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ORIGINAL ARTICLE

The effects of aerobic exercise on biochemical parameters in individuals with CKD on hemodialysis: A longitudinal study

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Abstract

Backgroung: Chronic kidney disease is directly related to cardiovascular disorders. Guided physical exercises significantly improve the adverse effects of dialytic treatment.

Objective: To analyze changes in biochemical parameters of subjects with chronic kidney disease undergoing moderate exercise during hemodialysis.

Methods: This is an experimental study composed of 54 subjects submitted to hemodialysis, split into a control group and a group with intervention. The experimental group underwent three weekly sessions of aerobic exercise, performed during hemodialysis sessions, with a duration of 30 minutes, for 12 weeks. The blood parameters of both groups were compared.

Results: Statistically significant differences were observed between pre (p=0.001) and post-exercise protocol for urea (p=0.006), calcium (p=0.001), alanine aminotransferase (p=0.020) and sodium (p=<0.001). In the control group, we observed significant differences for the calcium variable (p<0.001), alanine aminotransferase (p=0.024), hematocrit (p=0.015), calcium vs phosphorus (p=0.018), and sodium (p=0.023), before and after the period.

Conclusion: Aerobic training during hemodialysis was able to maintain blood level stability in patients with chronic kidney disease, both during and at the end of the protocol, even considering increased blood flow. This trial is registered in the Brazilian registry of clinical Trials - number RBR-7354r6. Registration date: July 5, 2018 at 12:59 PM. Last Update: July 24, 2018 at 10:24 AM. Identification of the test - UTN Number: U1111-1216-8272.

Keywords: Chronic kidney disease, hemodialysis, blood parameters, aerobic exercises.

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Authors summary

Why was this study done?
Chronic kidney disease is one of the major health problems worldwide, because in addition to the disease, we have associated comorbidities increasing morbidity as well as mortality. Physical exercise is a great ally, having beneficial effects on patients with CKD, and with that, this study was done to analyze the effects of aerobic exercise on the biochemical parameters of patients with CKD during hemodialysis.

What did the researchers do and find?
The researchers worked with two groups of patients on hemodialysis (control group and intervention group). The intervention group underwent 3 months of aerobic exercise on a cycle ergometer for 30 min three times a week. We performed analyzes of the blood parameters of the two groups at three times: at the beginning before we started to apply the protocol. After 45 days of exercise and three months after the exercise intervention. When comparing the two groups, the researchers found no significant differences in the parameters evaluated.

What do these findings mean?
This discovery means that when comparing the two groups of the project after 3 months of aerobic exercise 3 times a week, we did not have changes in blood levels of urea, creatinine, calcium, phosphorus, pyruvic glutamic transaminase, glucose, potassium, hemoglobin, hematocrit, calcium , phosphorus and sodium in patients with chronic kidney disease. They demonstrate that patients with CKD on hemodialysis have great weakness in their health, because a safe aerobic exercise intervention was not able to significantly improve their blood parameters when compared to a group that did not undergo this intervention. More efficient mechanisms in the treatment of this disease should be investigated.

INTRODUCTION

The increase in chronic and degenerative diseases, such as chronic kidney disease (CKD), constitutes one of the most significant challenges of public health, as it is considered a worldwide social and economic problem, and associated to many co-morbidities, as well as to high expenses in public health[1,2].

Subjects with CKD present less aerobic strength and functional capacity when compared to healthy inactive people[3]. Low cardiopulmonary and functional capacity are associated with higher mortality risk, hospital admissions, and co-morbidities in subjects in this population[4,5]. On the other hand, several types of exercises proved to improve tolerance to exercise and optimize physical activity in subjects undergoing hemodialysis (HD)[6,7].

Regular physical exercise not only improves physical fitness, but also plays a beneficial and potentially therapeutic role in adults with CKD, through blood pressure control, a decrease in resting heart rate, and decrease in inflammatory cytokines[8,9].

During exercise, the muscular system's energy demand increases oxygen consumption to a level 10 to 20 times higher than in rest[10]. This induces increased ROS flow in muscle fibers[11]. A response to the increase in ROS during physical training, especially when not exhaustive, is the induction of enzymatic Endogenous Antioxidant System (EAS) activation, which regulates enzymes such as Glutathione Peroxidase (GPx), Glutathione Reductase (GR) and Catalase (Cat) and Superoxide Reductase (SOD)[12,13].

