Greater level of physical activity associated with better cognitive function in hemodialysis in end stage renal disease

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Abstract

Introduction: Patients with chronic kidney disease (CKD) have a lower exercise tolerance and poor functional capacity, carry on a sedentary lifestyle. Another important change found in patients with CKD is cognitive dysfunction. Physical inactivity has been associated with cognitive dysfunction in the general population, but few studies have evaluated this association in CKD. **Objectives:** To assess the association between physical activity and cognitive function in patients with CKD on hemodialysis (HD). **Methods:** We evaluated 102 patients undergoing HD. The participants completed the International Physical Activity Questionnaire, which assesses the level of physical activity and the Mini Mental State Examination, used for cognitive screening. Patients were divided into three groups according to their level of physical activity (GI: active/GII: irregularly active/GIII: sedentary). It was applied logistic regression analysis and adopted as outcome variable the presence of cognitive impairment and preserving as independent variables those with a probability of statistical difference between groups of less than 0.1. It was considered statistically significant when p less than 0.05. **Results:** The groups were similar in age, duration of HD, and smoking. Statistically significant difference regarding race, body mass index, diabetes mellitus, underlying disease and degree of cognitive impairment. Regarding laboratory data, the groups differed in terms of creatinine, glucose, hemoglobin and hematocrit. There was significant association with better physical activity and cognitive function, even adjusting for confounding variables. **Conclusion:** The highest level of physical activity was associated with better cognitive function in CKD patients undergoing HD.

Keywords: cognition disorders, dialysis, exercise, uremia.

Introduction

Patients with chronic kidney disease (CKD) have lower exercise tolerance and poor functional capacity, even in everyday activities, than healthy individuals or patients with less severe renal disease.[1] This difference is believed to be due to a set of changes that constitute uremic syndrome and cause dyspnea, fatigue, lower limb pain, high blood pressure (HBP), anemia, and general muscle weakness.[2]

Another important change observed in patients with CKD is cognitive dysfunction. Published work shows that only a minority of patients on hemodialysis (HD) have normal cognitive function when assessed by specific tests for different aspects of mental fitness.[3]

Recently, studies have begun to emerge suggesting the negative impact of kidney disease on cognitive function in these patients. This impact includes memory disorders, difficulty in planning activities, changes in attention, decreased information processing speed, motor disability, or speech deficits.[4] The etiology of cognitive impairment is multifactorial; however, the chronic and debilitating nature of CKD along with its exhaustive routine treatments may be responsible for these alterations.[5] The impairment of cognitive function is also attributed to the effect of uremic toxins.[6]

However, the persistence of cognitive deficits despite appropriate dialysis dosing indicates that other factors contribute to this cerebral dysfunction. Cerebrovascular disease is a major risk factor for the development of cognitive dysfunction. Traditional vascular risk factors include HBP, diabetes mellitus (DM), hypercholesterolemia, cardiovascular disease, and smoking. Other nontraditional vascular risk factors that may be associated with this disorder include hyperhomocysteinemia, hemostatic abnormalities, hypercoagulability, inflammation, and oxidative stress.[6]

Neurological manifestations of HD patients impose unique diagnostic and therapeutic challenges due to the heterogeneity of their commonly associated conditions. Regarding neuropsychological performance, one study found that the most marked characteristics of HD patients are cognitive and psychomotor slowness when compared to patients who underwent renal transplantation.[7]

Thus, low exercise capacity, muscle atrophy, and poor physical performance are prevalent factors among patients with CKD, which are potentially modifiable with physical activity.[8] Sedentary lifestyle, coupled with the high prevalence of risk factors such as DM, dyslipidemia, and HBP, is responsible for the increased risk of developing cardiovascular,[9] renal,[10] and cerebrovascular diseases.[11] Physical exercise programs have been proposed to treat the aforementioned risk factors and their severe impact on cognitive function.[9] Thus, apart from the possibility of improving cardiovascular conditioning, physical activity may be able to improve cognitive function.[12]

There are several studies that have assessed physical activity in CKD patients, and other studies report cognitive dysfunction in these patients. However, few studies have assessed the relationship between these important variables. Thus, the objective of this study was to assess the possible association between the level of physical activity and cognitive function in patients with CKD undergoing HD.

