Correlates of habitual physical activity in chronic haemodialysis patients

Sylwia Zamojska, Magdalena Szklarek, Maciej Niewodniczy and Michał Nowicki

Department of Nephrology, Hypertension and Kidney Transplantation, Medical University of Łódź, Poland

Abstract

Background. Results of physical performance tests may not reflect the level of habitual physical activity and health status of the dialysis patients. The aim of our study was to assess interdialytic spontaneous physical activity in chronic haemodialysis (HD) patients in relation to their nutritional status, severity of anaemia, inflammation and dialysis adequacy.

Methods. Sixty HD patients [27 female, 33 male; mean age 60±13 years, time on dialysis 46.2±62.1 months and body mass index (BMI) 25.1±4.7 kg/m²] without physical and neurological disabilities and 16 healthy individuals (10 female, six male, mean age 56±6 years, BMI 26.6±4.9 kg/m²) were enrolled into the study. In all patients, spontaneous daily physical activity was measured during 48 h between mid-week dialysis sessions by pedometers. Nutritional status was estimated by anthropometric methods (BMI and mid-arm muscle circumference) and serum albumin concentration. Additionally, body composition was estimated using a multifrequency phase-sensitive bioimpedance analysis (BIA). Severity of anaemia was determined by blood haemoglobin level and haematocrit value, and the presence of inflammatory state was determined by high sensitivity plasma C-reactive (CRP) protein measurements.

Results. The total number of steps during daily activities in dialysis patients and in healthy individuals was 6896±2357 vs 14 181±5383 per 48 h, respectively (P<0.001). Dialysis patients showed typical signs of malnutrition in the BIA, i.e. high extracellular mass/body cell mass index (1.17±0.28 in dialysis patients vs 0.97±0.1 in controls; P<0.001), low percentage cell mass (46.7±5.6 and 51.0±3.6, respectively; P=0.002) and low phase angle (5.1±0.9 and 5.8±0.7, respectively; P=0.006). Dialysis patients also showed lower serum albumin and blood haemoglobin and higher serum CRP levels than healthy controls. In dialysis patients, the number of steps taken positively correlated with body water (R=0.28, P=0.03), fat mass (r=0.29, P=0.04), BMI (R=0.25, P=0.04), lean body mass (R=0.26, P=0.04), intracellular water (r=0.30, P<0.01), phase angle (R=0.40, P=0.002), serum albumin (R=0.32, P=0.01), haematocrit (R=0.46, P=0.001) and haemoglobin (R=0.44, P=0.001). Furthermore, the number of steps taken correlated significantly with mid-arm muscle circumference (r=0.35, P=0.006). A negative correlation was found between the number of steps and extracellular mass/body cell mass index (R=−0.37; P=0.004). No significant relationships were found between the measures of physical activity and high sensitivity CRP or adequacy of dialysis. Multiple regression analysis revealed the independent associations between the number of steps taken by the patients and haemoglobin concentration, age, total body water, extracellular mass/body cell mass index and phase angle.

Conclusions. Low habitual physical activity assessed in HD patients with simple portable pedometers is strongly related to several factors of major clinical importance in this population.

Keywords: anaemia; haemodialysis; inflammation; malnutrition; physical activity

Introduction

It has been well recognized that most chronic dialysis patients are in poor general health, show signs of malnutrition and most of them are unable to perform physical training [1,2]. A decline in physical activity that begins in the early stages of kidney disease and progresses with its course is mainly due to the loss of strength caused by renal anaemia and skeletal muscle dysfunction [3]. Skeletal muscle atrophy, reduction in the number of muscle fibres and increased...
non-contractile tissue content are due to malnutrition, metabolic acidosis, decreased protein synthesis and increased protein catabolism or resistance to anabolic hormones [4,5]. Additionally, mental and social changes, accelerated ageing, long-term inactivity, unemployment and decreased quality of life may also contribute to low physical activity in dialysis patients [6].

Standard supervised physical performance measurements may not correlate with the level of spontaneous physical activity [7]. Therefore, counting the number of steps taken by a patient with the pedometer during their routine daily activities may give a much better assessment of their general health status [8]. This well validated and simple method is widely used in sport and preventive medicine [8,9]. To the best of our knowledge, pedometers were applied to study the physical activity patterns in chronic dialysis patients in only one very recent study [10]; however, in another study published in 2000, physical activity levels were assessed in haemodialysis (HD) patients with a similar method, i.e. with three-dimensional accelerometers [11].

