Nutrición Hospitalaria

Nutr Hosp. 2015;31(1):500-507
ISSN 0212-1611 • CODEN NUHOEQ
S.V.R. 318

Original/*Otros*

Adequacy of energy and nutrient intake in patients with heart failure

Karina Sanches Machado d'Almeida[1,2], Ingrid Dalira Schweigert Perry[3], Nadine Clausell[1,2,4] and Gabriela Corrêa Souza[2,3,5].

[1]Federal University of Rio Grande do Sul - Health Sciences Graduate Program - Cardiology and Cardiovascular Sciences. [2]Hospital de Clínicas de Porto Alegre - Cardiology Department - Heart Failure Clinic. [3]Food and Nutrition Research Center, Hospital de Clínicas de Porto Alegre/Federal University of Rio Grande do Sul. [4]Federal University of Rio Grande do Sul - School of Medicine - Department of Internal Medicine. [5]Federal University of Rio Grande do Sul - School of Medicine - Department of Nutrition. Brazil.

Abstract

Background: Nutritional factors have a significant influence on the prognosis of patients with heart failure (HF). Objective: The goal of the present study was to assess the food intake of stable patients with HF.

Methods: Patients of both genders aged over 18 years with a confirmed diagnosis of HF were recruited and matched with healthy individuals for age, sex and BMI. Food records and weighing were used to assess participant nutritional intake. DRIs and NCEP-ATP III recommendations were used to evaluate the adequacy of nutritional intake.

Results: Sixty-five percent of the 40 patients in the sample and 48% of the 25 control subjects were men. The mean age in both groups was 54±8 years and mean BMI was categorized as overweight. Carbohydrate, trans fatty acid and sodium intake were higher in the HF group as compared to control subjects (p=0.006, p<0.001 and p=0.029). A positive association was found between a diagnosis of HF and excess carbohydrate intake (p=0.038). Patients with HF were found to consume 130% of the recommended dietary allowance for trans fatty acids, and participants in both groups consumed only 50% of the recommended amounts of ω-3 and ω-6 fatty acids. Similar findings were obtained for calcium and potassium. Participants in both groups consumed only 5% of recommended daily vitamin D levels. Mean sodium intake was approximately 200% of the recommended dietary allowance, and was found to be significantly higher among patients in the HF group (p=0.042).

Conclusion: The present study demonstrated an inadequate intake of macro- and micronutrients such as sodium, trans fatty acids, ω-3 and ω-6 fatty acids, carbohydrates, calcium, potassium and vitamin D in patients with HF.

(*Nutr Hosp*. 2015;31:500-507)

DOI:10.3305/nh.2015.31.1.7518

Key words: *Heart failure. Food intake. Energy intake. Nutrients. Dietary records.*

Correspondence: Gabriela Corrêa Souza.
Hospital de Clínicas de Porto Alegre.
Rua Ramiro Barcelos, 2350, Prédio 12, Sala 12201 -
CEP: 90035-903. Porto Alegre - RS, Brazil.
E-mail: gabriela.souza@ufrgs.br

Recibido: 14-IV-2014.
1.ª Revisión: 15-V-2014.
2.ª Revisión: 14-VII-2014.
Aceptado: 18-VIII-2014.

ADECUACIÓN DE ENERGÍA Y LA INGESTA DE NUTRIENTES EN PACIENTES CON INSUFICIENCIA CARDIACA

Resumen

Introducción: **Factores nutricionales tienen una influencia significativa en el pronóstico de pacientes con insuficiencia cardíaca (IC). Objetivos: Evaluar la ingesta de alimentos de pacientes con IC estable.**

Métodos: **Pacientes de ambos sexos, mayores de 18 años, con diagnóstico confirmado de IC fueron reclutados y emparejados por edad, sexo y IMC con individuos sanos. La ingesta nutricional fue evaluada mediante el registro alimentario y pesaje de acuerdo con las recomendaciones de las DRIs y NCEP-ATP III para la evaluación de la adecuación de la ingesta nutricional.**

