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Original Article

Comparison between two physiotherapy protocols for patients with chronic kidney disease on dialysis

José Roberto Sostena Neto[1)], Letícia Magalhães Figueiredo e Castro[1)], Fernanda Santos de Oliveira[1)], Andréia Maria Silva[1)], Luciana Maria dos Reis[1)], Ana Paula Assunção Quirino[2)], Desanka Dragosavac[3)], Carolina Kosour[1, 3, 4)*]

[1)] *Nursing Department, Federal University of Alfenas, Alfenas-MG, Brazil*
[2)] *Hospital Casa da Caridade Alfenas Nossa Senhora do Perpétuo Socorro, Brazil*
[3)] *Division of Physiology and Metabology in Surgery, Department of Surgery, Medical Sciences Faculty, State University of Campinas, Brazil*
[4)] *Federal University of Alfenas (Unifal): Jovino Fernandes Sales Av., 2600-Building A, 37130-000, Alfenas-MG, Brazil*

Abstract. [Purpose] To compare the effects of two physiotherapy protocols for chronic kidney disease patients on dialysis. [Subjects and Methods] This is a prospective, randomized study, in chronic kidney disease patients 18 years of age or older on dialysis. Sessions for each group (were conducted three times per week for a total of 10 sessions), during hemodialysis. Respiratory muscle strength (maximal inspiratory and expiratory pressure), peak expiratory flow, and peripheral muscle strength were evaluated. The study group received motor and respiratory physiotherapy, and the control group received motor physiotherapy alone. [Results] We observed a significant increase in the maximal inspiratory pressure in the study group in the 5th and 10th sessions and in the maximal expiratory pressure in the 1st session, peak flow in the 1st and 10th sessions, and dynamometry in the 10th session. In the control group, there was a significant decrease in maximal inspiratory pressure in the 5th and 10th sessions, and in maximal expiratory pressure in the 10th session, peak flow in the 5th and 10th sessions, and dynamometry in the 5th session. [Conclusion] Implementation of motor physiotherapy combined with respiratory physiotherapy may have contributed to the improvement of the variables analyzed in the study group.

Key words: Renal failure, Renal dialysis, Physiotherapy

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INTRODUCTION

Chronic kidney disease (CKD) has a high morbidity and mortality rate. More than one million people require hemodialysis and kidney transplantation annually[1)].

CKD is defined as a slowly progressive and irreversible loss of kidney function, leading to a condition in which the kidneys are no longer able to function due to destruction of the nephrons, which reduces the ability of the body to sustain metabolic and hydroelectrolytic renal equilibrium. Kidney dysfunction is considered to occur when the glomerular filtration rate (GFR) falls below 60 ml/min/1.73 m^2, for longer than three months, and, end stage CKD occurs when the GFR falls below 15 ml/min/1.73 m^2. In this stage, hemodialysis (HD) is used to compensate for the reduced renal function. However, despite technological advancements, patients still have dysfunctions such as anemia, cardiomyopathy, depression, systemic arterial hypertension, metabolic and respiratory alterations, early fatigue, mental compromise, peripheral circulatory deficits,

*Corresponding author. Carolina Kosour (E-mail: carolina.kosour@unifal-mg.edu.br)

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and mental and muscular alterations, thus reducing their quality of life[2, 3].

It is known that a loss of muscle mass is associated with morbidity and mortality. The quantity of muscle fibers is strongly correlated with muscle strength, muscular oxygen extraction, and functional capacity in dialysis patients[4].

The muscles responsible for respiration, the diaphragm and intercostal muscles, are classified as skeletal muscles and can experience decreases in endurance and strength. Other pulmonary complications in chronic renal failure (CRF) patients include pulmonary edema, pleural effusion (mainly in terminal CRF patients), fibrosis, pulmonary and pleural calcification, pulmonary hypertension, capillary and pulmonary blood flow decreases, and hypoxemia[5].

Therefore, patients with CKD have less physical and functional capacity than the general population, and HD treatment limits the activity of these patients, which exacerbates functional limitations[6].

