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Paula Francinette Fernandes Aguiar[1]
Victor Nogueira da Cruz Silveira[1]
Letícia Cecília de Nazaré Rocha da Luz Messias[2]
Isabelle Christine Vieira da Silva Martins[2]
Andréa Dias Reis[3]
Alexsandro Ferreira dos Santos[4]
Amanda Negrão da Rocha[2]
Ahirlan Silva de Castro[1]
Helma Jane Ferreira Veloso[1]

[1] Universidade Federal do Maranhão – Campus Dom Delgado, Centro de Ciências Biológicas e da Saúde, Departamento de Ciências Fisiológicas. São Luís, MA, Brasil.

[2] Universidade Federal do Pará, Faculdade de Nutrição, Departamento de Nutrição. Belém, PA, Brasil.

[3] Universidade Estadual Paulista, Faculdade de Ciências e Tecnologias, Programa de Pós-Graduação de Ciências da Motricidade. Presidente Prudente, SP, Brasil.

[4] Universidade Federal do Maranhão – Campus Dom Delgado, Centro de Ciências Biológicas e da Saúde, Programa de Pós-Graduação em Ciências da Saúde. São Luís, MA, Brasil.

Correspondence
Victor Nogueira da Cruz Silveira
victorncsilveira@gmail.com.

Factors associated with the changes in glomerular filtration rate in physical activity practitioners in São Luís, Maranhão, Brasil

Fatores associados à alteração da taxa de filtração glomerular em praticantes de atividade física em São Luís, MA

Abstract

Introduction: Chronic kidney disease is characterized as an abnormality of kidney structure or function, which lasts for 43 months or more, and which has health implications and, traditionally, glomerular filtration rate (GFR) is considered as the best marker of renal function. Therefore, this study aimed to evaluate the factors associated with changes in GFR in physical activity practitioners from São Luís, Maranhão. ***Method:*** This is a cross-sectional study with a sample of 84 individuals practicing physical activity. Sociodemographic, biochemical, food consumption and anthropometric data were collected. Statistical analysis included the Shapiro Wilk test to verify normality and, once normality was confirmed, Student's *t*-test was used to evaluate the difference between the explanatory variables and the outcome (reduced renal function, ie: reduced TGF < 60 ml/min, calculated using the CKD-EPI equation). Statistical significance was set at p <0.05. ***Results:*** Reduced GFR (< 60 ml/min) was observed in 2.4% of individuals and its average was 89.5 ml/min/1.73m^2. Associated with the outcome: age (32.4 ± 9.4 years); females with 53.6% and protein consumption. *Conclusion:* The mean GFR found was reduced and most of the individuals evaluated had normal values. The outcome was associated with age and protein intake.

Keywords: Glomerular Filtration Rate. Renal insufficiency. Nephropathies. Motor activity.

Resumo

Introdução: A doença renal crônica é caracterizada como sendo uma anormalidade da estrutura ou função renal, que se mantêm por 43 meses ou mais, e que apresenta implicações para a saúde e, tradicionalmente, a taxa de filtração glomerular (TFG) é considerada como o melhor marcador de função renal. Objetivou-se avaliar os fatores associados a alterações na TFG em praticantes de atividade física de São Luís, Maranhão. ***Método:*** Estudo transversal com amostra de 84 indivíduos praticantes de atividade física. Foram coletados dados sociodemográficos, bioquímicos, de consumo alimentar e antropométricos. A análise estatística contemplou o teste de *Shapiro Wilk* para verificação da normalidade e, confirmada a normalidade, foi utilizado o teste *t* de *Student* para avaliar a diferença entre as variáveis explanatórias com o desfecho (redução da função renal, ou seja: TGF reduzida < 60 ml/min, calculada pela equação de CKD-EPI). A significância estatística foi estabelecida em p < 0,05. ***Resultados:*** A TFG reduzida (< 60 ml/min) foi observada em 2,4% dos indivíduos e sua média foi de 89,5 ± 19 ml/min/1,73m^2. Associaram-se ao desfecho: idade (32,4 ± 9,4 anos); o sexo feminino (53,6%) e o consumo de proteína. ***Conclusão:*** A média de TFG encontrada foi elevada e a maioria dos indivíduos avaliados estavam com valores dentro da normalidade.

Palavras-chave: Taxa de Filtração Glomerular. Insuficiência Renal. Nefropatias. Atividade Motora.

