

Assessment of respiratory function and quality of life of chronic kidney patients after physical activity in the Intradialytic period

Abstract

Introduction: Chronic Kidney Disease (CKD) is a progressive condition characterized by irreversible loss of kidney function, affecting millions of people globally and representing a serious public health problem. In the advanced stage of the disease, known as End-Stage CKD, an imbalance in body homeostasis occurs. Objective: To investigate how muscle strengthening affects the functional capacity and well-being of people with chronic kidney failure. **Methodology:** Randomized, blinded clinical teaching, long-term prospective cohort. Conducted at the Dr. Abelardo Santos Regional Hospital, with the application of three different physical activity protocols during hemodialysis in patients. Participants were distributed into three groups: Clinical Interval Exercise Group (G1), Clinical Continuous Exercise Group (G2) and Control Group (G3). Results: The results showed significant differences between the groups. The difference between the control group and the continuous group was 1098.91, with an adjusted p-value of 0.0000000, indicating statistical significance. The difference between the interval group and the continuous group was 1284.75, also with an adjusted p-value of 0.0000000, showing a significant difference. However, the difference between the interval group and the control group was 185.84, with an adjusted p-value of 0.3260391, indicating that this difference is not statistically significant.

Keywords: hemodialysis, muscle atrophy, respiratory function, quality of life, assessment

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Introduction

Chronic Kidney Disease (CKD) is a progressive condition characterized by irreversible loss of kidney function, affecting millions of people globally and representing a serious public health problem.¹ The kidneys perform vital functions in the body, such as filtering waste and fluids, maintaining acid-base and electrolyte balance, and producing hormones that regulate blood pressure and hematopoiesis.² When these functions are compromised, CKD can progress to end-stage renal failure, at which point Renal Replacement Therapies (RRT), such as hemodialysis, are necessary to perform the functions that the kidneys can no longer perform, being essential for maintaining life.³ Although RRT, such as hemodialysis, plays a crucial role in the treatment of CKD, they have a significant impact on the quality of life of patients, requiring constant adaptation and monitoring.¹ Diabetes mellitus and arterial hypertension are two of the main comorbidities associated with the development and progression of CKD. Diabetes, especially type 2, leads to an increase in blood glucose levels, which can damage blood vessels and kidney filters (glomeruli). This process is known as diabetic nephropathy, one of the most common complications of diabetes, which results in progressive loss of kidney function. Chronic hyperglycemia generates an overload of glucose in the kidneys, triggering an inflammatory response that culminates in damage to the glomeruli, increased thickness of the basement membrane and, eventually, kidney failure.^{4,5} In addition, inadequate blood glucose control can accelerate the progression of kidney disease, making adequate glucose management essential to prevent serious complications.¹ High blood pressure also has a deleterious effect on the kidneys. High blood pressure forces the renal blood vessels, contributing to the formation of lesions in the glomeruli and renal tubules, which compromises the organ's filtration capacity. High blood pressure can also favor renal fibrosis, accelerating the progression to chronic kidney disease (CKD). The interaction between

diabetes and hypertension is particularly detrimental, since these conditions often coexist in patients with CKD, potentiating kidney damage. It is estimated that approximately 30% to 40% of patients with type 2 diabetes develop some form of CKD, and hypertension is a factor that significantly aggravates this relationship.⁶⁻⁸ Globally, the countries with the highest numbers of patients diagnosed with CKD include the United States and Brazil, where prevalence rates have increased substantially in recent decades. In the United States, approximately 15% of the adult population is affected by CKD, with a higher prevalence among men.⁹ Brazil, in turn, has seen a significant increase in the number of patients with CKD, with more than 130,000 patients undergoing hemodialysis treatment, mainly due to the increase in risk factors such as hypertension and diabetes.¹⁰⁻¹²