Accordingly, physiotherapy programs have been proposed that aim not only to treat the clinical manifestations of the disease but also the adverse effects on cardiorespiratory and muscular function, the quality of life, would be enhanced by improving metabolic, physiological and psychological conditions. The literature shows that physiotherapy, during the intradialytic period and during the intermission between sessions in CRF patients produces better functional literature shows that physiotherapy, during the intradialytic period and during, the intermission between sessions in CRF capacity, blood pressure control, cardiac function, and muscular strength and resistance, in addition to being a motivational factor and providing a break from the monotony of treatment, which can be an effective psychosocial intervention. The practice of regular physical exercise decreases the prevalence of associated diseases and systemic complications[7].

However, there are no reports in the literature showing the superiority of any physiotherapy protocol used in patients with CKD on HD. The present study aims to compare two physiotherapy protocols applied inchronic renal patients during HD treatment.

SUBJECTS AND METHODS

All participants were informed about the experimental procedures and provided signed informed consent. This was a prospective randomized clinical study. The patients were allocated into a study group and a control group. The effects of two physiotherapy protocols were compared in patients with CKD (Fig. 1).

The initial sample consisted of 22 patients with CKD on HD; however, two patients discontinued participation in the study. The inclusion criteria for participation consisted of the following: either gender, between 18 and 70 years old, patients at Hospital Casa de Caridade Alfenas Nossa Senhora do Perpétuo Socorro, Hemodialysis Section; HD three times per week, using a bicipital fistula for access.

Patients were excluded from the study if they had hemodynamic instability, pathologic fractures, cognitive deficits including uncoordinated use of an gadgets, uncontrolled diabetes mellitus (DM) or systemic arterial hypertension (SAH), or

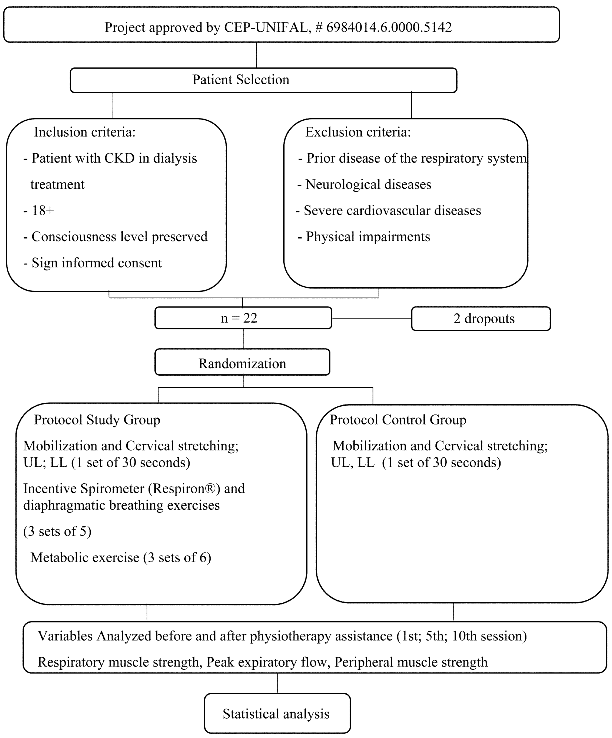

Fig. 1. Study flowchart

systemic diseases other than DM, SAH, and CKD.

All of the patients involved in the study were assisted by the same medical, nursing, and physiotherapy team.

Sessions were conducted (three times per week, for a total of 10 sessions) for each group during dialysis treatment. The patients were informed of the evaluation procedures and physiotherapy protocols during the study.

The patients were evaluated before and after the 1st, 5th, and 10th physiotherapy sessions.

The measured variables included the following:

-Respiratory Muscle Strength. At the beginning of the measurement, individuals were instructed to maintain mouth pressure to measure the maximal expiration capacity for 1.5 s to determine the maximal inspiratory pressure (MIP); then, maximal inspiration was measured for 1.5 s to determine the maximal expiratory pressure (MEP). The measures were repeated three times, and the highest value was used.

-Expiratory Peak Flow − This was measured with a PeakFlow Meter® Mini-wright Adult 3103. Expiratory, provided by the Federal University of Alfenas − MG UNIFAL. Peak flow was measured in a seated position to reduce obstruction of the upper airways. Three measurements were conducted, and the highest value was used.