INTRODUCTION

Non-communicable chronic diseases (NCD) are a group of disorders characterized by their uncertain origin, multifactorial etiology and prolonged course to be associated with disability and functional disabilities.[1] A small set of risk factors accounts for the majority of deaths from NCDs and for a substantial fraction of diseases burden from these NCDs.[2]

Among the most common risk factors for the appearance of NCDs, environmental ones stand out – smoking, inadequate food consumption, physical inactivity and excessive consumption of alcoholic beverages – which are directly associated with the increase in the prevalence of several comorbidities common to the risk of developing chronic kidney disease (CKD).[2-4]

CKD is the designation for the existence of an abnormality of the renal structure or function, present for more than three months and which has health implications.[5] The best way to assess the degree of impairment of CKD is through the glomerular filtration rate (GFR).[6] In humans, this renal marker cannot be measured directly, since its determination occurs from the clearance of an ideal filtration marker such as serum creatinine.[7]

Changes in GFR may be caused by comorbidities as diabetes and hypertension.[8,9] Furthermore, scientific organizations estimate that other habits, such as excessive consumption of dietary or supplemented protein, may damage the kidney tissue,[10,11] despite the lack of scientific evidence proving this harmful potential of dietary protein levels.

Considering that the high-protein diet is widespread among practitioners of physical exercise, and that there is evidence that protein needs are increased among this group,[12,13] the overestimated consumption is frequent, exceeding 2g/kg of weight per day in this group. The safety of this excessive consumption of proteins has been questioned, and some evidence points out that diets with such a concentration of proteins can damage the kidney tissue.[14,15] In addition, the study by Kalantar-Zadeh et al.[16] also suggests that protein-rich diets may have negative effects on the renal health of the population, especially those at risk or with pre-existing hyperfiltration, due to the association with increased glomerular filtration rate and progressive loss of renal function .

The American College of Sports Medicine (ACSM) guideline[17] emphasizes that the need for adequate protein intake for metabolic adaptation, repair, remodeling, and protein turnover generally ranges from 1.2 to 2.0 g of protein/kg of body weight per day for the physically active population. Such variation occurs according to the sport modality and the intensity of the exercise. Higher protein intake may be indicated for short periods during more intense training or in reducing energy intake. Daily protein intake should be met with a diet plan that provides a regular distribution of moderate amounts of high quality protein throughout the day and after intense training sessions.[17] In addition, protein has some notable characteristics, including satiety and thermogenic effect, which stimulate the high consumption of this nutrient both by dietary sources and in the form of supplements by physical activity practitioners.[18]

According to Frank et al.,[19] renal changes promoted by high protein consumption have been attributed to the greater workload received by the organ, secondary to the increased filtration of protein metabolites, especially urea and creatinine. Another factor involved is the development of metabolic acidosis, caused by the high production of ketone bodies, resulting from protein and lipid metabolism.[20]

There is insufficient evidence to restrict protein intake in the diet of healthy adults to preserve kidney function. However, caution should be exercised with some groups, considered at risk for kidney disease, such as hypertensive, diabetic, and obese individuals.[15] Thus, this study aimed to assess the factors associated with changes in GFR in practitioners of physical activity.

METHODS

This is a cross-sectional study within the project “Evaluation of protein consumption and kidney damage in physical activity practitioners in São Luís”. São Luís, capital of Maranhão state, Northeastern Brazil, has a population of 1,014,837 inhabitants. The choice of the municipality to carry out the data collection came from the convenience of the researchers who reside in the city.

To participate in the research, individuals should practice regular physical activity with a minimum frequency of two weekly sessions and be aged between 18 and 59 years; both sexes were included. The non-inclusion criteria were women who were pregnant at the time of the interview or the individual with chronic kidney disease. Individuals who did not perform the biochemical or anthropometric assessment were excluded.

Data collection was divided into two distinct moments. Initially, data were collected about sociodemographic conditions, food consumption and the consumption of dietary supplements. Then, anthropometric and biochemical data were collected from the evaluated individuals.

In the first moment, data from 462 individuals were collected, but in the second moment, only 144 individuals attended the collection of anthropometric and biochemical data; 60 did not show up for the creatinine clearance test, so they were excluded, making a final sample of 84 individuals.

Ethical criteria

Ethical approval for the study was obtained from the Ethics Committee of the Federal University of Maranhão (CEP-UFMA) under opinion number 1.378.129/2015. Written informed consent was obtained from all study participants. The study met the requirements demanded by Resolution No.466/2012 of the National Health Council and its complementary acts for research involving human subjects.