In the present study, we investigated whether poor nutritional status, aggravated anaemia, the dose of delivered dialysis and inflammation could influence not only physical performance but also habitual physical activity in chronic HD patients. Also our aim was to assess interdialytic habitual physical activity in chronic HD patients with pedometers as a novel method.

Patients and methods

Patients

The study group comprised 60 chronic HD patients [27 female, 33 male; mean age 60±13 years, time on dialysis 46.2±62.1 months and body mass index (BMI) 25.1±4.7 kg/m²]. Only patients who had no physical or neurological disabilities or had not reported any problems with walking were qualified for enrolment in the study. Patients with advanced heart failure (NYHA class III or IV), uncontrolled hypertension, unstable coronary artery disease, acute infections, symptomatic chronic inflammatory diseases and treatment-resistant hyperkalaemia were also excluded. Sixteen age- and BMI-matched healthy individuals (10 females, six males, mean age 56±6 years, BMI 26.6±4.9 kg/m²) served as controls.

Physical activity measurement

The level of spontaneous physical activity was assessed using commercially available pedometers (Oregon Scientific PE316CA, Portland, OR). Stride length was calibrated, and the number of steps taken and distance walked were recorded. The measurements were carried out during a mid-week interdialytic period of 2 days in the dialysis patients and during a corresponding 2 day period in the middle of the week in the healthy controls.

Biochemical parameters

For each subject, the following biochemical parameters were also obtained before a dialysis session at the study visit: C-reactive protein (by high sensitivity assay; hsCRP), haematocrit, serum albumin, and haemoglobin. Dialysis adequacy was assessed by Kt/V according to Mattar [18]. In the controls, blood count and plasma concentrations of hsCRP were determined.

Nutritional status and body composition

In order to establish the nutritional status, several anthropometric measurements were performed in all patients and controls. They included body mass (in dialysis patients after a mid-week dialysis session), body height, BMI, mid-arm circumference (MAC) and triceps skin fold thickness (TSF). Mid-arm muscle circumference (MAMC) was calculated according to the formula MAMC = MAC - 3.14 × TSF. Additionally, using a multifrequency phase-sensitive bioimpedance analysis (NutriGuard-M, Data Input, Darmstadt, Germany) with Bianostic-Classic6-Elektroden (Data Input, Darmstadt, Germany), the following body composition parameters were assessed in all studied subjects: body water (BW), fat mass (FM), percentage of fat (FM %), lean body mass (LBM), extracellular water (ECW), intracellular water (ICW), extracellular mass (ECM), body cell mass (BCM kg), ECM/BCM index, percentage cell amount and phase angle. We assumed that the normal range values for phase angle measured with BIANOSTATIC electrodes are ≥5.5–5.9 for women and 6.0–6.4 for men. For evaluation of ECM/BCM ratios measured with BIANOSTATIC electrodes for impedance, we assumed that a ratio >1.3 reveals poor nutritional status, 1.1–1.3 indicates a deficient nutritional condition and <1.1 characterizes a sufficient nutritional condition.

In dialysis patients, all anthropometric and bioimpedance measurements were performed after the mid-week dialysis session.

Statistical analysis

The results are expressed as mean±SD. The normality of data distribution was checked by Kolomogorov–Smirnoff test, and non-normally distributed data were logarithmically transformed before analysis. A t-test was used to test differences between groups. Spearman and Pearson correlation coefficients were calculated to study the relationships between physical activity measures and biochemical or anthropometric parameters. The relationships of all significant determinations (set at P<0.2) identified from univariate analyses with a level of spontaneous activity (number of steps taken by the patients in a given period) were studied with the stepwise multiple regression analysis using the F statistic with P = 0.05 as a criterion for selection. Statistical analysis was performed using the Statistica for Windows software (version 6.0, StatSoft, Tulsa, OK).

Results

Table 1 summarizes clinical and biochemical data of the study subjects. The groups were similar with
Table 1. Clinical and biochemical characteristics of haemodialysis (HD) patients and healthy controls

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HD patients</th>
<th>Controls</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kt/V</td>
<td>1.16±0.21</td>
<td>1.68±0.4</td>
<td>NS</td>
</tr>
<tr>
<td>Height (m)</td>
<td>65.1±11.8</td>
<td>75.3±14.2</td>
<td>NS</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>25.1±4.7</td>
<td>23.6±3.3</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>1.03±1.9</td>
<td>30.4±4.2</td>
<td>NS</td>
</tr>
<tr>
<td>MAMC (cm)</td>
<td>1.3±0.1</td>
<td>1.1±0.1</td>
<td>NS</td>
</tr>
<tr>
<td>HsCRP (mg/l)</td>
<td>1.0±0.7</td>
<td>0.002</td>
<td>NS</td>
</tr>
<tr>
<td>Hct (%)</td>
<td>30±14.2</td>
<td>36.1±1.4</td>
<td>NS</td>
</tr>
</tbody>
</table>

Values are given as mean±SD.
MAMC, mid-arm muscle circumference; hsCRP, high sensitivity C-reactive protein; BMI, body mass index; Hct, haematocrit.