-Peripheral Muscle Strength. This was measured with a hand-held hydraulic dynamometer (SAEHAN®-SH5001) provided by the Federal University of Alfenas − MG UNIFAL. Measurements were conducted with the patient seated, and the elbow of the arm without the fistula in 90° of flexion; the patient was asked to use maximal manual grip strength. Measurements were repeated three times, and the highest value was used.

-The respiratory frequency (RF), heart rate (HR), and systemic arterial pressure (AP) were measured before and after the physiotherapy sessions.

The physiotherapy protocols were conducted five min after the beginning of HD, with the approval of the physician and the responsible nurse on duty; the duration of the session was 40 min.

In the study group protocol, more structured and individualized procedures were conducted including motor physiotherapy with cervical mobilization (stretching, flexion, extension, lateral inclination, and rotation), upper limb (UL) exercises (shoulder, elbow, and fist flexion and extension), and lower limb (LL) exercises (flexion, extension, abduction and adduction) for 30 s for each series. Respiratory physiotherapy included exercises that utilized a Respiron® inspirometer provided by the Federal University of Alfenas − MG UNIFAL, for exercises involving the,diaphragmatic respiratory pattern that were conducted in three sets of five repetitions. Metabolic exercises included dorsiflexion and plantar flexion with the patient seated. Fifteen repetitions were performed for each limb.

The protocol in the control group consisted of motor physiotherapy, including mobilization and stretching of the cervical area (flexion, extension, lateral inclination and rotation), UL (shoulder, elbow, and fist flexion and extension), and LL (flexion, extension, abduction, and adduction), all protocols were conducted in 30 s series.

The Shapiro-Wilk test was used to determine data homogeneity. Independent t-tests and Mann-Whitney tests were used to compare variables between groups before the intervention. Paired t-tests and Wilcoxon tests were used for intragroup comparisons after the 1st, 5th and 10th and session. Two-way analysis of variance (ANOVA) was used for intergroup comparisons. Pearson's test was used to determine the correlation between respiratory variables and peripheral muscle strength. Statistical significance was determined by a value of $p<0.05$.

RESULTS

No significant differences were found between the groups for gender (p=0.49) and age (p=0.59). Table 1 shows that no significant differences were observed between the study and control groups during the pre-intervention period, thus showing that they were matched comparison groups.

Table 2 shows significant increases (in the MEP and MIP) in the study group after the protocol, including MEP (p=0.02) and peak flow (p=0.00) relative to the 1st session; CF (p=0.01) and MIP (p=0.00) relative to the 5th session; and HR (p=0.00), RF (p=0.01), MIP (p=0.01), peak flow (p=0.04), and dynamometry (p=0.00) relative to the 10th session using the paired t-test and Wilcoxon test.

Table 3 shows significant decreases in the control group after the protocol period including HR (p=0.04), MIP (p=0.04), MEP (p=0.06), peak flow (p=0.04), and dynamometry (p=0.00) relative to the 5th session, and MIP (p=0.00), MEP (p=0.02) and peak flow (p=0.00) relative to the 10th session using the paired t-test and Wilcoxon test.

Table 4, shows positive correlations between the respiratory variables MIP (p=0.00) and peak flow (p=0.01), and peripheral muscle strength at the 1st session; the MIP (p=0.00), MEP (p=0.00) and peak flow (p=0.04) at the 5th session; and the MIP (p=0.01), MEP (p=0.00), and peak flow (p=0.04) at the 10th session.

DISCUSSION

The respiratory system is affected by kidney disease and HD treatment. Alterations in the muscular respiratory, mechanical ventilatory, and pulmonary gas exchange functions are common in patients with CKD. This pulmonary dysfunction can be due to the direct effects of circulating toxins or the indirect effects of volume overload, anemia, immunosuppression, hypercalcemia, malnutrition and muscular weakness. Therefore, it is important to implement respiratory muscular training exercises during HD treatment[8]).

The present study showed the efficacy of a motor and respiratory physiotherapy protocol, conducted during the first two hours of HD treatment. The patients in the study group showed statistically significant improvements in muscular strength in all sessions compared with the values obtained before and after physiotherapy. The expiratory peak flow was increased at the 1st and 10th sessions relative to the pre- and post-physiotherapy values. Our findings demonstrate the importance of a more individualized treatment protocol for CKD HD patients.