CKD has a significant impact on skeletal muscles, leading to several complications, such as loss of muscle mass, muscle weakness and impaired motor function. Loss of muscle mass, known as sarcopenia, is one of the most common complications in patients with CKD and is strongly associated with disease progression. Several factors contribute to this muscle loss, including chronic inflammation, hormonal changes, protein malnutrition, and the accumulation of uremic toxins in the body.¹³ Persistent inflammation, common in advanced stages of CKD, promotes a catabolic environment in which accelerated breakdown of muscle proteins occurs, making it difficult for damaged muscles to regenerate and repair themselves.¹⁴ In addition, disturbances in hormone levels, such as parathyroid hormone (PTH) and vitamin D, exacerbate muscle weakness, since these hormones play an important role in regulating bone and muscle metabolism.¹⁵ Hemodialysis is the most common form of renal replacement therapy, and involves using a machine to filter blood outside the body, removing waste products and excess fluids. Hemodialysis is performed in weekly sessions and requires specific care to avoid complications.¹⁶ Hemodialysis patients must maintain

strict control of fluid intake, a balanced diet and blood pressure monitoring, in addition to being attentive to infection prevention, especially in the vascular access.¹⁷ Among the complications related to hemodialysis, pulmonary complications deserve special attention. Hypovolemia, hemodynamic instability during dialysis sessions and the accumulation of pulmonary edema can result in pulmonary edema, respiratory difficulty and, in severe cases, respiratory distress syndrome.¹⁸ Patients with CRF have severe impairment in both respiratory and motor function due to loss of muscle strength, especially due to the reduction of type I and II fibers, causing fatigue and functional limitation. Aspects such as quality of life are directly affected, leading to the development of psychosomatic illnesses, leading the individual to an even greater neuropsychomotor decline. Physiotherapy therefore seeks to understand these basic aspects to directly try to restore as much functionality as possible to the patient, in order to improve this physiological and consequently psychological condition so that there is an increase in survival and improvement in the quality of treatment. Therefore, the general objective of this study is to evaluate the respiratory muscles before and after physical activities in chronic kidney patients in the intradialysis period.

Material and methods

This is a randomized, blind, cohort, prospective, longitudinal clinical trial. The study was conducted in the hemodialysis sector of the Dr. Abelardo Santos Regional Hospital in Belem - PA, Brazil, from March to August 2024.

The sample was selected by convenience, and the project was presented in full to those who expressed interest in participating by signing the Free and Informed Consent Form. After that, they were randomized using the Randomizer® program, with a general profile sample, independent of gender, color, race, and social class, during the hemodialysis session, according to the evaluation of the multidisciplinary team of the sector, equally distributed into three groups: G1: Interval Group, G2: Continuous Group, and G3: Control Group. Individuals over 18 years of age were selected, with stable hemodynamic condition, heart rate above 60 bpm and below 130 bpm; systolic blood pressure above 90 mmHg and below 180 mmHg; mean arterial pressure above 60 mmHg and below 120 mmHg. Regarding breathing, the inclusion criteria are: respiratory rate above 10 bpm and below 25 bpm and oxygen saturation above 88%. Body temperature below 38.5°; blood glucose levels above 70 or below 200 mg/dl; lactate below 2 mmol/l; hemoglobin equal to or greater than 7 g/dl; platelets equal to or greater than 50,000 cells/mm³. The exclusion criteria for this study were defined in order to ensure sample homogeneity and the integrity of the data collected: Patients who refused to continue in the study, who had some problem that prevented them from performing physical activity, who developed flow difficulties in the arteriovenous fistula, who transferred to another hemodialysis center or who underwent a kidney transplant during the collection period. Finally, patients who died during the study period due to complications of the disease.

Lung ultrasound assessment protocol

Initially, the patient was positioned in bed, with the head elevated between 30 and 45°, and the Diaphragmatic Thickening Rate Assessment was initiated using a rectilinear transducer in the sagittal plane with the Probe Mark® ultrasound, model EDAN Acclarix-AX8. The equipment was positioned, pointing towards the head of the research volunteer. The same was placed over the apposition zone (za) (ninth intercostal space) and between the anterior axillary and mid-axillary lines. Afterwards, the evaluator recorded the values of the rate

of thickening during inspiration and expiration in 3 measurements, calculating the average to obtain the result. The rate of increase in thickness was determined by dividing the average thickness of the diaphragm during inspiration by the average thickness of the diaphragm during expiration, at 2 points. In addition, the fraction of increase in diaphragm thickness was calculated through an equation that involved subtracting the average thickness of the diaphragm during inspiration by the average thickness of the diaphragm during expiration, dividing the result by the average thickness of the diaphragm during expiration, and multiplying the value by 100. To ensure equality of evaluations, the values of Frequency (Hz), Post Focus, No Focus, Density, Power and Clear Tone were recorded, so that they could be repeated in the final evaluation.