Subjects under HD undergo deconditioning and low tolerance to physical activities. Such elements seem to be related to muscle atrophy, uremic muscle dysfunction and malnutrition[11,14]. The presence of circulating toxins, the excess of body fluids, electrolytic disorders, nutrition alterations, inactivity and proinflammatory substance release, contribute directly or indirectly to the decrease of survival in subjects under HD[15].

Qiu *et al.*[16], conducted a meta-analysis about physical exercise in patients with Chronic Renal Failure; the researchers concluded the exercises programs improved body function and physical capacity in patients with hemodialysis. The benefits are in blood pressure and maximal oxygen consumption. When a decline of renal function occurs, there is a progression of disorders in mineral metabolism, deregulating plasma levels and tissue concentrations of calcium, phosphorus and potassium, which are common complications of CKD, a significant cause of morbidity and decrease in quality of life. There is increasing evidence suggesting that these disorders in mineral and bone metabolism are associated with an increased risk of cardiovascular calcification, morbidity and mortality.

Research that can investigate better ways to achieve positive results, with the intention of producing new knowledge and becoming products that better the health of the population. This could be a new diagnosis, new therapeutic treatments or aimed at promoting population health[17,18]. Corroborating the authors, the study followed a protocol of safe and reliable quality in its execution and data generation, providing reliable information for the health area.

We raised the hypothesis that aerobic exercise training during hemodialysis could improve biochemical markers in CKD subjects. In this sense, we aimed to analyze the changes in biochemical parameters of subjects with chronic kidney disease undergoing moderate exercise during hemodialysis.

METHODS

This study followed the guidelines of research involving humans. It was approved by the Ethics Committee in Research, of the Faculdade de Juazeiro do Norte, by number 1,962,092. All subjects that agreed to participate in the research signed an informed consent. This trial is registered in the Brazilian registry of clinical Trials - number RBR-7354r6.

It was an experimental study composed of 248 subjects from the Sistema Único de Saúde (SUS) in HD treatment for at least six months, 3 times a week, ambulatory, of both genders, with age ≥18 years. We selected a control group (n=27) and an intervention group (n=27) with a protocol of three weekly sessions of aerobic exercise, during the HD sessions, for 12 weeks. The research was conducted on 54 subjects (Figure 1). We performed studies on the blood parameters of all of them.

The study included patients with unstable angina, uncontrolled hypertension (systolic blood pressure, SBP: 200 mmHg and / or diastolic blood pressure, DBP: 100 mmHg), use of antiarrhythmic drugs, severe lung disease, acute systemic infection, severe renal osteodystrophy, neurological disorders, disabling musculoskeletal disorders and patients with lower limb access.