Table 2. Body composition obtained by bioimpedance analysis in haemodialysis (HD) patients and controls

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HD patients</th>
<th>Controls</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW (kg)</td>
<td>35.4±6.6</td>
<td>36.9±7.5</td>
<td>NS</td>
</tr>
<tr>
<td>FM kg</td>
<td>19.3±8.8</td>
<td>23.3±9.2</td>
<td>NS</td>
</tr>
<tr>
<td>FM (%)</td>
<td>27.9±9.6</td>
<td>31.3±8.6</td>
<td>NS</td>
</tr>
<tr>
<td>LBM</td>
<td>48.1±9.3</td>
<td>50.5±10.3</td>
<td>NS</td>
</tr>
<tr>
<td>ECM</td>
<td>13.7±3.8</td>
<td>14.9±3.9</td>
<td>NS</td>
</tr>
<tr>
<td>ICW</td>
<td>22.5±2.9</td>
<td>23.7±3.3</td>
<td>NS</td>
</tr>
<tr>
<td>ECM/kg</td>
<td>22.6±5.1</td>
<td>24.5±3.7</td>
<td>NS</td>
</tr>
<tr>
<td>ECM/BCM index</td>
<td>1.17±0.28</td>
<td>0.97±0.13</td>
<td>0.001</td>
</tr>
<tr>
<td>% cell mass</td>
<td>46.7±5.6</td>
<td>51.0±3.6</td>
<td>0.002</td>
</tr>
<tr>
<td>Phase angle</td>
<td>5.1±0.9</td>
<td>5.8±0.8</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Values given are mean±SD.
BW, body water; FM kg, fat mass (kg); FM %, percentage of fat (%); LBM, lean body mass; ECM, extracellular water; ICW, intracellular water; ECM, extracellular mass; BCM kg, body cell mass (kg).

The mean concentration of serum albumin in HD patients remained in the low-normal range (37.9±3.0 mg/dl). The mean haematocrit value in HD patients was 30.4±4.2%, and differed significantly from healthy controls (36.1±1.4%; P < 0.001). HD patients had significantly higher serum CRP levels (1.03±1.98 vs 0.16±0.13; P = 0.002) than healthy subjects.

In HD patients, the level of spontaneous physical activity, i.e. the number of steps taken measured by pedometers, in the 48 h interdialytic period correlated positively with BW (R = 0.28, P = 0.03), FM (r = 0.29, P = 0.04), BMI (R = 0.25, P = 0.04), LBM (R = 0.26, P = 0.04), ECM (r = 0.30, P < 0.01), phase angle (R = 0.40, P = 0.002), serum albumin (R = 0.32, P = 0.01), haematocrit (R = 0.46, P = 0.001) and haemoglobin (R = 0.44, P = 0.001). Furthermore, the number of steps taken significantly correlated with MAMC (r = 0.35, P = 0.006). In contrast, a negative correlation was found between the number of steps and ECM/BCM index (R = −0.37; P = 0.004).

Multiple regression revealed that the numbers of steps taken by the patients were best predicted by haemoglobin concentration, age, BW, ECM/BCM index and phase angle (Table 3).

Discussion

The main result of the study is that a level of habitual physical activity measured with a simple method, i.e. portable pedometers, in long-term HD patients is strongly correlated with clinical and biochemical parameters which are known to determine not only patients’ physical condition but also their survival on dialysis [1].

Evaluating physical activity in chronic HD patients is difficult as this is a group of individuals who suffer from not only physical disabilities but also mental changes and various co-morbid conditions. Assessing physical activity in those patients by standard physical performance tests is thus usually impossible, and questionnaires designed to assess habitual activity (e.g. Baecke self-administered habitual physical activity questionnaire or the Five-City Project 7-day recall physical activity questionnaire [12]) can give only indirect measurements and are highly dependent on a
confirm that chronic HD patients are generally inactive as is typical for individuals suffering from chronic diseases.