Instruments for data collection

The socioeconomic, demographic, and behavioral questionnaire related to the individual's lifestyle was applied, in addition to the history of pathologies, training characteristics and personal motivation to practice physical activity.

Food consumption was assessed by two types of food surveys: a 24-hour recall applied by the interviewer and two food records delivered to the participants, who were instructed on the correct description of necessary information (day of the week, time, place, preparations and portions of meals); these records were delivered and reviewed in the second phase of the research. A questionnaire on the frequency of consumption of dietary supplements was also applied.

Anthropometric Assessment

Nutritional assessment was carried out by trained teachers and students of bachelor's in nutrition at the place where the participant exercised.

To identify the anthropometric profile, body weight was measured on a digital scale (Omron Healthcare®, Brazil), with a capacity of up to 150kg and accuracy of 100g. Volunteers were weighed standing, in the center of the scale, without shoes and with light clothing; height was measured using a wall stadiometer (Welmy®, Brazil) with a scale from 0 to 200 cm and intervals of 5 mm. The individuals were placed in an upright position, barefoot, with the upper limbs dangling along the body, the heels, the back, and the head touching the aluminum column.

To classify the weight-height nutritional status, the body mass index (BMI) determined by the ratio of the weight (kg)/height² (m) ratio was used, using the cut-off limits recommended by the World Health Organization (WHO).[21]

Circumferences were measured with a non-extensible anthropometric measuring tape (Sanny®, Brazil). The waist circumference (WC) was measured in the abdominal region surrounding the midpoint distance between the last rib and iliac crest at the time of expiration, according to the protocol established by WHO.[21] The classification of abdominal obesity used the measured WC values, considering the cut-off points: WC ≥ 94 cm for men and ≥ 80 cm for women.[21]

Assessment of body composition included the electrical bioimpedance test, using a tetrapolar device (*Biodynamics* 450®, USA), with the individual lying on a non-conductive surface, with legs apart and arms in parallel away from the trunk. Electrodes were placed in specific places on the hand and foot, on the dominant side. After entering the data into the device (sex, age, weight, height and hours of activity per week), the test was performed, and the body composition values were printed immediately. The percentage of body fat (% BF) obtained was classified according to the values proposed by Lohman.[22]

The food consumption data obtained through the food records, considering the average of the three days, were calculated in the spreadsheet for nutritional calculations NutriPlan version 2.7. To estimate energy needs and calculate the total energy expenditure of individuals, the FAO/WHO method was used.[23]

Variables

The outcome variable of this study was the GFR calculated from the proposed CKD-EPI equation cited by Felisberto et al.[24] We considered reduced renal function the GFR < 60 ml/min.[5]

The explanatory variables were distributed according to the form which they come from:

1. Sociodemographic factors: age (<30 years and ≥ 30 years); sex (male and female); ethnicity (white and non-white); marital status (with partner and without partner).

2. Factors related to lifestyle: has or has had smoking habits (yes and no); has or has had alcohol habits (yes and no); use of food supplement (yes and no); time of practice of physical activities (≤ 1 year and> 1 year); training duration in minutes (≤ 60 minutes and > 60 minutes), and weekly training hours (≤ 5 hours and > 5 hours).

3. Anthropometric data: BMI (normal weight and overweight); waist circumference (without cardiometabolic risk and with cardiometabolic risk); percentage of body fat (normal and high) and percentage of fat-free mass (<75% and ≥ 75%).

4. Food consumption variables: energy (< 2,000 kcal and ≥ 2,000 kcal); gram per kg of body weight per day of protein (< 2.0 g/kg/day and ≥ 2.0g/kg/day); percentage of dietary protein (< 30% and ≥ 30%); percentage of dietary carbohydrate (< 45% and ≥ 45%) and percentage of lipid (< 35% and ≥ 35%).

5. Physiological and biochemical factors: blood pressure levels (normal and altered); triglycerides (normal and altered); total cholesterol (normal and altered); HDL-cholesterol (ideal and sub-ideal).

Blood pressure was measured at the time of collection of demographic data with the individual sitting in the chair with the back resting on the backrest, the clamp apparatus little above the bending arm and the elbow on the desk with the palm facing to the top. A digital sphygmomanometer model HEM-7113 (Omron® brand) was used.