Methods

This study was conducted at the Hospital das Clínicas of the Faculty of Medicine of Botucatu (HC-FMB), according to resolution 196/96 of the National Health Council, and was approved by the Research Ethics Committee (resolution 3257-2009).

The inclusion criteria consisted of undergoing HD 3 times a week for 4 hours, for a period not less than 3 months between March and November 2010, and being at least 18 years of age. We adopted the following exclusion criteria: an inability to understand and answer the questionnaires due to intellectual or physical disability, loss of vision and/or uncorrected hearing, motor abnormalities (orthopedic/rheumatic) affecting physical performance, prior diagnosis of dementia, delirium, and depression, and hospitalization during the last month. All participants signed an informed consent form.

The interviews were conducted with patients during the first hour of an HD session by a single evaluator. Personal data were collected, after which the patients answered 2 questionnaires.

The first questionnaire was the short version of the International Physical Activity Questionnaire (IPAQ),[13] used to assess the level of physical activity. The IPAQ is divided into issues related to vigorous and moderate physical activity and walking, while exemplifying each activity. The patient is classified as very active, active, irregularly active B and A, or sedentary, according to the frequency and duration of different types of activities, as follows:

Very active: one who fulfilled the following recommendations.

a) Vigorous: ≥ 5 days/week and ≥ 30 minutes per session.

b) Vigorous: ≥ 3 days/week and ≥ 20 minutes per session + Moderate and/or Walking: ≥ 5 days/week and ≥ 30 minutes per session.

Active: one who fulfilled the following recommendations.

a) Vigorous: ≥ 3 days/week and ≥ 20 minutes per session, or

b) Moderate or Walking: ≥ 5 days/week and ≥ 30 minutes per session, or

c) Any activity added: ≥ 5 days/week and ≥ 150 minutes/week (Walking + Moderate + Vigorous).

- Irregularly active: one who performs physical activity, but not enough to be classified as active because he/she does not meet the recommendations regarding the frequency or duration. To achieve this rating, the frequency and duration of the different types of activities are added (Walking + Moderate + Vigorous). This group was divided into 2 subgroups according to the fulfillment of some of the recommended criteria:

- Irregularly active A: one who meets at least 1 of the recommended criteria regarding the frequency or duration of the activity:

a) Frequency: 5 days/week or

b) Duration: 150 minutes/week

- Irregularly active B: one who does not achieve any of the recommended criteria regarding the frequency or the duration of the activity.
- Sedentary: one who does not perform any physical activity for at least 10 continuous minutes during the week.

The second instrument was the Mini Mental State Examination (MMSE),[14-16] which was used for cognitive screening. It is subdivided into temporal orientation, spatial orientation, immediate memory, calculation, recall of words, naming, repetition, command, reading, sentences, and copying a drawing. It has a range of scores from 0 to 30. The higher the score, the higher the cognitive function, and the score should be adjusted for education level, as this is a major factor in determining the final scores.[15,16] We adopted the following cutoff points according to the education level: 13 points for illiterates, 18 for up to 8 years of education, and 26 for more than 8 years of education.[17]

In this study, patients who obtained scores higher than 24 points were considered to not be cognitively impaired, those with scores between 18 and 23 points were considered mild to moderate cases, and those with scores below 18 points were considered moderately to severely cognitive impaired and required complementary testing.[3] To adjust the MMSE for education level, patients were reclassified with a score that was higher or lower than the cutoff point, according to their education level.[17]

Along with consultation of the HD unit registry, sex, age, race, HD duration, number of schooling years, smoking, body mass index (BMI), presence of DM, and underlying diseases were recorded.