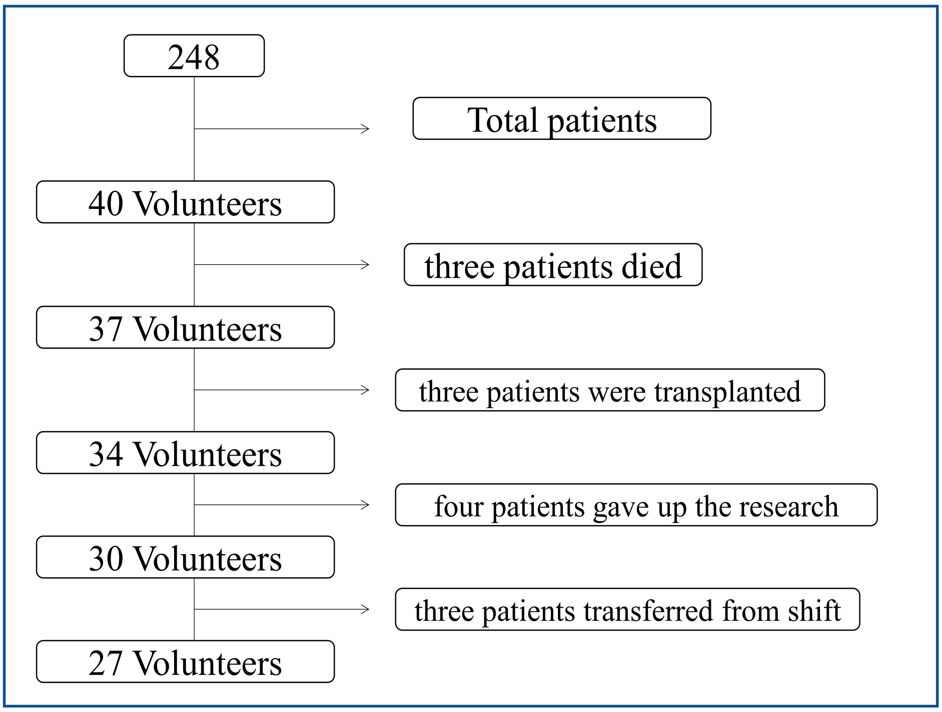

Figure 1: Flow chart of sample loss in the study. Source: Investigator's archive.

At the Nephrology unit, the HD sessions are held in four shifts from Monday to Saturday, divided into Monday, Wednesday and Friday and Tuesday, Thursday and Saturday, starting the first sessions at 5:00 p.m. and ending at 01:30 p.m., the following day. We initially selected 54 patients in two screening groups, in the first two shifts (5:00 to 9:30 and 10:00 to 14:00).

We selected, in the control group, patients with the same characteristics as the intervention group, taking into account the age range, time of treatment, presumed etiology of the disease, socio-demographic characteristics. The main findings of these characteristics are found in the Results section.

Program of aerobic exercise performed during HD

It is understood the importance of emphasizing the scientific method as a way to develop scientific research[19]. Following these guidelines, our protocol was directed according to Morais, where supervised aerobic training was performed in the initial two hours of hemodialysis, lasting 30 minutes. An ergometer cycle was used (Mini Bike Compact – E 14) with multifunction LCD: Scan, Time, ODO-RPM, distance, calories, speed, measuring (height x length x width: 49x41.5x34.5 m) to perform the aerobic exercise[20].

The subjects performed the aerobic exercises in cyclic movements of lower limbs with 45 to 60% of maximum predicted heart rate (Maximum heart rate=220 – age)[19]. They were directed to have their arms extended as usual, at length reaching the hips, close to the body, arranged as pleasantly as possible. They started with the tolerated time and were encouraged to increase the intensity to achieve a set zone, and if possible even exceed their upper limit, until reaching the intervention time[21].

In all the stages, the supplementary data of the subjects were collected through their clinical histories filled by the medical team of the hospital (age, gender, blood pressure, and heart rate measurement).

The criteria to interrupt the aerobic exercise included intense physical tiredness, chest pain, dizziness, pallor, fainting, tachycardia, hypotension and lower limbs fatigue, interdialytic weight gain greater than 5 kg, difficulty in vascular access and some significant complaint (pain, dyspnea, etc.) before or during training. In these cases, they were prevented from doing exercises on that day or while such alterations persisted, or according to the medical prescription of the sector. No patient was ill or had any undesirable symptoms that we had to discontinue the exercise with the cycle ergometer exercise.

The subjects blood parameters were evaluated monthly at the hospital of the clinics of Rio Branco, Acre, Brazil, in the department of Nephrology. In this way, during September, October, November and December, we took the blood results on the following parameters: Pre and post urea; Creatinine; Calcium; Phosphorus; pyruvic glutamic transaminase (GPT); Glucose; Potassium; Hemoglobin; Calcium, Phosphorus and Sodium. In this way, the subjects performed the exercises proposed in our work, and simultaneously, we collected the same blood parameters within their routine evaluations monthly.

Statistical analysis

The qualitative variables are presented by absolute and relative frequency and the quantitative variables are given by central tendency and variability measures, according to the normality test (Shapiro-Wilk test).

In order to evaluate the blood parameters before, during and after hemodialysis in the intervention group and in the control group, the Friedman test was used with post-test of pairwise comparison. Only the creatinine variable was compared before and after hemodialysis according to the group; this was made by Wilcoxon's test. A delta (Δ) was created by subtraction of the pre-HD time by the post HD time. To compare the deltas (Δ) of the blood parameters according to the type of treatment made, the Mann-Whitney test was used.