Consistent with the present study, another study of 28 CKD HD patients showed increases in the MIP and MEP when

Table 1. Pre-intervention intergroup comparison of variables.

Variables	Study group	Control group
	Preintervention	Preintervention
HR (beats/min)	85.1 ± 16.2	82.7 ± 18.9
	73.4–96.7	69.1–96.2
RF (times/min)	20.9 ± 4.9	23.4 ± 8.9
	17.3–24.4	17.0–29.7
PO_2S (%)	95.2 ± 2.7	95.4 ± 2.5
	93.2–97.1	93.5–97.2
MIP (mmHg)	61.6 ± 26.9	59.6 ± 20.1
	42.3–80.8	45.1–74.0
MEP (mmHg)	78.8 ± 25.5	90.4 ± 26.0
	60.5–97.0	71.7–109.0
PEAKFLOW (ml)	358.0 ± 130.1	392.0 ± 132.9
	264.8–451.1	296.8–487.1
DYNAMOMETER (kg)	22.4 ± 9.1	29.2 ± 10.8
	15.8–28.9	21.4–36.9

HR: Heart Rate; RF: Respiratory Frequency; PO_2S: Peripheral Oxygen Saturation; MIP: Maximal Inspiratory Pressure; MEP: Maximal Expiratory Pressure; PeakFlow: Expiratory Peak Flow; Dynamometer: Peripheral Muscular Strength.

Table 2. Mean, standard deviation, and confidence intervals of the variables at the 1st, 5th, and 10th sessions for the study group (SG)

	SG (n=10)					
	1st Session		5th Session		10th Session	
	Before	After	Before	After	Before	After
	Mean ± SD		Mean ± SD		Mean ± SD	
	CI		CI		CI	
HR (beats/min)	85.1 ± 16.2	77.6 ± 9.6	82.9 ± 12.2	79.6 ± 10.0	83.9 ± 73.4	76.8 ± 15.2
	73.4–96.7	70.6 – 84.5	74.1–91.6	72.4–86.7	70.8–94.3	65.8–87.7*
RF (times/min)	20.9 ± 4.9	19.6 ± 5.5	19.7 ± 5.8	17.9 ± 5.5	21.3 ± 6.6	19.1 ± 6.0
	17.3–24.4	15.6–23.5	15.4–23.9	13.9–21.8*	16.5–26.0	14.7–23.4*
PO_2S (%)	95.2 ± 2.74	97.2 ± 2.4	95.5 ± 2.0	97.6 ± 0.8	94.7 ± 3.1	98.0 ± 0.4
	93.2–97.1	95.4–98.9	94.0–96.9	96.9–98.2	92.4–96.9	97.6–98.3*
MIP (mmH_2O)	61.6 ± 26.9	70.0 ± 21.0	73.6 ± 20.5	79.2 ± 22.0	75.6 ± 26.8	83.6 ± 25.7
	42.3–80.8	54.9–85.0	58.8–88.3	63.4–94.9*	56.3–94.8	65.1–102.0*
MEP (mmH_2O)	78.8 ± 25.5	90.0 ± 25.5	101.6 ± 21.9	102.8 ± 22.9	105.6 ± 18.4	107.6 ± 17.7
	60.5–97.0	71.7–108.2*	85.9–117.2	86.3–119.2	92.3–118.8	94.9–120.6
PEAKFLOW (ml)	358.0 ± 130.9	400.0 ± 109.9	398.0 ± 98.0	413.0 ± 94.0	403.0 ± 106.3	421.0 ± 97.6
	264.8–451.1	321.3–478.6*	327.8–468.1	345.7–480.2	326.9–479.0	351.1–490.8*
DYNAMOMETER (kg)	22.4 ± 9.1	22.6 ± 8.3	23.2 ± 11.7	23.2 ± 10.3	23.4 ± 11.0	25.2 ± 11.0
	15.8–28.9	16.6–28.5	14.8–31.5	15.7–30.6	15.5–31.2	17.3–33.0*

*p<0.05; SD: standard deviation; CI: confidence interval; HR: Heart Rate; RF: Respiratory Frequency; PO_2S: Peripheral Oxygen Saturation; MIP: Maximal Inspiratory Pressure; MEP: Maximal Expiratory Pressure; PeakFlow: Expiratory Peak Flow; Dynamometer: Peripheral Muscular Strength.

these measures were compared before and after physiotherapy. In this study, motor physiotherapy consisted of warm-ups, stretching, and aerobic exercises, with exercise cycles consisting of 60% of the maximal HR, as well as diaphragmatic breathing pattern exercises[9]).