The question remains open of whether a distance measured by pedometers (and not only the number of steps taken) is a valid parameter for an evaluation of physical activity. As has been shown, the walking distance measured with pedometers may not fully reflect the real pattern of physical activity because pedometers, unlike more sophisticated and expensive accelerometers [11], count steps in a similar way (assuming the same step length) during running, walking and slow walking [8] and, therefore, the measurements may not reflect the accurate distance. Therefore, we used the number of steps rather than a walking distance for correlation analyses.

One of the main findings in our study was the observation of a high proportion of malnourished patients in the bioimpedance analysis expressed by low phase angle and high ECM/BCM ratio. The clinical relevance of such findings has already been confirmed in the HD population [17]. Most bioimpedance parameters showed significant correlations with habitual physical activity. It is noteworthy that the percentage cell mass, which positively correlated with physical activity, could indirectly reflect a ratio of anabolic to catabolic processes [18]. Therefore, all our results strongly support the hypothesis that malnutrition and decreased protein metabolism together with increased catabolism strongly influence the ability of the HD patients to perform daily physical activities.

MAMC is the most widely used and easy to measure anthropometric parameter that reflects muscle mass and protein stores [19]. Unfortunately, no studies have explored whether there are any relationships between MAMC and changes in skeletal muscle morphology typically found in uraemic patients [4]. Hence we cannot prove whether the relationship between low daily physical activity and low muscle mass estimated by the MAMC value that we found in our study could be explained by poor nutritional status or/and muscle atrophy. It is also noteworthy that inactivity per se leads to muscle atrophy [20], and therefore our findings may also reflect loss of muscle mass and strength due to low daily physical activity.

We also found that the patients who were less physically active also showed lower concentrations of albumin which a well established mortality risk factor in HD patients [1].

In subjects with normal renal function, the negative correlation between the level of spontaneous physical activity and LBM, FM and BMI has been well described. It possibly reflects a high proportion of overweight and obesity in the general population which are well known determinants of a sedentary lifestyle [21]. Our observation of reversed associations between these parameters in chronic HD patients are not unexpected since higher BMI, LBM and FM could in fact indicate better nutritional status in this population and hence may be associated with better

---

Table 3. Results of multiple regression with the level of habitual physical activity (the number of steps taken by the patients between two mid-week dialysis sessions) as a dependent variable.

<table>
<thead>
<tr>
<th>Predictor variables</th>
<th>β</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemoglobin</td>
<td>0.26</td>
<td>0.01</td>
</tr>
<tr>
<td>Age</td>
<td>0.19</td>
<td>0.02</td>
</tr>
<tr>
<td>Body water</td>
<td>1.92</td>
<td>0.005</td>
</tr>
<tr>
<td>ECM/BCM index</td>
<td>−0.82</td>
<td>0.003</td>
</tr>
<tr>
<td>Phase angle</td>
<td>−0.48</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Multiple adjusted $R^2 = 0.47$, $F = 6.58$, SE of estimate 1701 and $P < 0.0001$. 

---

**Fig. 1.** Number of steps measured by pedometers during a mid-week period of 48 h in haemodialysis (HD) patients and controls (individual values and mean±SD).
physical functioning and survival [22]. We can speculate that the strong positive correlation between physical activity and total BW measured by bioimpedance analysis could be explained by the fact that the patients who can tolerate a state of persistent overhydration could also have better cardiac status. On the other hand, the patients with low BW may not tolerate dialysis so well, and that could adversely influence their physical activity in the interdialytic period.

As could be expected, we also found that the patients with lower spontaneous physical activity were more anaemic. The strong positive correlation between anaemia and physical performance has been well studied [3]. The lack of a significant relationship between physical activity and serum levels of CRP may be a result of small group size; however, similar results were described in another study [23]. Similar to another study [11], we also did not reveal a significant correlation between the level of spontaneous physical activity and dialysis adequacy parameters.

In conclusion, we found that even those chronic dialysis patients who did not report any problems with walking were physically inactive, malnourished and more anaemic. Interdialytic physical activity measured by pedometers reflects habitual daily activity and is correlated with nutritional status and the severity of anaemia. Thus we think that measuring daily physical activity with pedometers could become a valuable method for evaluating the general physical condition in HD patients. Furthermore, the patients can see the readings of the pedometer which could encourage them to increase physical activity [13] and hopefully also to participate in exercise training programmes.

Acknowledgements. The results presented in this paper have not been published previously in whole or part, except in abstract form.

Conflict of interest statement. None declared.

References


Received for publication: 15.03.05
Accepted in revised form: 17.11.05