Quality of life assessment

The Kidney Disease and Quality of Life Short-Form (KDQOL-SFTM) questionnaire was used in both the initial and final analyses of the study. This instrument, which has already undergone validation in Brazil, consists of 80 questions, including the Short Form Health Survey (SF-36) and 43 specific questions about chronic kidney disease (CKD). The SF-36 assesses eight dimensions: functional capacity, physical limitations, emotional restrictions, social interaction, mental health, pain, energy/vitality, and perception of overall health. In turn, the items focused on CKD are divided into 11 areas, covering symptoms, impact on daily life, burden, work, cognition, social relationships, sexual performance, sleep quality, social support, encouragement from the dialysis team, and patient satisfaction. In addition, the instrument includes a scale from 0 to 10 for assessing global health. The results are presented in scores ranging from 0 to 100, with higher values indicating a better health-related quality of life (HRQoL). The questionnaire also provides summary scores for physical and mental components, calculated based on specific items.¹⁹

Respiratory assessment

The strength of the respiratory muscles (both inspiratory (Pimax) and expiratory (Pemax)) was measured by manovacuometry, using the Analog Manovacuometer of -120/+120, with the average of the values obtained in 3 attempts in the first and last session.

Training protocol

During the first two hours of each hemodialysis session, 10 sessions were performed, divided into 3 times per week:

Individuals in G1 performed exercises using a cycle ergometer, following a programmed rest interval, as described:

- i. First week: The patient performed the physical activity with an effort intensity of «1 to 1», with a maximum duration of 5 minutes, alternating with 1 minute of rest between sets.
- ii. Second week: The total time dedicated to the exercise varied from 5 to 10 minutes, with a 1-minute break between sets, progressively increasing the frequency of use of the cycle ergometer.
- iii. Third week: The patient performed the exercise for a total period of 5 to 15 minutes, divided into 4 sets. Each set was followed by a 1-minute break, with a total effort of no more than 15 minutes.
- iv. Fourth week: The duration of the exercise varied between 5 and 20 minutes, maintaining the division into series, with 1-minute rest intervals between them.

The G2 group began the cycle ergometry protocol with a total duration of 10 to 20 minutes in the first training session. During the

rehabilitation process, the time was gradually increased to 30 to 40 minutes per session, with the intensity being progressively adjusted according to the symptoms described by the patients and respecting their resistance limits.²⁰ The volunteers in G3 were not subjected to the proposed experimental interventions, that is, they did not perform specific physical activities like the other groups. The main function of this group was to provide a baseline for observing and comparing variations in muscle function, respiratory capacity and quality of life.

Statistical analysis

The data were double entered, organized and processed using descriptive statistics in Excel spreadsheets (Microsoft Office® 365), determining the mean and standard deviation. In the inferential analysis, after determining the normality of the data, using the parametric ANOVA test and a Tukey post-hoc criterion for intergroup comparative analysis. In all tests, we used $p \leq 0.05$ for statistical significance and a 95% confidence interval. The tests were performed using the SPSS® 24 program.

Results

A total of 83 patients were selected, of which 23 were excluded due to: surgical procedures (3); low flow of arteriovenous fistula or catheter (2); kidney transplant (1); death due to complications of the disease (3); and patients who chose not to continue in the study (8); hemodynamic instability during exercise (3); skin lesion that prevented exercise application (2); rib fracture (1). A total of 60 individuals were distributed into 20 participants in G1, G2 and G3, according to randomization. After distribution, evaluation processes were performed to collect data to determine the sample profile (Table 1). The results of the multiple comparison analysis between the groups indicate that the mean difference between the control group and the continuous group was 72.21, with a confidence interval (CI) of -12.59 to 157.00 and an adjusted p-value of 0.11, suggesting that this difference is not statistically significant. The comparison between the interval group and the continuous group showed a mean difference of 107.00, with a CI of 18.44 to 195.56 and an adjusted p-value of 0.014, which indicates a significant difference between these two groups. Finally, the difference between the interval group and the control group was 34.79, with a CI of -50.00 to 119.59 and an adjusted p-value of 0.59, indicating that this difference is not statistically significant (Figure 1). The results indicate that there were significant differences