Resultados: **El 65% de los 40 pacientes con IC y el 48% de los 25 individuos control eran hombres. La edad media en los grupos fue de 54±8 años y los valores del IMC fueron indicativos de sobrepeso. La ingesta de carbohidratos, ácidos grasos trans y sodio fue mayor en el grupo IC que en el grupo control (p=0,006, p<0,001 y p=0,029). Se encontró una asociación positiva entre IC y consumo excesivo de carbohidratos (p=0,038). El grupo IC consumió el 130% de los valores diarios recomendados de ácidos grasos trans, y ambos grupos consumieron el 50% de la cantidad recomendada de ácidos grasos ω-3 y ω-6. Resultados similares se obtuvieron para el calcio y el potasio. La ingesta de vitamina D correspondió al 5% los valores recomendados en ambos grupos. La media de los niveles de ingesta de sodio representó aproximadamente el 200% de la cantidad recomendada y fue significativamente mayor entre los pacientes con IC (p=0,042).**

Conclusiones: El presente estudio demostró un consumo inadecuado de macro y micronutrientes, tales como sodio, ácidos grasos trans, ω-3 y ω-6, carbohidratos, calcio, potasio y vitamina D, en pacientes con IC.

(*Nutr Hosp*. 2015;31:500-507)

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Palabras clave: *Insuficiencia cardíaca. Ingesta de alimentos. Ingesta de energía. Nutrimentos. Registros dietéticos.*

Abbreviations

ADA: American Diabetes Association.
ACEI: Angiotensin converting enzyme inhibitors.
BMI: Body mass index.
CBC: Complete blood count.
CG: Control group.
DRI: Dietary Reference Intakes.
EAR: Estimated average requirement.
FA: Fatty acid.
HF: Heart failure.
NCEP-ATP III: National Cholesterol Education Program-Adult Treatment Panel.
NYHA: New York Heart Association.

Introduction

Heart failure (HF) is a complex clinical syndrome with high prevalence and incidence rates. Its recognition as an important public health concern has expanded greatly over recent years, especially as a result of population aging[1,2]. Decompensated HF is responsible for one million hospitalizations a year in the United States alone, where its annual cost to the public health system exceeds US$35 billion[3].

Recently efforts to maintain patient stability and reduce hospitalization and mortality rates[4], have led to an increase in the use of non-pharmacological treatment strategies, such as low-sodium diets and weight control interventions, in cases of HF[2,5,6].

The influence of dietary factors in HF has been extensively studied. However, while several dietary guidelines have been developed for patients at risk for HF, in an attempt to decrease hypertension, hyperlipidemia and obesity, few such recommendations are available for patients already diagnosed with HF[7].

In order to obtain more conclusive data on the role of nutrition in HF, further studies must be performed on the nutrient intake and metabolism, as well as on the nutritional status of patients with HF, especially those in more advanced stages of the disease. The presence of factors such as multiple comorbidities, widely varying pharmacological treatments, diuretic medication, frequent hospitalizations, sodium and fluid retention and alterations in nutritional status result in a need for highly individualized nutritional interventions in cases of HF[7,8].

Studies have shown that patients with HF often have inadequate dietary intake[9,10]. Investigations of macronutrient intake have reported that both the development and the evolution of HF may be associated with lipid intake levels[11]. Patients with HF have also been found to have higher protein requirements than healthy adults of the same age, and to present with hypoalbuminemia in 20 to 30% of cases[12]. The diet of individuals with HF also tends to have a low vitamin and mineral content. Given the role of micronutrients in antioxidant defense and neurohormonal signaling, it is possible that such alterations in their dietary levels may play an important role in the evolution of HF[13].

Given the importance of nutritional factors for the prognosis of patients with HF, the goal of the present study was to assess the food intake of stable patients recruited from a HF clinic.

Methods

Population

This cross-sectional study was conducted on outpatients recruited from a university hospital in southern Brazil between August 2008 and August 2011. The sample was composed of participants of both genders aged over 18 years, who were diagnosed with HF based on ventricular ejection fractions as assessed by echocardiography using Simpson's method. All patients were categorized as New York Heart Association (NYHA) [14] functional class I to III. Patients with diabetes mellitus, chronic kidney disease, signs of congestion or who had been recently hospitalized (in the previous 3 months) for decompensated HF were excluded from the study.

