cintura y actividad física (AF). La asociación entre ApCr y factores de riesgo cardiometabólico fue estimada por la regresión logística, obteniéndose los valores de odds ratio y sus intervalos de confianza (95%). **Resultados:** Después del ajuste, se observó que los profesores con menores niveles de ApCr eran mayores, del sexo femenino, tenían mayores valores de IMC y mayor probabilidad de ser físicamente inactivos. **Conclusión:** En general, los resultados muestran que la probabilidad de baja ApCr aumenta con la elevación del IMC, además de la fuerte asociación con la práctica de AF, que constituye un importante foco de las medidas de intervención que apunte a la mejora de la salud del trabajador y de su capacidad de trabajo. **Nivel de Evidencia III; Estudio de caso-control.**

**Descriptorios:** Aptitud física; Actividad motora; Índice de masa corporal, Salud laboral.



## INTRODUCTION

Cardiorespiratory fitness (CF) is the ability of the cardiovascular and respiratory system to withstand physical exertion for a prolonged period, and is often considered the most important marker of health status and efficiency of the cardiorespiratory system.<sup>1</sup> CF is related to all-cause mortality and the development of cardiovascular diseases,<sup>2</sup> regardless of known cardiovascular risk factors.<sup>2,3</sup>

Although part of the variability in CF is genetically determined, behavioral factors such as the performance of physical activity (PA), also influence this measure.<sup>4</sup> In the US adult population, low CF has been associated with obesity, metabolic syndrome, physical inactivity, lower HDL cholesterol and higher systolic pressure levels, triglycerides, non-HDL cholesterol, and triglyceride/HDL ratio.<sup>5</sup> Recent studies among workers suggest that CF is a stronger indicator for cardiometabolic risk and risk of death than self-reported levels of physical activity.<sup>2,6</sup> Moreover, use of the measure of CF should be prioritized, whenever possible, to the detriment of self-reported physical activity to predict health status and association with risk factors.<sup>7</sup>

In addition, we should emphasize that CF and musculoskeletal functioning are the aspects that produce the greatest impact on functional capacity, regarded as being of fundamental importance for the ability to work, given their significant role in the strain on workers.<sup>8</sup> In this context, it is worth noting that malaise and sickness among workers can influence high rates of absenteeism, sick leave, and a reduction in quality of life at work, with a detrimental effect on society.<sup>9</sup> In regard to university professors, we must consider the high risk of illness due to constant exposure to stressful situations, which is prejudicial to the educational process. Note that in Brazil and Latin American countries, there are few<sup>2</sup> studies assessing the association between CF and cardiometabolic risk factors among workers.

This study aimed to evaluate CF in a representative sample of higher education instructors from a public university, and to verify the demographic, cardiometabolic and behavioral factors associated with CF.

## MATERIALS AND METHODS

This study is of a cross-sectional design and was conducted among higher education instructors with an employment relationship at the Universidade Federal de Ouro Preto (UFOP), Ouro Preto campus in August 2013, which totaled 591 full-time members of the teaching staff. The sample was calculated to estimate the prevalence of physical inactivity (30%), with a sampling error of 5% and a 95% confidence interval. There was a 20% increase for withdrawals and refusals, totaling 232 professors. This sample group subsequently underwent a random draw, using the list of teachers provided by UFOP.

UFOP has academic units on three campuses, located in the cities of Ouro Preto, Mariana and João Monlevade. The largest campus is located in the municipality of Ouro Preto (state of Minas Gerais), a city covering an area of 1,245.86 km<sup>2</sup>, declared a "World Heritage Site" by the United Nations Educational, Scientific and Cultural Organization (UNESCO), and houses a population of approximately 74,036 thousand.<sup>10</sup> Over the study period, UFOP had a total of 42 undergraduate courses (29 in Ouro Preto), 41 graduate courses in specialized fields (35 in Ouro Preto), and 17 non-degree graduate courses. Considering the three campuses, more than 15 thousand students were enrolled, and about 800 administrative technical employees and 800 lecturers/professors were affiliated to UFOP.

The project was approved by the Institutional Review Board of UFOP and of Universidade Federal de Minas Gerais (UFMG) (08604212.5.0000.5149), and all participants signed the informed consent form.

## Variables and data collection

Data collection comprised three stages (interview, physical evaluation and biochemical test) and was scheduled previously with each randomly drawn professor. The evaluators (Physical Education undergraduate students at UFOP) received training and a manual on the collection procedures. All the information for this study was collected between September 2013 and February 2015.