between the groups. The difference between the control group and the continuous group was 1098.91, with a confidence interval (CI) of 789.25 to 1408.57 and an adjusted p-value of 0.0000000, suggesting a statistically significant difference. The difference between the interval group and the continuous group was 1284.75, with a CI of 964.47 to 1605.03 and an adjusted p-value of 0.0000000, also indicating a significant difference. However, the difference between the interval group and the control group was 185.84, with a CI of -123.82 to 495.50 and an adjusted p-value of 0.3260391, indicating that this difference is not statistically significant (Figure 2). The results indicate that there were significant differences between the analyzed groups. The difference between the control group and the continuous group was 1863.75, with a confidence interval (CI) of 1628.43 to 2099.08 and an adjusted p-value of 0.0000000, suggesting a statistically significant difference. The difference between the interval group and the continuous group was 2390.99, with a CI of 2049.66 to 2732.33 and an adjusted p-value of 0.0000000, also indicating a significant difference. On the other hand, the difference between the interval group and the control group was 527.24, with a CI of 193.36 to 861.12 and an adjusted p-value of 0.0011009, indicating that this difference is also statistically significant (Table 2). The results indicate that the differences between some of the groups were statistically significant. The difference between the Control group and the Continuous group was -123.20, with a confidence interval (CI) of -149.79 to -96.61 and an adjusted p-value of 0.0000000, suggesting a significant difference. The difference between the Interval group and the Continuous group was -131.38, with a CI of -159.52 to -103.25 and an adjusted p-value of 0.0000000, also indicating a significant difference. However, the difference between the Interval group and the Control group was -8.19, with a CI of -35.16 to 18.78 and an adjusted p-value of 0.7470992, suggesting that this difference is not statistically significant (Table 3). The results indicate that there are no statistically significant differences between the compared groups. The difference between the Control and Continuous groups was 2.93, with a confidence interval (CI) of -9.76 to 15.62, and an adjusted p-value of 0.84, suggesting that the difference is not significant. For the comparison between Interval and Continuous, the difference was 11.03, with a CI of -2.26 to 24.32 and an adjusted p-value of 0.12, also without statistical significance. Finally, the comparison between Interval and Control resulted in a difference of 8.10, with a CI of -4.76 to 20.96 and an adjusted p-value of 0.29, again without significant difference.

Table 1 Distribution of KDQOL-SFTM domains in intragroup comparison

DOMAIN ₁	Total N = 60 ₂	Continuos N = 20 ₁	Control N = 20 ₁	Intervalled. N = 20 ₁	p-value ₁
Age ₃	54 (13)	60 (13)	52 (13)	52 (12)	0.3
Emotional well-being ₃	270 (123)	209 (169)	281 (71)	316 (95)	0.042
Pain ₃	115 (64)	89 (61)	136 (64)	116 (60)	0.056
Energy/fatigue ₃	165 (93)	64 (21)	199 (69)	224 (81)	<0.001
Emotional Function ₃	99 (95)	44 (38)	119 (105)	131 (103)	0.02
Physical function ₃	17 (124)	27 (35)	132 (128)	189 (124)	<0.001
Social Function ₃	118 (55)	64 (25)	145 (51)	139 (43)	<0.001
General health ₃	197 (121)	43 (17)	270 (54)	264 (89)	<0.001
Effects of kidney disease ₄	366 (256)	62 (16)	509 (156)	499 (216)	<0.001
Encouragement from the dialysis team ₄	148 (57)	77 (20)	182 (37)	178 (31)	<0.001
Cognitive function ₄	143 (98)	65 (32)	141 (107)	226 (60)	<0.001
Sexual function ₄	94 (74)	30 (47)	119 (52)	193 (19)	<0.001
List of symptoms ₄	618 (414)	70 (17)	842 (208)	899 (228)	<0.001
Professional role ₄	23 (48)	15 (29)	25 (53)	30 (57)	>0.9
Quality of social interaction ₄	143 (86)	58 (25)	138 (60)	234 (55)	<0.001

Table 1 Continued.....

