

Does Physical Activity Have an Effect on Physical Capacities, Food Behavior and Body Composition in Hemodialysis Patients?

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Abstract Purpose: Chronic kidney disease and its treatment, hemodialysis, cause many side effects and disease-related pathologies appear due to inactivity, which characterizes the dialysis population. However, literature demonstrates that physical activity is beneficial for these patients. Nevertheless, few data are available concerning our studied parameters with a resistance training program.

Methodologies: We observed the effects of a 3-month intradialytic resistance training program (t_0 vs t_3) on body composition, food behavior and physical capacities of 23 patients; 17 patients in the physical activity group and 6 patients in the control group. The resistance training program consisted of 3 sessions per week and involved the use of elastic bands and soft balls on the lower extremities. All the measures were realized at t_0 and t_3 .

Principal results: The leg muscle mass and the Time Up and Go test were improved after the resistance training program. The other body composition parameters and physical capacity tests (2 min step test and one leg balance test) presented no significant differences. No food behavior modification was observed. No changes were observed in the control group, regardless of the parameters measured.

Major conclusion: A three-month resistance training program can improve both the leg muscle mass and the associated physical capacities. **Contributions to the fields:** Our study provided additional knowledge about resistance physical activity during hemodialysis sessions, few studied with our measured parameters.

Keywords Intradialytic Hemodialysis Sessions, Food Records, Adapted Physical Activity, Chronic Kidney Disease, Capacities Tests, Body Composition

1. Introduction

Chronic kidney disease (CKD) is a pathology which needs treatment called replacement therapy, for example, hemodialysis. Both the pathology and the treatment cause side effects such as an increase in sedentary lifestyle, body composition modifications, a decrease in physical capacities, food behavior modifications and a decrease in the quality of life [1-3]. Disease processes related to inactivity, such as cardiovascular disease, are more prevalent in the dialysis population [4]. In fact, dialysis patients are approximately 35% less active than healthy people [4]. O'Hare [1] showed that mortality in dialysis patients is 62% higher than that in healthy people; the main cause of death being cardiovascular disease [5].

Anatomic and physiologic modifications appear as a consequence of the inactivity of the dialysis population and correspond to physical deconditioning [6]. As a result, muscle wasting and a decrease in strength and physical capacities are observed [7-9].

Muscle wasting in hemodialysis patients is influenced

by certain parameters such as malnutrition, disease-related pathologies, hemodialysis treatment and inactivity enhanced by the three weekly dialysis sessions [10]. Endurance exercises are positively correlated with the body composition (in particular, decreasing of fat mass) and the food intakes of hemodialysis patients [11]. Whereas resistance exercises can improve the muscle mass which is positively correlated with the muscular strength [12]. Nevertheless, more research is needed concerning the effects of resistance training because fewer studies carried out this type of exercise and so fewer parameters were measured in hemodialysis patients [12].

Anorexia, low total energy intake and low protein intake are common in dialysis patients [13]. Concerning the total energy intake, more than 50% of dialysis patients have some difficulties in following the recommendations given to them [14] due to lack of time, specific food preparation and their physical condition [15]. Therefore, in order to prevent certain metabolic disorders such as protein catabolism and muscle wasting, the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF KDOQI) [16] recommends improving the total energy intake. Concerning protein, the NKF KDOQI recommends 1.2g/kg of body weight/day. However, a higher patient survival rate is observed with a protein intake superior to 1.25g/kg of body weight/day [17] whereas muscle wasting and malnutrition are observed with a protein intake inferior to 0.8 g/kg of body weight/day [18]. Moreover, nutritional supplements during hemodialysis sessions seem to be beneficial for the muscular protein status [19,20].

Physical activity in general has many positive effects on hemodialysis patients such as an increase in physical capacities [12], a decrease in kidney disease-related pathologies [21], an improvement in the quality of life [3], and an increase in appetite [19]. Its improvements were mainly due to endurance exercises. As explained above, resistance training and its advantages were less studied [12]. Exercise guidelines for CKD patients are similar to the general aged population; aerobic training, resistance training and balance and flexibility exercises [22].

To our knowledge, few studies have carried out resistance training programs on hemodialysis patients only [23] and on the parameters we studied (body composition, food behavior and physical capacities). Moreover, the resistance exercise training was easier to implement during hemodialysis sessions: exercises need little materials, materials are not cumbersome and easy to be used by medical staff and hemodialysis patients. Finally, one of the major negative side effects in hemodialysis patients is the body composition alteration: decrease of the muscle mass and increase of the fat mass, which are responsible of many diseases. Resistance exercises are the most beneficial exercises type to improve these body composition alterations.