The magnitude of the difference between the groups of the biochemical parameters by the Cohen d test was calculated. The effect size was considered small (<0.5), medium (0.5 to 0.9) and large (> 0.9).

The level of significance adopted for this analysis was $p<0.05$. The statistical software used was Stata, version 11.0

RESULTS

A total of 54 patients were selected, 27 from the intervention group and 27 from the control group. The average age of the intervention group was 42+13 years, height of 1.59+0.08m, and weight was 64+15Kg. The control group, mean age was 46+15 years, with a mean height of 1.57+0.09m and weight average of 68+17Kg.

When analyzing Table 1, the intervention group, it shows an improvement in systolic blood pressure, from 160 mmHg to the beginning of the intervention to 150 mmHg three months later. In relation to diastolic blood pressure, the initial measure was 91 mmHg and after three months decreased to 90 mmHg remaining stable.

In the heart rate assessment, it started with an average of 86.47 beats per minute, ended with an average of 105.11 beats per minute, with an increase of 18.64 bpm after three months. Considering that heart rate average of 105 bpm is defined as a safe value and at the same time much better than what was started, we concluded that the patient's physical conditions improved at the end of the program. The control group, on the other hand, maintained an average of these same variables over the same three months, with no significant changes, as well as keeping the results very close to the intervention group (Table 1).

Table 1: Comparison of in the intervention group and the group without intervention. Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), mean BP, Heart Rate (HR), Age, Height, Weight and Body Mass Index (BMI) of patients with CKD in aerobic training during Hemodialysis. Rio Branco, Acre State, Brazil 2017.

Variables	Intervention				No intervention			
	Start	After 20 sessions	End (39 sessions)	p*	Start	After 20 sessions	End (39 sessions)	p*
	Median (CI 95%)				Median (CI 95%)			
SBP(mmHg)[2]	160+24	148±11,05	150±13,68	0.18	157+22	149±10,02	148±12,57	0.16
DBP(mmHg)[2]	91+35	88±11,05	90±8,59	0.10	89+37	89±11,10	93±9,51	0.12
mean BP	123+37	118+34	117+35		121+35	114+31	116+36	
HR	86+12	98+15	105+16	0.01	81+11	99+14	94+11	0.10
Age	42.+13				46.+15			
Height	1.59+0.08				1.57+0.09			
Weight	64+15				68+17			
BMI	25+4,96				27+5,91			

OBS: SBP, DBP and HR analyzed at the beginning of the intervention, 45 days after the intervention and at the end of the 90 days of intervention.

In the comparison of blood parameters before, during and after hemodialysis for the intervention group, statistically significant differences were observed for urea (p=0.001, before vs during and after HD; p=0.006, before vs during HD), calcium (p=0.001, before vs during and before vs after HD), pyruvic glutamic transaminase (GPT) (p=0.020, before vs during HD) and sodium (p=<0.001, before vs during and before vs after HD) (Table 2).

When the blood parameters were compared before, during and after HD in the control group, we also observed significant differences for the calcium variable (p<0.001, before vs during and before vs after HD), GPT (p=0.024, before vs after HD), hematocrit (p=0.015, during vs after HD), calcium vs phosphorus (p=0.018, before vs during HD) and sodium (p=0.023, before vs during HD) (Table 2).

When comparing blood parameters between trained and control groups, no statistically significant differences were observed between all parameters analyzed (p>0.05) (Table 3).

Table 2: Comparison of blood parameters before, during and after hemodialysis in the intervention group and the group without intervention.