Patient satisfaction ₄	73 (25)	79 (33)	74 (18)	66 (21)	0.041
Kidney disease burden ₄	123 (116)	36 (23)	138 (110)	194 (126)	<0.001
Sleep ₄	180 (101)	59 (21)	248 (57)	218 (81)	<0.001
Social support ₄	118 (67)	67 (34)	135 (68)	148 (62)	<0.001
Total SF-36	1,184 (698)	375 (163)	1,474 (437)	1,660 (559)	<0.001
Total QRVS	1,757 (1,042)	551 (121)	2,415 (381)	2,942 (472)	<0.001

1, Parametric Test ANOVA; 2, Average (SD); 3, Domain SF-36; 4, Domain QRVS

Table 2 Comparison of intergroup MIP values based on group characteristics

Features ₁	Total N = 60 ₂	Continuos N = 20 ₁	Control N = 20 ₁	Intervalled N = 20 ₁	p-value ₁
Pimax	-21 (70)	65 (39)	-58 (27)	-66 (44)	<0.001
Age	54 (12)	58 (12)	52 (13)	52 (12)	0.3
Gender					0.4
F	31/64 (48%)	9/20 (45%)	14/24 (58%)	8/20 (40%)	
M	33/64 (52%)	11/20 (55%)	10/24 (42%)	12/20 (60%)	

1, Parametric test ANOVA; 2, Average (SD); n/N (%)

Table 3 Comparison of intergroup MEP values based on group characteristics from the sample

Features ₁	Total N = 60 ₂	Continuos N = 20 ₁	Control N = 20 ₁	Intervalled N = 20 ₁	p-value ₁
Pemax	53 (18)	49 (18)	52 (18)	60 (16)	0.044
Age	54 (12)	58 (12)	52 (13)	52 (12)	0.3
Gender					0.4
F	31/64 (48%)	9/20 (45%)	14/24 (58%)	8/20 (40%)	
M	33/64 (52%)	11/20 (55%)	10/24 (42%)	12/20 (60%)	

1, Parametric test ANOVA; 2, Average (SD); n/N (%)

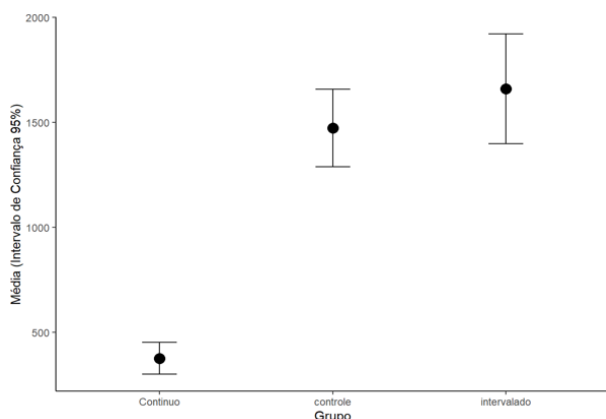


Figure 1 Comparison of total SF-36 scores between groups.

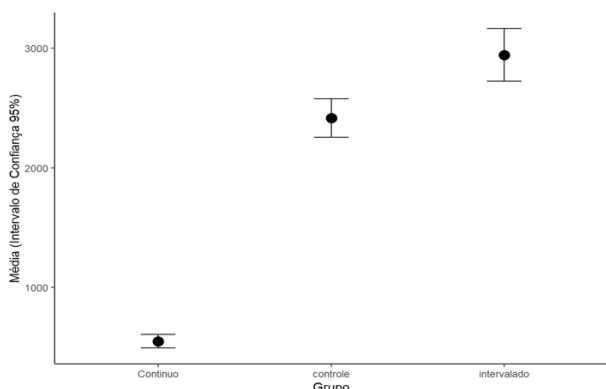


Figure 2 Comparison of total QRVS values between groups.