Participants in the control group (CG) were recruited through media announcements, and matched to patients with HF for age, sex and body mass index (BMI). All experimental procedures were conducted in accordance with the ethical standards for human experimentation established by the Declaration of Helsinki. The present study was also approved by the Research Ethics Committee of the Clinical Hospital of Porto Alegre. All patients were notified of the aims of the study, and provided written informed consent prior to participation.

Anthropometric measurements

Participants were weighed barefoot, wearing minimal clothing, while standing with feet together in the center of a Toledo® 2096PP digital scale with 50 g precision and a maximum capacity of 200kg (São Bernardo do Campo, SP, Brazil). Height was measured using a wall-mounted vertical anthropometer ranging from 600 to 2100 mm (Harpenden, Holtain Limited, UK). Individuals stood barefoot in an orthostatic posture with their backs turned to the instrument, with their feet positioned together, arms down the sides of their bodies, and their gaze at eye-level.

BMI was calculated by dividing patient weights (kg) by the square of their heights (m). Nutritional status was classified based on World Health Organization (WHO) recommendations for BMI values[15].

Nutritional intake

Nutritional intake was assessed by food records and weighing conducted on two non-consecutive

weekdays, as well as one weekend day. Participants were provided with portable Cuori scales (model CUO-840, Max 2000g/d=1g, Cuori Group, Italy) and measuring cups, which they used to weigh and measure the amounts of food and liquid consumed throughout the day. The weighing and measuring procedures were explained and demonstrated to each participant by a nutritionist. On the last day in which nutritional intake was assessed, a 24h urine sample was collected for the assessment of urea, creatinine and sodium levels.

The accuracy of patients' nutritional intake records was confirmed by estimating each individual's protein intake and comparing it with their 24-h nitrogen excretion rates[16] using the following formula: urea (mg) x 0.46 + 4 x 6.25[17]. Ninety-five percent confidence intervals of the log-transformed ratio of protein intake to nitrogen excretion were then calculated, and participant nutritional records were compared to these expected values. Only the assessments whose values fell in the expected range were included in the analysis.

The total calorie intake as well as the total amount of macro- and micronutrients consumed by each patient were calculated using the NUTRIBASE Software, Clinical Edition, version 7.18. Nutritional data pertaining to processed foodstuffs reported to have been consumed during the study period were obtained from these products' nutritional composition tables when necessary.

Since specific recommendations for macro and micronutrient intake are not available for individuals with HF, Dietary Reference Intakes (DRIs)[18] were used to assess energy and nutrient intake adequacy, and estimated average requirement (EAR) values were used to calculate patients' micronutrients requirements. Acceptable macronutrient distribution ranges were established, and NCEP-ATP III[19] recommendations were used to evaluate lipid intake.

Demographic and clinical variables

Data regarding age, marital status and gender, as well as disease etiology, current medications and comorbidities, were collected from all participants. Laboratory analyses were performed (CBC, lipid profile, glucose and creatinine levels), and urinary sodium and nitrogen levels were assessed. Blood pressure data were obtained from the electronic records of each patient's last medical appointment prior to study participation.

Statistical analysis

Quantitative variables were presented as mean ± standard deviation or median and interquartile ranges, while categorical variables were expressed as frequencies and percentages. Chi-square tests were used to

Table I
Demographic and clinical characteristics of control participants and patients with HF