Blood measurements were performed according to the methods employed in routine tests of the Technical Laboratory Section and Clinical Analysis of HC-FMB. The following tests were evaluated: creatinine, urea, potassium, serum glutamic pyruvic transaminase (SGPT), bicarbonate, blood glucose, β2-microglobulin, C-reactive protein (CRP), fractional clearance of urea (Kt/v ratio), albumin, calcium, phosphorus, parathyroid hormone, hemoglobin, hematocrit, white blood cells, ferritin, serum iron, transferrin saturation index (TSI), total cholesterol, low-density lipoprotein (LDL) and high-density lipoprotein (HDL), and triglyceride levels. These tests are all performed routinely for patients with CKD who receive this service.

The patients were divided into 3 groups according to their level of physical activity. Group I (GI) consisted of patients classified as active and very active. Group II (GII) consisted of patients classified as irregularly active B and A. Finally, Group III (GIII) included patients classified as sedentary.

For comparison of continuous variables and parametric distributions between the groups, analysis of variance (ANOVA) was used by conducting multiple comparisons with Tukey's test. For comparison of continuous variables and nonparametric distributions between the groups, ANOVA by ranks was used. The Chi square test was used to compare frequencies. These tests were applied to each variable separately. Only variables for which the effect was significant at a 10% level were maintained to compose the logistic regression analysis. Multivariate logistic regression was performed by adopting the presence of cognitive dysfunction as the dependent variable and the level of physical activity as the independent variable. This regression was adjusted for all variables with a probability of statistical difference between the groups below 0.1. The relative risks and 95% confidence intervals (CIs) are shown. Statistical significance was set at $p < 0.05$. Data are presented as mean ± standard deviation or median (first, third quartile) when appropriate. The Statistical Package for the Social Sciences (SPSS) 12.0 (SPSS Inc., Chicago, IL, USA) was used for storage and data analysis.

Results

Of the 138 patients who met the inclusion criteria, we excluded 36 patients who were unable to understand and answer the questions proposed due to visual (21), auditory (8), and intellectual (7) impairment, which resulted in a final sample of 102 patients.

The sociodemographic and clinical data of the 102 patients studied are presented in Table 1.

Table 1 Sociodemographic and clinical data of 102 hemodialysis patients

Variable	Mean ± Standard deviation, % or Median (1st; 3rd quartile)
Male Sex	56 (54.9%)
Age (years)	58.7 ± 15.12
Race	
White	66 (64.7%)
Non-White	36 (35.3%)
Hemodialysis Duration (months)	25 (10;64)
Body Mass Index (kg/m^2)	24 (22;27)
Presence of Diabetes Mellitus	41 (40.2%)
Tobacco Use	7 (6.9%)
Education (years)	4 (1;8)
Underlying Disease	
High Blood Pressure	46 (45.1%)
Diabetic Nephropathy	20 (19.6%)
Glomerular Diseases	15 (14.7%)
Others	21 (20.6%)

Data are expressed as mean ± standard deviation, percent (%), or median (first, third quartile).

Table 2 presents data regarding the level of physical activity and cognitive function of the study sample. It was observed that 44.1% of patients had some type of cognitive impairment. When the MMSE was adjusted for education level, 18 (17.6%) patients had scores below the cutoff point according to the level of education.

GI (active and very active) consisted of 26 patients, GII (irregularly active) included 35 patients, and GIII (sedentary) included 41 patients. The sociodemographic and clinical characteristics of the different groups are shown in Table 3. The groups were similar in age, HD duration, education level, and smoking status. The groups presented statistically significant differences regarding ethnicity, BMI, presence of DM, underlying diseases, and cognitive function, both when unadjusted (Figure 1) and adjusted for education level. The groups differed in the degree of cognitive impairment as measured by the MMSE (Figure 2). Sex showed a statistical probability of difference between groups of less than 0.1 (p = 0.063) and was selected for multivariate analysis.