Therefore, the aim of our study was to evaluate the effects of a short intradialytic resistance training program

on chronic hemodialysis patients and their physical capacities, body composition and food behavior using simple and easy to implement tools.

2. Materials and Methods

2.1. Population

Patients, undertaking hemodialysis in two different dialysis units, participated in this study.

The participants selected were stable hemodialysis patients aged at least 18 years, had been undergoing dialysis three times a week for a minimum duration of three months, and with no contraindication to physical activity.

In order to have 25 patients whose data will be analyzed with an alpha risk at 0.05 and a power of 80%, 29 patients in total can be recruited. A biostatistician performed these calculations thanks to Software R3.1.2 and the EpiR package.

We recruited 36 patients who were randomly assigned to either the physical activity group (PA group) or the control group (C group). Due to different reasons (renal transplant, change of mind, health problem or hospitalization), a total of 23 patients fully completed the study (age: 58.5 ± 13.8 years); 17 patients in the PA group (Body Mass Index: 28.4 ± 6.1 kg/m²) and 6 in the C group (Body Mass Index: 24.1 ± 4.4 kg/m²). There was no significant difference in the Body Mass Index between the two groups.

Written informed consent was obtained from all patients. Ethical approval was obtained from both the CPP (Comité de Protection des Personnes) in Tours (France) and the ANSM (Agence nationale de sécurité du médicament et des produits de santé, France).

2.2. Experimental Protocol

2.2.1. Physical Training Program

The physical training program lasted 3 months and concerned the PA group only. It encompassed 3 weekly intradialytic sessions during the first two hours of dialysis [21]. An adapted physical activity instructor supervised the entire duration of the exercise sessions.

For the control group patients, no adapted physical activity was realized. But they could observe the patients which performed the exercises because all the patients were in the same room. The adapted physical activity instructor could discuss with every patients.

The training program included resistance exercises with the aid of elastic bands and soft balls for the lower extremity muscles only, due to fistula in the upper extremities. The elastic band was placed on the foot patients (figure 1) and the exercises consisted of hip, knee and ankle flexions and extensions, hip adductions and

abductions and ankle rotations. The soft ball was placed between the patients thighs to work adductor muscle or between the patient feet and the edge of the dialysis chair to work ankle flexions and extensions.



Figure 1. Patient during its hemodialysis session. Elastic band position for resistance exercise

After a learning phase with no material, the exercise volume (number of sets and repetitions) or resistance (material possibilities) was progressively increased, based on Borg's scale of perceived exertion (from 6: very easier to 20: very very hard) after each exercise. A score of 17 needs a decrease of the exercise intensity whereas a score of 13, an increase of the exercise intensity [24].

2.2.2. Body Composition

The body composition measurements were carried out by means of an bioelectrical impedance analyzer (BIA) (TANITA MC-780). We obtained the body weight, body mass index (BMI), fat mass, muscle mass and lean mass for the whole body. The fat mass and the muscle mass were also obtained for the lower and upper extremities and the trunk [25].

To use the BIA, the patient must be fasting. Therefore, only the results of patients dialyzed during the morning sessions could be analyzed.

2.2.3. Food Behavior

The patients' food behavior was studied with the aid of three-day food records. The participants were given detailed instructions on how to complete the records. The

diet records were checked, coded, entered and analyzed with the use of the Nutrilog® software. The software databank is based on the French general food directory (CIQUAL). The total energy intake (TEI) as well as the macronutrient intake (carbohydrate, protein and fat) were determined [26,27].

2.2.4. Physical Capacities

The general physical capacities were evaluated with the 2-minute step test. This consists of raising bent legs alternately to mid-height between the hip and the patella for two minutes. The score is the number of times the patients raise their right leg. A score lower than 65 is a fall risk factor. The 2- minute step test substituted the 6-minute walk test when this latter was unrealizable (space and time). We can therefore compare the two tests [28].

The static balance was evaluated with the one-leg balance test. This consists of standing on one leg for as long as possible, for a maximum of 60 seconds. A time less than 30 seconds is a low fall risk factor and a time less than 5 seconds is a high fall risk factor.