Variables	Intervention				No intervention			
	Before	During	After		Before	During	After	
		Median (CI 95%)		p*		Median (CI 95%)		p*
Pre HD urea	140.0 (113.7; 153.0)	148.5 (139.3; 165.7)a	152.0 (135.7; 170.4)b	0.001	136.0 (108.0; 146.0)	140.0 (119.5; 161.6)	144.0 (131.4; 160.4)	0.129
Post HD urea	24.5 (10.0; 38.5)	48.5 (31.4; 57.5)a	41.5 (36.4; 47.6)	0.006	34.0 (28.9; 44.1)	41.0 (31.3; 53.1)	40.0 (33.7; 48.1)	0.091
Creatinine#	13.1 (11.5; 14.8)	-	14.1 (13.1; 15.5)	0.077	11.8 (11.0; 13.9)	-	12.8 (11.8; 13.5)	0.441
Calcium	8.7 (8.3; 8.8)	8.9 (8.7; 9.3)a	9.2 (8.9; 9.5)b	0.001	8.7 (8.4; 9.0)	9.4 (9.1; 9.8)a	9.4 (9.0; 9.7)b	<0.001
Phosphorus	5.2 (3.9; 6.1)	4.6 (3.8; 5.7)	4.6 (3.3; 5.4)	0.555	3.9 (2.9; 5.4)	4.3 (3.4; 5.5)	4.4 (3.7; 5.5)	0.049
Pyruvic Glutamic Transaminase	10.0 (7.0; 11.0)	12.5 (10.4; 15.0)a	10.0 (9.0; 13.1)	0.020	11.0 (7.0; 12.0)	12.0 (8.9; 14.0)	12.0 (9.9; 15.1)b	0.024
Glucose	89.0 (74.8; 98.0)	94.5 (87.3; 108.4)	89.0 (83.9; 100.5)	0.618	87.0 (76.0; 109.0)	100.5 (86.4; 128.8)	102.0 (91.9; 114.6)	0.104
Potassium	4.6 (4.1; 4.9)	5.0 (4.7; 5.2)	4.7 (4.3; 5.2)	0.142	4.9 (4.3; 5.4)	5.1 (4.8; 5.5)	4.8 (4.5; 5.4)	0.165
Hemoglobin	10.7 (9.8; 11.0)	10.7 (10.2; 11.4)	10.3 (9.5; 11.6)	0.857	10.7 (9.4; 11.4)	10.1 (8.9; 11.8)	10.0 (8.3; 12.0)	0.459
Hematocrit	32.9 (29.9; 35.4)	32.8 (30.4; 34.8)	32.7 (29.2; 35.7)	0.857	32.4 (29.2; 34.9)	29.9 (26.9; 35.3)	31.8 (25.9; 36.9)c	0.015
Calcium vs Phosphorus	45.2 (35.6; 50.5)	40.2 (35.7; 50.4)	41.3 (31.3; 51.0)	0.459	36.1 (25.8; 48.2)	39.5 (32.3; 50.0)a	40.0 (34.1; 54.6)	0.018
Sodium	137.0 (134.9; 138.0)	140.5 (139.9; 141.5)a	141.0 (139.0; 143.0)b	<0.001	138.0 (136.0; 138.0)	140.5 (139.4; 141.0) a	140.0 (138.0; 141.0)	0.023

* Friedman test. 95% CI: 95% confidence intervals. #There was no comparison with the time due to lack of data in this period, the Wilcoxon test performed; hemodialysis (HD)
a Comparison between the moments during vs before.
b Comparison between the moments after vs before.
c Comparison between the moments after vs during.

Table 3: The difference (Δ) of blood parameters according to the type of treatment

Variables	Intervention	No intervention		
	Median (CI 95%)		p*	Effect size**
Pre HD Urea	24.0 (14.5; 33.2)	9.0 (-8.2; 29.2)	0.319	0.12
Post HD Urea	11.0 (1.6; 26.7)	8.0 (-2.0; 12.1)	0.331	0.06
Creatinine	1.8 (-0.1; 3.3)	0.7 (-1.0; 1.3)	0.315	0.05
Calcium	0.5 (0.3; 0.7)	0.5 (0.3; 0.7)	0.709	-0.10
Phosphorus	-0.5 (-1.2; 0.3)	0.5 (-0.1; 0.8)	0.287	-0.18
Glutamic Pyruvic Transaminase	2.0 (-1.1; 3.1)	2.0 (0; 5.0)	0.450	-0.17
Glucose	12.0 (-5.4; 20.0)	9.0 (-4.1; 28.1)	0.677	-0.02
Potassium	0.1 (-0.2; 0.4)	0.1 (-0.3; 0.5)	0.869	0.10
Hemoglobin	0.01 (-1.2; 1.0)	0.1 (-1.7; 0.8)	0.587	0.18
Hematocrit	0.9 (-3.0; 2.9)	0 (-4.3; 4.0)	0.630	0.15
Calcium vs Phosphorus	-1.5 (-10.8; 12.6)	4.7 (1.8; 11.3)	0.462	-0.13
Sodium	2.0 (1.0; 7.0)	1.0 (0; 5.2)	0.216	0.06