Table 2 Data regarding physical activity as evaluated by the "International Physical Activity Questionnaire" and cognitive function as evaluated by the Mini Mental State Examination of 102 hemodialysis patients

Variable	Number of patients (%)
Level of Physical Activity	
Sedentary	41 (40.2%)
Irregularly Active B	25 (24.5%)
Irregularly Active A	10 (9.8%)
Active	26 (25.5%)
MMSE (points)	24 (21;28)
Without cognitive impairment	57 (55.9%)
Mild to moderate cognitive impairment	31 (30.4%)
Moderate to severe cognitive impairment	14 (13.7%)
Cognitive deficit (adjusted for education level)*	18 (17.6%)

Data are expressed as the number of patients (%). * According to the MMSE. MMSE: Mini Mental State Examination.

Table 4 shows the comparison of clinical laboratory data of the study groups. The groups were similar with respect to urea, potassium, SGPT, bicarbonate, β2-microglobulin, Kt/v, albumin, calcium, phosphorus, parathyroid hormone, white blood cells, ferritin, TSI, total cholesterol, LDL, HDL, and triglyceride levels. The groups differed in creatinine, glucose, hemoglobin, and hematocrit levels, which were generally unfavorable in the inactive group. The CRP level showed a statistical probability of difference between groups of less than 0.1 (p = 0.070) and was selected for multivariate analysis.

In the logistic regression model, we adopted the presence of MMSE-confirmed cognitive impairment adjusted for education level as the dependent variable. There was an association between physical activity and cognitive function, even after adjusting for sex, race, presence of DM, BMI, creatinine, CRP, and hemoglobin levels, with p = 0.030 (relative risk: 0.063, 95% CI: 0.005-0.762), as shown in Table 5. Additionally, the creatinine level (p = 0.024) was associated with better MMSE scores.

Discussion

Physical inactivity and poor cognitive performance are features observed in patients with CKD. Exercise

Table 3 Social, demographic, and clinical characteristics of 102 hemodialysis patients divided into groups according to the level of physical activity as assessed by the "International Physical Activity Questionnaire"

Variables	Group I n = 26	Group II n = 35	Group III n = 41	*p*
Male Sex	18 (69%)	21 (60%)	17 (41%)	0.063
Age (years)	55.5 ± 17.21	59.2 ± 15.10	60.3 ± 12.95	0.431
Race White	13 (50%)[a]	18 (51%)[a]	33 (80%)[b]	0.010
Time in HD (months)	47 (12;67)	18 (6;59)	36 (12;57)	0.288
Education (years)	4 (3;8)	4 (0.5;5)	4 (2;8)	0.826
Tobacco	2 (8%)	3 (9%)	2 (5%)	0.802
BMI (kg/m^2)	22 (21;25)[a]	23 (22;27)[ab]	26 (23;31)[b]	0.004
Presence of DM	4 (15%)[a]	13 (37%)[b]	24 (59%)[c]	0.002
Underlying Disease				
HBP	8 (31%)	18 (51%)	20 (49%)	0.048
DM	3 (11%)	6 (17%)	11 (27%)	
Glomerular diseases	8 (31%)	2 (6%)	5 (12%)	
Others	7 (27%)	9 (26%)	5 (12%)	
MMSE (points)	26 (23;29)[a]	23 (21;27)[b]	24 (16;27)[c]	0.032
Cognitive deficit (adjusted for education level)*	1 (3.8%)[a]	4 (11.4%)[b]	13 (31.7%)[c]	0.026

Data are expressed as mean ± standard deviation, percent (%), or median (first; third quartile). Group I: IPAQ active and very active; Group II: IPAQ irregularly active B and A, Group III: IPAQ sedentary. * According to the MMSE. HD: hemodialysis; BMI: Body Mass Index; DM: Diabetes Mellitus; HBP: High Blood Pressure; IPAQ: International Physical Activity Questionnaire; MMSE: Mini Mental State Examination. [a,b] Values followed by the same letter do not differ at the 5% level.