A face-to-face questionnaire administered in the professor's workplace was used to collect demographic information (age, sex) and level of physical activity (PA). PA was evaluated by IPAQ (International Physical Activity Questionnaire) in its short version. The instrument contains questions relating to the frequency, duration and intensity of PA in the past 7 days. The information collected through IPAQ was converted into metabolic equivalents (METs), based on the Compendium of PA. Physical inactivity was characterized by an energy expenditure in physical activities of less than 450 MET.min/week.<sup>11</sup>

The physical examination included an assessment of cardiorespiratory fitness and collection of anthropometric measurements. CF was assessed with VO2000 equipment and the test protocol used was Ellestad. Maximum/peak oxygen consumption was measured directly and determined on a basis of the highest VO<sub>2</sub> obtained before voluntary fatigue. The volume of oxygen consumed in milliliters per kilogram of weight per minute was considered. Professors with a diagnosis of hypertension and those with systolic blood pressure greater than or equal to 140 mmHg and/or diastolic blood pressure greater than or equal to 90 mmHg on three different pre-test days were excluded from this test.

As regard to anthropometric measurements, waist circumference was obtained during normal expiration with a flexible and inelastic tape measure. The measurement was performed at the midpoint between the iliac crest and the last rib. A portable 100-gram precision EKS Sport weighing scale was used to measure body weight while a Sanny portable stadiometer with millimeter accuracy was used to measure the height of the individuals. These measurements were collected considering the standard procedures described in the literature, while body mass index (BMI) was calculated as the ratio between weight (kg) and height squared (m).

Blood samples were collected by venipuncture to perform the biochemical test. Fasting blood glucose, total cholesterol and HDL and LDL fractions, triglycerides and C-reactive protein (CRP) were analyzed. The blood was drawn after 12 hours of fasting. Plasma concentrations of Total Cholesterol (TC), HDL Cholesterol (HDL-C) and Triglycerides (TG) were determined through the enzymatic colorimetric assay (Labtest®). LDL-C was calculated by the Friedewald equation, in mg/dL:  $LDL-C = TC - HDL-C - TG/5$ . Blood glucose concentration was determined using the enzymatic glucose oxidase method (Labtest®). Internal controls (normal and pathological) were used to validate the biochemical tests. The concentration of C-reactive protein (CRP) was measured with the chemiluminescence method (Siemens Healthcare Diagnostics Inc., Los Angeles, CA, USA).

## Statistical analysis

A descriptive analysis of the variables considered in this study was performed using percentage and mean (standard deviation), in addition to the association with CF. The chi-square test was used to compare proportions or the Student's t-test to compare means.

The CF level was divided into tertiles and dichotomized as "low CF" (first tertile) and "good CF" (second and third tertiles). The association between CF and cardiometabolic risk factors, considered continuous variables, was estimated by logistic regression, obtaining the odds ratio values and confidence intervals (95%), with the performance of a crude

analysis and another adjusted for all variables considered. The predicted odds of having low CF were subsequently estimated according to BMI values and the level of physical activity, considering the regression model adjusted for all variables.

The data were typed and checked in EpiData and the other analyses were conducted in the Stata 13.0 program.

## RESULTS

Of the 163 (70.3% of the randomized sample) professors in the study, 104 (63.8%) participated in all stages of the research and had information for all variables included in this analysis. In regard to CF, this population had a mean VO<sub>2</sub> of 33.0 mL/kg/min (standard deviation = 9.4 mL/kg/min), with variation of 13.8 to 63.6 mL/kg/min, with a mean of 34.8 mL/kg/min (standard deviation = 9.3 mL/kg/min) for the men and 30.0 mL/kg/min (standard deviation = 8.6 mL/kg/min) for the women. Teachers located in the first tertile of the distribution were regarded as having low CF (<28.9 mL/kg/min).

The average age was 43.3 years (standard deviation = 9.6 years); 65.4% were men and 28.9% were classified as physically inactive. The mean and standard deviation values of the other variables studied are described in Table 1. The group with low CF included older individuals, with a lower proportion of men and higher fasting blood glucose, waist circumference, and body mass index values (Table 1).

The logistic regression model of the association between cardiorespiratory fitness and the variables studied is presented in Table 2. After adjusting for all variables, it was possible to note that professors with lower CF levels were older, had higher BMI values and a greater chance of being physically inactive. In addition, male professors were less likely to have low CF when compared to women.

Figure 1 shows the result of the predicted probability of having low CF (first tertile) for each individual in the sample, considering adjustment for all variables considered, in relation to BMI and level of physical activity. Note that the probability of low CF in this population are always higher in physically inactive individuals, and increase with BMI elevation consistently across both groups.