However, the control group, which received only motor physiotherapy, showed significant worsening of muscular strength at the 5th and 10th sessions. The expiratory peak flow in this group was decreased in all sessions compared to the pre- and post-physiotherapy values.

Additionally, in a non-randomized experimental study of 13 CKD HD patients, the respiratory pressure (MIP and MEP) and expiratory peak flow were measured before and after physiotherapy during HD treatment. Motor physiotherapy consist-

Table 3. Mean, standard deviation and confidence intervals of the variables concerning the 1st, 5th and 10th session for the control group (CG)

	CG (n=10)					
	1st session		5th session		10th session	
	Before	After	Before	After	Before	After
	Mean ± SD		Mean ± SD		Mean ± SD	
	CI		CI		CI	
CF (beats/min)	82.7 ± 18.9	78.2 ± 15.8	90.0 ± 13.5	77.7 ± 14.0	78.6 ± 15.4	78.8 ± 14.7
	69.1–96.2	66.8–89.5	80.3–99.6	67.6–87.7*	67.5–89.6	68.2–89.3
RF (times/min)	23.4 ± 8.9	24.2 ± 7.3	20.2 ± 5.8	20.9 ± 7.4	20.1 ± 6.2	20.9 ± 3.9
	17.0–29.7	18.9–29.4	16.0–24.3	15.5–26.2	15.6–24.5	18.0–23.7
PO_2S (%)	95.4 ± 2.5	95.9 ± 2.6	96.1 ± 2.5	96.2 ± 1.5	96.3 ± 2.0	94.2 ± 2.9
	93.5–97.2	94.0–97.7	94.3–97.8	95.0–97.3	94.8–97.7	92.0–96.3
MIP (mmHg)	59.6 ± 20.1	63.6 ± 29.0	86.4 ± 26.4	79.6 ± 27.3	86.8 ± 24.5	78.4 ± 25.6
	45.1–74.0	42.8–84.3	67.4–105.3	60.0–99.1*	69.2–104.3	60.0–96.7*
MEP(mmHg)	90.4 ± 26.0	86.4 ± 30.2	104.0 ± 23.3	99.6 ± 24.4	106.8 ± 19.0	102.0 ± 22.7
	71.7–109.0	64.7–108.0	87.3–120.6	82.1–117.0	93.1–120.4	85.7–118.2*
PEAKFLOW (ml)	392.0 ± 132.9	415.0 ± 140.2	446.0 ± 116.9	427.0 ± 121.2	447.0 ± 118.8	422.0 ± 112.3
	296.8–487.1	314.6–515.3	362.3–529.6	340.2–513.7*	361.9–532.0	334.4–509.5*
DYNAMOMETER (Kg)	29.2 ± 10.8	28.2 ± 12.0	28.2 ± 11.0	26.4 ± 10.5	27.8 ± 9.9	26.8 ± 10.7
	21.4–36.9	19.5–36.8	20.2–36.1	18.8–33.9*	20.6–34.9	19.1–34.4

*p<0.05; SD: standard deviation; CI: confidence interval; CF: Cardiac Frequency; RF: Respiratory Frequency; PO_2S: Peripheral oxygen saturation; MIP: Maximal Inspiratory Pressure; MEP: Maximal Expiratory Pressure; PeakFlow: Expiratory Peak Flow; Dynamometer: Peripheral Muscular Strength.