Figure 1. Values of cognitive function as assessed by the Mini Mental State Examination according to the level of physical activity as assessed by the International Physical Activity Questionnaire in 102 hemodialysis patients.

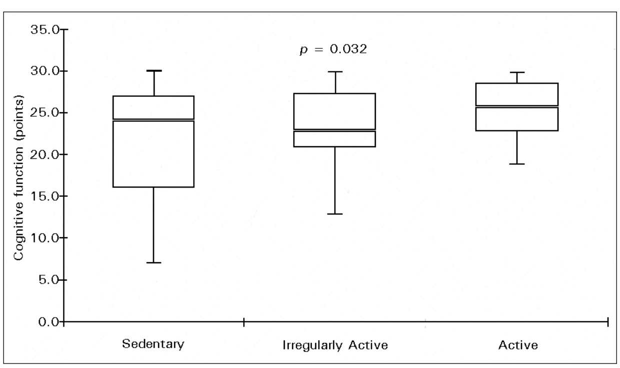
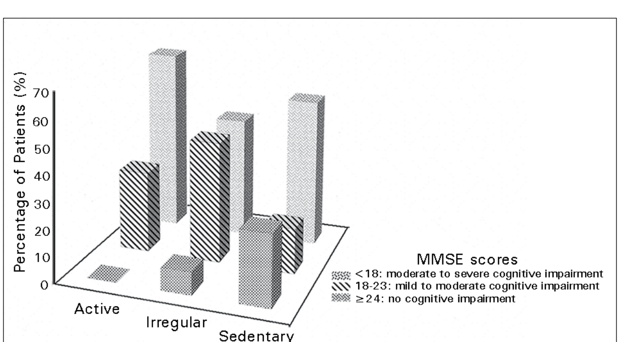


Figure 2. Degree of cognitive impairment as assessed by the Mini Mental State Examination according to the level of physical activity as assessed by the International Physical Activity Questionnaire of 102 hemodialysis patients.



is an important adjunct to the treatment of these patients as it is associated with improved mental and physical parameters. Thus, the current study aimed at examining the possible association between physical activity and cognitive function in patients undergoing HD.

In this study, we observed an association between higher levels of physical activity and improved cognitive function in patients with CKD undergoing HD. We noted that the more active patients had a lower risk for severe cognitive impairment when compared with irregularly active and sedentary individuals. Patients classified as active according to the IPAQ obtained better scores on the cognitive function test (MMSE) when compared to sedentary and irregularly active individuals. This finding corroborates a recent Brazilian study that evaluated 86 patients undergoing HD, with 49 participants in a physical activity program and 37 who remained inactive. The author observed that physically active patients achieved higher cognitive test scores.[18] It is important to note that equivalent data are found in the general population, as shown by a recent meta-analysis that described a positive correlation between the implementation of physical exercise and improvement in cognitive function. The authors

Table 4 Clinical laboratory data of 102 hemodialysis patients divided into groups according to the level of physical activity as assessed by the "International Physical Activity Questionnaire"