* Mann-Whitney test. **Teste de Cohen (d). 95% CI: 95% confidence interval; hemodialysis (HD).

DISCUSSION

The number of chronic kidney failure treated with hemodialysis is continuously increasing, and most patients have reduced exercise and are at high risk for heart and vascular disease[22]. The findings of our study showed that a moderate-load aerobic exercise protocol in patients undergoing hemodialysis for 3 months on a cycle ergometer did not change the blood parameters of patients with CKD.

Zhenzhen Qiu *et al.*[23] in their research, evaluated the effects of exercise on the health of patients with chronic renal failure. They show that physical activity benefits blood pressure among sick people and improves their maximal oxygen uptake. This can help patients with physical function and aerobic capacity, while offering additional benefits[23]. Our findings corroborate the author with regard to systolic blood pressure and heart rate, because at the end of the 3 months of intervention, although there was no statistically significant difference in systolic blood pressure (Table 3), the results showed better control. in this aspect. In heart rate, there was significant difference, showing positive results in physical aspect.

In this context, Fuhro *et al.*[24] reported that intradialytic exercise does not have the additional effect of removing systemic solutes (*i.e.*, urea and creatinine) nor does it alter C-reactive protein levels, corroborating our findings.

Musavian *et al.*[25] compared the effects of active and passive intradialytic pedaling exercises in subjects undergoing HD. The authors reported no significant alterations in potassium, phosphorus and calcium serum levels at the end of the fourth and eighth weeks of passive intradialytic exercise. However, phosphorus levels were insignificantly reduced and calcium levels slightly increased. The efficacy of dialysis and urea uptake discretely decreased in the fourth week and mildly increased at the end of the eighth week of passive exercise. Nevertheless, these changes were not statistically significant[26]. The same results of the analyzed parameters were approximated of these same values without statistical difference.

Mohseni *et al.*[27] examined the effect of intradialytic aerobic exercise on the efficacy of dialysis in subjects under HD. There was no significant difference in the reduction rate of basal urea between the two groups. The investigation showed that aerobic exercise could improve the efficacy of dialysis. This improvement could be due to the direct beneficial effects of aerobic exercise or the general effects of regular physical exercise. It seems that during exercise under HD, muscle blood flow increases and opens the capillary surface area that subsequently increased the flow of urea from the tissue into the vascular compartment[28]. Such growth would lead to an increase in serum clearance of urea and improvement in the efficacy of dialysis[29]. In the study published by Indralingam Vaithilingam et al.30 the rate of urea reduction (69% ± 0.02% versus 68% ± 0.07, 4 versus 5 hours) and the weekly removal of urea were not different between the control group and the intervention group. In our study we also found no difference in urea reduction rate between the two groups.

According to the Hermes Pardini Laboratory, the reference values to measure GPT by using the kinetic study through UV are: men - up to 50 U/L and women - up to 35 U/L. Some studies showed that subjects with CKD under HD could have lower serum levels of liver enzymes than those with a normal renal function for reasons that remain uncertain[31,32].

In our study, we verified no difference of GTP levels between control and trained groups. These data corroborate the research of Block *et al.*[33], in which subjects with CKD under HD had reduced serum levels of aminotransferases.

Small *et al.*[31], showed that exercise training and lifestyle intervention in subjects with CKD in standard nephrology care did not produce significant changes in systemic biomarkers of oxidative stress. Our data indicated that aerobic exercise during HD did not avoid the impairment of blood parameters in CKD subjects. We should be careful when investigating HD for kidney diseases treatment.