**Table 1.** Distribution of the participants' characteristics according to cardiorespiratory fitness. Ouro Preto, MG, 2015.

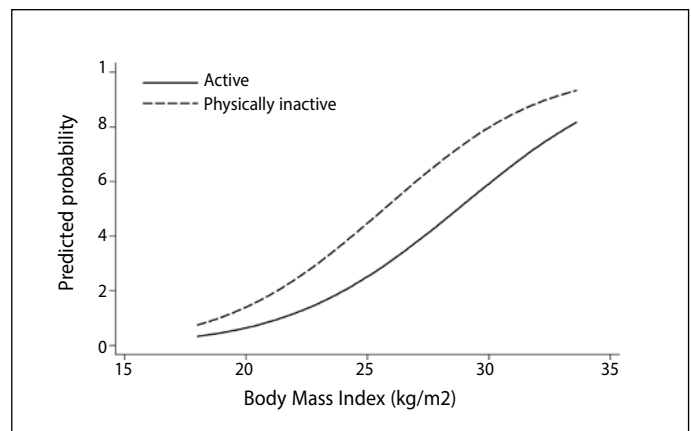
Variables	Total	Cardiorespiratory fitness		p-value*
		Low (<28.9 mL/kg/min.)	Adequate (≥28.9 mL/kg/min.)	
Age (years)	43.3 (9.6)	47.2 (10.1)	41.4 (8.9)	0.004
Male sex, %	65.4	51.5	71.8	0.043
Fasting blood glucose (mg/dL)	100.0 (16.3)	104.6 (22.3)	97.8 (12.3)	0.050
Triglycerides (mg/dL)	125.3 (85.1)	141.6 (98.3)	117.8 (77.8)	0.185
HDL cholesterol (mg/dL)	64.5 (14.5)	64.3 (13.5)	64.6 (15.0)	0.926
LDL cholesterol (mg/dL)	113.2 (28.5)	111.7 (32.5)	113.9 (26.7)	0.718
C-Reactive Protein (mg/dL)	2.9 (3.3)	3.6 (3.5)	2.54 (3.1)	0.143
Waist Circumference (cm)	88.3 (10.4)	93.2 (11.6)	86.0 (9.0)	0.001
Body Mass Index (kg/m <sup>2</sup> )	24.7 (3.3)	26.8 (3.5)	23.8 (2.8)	<0.001
Sedentary Lifestyle, %	28.9	36.4	25.4	0.249

Values expressed in mean and standard deviation, except where otherwise specified. \* Pearson's Chi-Squared or Student's t-Test for comparison between proportion and means, respectively.

**Table 2.** Crude and adjusted analyses of the association between lower cardiorespiratory fitness and risk factors among university professors of a federal public institution. Ouro Preto, MG, 2015.

Variables	OR crude analysis (95% CI)	OR adjusted analysis (95% CI)
Age (years)	1.05 (1.01-1.09)*	1.09 (1.02-1.16)*
<b>Sex</b>		
Male	0.34 (0.15-0.77)*	0.17 (0.37-0.83)*
Female	1.00	1.00
Fasting blood glucose	1.03 (0.99-1.06)	1.01 (0.97-1.57)
Triglycerides	1.00 (0.99-1.00)	1.00 (0.99-1.01)
HDL cholesterol	1.00 (0.97-1.03)	0.99 (0.95-1.04)
LDL cholesterol	0.99 (0.98-1.01)	1.00 (0.98-1.02)
C-Reactive Protein	1.09 (0.97-1.24)	1.02 (0.86-1.20)
Waist Circumference	1.05 (1.01-1.09)*	1.00 (0.89-1.12)
Body Mass Index	1.25 (1.09-1.42)*	1.47 (1.05-2.05)*
<b>Sedentary Lifestyle</b>		
Yes	1.86 (0.82-4.24)	4.77 (1.24-18.38)*
No	1.00	1.00

OR (95% CI): Odds Ratio and 95% confidence intervals estimated by logistic regression. \*p <0.05.



**Figure 1.** Predicted probability of having low cardiorespiratory fitness, according to body mass index and physical activity level. Ouro Preto, MG, 2015.