Table 4. Correlation between respiratory variables and peripheral muscle strength after intervention

Sessions		Study group	Control group
		Dynamometer	Dynamometer
		r	r
1st	MIP	0.79*	0.83*
	MEP	0.60	0.64*
	PeakFlow	0.74*	0.82*
5th	MIP	0.77*	0.90*
	MEP	0.81*	0.67*
	PeakFlow	0.64*	0.78*
10th	MIP	0.74*	0.83*
	MEP	0.77*	0.64*
	PeakFlow	0.65*	0.75*

*p<0.05; MIP: Maximal Inspiratory Pressure; MEP: Maximal Expiratory Pressure; PeakFlow: Expiratory Peak Flow; Dynamometer: Peripheral Muscular Strength.

ing of resistance exercises of the ULs and LLs was conducted, but it did not result in significant improvements in the MIP and MEP. However, the peak flow values were increased compared to pre- and post-physiotherapy values[7)].

but this did not result in significant improvements in the MIP and MEP. However, the PeakFlow values were increased compared the pre and post physiotherapeutic assistance values[7)].

The mechanisms proposed in the literature to explain decreased respiratory muscular strength result from uremic myopathy. These mechanisms include decreases in muscle mass (transverse area section, mainly type II fibers), oxidative metabolism, muscular protein synthesis, and plasma calcium concentration[10–14)].

In a cross-sectional observational study comparing respiratory muscular strength (MIP and MEP) and expiratory forced flow (peak flow) in 32 CKD HD patients, with that of 30 healthy individuals, decreases in respiratory muscular strength and peak flow were observed in the patient group. These results showed that CKD HD patients exhibit respiratory muscular strength dysfunction due to the conditions of the disease and the treatment[5)].

Another clinical study involving 15 CKD HD patients conducted inspiratory muscular training with a Threshold Loaded IMT® provided by the hospital. The training protocol used 40% of the MIP measured in the first session; however, no significant increases in MIP, MEP and expired volume were observed after training[15)].

Another study in which the effect of a physiotherapy protocol using inspirometers in patients with pleural effusion (a condition that affects patients with CKD) was evaluated showed that at the time of admission, the parameters of the patients who received treatment with respiratory support were lower than those of patients who received only drug treatment and drainage. Moreover, radiological images showed an increase in lung expansion in the intervention group compared to the control group[16)].

Therefore, the present study shows that motor and respiratory physiotherapy can minimize the effects of uremic myopathy, and can improve pulmonary and muscular function and general clinical status.

According to some authors, HD promotes systemic degradation of muscles and proteins. The general muscular weakness observed in patients who undergo treatment predominately affects the lower limbs and proximal musculature. The skeletal muscular system demonstrates the most changes, including decreased physical capacity and reduced aerobic activity, in addition to decreased peripheral muscular strength[17–21)].

Studies have shown that stretching exercises are beneficial because they restore muscular physiological length and elasticity, which can be very helpful for reducing the incidence of cramps and minimizing the loss of muscle mass, in addition to promoting the necessary strength for the individual to perform his or her daily activities[6–8)].

Peripheral muscular and grip strength are important measures used to evaluate global muscular function. HD patients show compromised structural and muscular function, manifested by atrophy and decreased proximal muscular strength[22–25)].

A study of 43 patients undergoing HD treatment evaluated grip pressure strength, using a dynamometer, before and after dialysis; the study determined that patients showed a distinct loss of peripheral muscular strength[26)].

The present study showed an increase in peripheral muscular strength, which was measured by the analog manual grip pressure in the ULs using a dynamometry device at the 10th session in the study group, indicating that the proposed exercise protocol was effective in increasing muscular strength.

The control group showed decreased peripheral muscular strength in all sessions; however, a significant difference was only observed at the 5th session.

A study conducted on 13 CKD HD patients assessed peripheral muscular strength by measuring manual grip in the upper limbs, with a dynamometer before and after physiotherapy. The study used a protocol involving resistance exercises of the ULs and LLs for 24 sessions over two months that were applied during the first two hours of HD. The results indicated worsening of the dynamometry values after physiotherapy, but no significant difference was observed[7)].

One of the factors that possibly contributed to the improvement of peripheral muscular strength was the implementation of combined respiratory and motor physiotherapy. Increases in peripheral muscle and respiratory muscular strength (MIP and MEP) were observed, indicating that motor and respiratory exercises contributed to increasing global muscular strength.

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