The dynamic balance was evaluated with the Time Up and Go test. It consists of getting up from a chair, going around a cone situated at a distance of 2.44 meters and sitting back down. A time superior to 9 seconds is a high fall risk factor.

2.2.5. Measurements

All the measurements and evaluations (body composition, food behavior and physical capacities) were taken at the beginning (t_0) and at the end (t_3) of the study for the two groups.

2.3. Statistics

Statistica 7.1 was used for statistical analyses. A Shapiro-Wilk test was used for each variable to observe its normality. A Student t test or a Mann-Whitney test was subsequently performed in order to locate the differences.

The data collected are presented in mean \pm SD. The significance is set as $p \leq 0.05$.

3. Results

3.1. Anthropometric Characteristics

The results of the anthropometric characteristics presented no significant intra or inter-group differences regardless of the measurement period.

Table 1. Anthropometric characteristics at the beginning (t_0) and at the end (t_3) of the training program for both the physical group (PA) and the control group (C)

| | PA | | C | |
|-------------------------------------------|---------------|---------------|--------------|---------------|
| | t_0 | t_3 | t_0 | t_3 |
| Weight (kg) | 77.88 ± 13.88 | 78.03 ± 13.48 | 67.27 ± 9.9 | 67.51 ± 10.26 |
| Body Mass Index (kg/m²) | 28.4 ± 6.6 | 28.49 ± 5.93 | 24.13 ± 4.39 | 24.21 ± 4.59 |

Table 2. Bioelectrical impedance analyzer measurements at the beginning (t_0) and at the end (t_3) of the study for both the physical group (PA) and the control group (C).

| Unit kg | PA | | C | |
|--------------------------|------------|-------------|------------|------------|
| | t_0 | t_3 | t_0 | t_3 |
| Fat mass | 24.2 ± 9.7 | 24.4 ± 10.1 | 21.6 ± 8.4 | 21.7 ± 8.8 |
| Lean mass | 50.9 ± 6.8 | 51.3 ± 7.4 | 48.8 ± 7.9 | 49.3 ± 7.7 |
| Muscle mass | 48.4 ± 6.5 | 48.7 ± 7 | 46.3 ± 7.6 | 46.8 ± 7.3 |
| Bone mass | 2.6 ± 0.3 | 2.6 ± 0.3 | 2.5 ± 0.4 | 2.5 ± 0.4 |
| Trunk muscle mass | 28.3 ± 3.8 | 28.3 ± 4.1 | 27 ± 4.3 | 27.2 ± 4.2 |
| Arm muscle mass | 2.6 ± 0.4 | 2.6 ± 0.5 | 2.5 ± 0.4 | 2.5 ± 0.4 |
| Leg muscle mass | 7.4 ± 1 | 7.5 ± 1.1* | 7.2 ± 1.2 | 7.2 ± 1.2 |
| Trunk fat mass | 14.6 ± 8.3 | 14.7 ± 8 | 11.1 ± 3.3 | 11.2 ± 3.6 |
| Arm fat mass | 1.3 ± 0.8 | 1.3 ± 0.7 | 1 ± 0.5 | 1.1 ± 0.5 |
| Leg fat mass | 4.8 ± 2.3 | 4.7 ± 2.3 | 4.2 ± 1.9 | 4.2 ± 2 |

*: $p < 0.05$ between t_0 and t_3 for the PA group

Table 3. Food behavior record analyses at the beginning (t_0) and at the end (t_3) of the study for both the physical group (PA) and the control group (C).

| | PA | | C | |
|-------------------------------|---------------|-----------------|-----------------|---------------|
| | t_0 | t_3 | t_0 | t_3 |
| TEI (kcal) | 1593 ± 496.97 | 1457.17 ± 636.1 | 1309.8 ± 300.23 | 1629 ± 475.43 |
| kcal/kg of body weight | 20.45 | 18.67 | 19.47 | 24.13 |
| Protein (g) | 70.83 ± 26.58 | 65.11 ± 20.14 | 60.4 ± 26.37 | 71 ± 20.32 |
| % protein | 18.7 ± 5.03 | 18.82 ± 3.35 | 17.86 ± 3.88 | 17.7 ± 3.96 |
| g/kg of body weight | 0.91 | 0.83 | 0.9 | 1.05 |
| Fat (g) | 62.39 ± 21.5 | 53.5 ± 24.86 | 52.4 ± 18.66 | 66.4 ± 13.39 |
| % fat | 35.52 ± 6.2 | 33.83 ± 9.52 | 36.28 ± 10.6 | 37.82 ± 6.84 |
| g/kg of body weight | 0.8 | 0.69 | 0.79 | 0.98 |
| Carbohydrates (g) | 180.11 ± 69.3 | 173.06 ± 96.87 | 150.2 ± 48.45 | 183 ± 85.33 |
| % carbohydrates | 44.88 ± 6.12 | 46.6 ± 9.94 | 45.84 ± 9.69 | 43.48 ± 7.24 |
| g/kg of body weight | 2.31 | 2.22 | 2.23 | 2.71 |