The acute effects of exercise on CKD subjects were evaluated by Santana et al.[32] which reported that a single aerobic exercise of moderate intensity of 30 minutes does not harm renal function in subjects with non-dialytic CKD, regardless of the stage of the disease, supporting the notion that exercise training could be safe in this disease.

In a systematic review and meta-analysis, Heiwe *et al.*[6], verified whether physical exercise could affect health results in individuals with CKD. This review proposed that training with regular physical exercise is generally associated with better health outcomes in individuals with CKD.

CONCLUSION

There was no change during moderate aerobic exercise in the biochemical parameters during the three months intervention on blood levels of urea, creatinine, calcium, phosphorus, pyruvic glutamic transaminase, glucose, potassium, hemoglobin, hematocrit, calcium, phosphorus and sodium in patients with chronic kidney disease. The feasibility of using exercise in this population should be considered to control blood pressure, cardiac function and improvement of physical condition.

Declarations

Abbreviations

ADP – Adenosine Diphosphate
AMPK – AMP-activated protein kinase
AMP – Adenosine Monophosphate
ATP – Adenosine Triphosphate
Cat - Catalase
CKD - Chronic kidney disease
DOQI - Disease Outcomes Quality Initiative
EAS – Endogenous antioxidant systems
ROS – Reactive oxygen species
ERRα - Orphan Nuclear Receptor
GR - Glutathione Reductase
GPT - Glutamic Pyruvic Transaminase
GPx - Glutathione Peroxidase
HD – Hemodialysis
H2O2 – Hydrogen peroxide
IL-6 - Interleukin 6
Keap1- Kelch-like protein 1
LCD - Panel Reader
Nrf1 - Nuclear Respiratory Factor 1,
Nrf2 - Nuclear factor erythroid 2-related factor 2
ODO-RPM - Odometer with Rotation Per Minute
PGC-1α - Peroxisome Proliferator-Activated Receptor Gamma Coactivator 1-Alpha
PPAR - Peroxisome Proliferator-Activated Receptor
PTH – Parathormone
SIRT1 - Sirtuin 1
SOD - Superoxide Reductase
TNF-α - Tumor necrosis factor alpha
U / L - Unit per liter

Ethics approval and consent to participate

Not applicable

Consent for publication, availability of data and material, competitive interest, funding, authors' contributions are all included in the letter described below.

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Resumo

Introdução: A doença renal crônica está diretamente relacionada a distúrbios cardiovasculares. Exercícios físicos guiados melhoram significativamente os efeitos adversos do tratamento dialítico.

Objetivo: Analisar as alterações nos parâmetros bioquímicos de indivíduos com doença renal crônica submetidos a exercícios moderados durante a hemodiálise.

Método: Este é um estudo experimental composto por 54 indivíduos submetidos à hemodiálise, divididos em um grupo controle e um grupo com intervenção. O grupo experimental passou por três sessões semanais de exercício aeróbico, realizadas durante as sessões de hemodiálise, com duração de 30 minutos, por 12 semanas. Os parâmetros sanguíneos de ambos os grupos foram comparados.

Resultados: Diferenças estatisticamente significativas foram observadas entre o protocolo pré (p=0,001) e pós-exercício para urea (p=0,006), cálcio (p=0,001), alanina aminotransferase (p=0,020) e sódio (p=&0.001). No grupo controle, observamos diferenças significativas para a variável cálcio (p<0.001), alanina aminotransferase (p=0,024), hematócrito (p=0,015), cálcio vs fósforo (p=0,018) e sódio (p=0,023), antes e depois do período.

Conclusão: O treinamento aeróbico durante a hemodiálise foi capaz de manter a estabilidade do nível sanguíneo em pacientes com doença renal crônica, tanto durante quanto no final do protocolo, considerando mesmo o aumento do fluxo sanguíneo. Este ensaio está registrado no registro brasileiro de Ensaios Clínicos - número RBR-7354r6. Data de inscrição: 5 de julho de 2018 às 12h59. Última atualização: 24 de julho de 2018 às 10h24. Identificação do teste - UTN Número: U1111-1216-8272.

Palavras-chave: Doença renal crônica, hemodiálise, parâmetros sanguíneos, exercícios aeróbicos.