Variables	Group I n = 26	Group II n = 35	Group III n = 41	*p*
Creatinine (mg/dL)	9.2 ± 2.81[ab]	9.5 ± 2.47[a]	7.9 ± 2.41[b]	0.014
Urea (mg/dL)	108.2 ± 29.44	123.2 ± 37.46	112.5 ± 34.85	0.205
Potassium (mmol/L)	4.8 ± 0.74	4.9 ± 0.79	4.8 ± 0.78	0.853
SGPT (U/L)	13 (10;25)	17 (12.5;13)	16 (10;25)	0.446
Bicarbonate (mEq/L)	22.0 ± 1.98	22.3 ± 2.40	22.6 ± 2.43	0.565
Blood glucose (mg/dL)	104 (79;129)[a]	97 (85;141)[ab]	127 (98;224)[b]	0.012
β2-microglobulin (mg/dL)	24 (21;30)	27 (24;33)	25 (21;36)	0.490
C-reactive Protein (mg/dL)	0.7 (0.3;1.3)	0.6 (0.5;0.9)	0.8 (0.5;2.3)	0.070
Kt/v	1.35 (1.2;1.5)	1.4 (1.2;1.6)	1.4 (1.1;1.6)	0.678
Albumin (g/dL)	3.7 ± 0.40	3.7 ± 0.41	3.6 ± 0.58	0.509
Calcium (mg/dL)	9.1 (8.4;9.6)	8.7 (8.2;9)	8.9 (8.4;9.3)	0.119
Phosphorus (mg/dL)	5.2 (4.1;6.3)	4.9 (4.5;6.2)	5 (4.2;6)	0.989
Parathyroid hormone	412 (245;714)	457 (249;687)	474 (308;955)	0.509
Hemoglobin (g/dL)	12.1 ± 1.80[a]	11.1 ± 2.03[ab]	10.8 ± 1.75[b]	0.027
Hematocrit (%)	35.7 ± 5.27[a]	33.2 ± 6.16[ab]	32.1 ± 5.12[b]	0.041
White blood cells (×103/mm^3)	5.3 (4.2;6.5)	6.2 (5.2;7.5)	5.6 (4.9;10.1)	0.116
Ferritin (ng/mL)	656 (397;1116)	412 (211;22)	527 (326;944)	0.198
TSI (%)	36 (24;44)	35 (23;55)	32 (28;43)	0.920
Cholesterol (mg/dL)	147.4 ± 35.17	135.2 ± 41.45	140.5 ± 36.99	0.472
LDL (mg/dL)	72.1 ± 27.66	67.4 ± 24.63	66.9 ± 27.26	0.724
HDL (mg/dL)	43.8 ± 19.00	39.6 ± 14.80	39.4 ± 14.20	0.507
Triglycerides (mg/dL)	130 (86;168)	134 (89;183)	153 (92;194)	0.834

Data are expressed as mean ± standard deviation or median (first; third quartile). Group I: IPAQ active and very active; Group II: IPAQ irregularly active B and A; Group III: IPAQ sedentary. Kt/v: fractional clearance of urea. SGPT: serum glutamic pyruvic transaminase; TSI: Transferrin Saturation Index; LDL: low-density lipoprotein; HDL: high-density lipoprotein; IPAQ: International Physical Activity Questionnaire. [a,b] Values followed by the same letter do not differ at the 5% level.

Table 5 Relative risk of cognitive dysfunction in the mini mental state examination according to education level of hemodialysis patients, adjusted for sex, race, diabetes mellitus, body mass index, creatinine, C-reactive protein, and hemoglobin levels

Variables	RR	95.0% CI		*p*
		Inferior	Superior	
Group III (reference)				
Group II	0.287	0.056	1.476	0.135
Group I	**0.063**	**0.005**	**0.762**	**0.030**
Male sex	0.804	0.220	2.945	0.742
White Race	1.524	0.301	7.708	0.611
Diabetes Mellitus	1.116	0.264	4.709	0.881
BMI (kg/m^2)	0.855	0.711	1.028	0.096
Creatinine (mg/dL)	**0.677**	**0.483**	**0.949**	**0.024**
CRP (mg/dL)	1.021	0.905	1.152	0.736
Hemoglobin (g/dL)	0.777	0.527	1.148	0.205

Group I: IPAQ active and very active; Group II: IPAQ irregularly active B and A; Group III: IPAQ sedentary. BMI: body mass index; CRP: C-reactive protein.

of this meta-analysis concluded that improved cardiovascular fitness results in improved cognition, with a positive impact in the areas responsible for memory, information processing speed, and attention.[19]

The prevalence of cognitive dysfunction in this study as evaluated by the MMSE was 44.1%, and 17.6% when adjusted for education level. This decrease in prevalence can be explained by the low education level of the sample (median: 4 years). Previous studies show that the prevalence of cognitive impairment among patients with CKD can vary between 24% and 60%; however, these studies have been conducted in developed countries where around 8 years of education is compulsory.[20-23]