3.2. Body Composition

As mentioned earlier, only the patients dialyzed during the morning sessions could realize the BIA measurement; a total of 8 patients in the PA group (IMC: 27.44 ± 5.41 kg/m²) and 5 patients in the C group (IMC: 25.34 ± 4.4 kg/m²). There was no significant difference in the Body Mass Index between the two groups.

The BIA measurement results presented no significant inter-group differences regardless of the measurement period.

For the PA group, we observed an increase in the leg muscle mass after the training program (t_0 vs t_3).

For the C group, no significant difference was observed.

3.3. Food Behavior

The three-day food record results presented no significant inter-group differences regardless of the measurement period. However, concerning fat intakes, a more significant trend was observed in the C group than in the PA group at the end of the study (t_3).

For the PA group, no significant difference was observed between the t_0 and the t_3 periods but decreasing trends in all of the food parameters were observed except for the carbohydrate intake.

For the C group, increasing trends were observed for the TEI and for the carbohydrate intake only between the two measurement periods.

Table 4. Physical capacity measurements at the beginning (t_0) and at the end (t_3) of the study for both the physical group (PA) and the control group (C)

| | PA | | C | |
|-----------------------------------------|--------------|---------------|---------------|---------------|
| | t_0 | t_3 | t_0 | t_3 |
| 2-min step (number of steps) | 71 ± 29 | 78 ± 25 | 80 ± 29 | 82 ± 36 |
| Time Up and Go (seconds) | 6.84 ± 3.24 | 5.99 ± 2.96 * | 5.77 ± 1.69 | 5.84 ± 2.66 |
| One leg balance (seconds) | 29.96 ± 23.7 | 32.47 ± 23.28 | 31.05 ± 27.35 | 34.19 ± 24.95 |

*: $p < 0.05$ between t_0 and t_3 for the PA group

3.4. Physical Capacities

The different physical capacity tests presented no significant inter group differences regardless of the measurement period.

For the PA group, we observed a significant decrease in the Time Up and Go test time between periods t_0 and t_3 and an increasing trend in the 2-min step test.

For the C group, no significant difference was observed.

4. Discussion

4.1. Anthropometric Parameters and Body Composition

Following our 3-month resistance training program, no significant differences were observed for either the body weight or the body mass index (BMI). Our results were contrary to those of Cheema et al. (2007) [29], who observed an increase in body weight and BMI after 36 resistance training sessions carried out by 24 hemodialysis patients, but were similar to those of Depaul et al. (2002)[29] and Headley et al. (2002) [31]. Depaul et al. studied the effects of a combined aerobic and resistance exercise program on 20 hemodialysis patients over a 36-session period. Headley et al. studied the effects of 24 resistance training sessions on 10 hemodialysis patients. We can hypothesize that a resistance training program alone can modify the body weight and the body mass index but the number of both the patients and the training sessions is determinant.

In our study, we also observed an increase in the leg muscle mass but no modification of the whole muscle mass. In fact, the MCID for lower-body muscle mass is 0.43 with a confidence interval 0.11 to 0.76 [32]. Statistical analyses showed a significant result for the leg muscle mass, even if it was at the lower limit of the confidence interval (t_0 : 7.4 ± 1 vs t_3 : 7.5 ± 1.1 kg). Whereas, for the whole muscle mass, the MCID is 0.34 with a confidence interval 0.05 to 0.63 [32] and statistical analyses did not show a significant result for this parameter (t_0 : 48.4 ± 6.5 vs t_3 : 48.7 ± 7 kg). The leg muscle mass increase was probably too low to observe a whole muscle mass increase.