	Controls (n=25)	*HF (n=40)*	*P*
Clinical variables			
Age (years)	53.96 ± 8.60	54.43 ± 8.73	0.834
Male (n and %)	12 (48%)	26 (65%)	0.176
BMI (kg/m²)	28.12 ± 5.16	26.70 ± 5.85	0.325
Biochemical results			
Hb (g/dL)	14.09 ± 1.33	13.65 ± 1.42	0.217
Ht (%)	41.64 ± 3.30	40.97 ± 3.60	0.462
Total cholesterol (mg/dL)	192.88 ± 37.14	183.08 ± 48.68	0.392
HDL (mg/dL)	43.72 ± 10.23	45.10 ± 11.63	0.628
Triglycerides (mg/dL)	125.48 ± 53.65	141.25 ± 81.84	0.396
Glucose (n and %)			0.048
<100 (mg/dL)	22 (88%)	24 (60%)	
100 – 125 (mg/dL)	3 (12%)	14 (35%)	
≥ 126 (mg/dL)	0	2 (5%)	
Creatinine (mg/dL)	0.88 ± 0.17	1.17 ± 0.49	0.001
Urinary sodium (mg/24h)	3934.84 ± 1401.87	3646.65 ± 1433.46	0.429

Chi-square tests were used for between-group gender and glucose intolerance comparisons. Student's T-tests were used for all other variables. BMI: body mass index; Hb: hemoglobin; Ht: hematocrit; HDL: high density lipoprotein.

investigate associations between categorical variables, while Student's t tests or Mann-Whitney U tests were used for between-group comparisons of mean and median values, respectively. Results were considered significant at $p < 0.05$.

Nutritional intake values were adjusted for energy intake using the residual method, and intraindividual variability was taken into account[20]. Statistical analyses were performed using the Statistical Package for the Social Sciences, version 18.0 (SPSS Inc, Chicago, IL).

Table II
Calorie intake and amount of macro and micronutrients consumed by participants in each group

Nutrient	*Controls (n=25)* *Mean ± DP / Median (P25-P75)*	*HF (n=40)* *Mean ± DP / Median (P25-P75)*	*P*
Energy (kcal)	2238.52 ± 535.56	1998.56 ± 495.46	0.070
Kcal/kg weight	29.35 ± 6.59	28.71 ± 8.27	0.194
Carbohydrates (g)	283.72 ± 35.8	308.86 ± 34.35	0.006
Fiber (g)	19.72 ± 7.93	22.05 ± 6.63	0.205
Protein (g)	87.70 ± 12.73	83.23 ± 13.74	0.194
Protein (g/kg weight)	1.16 ± 0.23	1.21 ± 0.32	0.521
Lipids (g)	56.44 ± 9.90	51.77 ± 10.31	0.076
Saturated FA (g)	20.32 ± 4.69	18.14 ± 5.29	0.097
Polyunsaturated FA (g)	8.48 ± 1.87	7.73 ± 1.99	0.139
Monounsaturated FA (g)	22.85 ± 3.61	21.14 ± 3.48	0.062
Trans FA (g)	1.45 ± 1.21	2.80 ± 1.56	<0.001
Cholesterol (mg)	245.95 ± 83.64	225.90 ± 70.33	0.303
ω-6 (g)	5.69 ± 1.22	5.56 ± 1.34	0.680
ω-3 (g)	0.54 ± 0.20	0.56 ± 0.19	0.701
ω-6: ω-3 Ratio	11.53 ± 3.66	11.28 ± 6.38	0.857
Phytosterol (mg)	34.19 ± 19.40	43.58 ± 24.57	0.110
Vitamin A (IU)	6069.22 (3495.19 – 8545.16)	4458.46 (3105.14 – 8249.12)	0.467
Vitamin C (mg)	50.19 (34.93 – 115.19)	61.82 (28.19 – 98.39)	0.819
Vitamin D (μg)	0.28 (0 – 0.96)	0.41 (0.19 – 0.92)	0.220
Vitamin B_6 (mg)	1.59 ± 0.45	1.54 ± 0.29	0.580
Vitamin B_{12} (μg)	4.97 (1.93 – 10.29)	4.69 (1.70 – 7.17)	0.535
Folate (μg)	385.78 ± 105.05	409.89 ± 96.55	0.347
Thiamine (mg)	1.43 (1.22 – 1.873)	1.31 (1.00 – 1.68)	0.978
Niacin (mg)	21.44 ± 5.77	20.14 ± 6.41	0.411
Riboflavin (mg)	2.02 (1.47 – 2.80)	1.68 (1.22 – 2.02)	0.165
Selenium (μg)	116.56 ± 24.67	105.56 ± 25.50	0.091
Zinc (mg)	13.39 ± 2.86	12.47 ± 2.42	0.169
Iron (mg)	13.22 ± 1.96	12.75 ± 1.90	0.341
Calcium (mg)	629.29 ± 224.79	567.91 ± 241.39	0.310
Magnesium (mg)	261.70 ± 68.07	270.05 ± 44.29	0.589
Potassium (g)	2.10 (1.80 – 2.55)	2.37 (2.16 – 2.67)	0.210
Sodium (mg)	2628.28 ± 398.75	2943.71 ± 630.61	0.029