The individuals' blood pressure levels were classified according to what was proposed by the Brazilian Society of Cardiology;[25] the variables referring to the lipid profile, according to the Brazilian Guidelines on Dyslipidemias and Atherosclerosis Prevention;[26] and those referring to food consumption, according to the FAO/WHO method.[27]

The intensity of physical activity practiced by individuals was assessed according to the average duration in daily minutes and weekly hours of training. For the purposes of classification, the daily practice of 60 minutes and five hours per week was established as reference (accounting for 60 minutes per day for the five working days weekly).

The variable “total energy expenditure” also was accounted for training intensity identification of individuals, but because of the inability to distinguish how much of the energy expenditure comes from exercise, we chose to not include it in the model.

Statistical analysis

The data obtained were tabulated and stored in the Microsoft Office Excel® version 2007 program and analyzed using Stata® (version 14).

Initially, the prevalence of the main independent variables to characterize the study population were analyzed. Then, the *Shapiro-Wilk* test was performed to verify the normality of the variables evaluated and, later, Pearson's correlation was used, when normality was detected, or its nonparametric correspondent, Spearman, to identify the factors associated with GFR. Subsequently, multiple linear regression analysis was performed with the variables that showed an association in the correlation analysis. Statistical significance was established at $p < 0.05$.

RESULTS

The average age of the assessed individuals was 32.4 years (± 9.4), most being women (53.6%). A brief sociodemographic and lifestyle description of individuals can be seen in Table 1.

Table 1. Average glomerular filtration rate ± standard deviation (SD) by sociodemographic and lifestyle factors of physical activity practitioners in São Luís, Maranhão, 2017.

Variable	n (%)	Glomerular filtration rate (mean ± SD)
Age		
<30 years	37 (44.0%)	95.8 (± 17.4)
≥ 30 years	47 (56.0%)	84.6 (± 19.0)
Sex		
Male	39 (46.4%)	94.1 (± 18.9)
Female	45 (53.6%)	85.6 (± 18.5)
Ethnicity		
White	40 (47.6%)	89.8 (± 18.6)
Nonwhite	44 (52.4%)	89.3 (± 19.7)
Marital status		
With companion	27 (32.1%)	87.8 (± 18.8)
No companion	57 (67.9%)	90.4 (± 19.2)
Smoking*		
Yes	7 (8.3%)	89.9 (± 22.8)
No	77 (91.7%)	89.5 (± 18.8)
Alcoholism*		
Yes	27 (32.1%)	91.8 (± 17.5)
No	57 (67.9%)	88.4 (± 19.8)
Use of food supplement		
Yes	47 (56.0%)	90.3 (± 19.3)
No	37 (44.0%)	88.6 (± 19.0)
Time of physical exercise		
≤ 1 year	50 (59.5%)	90.2 (± 18.7)
> 1 year	34 (40.5%)	88.5 (± 19.8)
Training duration in minutes		
≤ 60 minutes	56 (66.7%)	91.0 (± 21.1)
> 60 minutes	28 (33.3%)	86.6 (± 13.9)
Weekly hours of training		
≤ 5 hours	50 (59.5%)	91.1 (± 20.3)
> 5 hours	34 (40.5%)	87.3 (± 17.1)

*: the "yes" category of the highlighted variables corresponds to whether the individual has or has had the highlighted habit.

Descriptions about the demographics and food consumption of the sample are also presented (Table 2), and physiological and biochemical factors (Table 3) as well as the mean GFR by variable.

Table 2. Average glomerular filtration rate ± standard deviation (SD) due to anthropometric and food consumption factors of physical activity practitioners in São Luís, Maranhão, 2017.

Variable	n (%)	Glomerular filtration rate (mean ± SD)
Body mass index		
Eutrophy	51 (60.7%)	88.2 (± 18.2)
Overweight	33 (39.3%)	91.7 (± 20.4)
Waist circumference		
Without risk	69 (82.1%)	88.3 (± 17.6)
At risk	15 (17.9%)	95.0 (± 24.6)
% body fat		
Normal	26 (31.0%)	89.0 (± 17.1)
High	58 (69.0%)	89.8 (± 20.0)

Table 2. Average glomerular filtration rate ± standard deviation (SD) due to anthropometric and food consumption factors of physical activity practitioners in São Luís, Maranhão, 2017.(Continues)