As for the influence of education on the MMSE scores, a study divided individuals into groups according to schooling years and concluded that this variable is the most important factor in determining the final MMSE scores.[16] This factor was evaluated in the current study, in which education level was homogeneous between the groups. Similarly, a study that evaluated 119 patients at different stages of renal disease, with 30 patients undergoing HD, concluded that schooling had no influence on the groups' cognitive scores.[24]

We observed a positive correlation trend in the multivariate analysis (p = 0.096) between MMSE scores and BMI. In patients with CKD, decreased body fat increases the mortality risk. One study found that fat mass was directly associated with improved survival in HD patients and demonstrated an increased mortality rate in patients with less than 12% body fat.[25]

Another important result of this study is that, when analyzing the clinical laboratory data, we observed statistically higher values of serum creatinine in the active group as compared to the sedentary group. These results are similar to those demonstrated in a study that evaluated the physical activity level of 375 patients undergoing HD.[26] The creatinine levels in HD patients no longer merely reflect renal function and begin to reflect the individual's muscle mass. Thus, it is expected that patients with a higher level of physical activity have larger muscle mass and therefore higher creatinine values.

Active patients exhibited higher hemoglobin levels than irregularly active and sedentary patients. CKD entails an inadequate production of erythropoietin that results from reduced renal mass, and frequent supplementation with exogenous erythropoietin is not sufficient to correct the hemoglobin level. In addition, the inflammatory state contributes to the decline in hemoglobin levels, as high CRP levels are associated with anemia due to increased resistance to erythropoietin.[27] Accordingly, a former study showed that intradialytic physical exercise contributed to increased hemoglobin levels and controlled anemia. The mechanism of this phenomenon seems to be the improvement in sensitivity to erythropoietin.[28]

However, in our sample, there was no correlation between hemoglobin levels and cognitive impairment as measured by the MMSE. In contrast to our findings, a large prospective clinical study evaluated the relationship between nontraditional risk factors in CKD and cognitive function and showed that anemia is an independent risk factor for cognitive impairment. Nevertheless, in this study, higher values of CRP were related to larger cognitive deficits.[29]

The presence of DM and blood glucose levels were more pronounced in the sedentary patients. The association between a higher glycemic index and less physical activity is in agreement with a clinical study of healthy subjects, which showed that periods of inactivity lead to higher blood glucose levels.[30]

Regarding the level of physical activity, in this study, 74.5% of the total sample was sedentary and irregularly active. This finding is consistent with a previous study that evaluated the low level of physical activity of 1547 patients with chronic renal failure. The study cited advanced age, female sex, diabetes, atherosclerosis, and low education level as variables associated with a low physical activity level.[31] As expected, our findings show that the sample had a higher percentage of sedentary and irregularly active individuals when compared to a healthy population. In a study that evaluated the physical activity of a sample of a healthy population of the State of São Paulo, the authors found that 46.5% of the total sample was considered sedentary and irregularly active in a sample of 2001 individuals.[32]

Some limitations of this study should be recognized. The prevalence of cognitive impairment may be underestimated due to the exclusion criteria (inherent in the MMSE method). Patients with visual, auditory, and intellectual impairment were excluded from the study and this may have affected the final scores of the cognitive test. However, this method was employed in the studies used for the discussion of our findings. This is a cross-sectional study, thereby subject to limitations inherent to this type of design; hence, we cannot establish cause-and-effect relationships. To obtain these, a longitudinal intervention study would be necessary. On the other hand, we evaluated the confounding variables in a multivariate analysis and the associations obtained were independent of these factors.

As for the strengths of this study, the number of subjects evaluated was significant and large enough to detect statistically significant correlations. Data were obtained by a single evaluator, which provides homogeneity in the results. Finally, the diversity of the variables measured allowed the assessment of their influence on the results obtained.

Conclusion

The data from this study show that the level of physical activity was associated with cognitive performance in HD patients, independent of other confounding factors.

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