Mann Whitney U tests were used for between-group comparisons of Vitamins A, C, D and B12, Thiamine, Riboflavin, and Potassium intake. Student's T-tests were used for all other variables. FA = fatty acid.

Results

Forty patients with HF and 25 healthy controls were included in the study. Sixty-five percent of patients in the HF group and 48% of participants in the control group were men. Both groups had a mean age of 54±8 years, and mean BMI values categorized as overweight. Biochemical test results were similar between groups, save for fasting glucose (91.7± 9.7 for the HF group and 98.8±12.8 for control; p=0.020) and creatinine (p=0.001) levels, both of which were higher in patients with HF (Table I).

Individuals in the HF group had a mean systolic blood pressure of 117±22 mmHg and a mean diastolic pressure of 74±13 mmHg, with a mean ejection fraction of 30±10% and a serum sodium level of 141±2mEq/L. Myocardial enlargement was the most frequently reported cause of HF (25%), followed by alcohol and hypertension (20% for both). Most patients were classified as NYHA I (47.5%) and II (35%), and the most commonly reported comorbidity was hypertension (45%). Patients were receiving adequate pharmacological treatment, with 95% taking beta-blockers, 75% receiving angiotensin converting enzyme inhibitors (ACEI) and 82% taking diuretics (furosemide).

Information regarding the nutritional intake of patients in both groups is displayed in Table II. Energy and micronutrient intake was similar between groups. However, higher carbohydrate, trans fatty acids and sodium intake levels were observed in the HF group (p=0.006, p<0.001 and p=0.029, respectively). Carbohydrates, proteins and lipids accounted for 65.5±17%, 18±6% and 25±8% of the total nutritional intake in the HF group, and represented 54±16%, 16±4% and 24±7% of the total intake in control participants, respectively.

Figure 1 displays the proportions of individuals with adequate, above average or below average macronutrient intake according to DRI definitions. A positive association was found between the presence of HF and excess carbohydrate intake (p=0.038).

Data regarding the adequacy of nutrient intake are displayed in table III. Trans fatty acid intake differed significantly between groups. Additionally, participants in both groups only consumed approximately 50% of the recommended amounts of ω-3 and ω-6 fatty acids. Similar results were obtained for calcium and potassium intake. Individuals in both groups were found to consume only 5% of daily recommended vitamin D requirements. Although sodium intake levels differed significantly between groups, with individuals with HF consuming significantly higher amounts of this nutrient than control participants, both groups consumed approximately 200% of the daily recommended sodium intake.

Discussion

The present results suggested that, although the diets of individuals with and without HF may be similar in their energy content, they differ significantly in their macronutrient composition. Patients with HF, for instance, appeared to consume a significantly greater amount of carbohydrates than control participants. Although little evidence is available on the role of carbohydrates in HF, reduced glucose tolerance has been considered a risk factor for cardiovascular disease[21], and has been investigated in several studies of patients with HF. Hyperglycemia may contribute to the development of atherosclerosis through alterations in cellular redox state which lead to greater oxidative stress[11]. In the present study, 35% of patients in the HF group were at increased risk for diabetes according to ADA criteria[22].