## DISCUSSION

The main results of this study are related to the observation of lower CF among older individuals, women, those with higher body mass index and physically inactive individuals. On the other hand, the other cardiometabolic variables did not appear to be associated with CF in this population. The use of this indicator is relevant due to the high predictive capacity for both development of risk factors and cardiovascular events and mortality in other populations,<sup>12,13</sup> besides being related to capacity for work.<sup>14</sup> To the best of our knowledge, only one previous study has explored the association between CF and risk factors among workers in a Latin American country.<sup>2</sup>

The results of studies on the relationship between CF and cardiometabolic risk factors are controversial, and especially among workers with a high level of education, little is known. Age and sex are important non-modifiable risk factors that interfere with CF. Age-related changes are associated with decreased maximal heart rate, ejection fraction, maximal cardiac output, and a decrease in arteriovenous oxygen difference, which reduces CF with age,<sup>12,14</sup> as observed in this study. In regard to sex, the higher CF values among men also corroborate previous studies.<sup>13,15</sup>

Higher BMI values were observed in the group with lower levels of CF. This association is not fully understood but can be attributed to the higher energy intake among individuals with low CF, the decrease of energy expenditure in the overweight population, or the genetic determination of these two events.<sup>5</sup> Nevertheless, in general, a low CF is associated with a higher body weight<sup>3,16</sup> and higher BMI values, both in the general population<sup>5,15</sup> and among workers.<sup>16</sup>

Increased BMI and body adiposity are associated with impaired vascular endothelial function,<sup>17,18</sup> which is related to the general functional capacity of vascular endothelial cells and their ability to synthesize and release nitric oxide (NO).<sup>19</sup> A reduced and/or unavailable synthesis of NO is associated with various endothelial function abnormalities and reduced vasodilation capacity, and has been associated with a number of risk factors for CVD.<sup>20</sup> This mechanism may explain the association found between CF and BMI in this study. In addition, previous studies have shown that BMI and WC were the anthropometric indicators most closely associated with insulin resistance,<sup>21</sup> but improving CF can mitigate this risk.<sup>22</sup> Therefore, there is evidence of the need for strategies geared towards controlling body adiposity, as well as increasing or maintaining CF levels among workers, considering that a high BMI is also considered a risk factor for loss of work capacity, exerting a negative impact by affecting cardiorespiratory and musculoskeletal capacity and favoring an increase in morbidity due to chronic diseases.<sup>21,23</sup>

The group of professors with lower CF had a greater chance of being physically inactive. This was the variable with greatest strength of association. The relationship between CF and physical activity seems to be explained by the performance of aerobic exercises.<sup>5</sup> Intervention studies have shown that these exercises, of moderate to vigorous intensity, performed frequently over weeks or months, increased CF by 10 to 20%.<sup>24,25</sup> Although some studies did not report this association,<sup>2,7,14</sup> a recent meta-analysis involving 7487 adult participants showed that exercise can significantly improve CF.<sup>26</sup> Furthermore, Grundy et al.<sup>5</sup> observed lower levels of self-reported physical activity in the lower quintiles of CF in a cohort of US adults of both sexes. These results may suggest that the performance of physical activity favors CF, but the direction of this association cannot be confirmed in the current study due to its cross-sectional nature.

Studies have reported greater issues and higher expenditures with health, higher levels of disability and lower productivity among physically inactive individuals, evidencing the importance of interventions in this risk factor, which may favor CF and consequently improve cardiovascular condition and capacity for work.<sup>14,27</sup>

In this study we did not observe any significant associations between CF and biochemical markers, inflammatory markers and fasting blood glucose. Previous studies have shown controversial results in relation to these associations.<sup>13,28</sup> Since CF is influenced by both genetic and behavioral factors,<sup>28</sup> these disparities can be at least partly attributed to hereditary factors, which could explain differences in maximal oxygen uptake.<sup>29</sup>

The limitations of this study include the sectional design, which does not allow us to establish a temporal relationship between variables. In addition, sample loss, caused both by nonperformance of the VO2 test, and by the difficulty contacting research participants, and their refusal to participate, may have compromised the study inferences. On the other hand, this is a study that considered a specific population of workers, which measured CF and explored traditional cardiometabolic risk factors, which may have an impact on the future health of economically active adults. In addition, unlike most studies among workers, the use of a probabilistic sample is an additional advantage of the current study.

Considering that CF levels significantly influence the risk profile for CVD, regardless of exposure to classical risk factors and in view of the evidence that daily physical activity has a more significant effect on CF than genetic determinants,<sup>28</sup> it is necessary to focus on behavioral interventions, which may favor the performance of physical activity by workers, and may also favor performance in work activities.<sup>14</sup>

## CONCLUSIONS

The likelihood of low CF increases with BMI elevation, a major marker of risk for cardiovascular events and mortality, as well as the strong association with physical activity, which is shown to be an important focal point of intervention measures aimed at improving workers' health with the consequent improvement of their work capacity.

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