Discussion

This study evaluated the correlation between respiratory function and quality of life in chronic kidney patients after practicing physical activity during the intradialysis period. It was found that patients with CKD participating in the interval group (G1), when compared to the other groups, G2 and G3, presented higher means in the distribution of the KDQOL-SFTM domains. When comparing the means of SF-36 and QRVS between the groups, it was observed that participants in G1 presented higher means, showing a significant difference from the continuous group (G2). These findings corroborate the results found in a study,²¹ which aimed to evaluate the level of physical activity (PAL) of patients with CKD on hemodialysis and correlate it with HRQoL. The authors were able to verify that active patients presented a better perception of HRQoL, in all dimensions, when compared to insufficiently active patients. Based on Spearman's correlation coefficient, it can also be suggested that the practice and good levels of physical activity tend to contribute to better HRQoL scores in patients undergoing hemodialysis. Also in this context, in their systematic review and meta-analysis, it was found that intradialytic exercise improves, with some certainty, peak VO_2 , hemoglobin, depression and the physical component of QoL. Thus, the authors suggest that performing intradialytic exercises for 30 minutes per session three times a week for at least ≥ 8 weeks is beneficial, thus, regular exercise should be considered a crucial therapeutic modality for the management of patients undergoing HD, thus guiding clinical practice.²² When analyzing the respiratory function of the participants by comparing the values of Pimax (maximum inspiratory pressure) and Pemax (maximum expiratory pressure), between the groups, according to the main characteristics of the sample (sex and age), it can be observed that, when checking the Pimax values, groups G1 and G2 presented a statistically significant difference when compared to each other, with the interval group (G1) presenting the greatest values

of improvement in respiratory function. However, when checking the P_{max} values, the results did not present statistically significant differences between groups G1, G2 and G3.

Similar to the findings of the present study,²³ it was also possible to verify an increase in MIP after physical activity. The authors emphasize that in the comparison between the groups, no differences were demonstrated, suggesting a similar increase in MIP after Inspiratory Muscle Training (IMT), Aerobic Training (AT) and Combined Training (CT). Furthermore, the increase in MIP after all interventions was greater than the minimum clinically important difference in individuals with chronic respiratory disease. The results of a training protocol with a cycle ergometer during hemodialysis sessions on the respiratory function and functional capacity of patients with chronic kidney disease on hemodialysis show that the patients presented positive clinical evolution in relation to respiratory parameters. The improvement in MIP and MEP after the intervention in patients in the treatment group indicated clinical progression. This can be explained by the training cycle based on the cycle ergometer, which improved the recruitment of type I fibers in the muscles of the lower limbs and resulted in cardiac conditioning, which is reflected in respiratory function.²⁴ Other authors also addressed the effects of combined intradialytic exercises using a cycle ergometer, which offered two exercise modalities to analyze hemodialysis efficiency, blood pressure, exercise capacity, and quality of life. The program consisted of forty minutes of exercise, performed 3 times a week, for 24 weeks. An increase in the Kt/V rate and in the distance covered in the 6MWT could be observed, indicating a better quality of post-exercise dialysis and an increase in submaximal exercise capacity. There was also a significant reduction in systolic and diastolic blood pressure. However, the results did not show significant changes in quality of life indices.²⁵ In general, researchers state that performing intradialytic exercises usually has a positive impact on rebound, which is one of the factors that most contributes to improving the quality of dialysis, due to cardiovascular and lymphatic changes caused by exercise. However, it is directly linked to the intensity, modality and frequency with which the exercise is performed, and the time of evaluation after the intervention will also be reflected in it, the longer this time, the greater the chance of an increase in this rebound.²⁶ It is worth mentioning that even though intradialytic exercises are well explained in the literature, the implementation of exercise programs is still considered a major challenge within large centers, either due to barriers raised by the patients themselves or due to the lack of resources/materials. However, this research has important relevance in the clinical/hospital environment of the treatment of these patients, enabling the proof that intradialytic rehabilitation programs can provide CRPs with better quality treatment, improving the physiological aspects and physical-functional characteristics that directly reflect on the quality of life.

Conclusion

Despite the fact that intradialytic exercises are well explained in the literature, the implementation of exercise programs is still considered a major challenge within large centers, either due to barriers raised by the patients themselves or due to the lack of resources/materials. However, this research has important relevance in the clinical/hospital environment of the treatment of these patients, enabling the proof that intradialytic rehabilitation programs can provide CRPs with better quality treatment, improving the physiological aspects and physical-functional characteristics that directly reflect on quality of life. Therefore, we hope that more studies with new types of approaches for this population can be carried out in order to provide better survival for chronic kidney patients.

Acknowledgments

None.

Conflicts of interest

The authors declares that there are no conflicts of interest.

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