Individuals with HF were found to consume a higher amount of trans fatty acids than control participants, and neither group met the dietary requirements for ω-3 and ω-6 fatty acids. NCEP-ATP III criteria[19] only specify that saturated and trans fatty acid intake should be as low as possible, so that the levels of saturated, mono- and polyunsaturated fatty acid intake which would still be considered adequate for patients with HF is still unknown[23]. On the other hand, experimental and clinical studies have made it increasingly clear that individuals who obtain approximately 0.4%

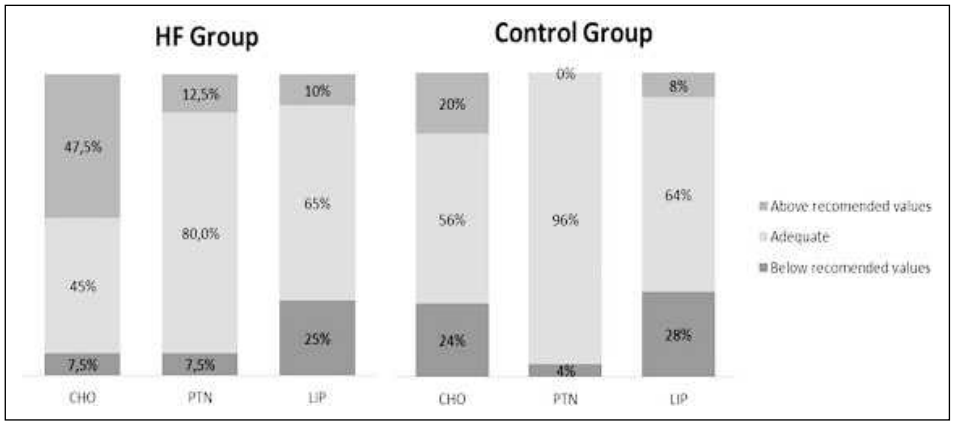

Fig. 1.—Percent adequacy of macronutrient intake according to DRI recommendations. CHO - carbohydrate; PTN - protein; LIP - lipids.

Table III
Percent adequacy of nutrient intake by group

Nutrient	*Controls (n=25) Mean ± DP / Median (P25-P75)**	*HF (n=40) Mean ± DP / Median (P25-P75)**	*P*
Fiber	66.54 (48.09 – 101.53)	69.37 (59.85 – 97.66)	0.483
Saturated FA	122.67 ± 37.56	125.22 ± 48.06	0.822
Trans FA	64.49 ± 57.10	129.81 ± 71.06	<0.001
Cholesterol	114.60 (100.77 – 141.04)	109.52 (93.06 – 132.19)	0.458
ω-6	49.11 ± 18.02	52.55 ± 15.15	0.411
ω-3	38.58 ± 16.87	43.92 ± 15.24	0.191
Vitamin A	291.32 (177.74 461.37)	240.15 (149.05 – 397.34)	0.434
Vitamin C	66.92 (47.47 – 179.37)	87.29 (46.98 – 148.89)	0.696
Vitamin D	4.47 (0.04 – 9.64)	4.56 (1.88 – 12.68)	0.220
Vitamin B_6	126.08 ± 35.06	119.95 ± 23.84	0.404
Vitamin B_{12}	248.37 (96.27 – 514.71)	234.42 (85.11 – 358.32)	0.535
Folate	120.56 ± 32.83	128.09 ± 30.17	0.347
Thiamine	142.85 (120.36 – 166.83)	143.41 (118.44 – 170.31)	0.819
Niacin	178.69 ± 48.09	167.82 ± 53.44	0.411
Riboflavin	184.74 (152.52 – 249.34)	168.55 (138.97 – 204.89)	0.087
Selenium	255.57 (255.74 – 294.48)	230.70 (209.92 – 266.23)	0.080
Zinc	170.51 ± 46.07	150.30 ± 36.39	0.054
Iron	225.20 ± 39.37	217.81 ± 42.77	0.488
Calcium	51.72 (42.47 – 70.00)	46.79 (34.03 – 61.40)	0.220
Magnesium	82.99 (66.50 – 100.85)	84.84 (74.12 – 90.70)	0.840
Potassium	44.20 (38.30 – 54.17)	50.44 (45.96 – 56.90)	0.210
Sodium	202.74 (163.97 – 221.18)	215.31 (187.74 – 243.99)	0.042