Variable	n (%)	Glomerular filtration rate (mean ± SD)
% of fat-free mass		
< 75%	32 (38.1%)	89.9 (± 19.0)
≥ 75%	52 (61.9%)	89.0 (± 19.4)
Energy		
< 2000 kcal	46 (54.8%)	90.1 (± 21.2)
≥ 2000 kcal	38 (45.2%)	88.8 (± 16.3)
% dietary protein		
< 30%	74 (88.1%)	90.7 (± 19.1)
≥ 30%	10 (11.9%)	80.8 (16.9)
g / kg / day of protein		
< 2.0 g/kg/day	62 (73.8%)	92.3 (± 19.4)
≥ 2.0 g/kg/day	22 (26.2%)	81.8 (± 16.1)
% dietary carbohydrate		
< 45%	41 (48.8%)	89.5 (± 20.2)
≥ 45%	43 (51.2%)	89.5 (± 18.2)
% of dietary lipid		
< 35%	59 (70.2%)	91.1 (± 20.0)
≥ 35%	25 (29.8%)	85.9 (± 16.4)

Table 3. Average glomerular filtration rate ± standard deviation (SD) due to physiological and biochemical factors of physical activity practitioners in São Luís, Maranhão, 2017.

Variable	n (%)	Glomerular filtration rate (mean ± SD)
Blood pressure levels		
Normal	54 (64.3%)	89.0 (± 19.1)
Changed	30 (35.7%)	90.4 (± 19.1)
Triglycerides		
Normal	73 (86.9%)	88.4 (± 18.9)
Changed	11 (13.1%)	97.1 (± 19.4)
Total cholesterol		
Normal	64 (76.2%)	89.5 (± 19.1)
Changed	20 (23.8%)	89.4 (± 19.5)
HDL-cholesterol		
Ideal	82 (97.6%)	88.9 (± 18.0)
Below ideal	2 (2.4%)	114.3 (± 49.9)

Regarding renal markers, the mean creatinine clearance was 89.5ml/min/1.73m^2 (± 19.1) and the GFR showed that only 2.4% (95% CI = -0.9% - 5.7%) had reduced renal function (data not shown in table). The age of individuals, sex and consumption of grams of protein per kg of body weight were associated with the lower GFR ($p < 0.05$) (Tables 1, 2 and 3).

In the linear correlation, it was observed that only age, sex, protein consumption in g/kg/day and waist circumference were statistically ($p < 0.05$) correlated to GFR, with age (moderate correlation, $0.3 < |r| < 0.5$), female and protein intake in g/kg/day (weak correlation, $0.0 < |r| < 0.3$) inversely correlated to GFR. On the other hand, the waist circumference correlated weakly ($0.0 < |r| < 0.3$) and positively with GFR (Table 4).

Table 4. Analysis of correlation of independent variables with the glomerular filtration rate of individuals practicing physical activity São Luís, Maranhão, 2017.

Variable	Correlation Coefficient	*p*
Age*	-0.3672	<0.001
Women	-0.2241	0.040
Ethnicity	-0.0137	0.901
marital status	0.0636	0.565
Smoking*	-0.0275	0.804
Ethics	0.0828	0.454
Use of food supplement	0.0458	0.679
Physical exercise time (years)*	0.0372	0.737
Training duration (in minutes)*	0.1481	0.179
Weekly hours of training*	0.1288	0.243
Body mass index*	0.1342	0.224
Waist circumference*	0.2284	0.037
% body fat	0.0085	0.939
% of fat-free mass*	0.0827	0.454
Energy (in kcal)	-0.1600	0.146
% of dietary protein*	-0.0673	0.543
g / kg / day of protein*	-0.2887	0.007
% dietary carbohydrate	0.0892	0.420
% of dietary lipid*	0.0755	0.495
Blood pressure levels	0.0356	0.748
Triglycerides	0.0865	0.434
Total cholesterol*	-0.0234	0.833
HDL-cholesterol *	0.0083	0.940

*: variables with non-normal distribution (Spearman correlation)In the simple linear regression analysis, only age (β = -0.590; 95%CI: -0.982 to -0.200) and protein consumption in g/kg/day (β = -7.626; 95% CI: -12.607 to -2.645) were inversely associated with GFR (p <0.05), as shown in Table 5.

Table 5. Multiple linear regression of the glomerular filtration rate with the associated variables during the simple correlation analysis. São Luís, Maranhão, 2017.

Variable	Regression coefficient	95%CI	*p*
Age	-0.590	-0.982 to -0.200	0.004
Women	-6,660	-14,330 to 1,013	0.088
Waist circumference	0.241	-0.170 to 0.498	0.066
g / kg / day of protein	-7,626	-12.607 to -2.645	0.003

DISCUSSION

The prevalence of individuals with low GFR was small, and their average was within the normal range for CKD. This is probably due to a physically active life and a guided diet. The factors associated with this outcome were sociodemographic and food consumption. Despite the known effects of nutritional status[13,20] and exercise intensity [12-14] on the GFR, in this study, these variables were not associated with this indicator, probably because the sample was made up homogeneously physically active public.