Cheema et al. (2014) [32] observed the same results in 6 studies of varying duration. However, our results partially contrast with those of Chen et al. (2010) [33] who studied the effects of a 48-session resistance training program with the use of ankle weights on 22 hemodialysis patients. The authors observed an increase in the leg lean mass and the whole body lean mass and a decrease in the whole body fat mass. The duration of the program and the material used seemed to have a consequence on the body composition modifications.

4.2. Food Behavior

Concerning the food behavior, no significant difference was observed following the resistance training program. Our results are contrary to those of Castaneda et al. (1998) [34] who explained that in patients with chronic renal insufficiency, the total energy and protein intake are increased after resistance exercise due to its anabolic effect. No further data were available on the study subjects but we can hypothesize that the duration and/or the intensity of the resistance training program can have an effect. Moreover, Frey et al. (1988) [35] observed an increase in the total energy intake and no protein intake variation in 5 patients after a 12-week aerobic training program. It seems that short-term aerobic training programs would be more efficient.

In our study, the TEI of our patients represented 20.45 and 19.47 kcal/kg of the body weight for the physical activity group and the control group respectively and the protein intake represented 0.91 and 0.9 g/kg of the body weight for the physical activity group and the control group respectively. Our results were below the recommendations for this population per day (30-35 kcal/kg of body weight for the TEI [14] and 1.1-1.2 g/kg of body weight for the protein intake [16,36]), according to certain studies [11,17]. Protein intake and total energy intake below 0.8 g/kg of the body weight and 25 kcal/kg of the body weight involve malnutrition and muscle wasting respectively [18]. We could observe that the total energy intake is below the recommendations and the protein intake still higher. Maintaining correct protein intake despite lower total energy intake seems to prevent the negative effects of poor nutrition.

In our study, the lack of food behavior modifications following the training program and intakes below

recommendation could be explained by the difficulty in following the recommendation [11].

4.3. Physical Capacities

As previously mentioned, the 2-minute step test and the 6-minute walk test can be compared.

Concerning the physical capacities, an improvement in the Timed Up and Go test was observed following our resistance training program. The Minimal Clinically Important Difference for the Timed Up and Go test is 2.9 seconds. Moreover, in our study, the average age of the patients, male and female combined, was 58.5 years. The Timed Up and Go safe values for this age category are: <6 seconds for female and <5.6 seconds for men. Our data (t_0 : 6.84 ± 3.24 seconds vs t_3 : 5.99 ± 2.96 seconds) showed an improvement of this test result, close to the safe values.

The two other tests, the 2-minute step test and the one leg balance, presented no significant differences. The results of the Timed Up and Go test concurred with the studies of Bullani et al. (2011) [23] and Suzuki et al. (2018) [37]. Bullani et al. observed the effects of a 36-session resistance training program with the aid of elastic bands on 11 hemodialysis patients and Suzuki et al. observed the effects of another method of resistance training, electrical muscle stimulation, over an 8-week period. However, our results were contrary to those of Oliveros et al. (2011) [38] who observed an improvement in the 6-minute walk test after 16 weeks of a combined aerobic and resistance training program carried out by 5 hemodialysis patients. The combination of the two types of exercise seems to be more effective for this test. Oliveros's results were contradicted by Segura et al. (2009) [39] who compared the effects of the two types of exercise over a 6-month period and observed an improvement in the 6-minute walk test for the group who realized the resistance training program only. Ling et al. (2003) [40] studied the effects of a low intensity aerobic training program on 33 hemodialysis patients over three months and observed an improvement in the Timed Up and Go test but no modification of the 6-minute walk test. We can now hypothesize that the two types of exercise have some effects on physical capacities, but the duration of the resistance training program and the intensity of the aerobic exercise also play an important role.

5. Conclusion and Limits

It was interesting to note that after only 3 months of a resistance training program, an improvement was observed in the physical capacities using the Time Up and Go test and the leg muscle mass. However, with regard to existing literature, the duration and the intensity of the training program may have been insufficient in order to observe more significant results. Of course, the study

should be continued for longer periods of time in order to observe other results and to make more relevant conclusions. And more specific tools should also be used to improve the analysis of the parameters studied. But in our study, we would like to show that with a short adapted physical activity program (3 months), some benefits could be brought to hemodialysis patients. Therefore, our study encourages patients to participate in a regular physical activity because benefits could be observed quickly.

In addition, we wanted to use simple and easy ways to implement assessment and measurement tools to make physical activity more accessible in dialysis centers. Moreover, the combination of an aerobic and resistance training program is interesting and shows different complementary results.

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