Mann Whitney U tests were used for between-group comparisons of Fiber, Cholesterol, Vitamins A, C, D and B12, Thiamine, Riboflavin, Selenium, Calcium, Magnesium, Potassium and Sodium intake. Student's T-tests were used for all other variables.
FA= Fatty acid
* Data are expressed as Mean ± SD or Median (P25-P75) of percent adequacy of nutrient intake according to DRIs[18] and/or NCEP-ATP III[19].

to 2% of their daily energy intake from ω-3 display alterations in the phospholipid composition of heart membranes which lead to decreased inflammation and enhanced resistance to mitochondrial permeability transition, decreasing the likelihood or delaying the progression of HF[23,24].

Mineral intake values were below the recommended amounts for participants in both groups. Patients with HF are at a greater risk of nutritional status deterioration due to changes in food intake patterns caused by early satiety, nausea and dyspnea, as well as alterations in nutrient absorption and metabolism[13,25].

In the present study, patients with HF were found to consume only 5% of the recommended daily amount of vitamin D. Studies have reported that vitamin D deficiencies are common in patients with HF[26,27], and may be associated with the physiopathology of the condition through alterations in the renin-angiotensin-aldosterone system which result in hypertension, ventricular hypertrophy, impaired endothelial function and inflammation[26,28]. Additionally, vitamin D deficiency has been identified as an independent mortality factor for patients with HF[29]. Calcium intake was also below recommended values in the present sample. Such results have been previously reported in other samples of patients with HF, in whom calcium deficiencies have also been found to be associated with arrhythmia. Calcium absorption can be negatively affected by vitamin D deficiency and by the use of diuretics, which lead to increased urinary calcium excretion[8,30].

Participants were also found to consume only 50% of the daily recommended potassium intake. Although there are no dietary recommendations for potassium

intake in patients with HF, hypokalemia is common in these individuals, especially due to the use of diuretics and their elevated aldosterone levels[31]. Additionally, mortality rates have been found to be especially high in patients with serum potassium levels below 4 mmol/L[32].

Sodium intake was higher than recommended in both groups, although it was found to be significantly higher for individuals with HF. Daily sodium intake was above the recommended upper limit (2.3g) for 85% of patients with HF and 76% of controls. Current guidelines for patients with HF[1,2] recommend a daily intake of approximately 1.5 to 3g/day depending on patient symptomatology. However, in the present study, 37.5% of patients with HF were found to consume over 3g of sodium a day.

Sodium restrictions are an important component of nutritional interventions for the treatment of HF, although there is still no consensus as to the extent to which sodium intake should be restricted, and as to whether it is possible to establish sodium intake recommendations that apply to all patients with HF[33], since the neurohormonal activation caused by an overly-restrictive diet[34,35] may at times be more harmful than the symptom aggravation and liquid retention observed when sodium intake is excessive[36,37].

The present results should be interpreted in light of a few limitations. DRIs were originally developed for healthy populations and may not reflect the nutritional needs of patients with HF, which are often influenced by the condition itself as well as its treatment[11]. Therefore, the present study may have underestimated the nutritional deficit observed in these individuals. Due to the small sample size, it was also impossible to stratify data into smaller categories to allow for more detailed analyses. The fact that participants consisted of patients from a HF clinic who were stable at the time of testing and were receiving comprehensive treatment from a multidisciplinary team may have also decreased the generalizability of the present results to other populations with HF. Lastly, the dosages of the diuretics used by patients in the present sample was not assessed.

In conclusion, the present study found that patients with HF tend to have inadequate macro and micronutrient intakes. These findings underscore the importance of nutritional interventions in patients with HF, especially the modification of eating habits for the control of nutritional deficiencies. The present results also call for further studies of the nutritional efficacy of existing interventions, so as to identify the possible need for the development of more appropriate nutritional treatments.

Acknowledgements

The authors would like to thank the Research Incentive Fund of the Hospital de Clínicas de Porto Alegre - Porto Alegre, Brazil, for their financial support to this research.

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