The observed average in this study was lower than that found in obese children and adolescents,[28] remnants of quilombos in the state of Maranhão,[29] in asymptomatic patients in the state of Pará[30] and in a physically active public.[31] And yet, it was above that observed in diabetic patients.[32]

It was noticed that individuals older than or equal to 30 years of age had a lower GFR mean than younger ones. This is already widely reproduced in the literature by studies that show that older age is a common risk factor for the appearance of CKD.[33,34] With increasing age, there is a physiological decrease in glomerular function and kidney damage resulting from diseases common to this age group.[32,35,36]

Another factor that was initially associated with the mean GFR was the gender of the individuals, more specifically the lowest mean in females. Sex has a strong influence on the progression of CKD.[29,37] This is probably explained by social, cultural, and environmental differences, such as genetic predisposition, self-care, and hormonal factors.[37]

Regarding the consumption of dietary protein, associated with the reduction of GFR values, Kalantar-Zadeh et al.,[16] in their study, suggest that a diet with a high protein content may be related to harmful effects on the renal health of the general population, especially in individuals with pre-existing hyperfiltration or with other risk factors for CKD. Similarly, Brenner et al.[38] proposed that the habitual consumption of excessive dietary protein negatively impacts renal function by a sustained increase in glomerular pressure and renal hyperfiltration. However, since most of the scientific evidence cited by the authors was generated from animal models and patients with existing kidney disease, the extent of this relationship to healthy individuals with normal kidney function is discussed.

Helal et al.[39] state that the mechanism which contributes to the increased pressure intraglomerular consists in intrarenal compensatory means, via activation of the renin-angiotensin-aldosterone system, which regulate afferent arteriole vasodilation and/or efferent arteriolar vasoconstriction. This mechanism would generate an increase in GFR for nephron, thus compensating for the fall in global GFR. However, this increase in intraglomerular pressure would cause damage to its own structure, giving rise to a process that would lead to glomerular sclerosis, decrease in the amount of healthy renal parenchyma and, thus, reduce GFR, which would translate into proteinuria and progression for DRC.[39]

However, contrary to the idea of the above mentioned authors, a healthy individual, with excessive protein intake typical of the Western diet, has no deleterious effects on renal function, since glomerular hyperfiltration would be a response to various physiological stimuli, thus being a normal adaptive mechanism.[15]

Frank et al.[19] analyzed the effect of a hyperproteic (2.4 g/kg weight) and normoproteic (1.2 g/kg weight) diet on healthy young individuals for seven days, to compare the effects on renal function. Contrary to what was observed in our study, they found an increase in GFR, in addition to an increase in serum uric acid levels, pH, excretion of urea and urinary albumin. In this sense, it is important to note that there is limited knowledge about the possible deleterious effects of vigorous activity and thermal stress on renal function.[40,41] Authors state that prolonged acute physical exercise promotes a plasma increase in urea, creatinine and uric acid, but under normal conditions, three days are sufficient to recover baseline values.[42]

Mansour et al.[41] ratify that these changes may be due to reduced renal blood flow, since there is an increase in blood flow to skeletal muscles and skin associated with a decrease in blood flow to the kidneys. It is also necessary to consider the influence of the degree of hydration on the decrease in GFR that would lead to an increase in creatinine levels.[40]

Regarding the limitations of this study, we can mention the existing large losses from one phase to another in the survey, as many people met the socioeconomic, demographic and behavioral questionnaires (1st phase), but did not attend on the day of collection blood and urine (2nd phase), limiting the number of participants. Furthermore, the absence of variables classically associated with the changes in GFR, as the hydration state, may also be considered a limitation. We consider strong point of this study the fact that it was conducted with physically active population, with analysis of biochemical and nutritional variables involved in GFR alteration.

CONCLUSION

The mean GFR found was high, and most of the individuals evaluated had normal values. Prevalence of reduced GFR was small and, in addition, associations with this outcome (reduced GFR) with the age and high protein intake were observed. It is noteworthy that CKD is a silent health problem with a multifactorial etiology, therefore constant monitoring, and encouragement of health education in physically active populations with a greater propensity to indiscriminate and unguided protein consumption are recommended.

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Contributors

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