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Effect of aerobic training on autonomic modulation, body composition, functional capacity and 24-hour interdialytic blood pressure

Efeito do treinamento aeróbico na mdulação autonômica, composição corporal, capacidade funcional e pressão arterial interdialítica 24 horas

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ABSTRACT
The aim was to analyze the effect of aerobic training on autonomic modulation, functional capacity, body composition and 24-hour interdialysis blood pressure. This is a cross-sectional intervention study, including 28 hemodialysis patients, divided into two groups: (Exercise, n = 13; Control n = 15), who underwent an aerobic exercise program for 12 weeks. Heart rate variability, 6-minute walk test (6MWT), 24-hour interdialysis blood pressure and biochemical markers were assessed before and after the exercise program. After 12 weeks of aerobic exercise training, the Exercise group showed a reduction in the number of heartbeats compared to the Control group (69.86 ± 7.53 vs 74.71 ± 3.3), respectively. In addition, in the Exercise group, there was a decrease in the sympathetic component, as seen by the 0V (%) index (pre 24.85 ± 8.99 vs post 16.2 ± 12), and an increase in the parasympathetic index, as seen by the 2V (%) index (pre 29.1 ± 5 vs post 43.5 ± 5). What's more, there was a greater distance in the 6MWT (pre 489 ± 81 vs post 607 ± 84), lower 24-hour interdialytic blood pressure, and an improvement in biochemical markers at post compared to the control group. Therefore, after 12 weeks of moderate-intensity aerobic training, there was an improvement in cardiovascular risk parameters such as autonomic modulation, 6MWT, systolic blood pressure and lipid profile in these advanced chronic kidney disease patients undergoing hemodialysis.

Keywords: Autonomic Modulation. Blood pressure. Exercise. Hemodialysis.

RESUMO
O objetivo foi analisar o efeito do treinamento aeróbico sobre a modulação autonômica, capacidade funcional, composição corporal e pressão arterial de 24 horas interdiálise. Trata-se de um estudo transversal de intervenção, incluindo 28 pacientes em hemodiálise, divididos em dois grupos: (Exercício, n = 13; Controle n = 15), submetidos a um programa de exercício aeróbico durante 12 semanas. Foram avaliados a Variabilidade da Frequência Cardíaca, Teste de caminhada de 6 minutos (TC6), Pressão arterial de 24 horas interdiálise, e marcadores bioquímicos antes e após o programa de exercício. Pós treinamento de 12 semanas com exercício aeróbico o grupo Exercício apresentou redução no número de batimentos cardíacos em comparação ao grupo Controle (69.86 ± 7.53 *vs* 74.71 ± 3.3), respectivamente. Além disso, no grupo Exercício, houve diminuição do componente simpático, visto pelo índice 0V (%) (pré 24.85 ± 8.99 *vs* pós 16.2 ± 12), e incremento no índice parassimpático, observado através de 2V (%) (pré 29.1 ± 5 *vs* pós 43.5 ± 5). Mais ainda, maior distância no TC6 (pré 489 ± 81 *vs* pós 607 ± 84), menor pressão arterial de 24 horas interdialítico, e melhora nos marcadores bioquímicos no momento pós em comparação ao grupo controle. Diante disso, após 12 semanas de treinamento aeróbio com intensidade moderada houve melhora nos parâmetros de risco cardiovascular, como modulação autonômica, TC6, pressão arterial sistólica e perfil lipídico nestes pacientes renais crônicos avançado que realizam hemodiálise.

Palavras-chave: Exercício. Hemodiálise. Modulação autonômica. Pressão arterial.

INTRODUCTION

Chronic kidney disease is established by a long-term reduction in glomerular filtration rate or markers of kidney damage. It is divided into 5 stages, the last of which requires renal replacement therapy to maintain vital functions[1,2], and is a growing public health problem worldwide.

According to the most recent census, one in every million people will need a kidney transplant or will be dependent on other renal replacement therapies[3]. It is estimated that approximately 13% of the world's population has some degree of kidney dysfunction, but because it is asymptomatic in the early stages, it is often underdiagnosed and most patients are referred to specialists late, delaying the start of treatment and impacting on morbidity and mortality[4].

The average prevalence of patients requiring hemodialysis is 759 per million population (pmp)[5]. In Brazil, in 2018, the latest census by the Brazilian Society of Nephrology found that the prevalence of patients on dialysis treatment was 640 pmp[6].

There are currently more than 2,5 million people undergoing renal replacement therapy worldwide, and it is estimated that this number will double by 2030[7,8]. In Brazil, it is estimated that in 2009 there were more than 77,000 people on dialysis treatment, and the population's increased life expectancy is one of the factors responsible for the large increase in this number in recent years[9].

These patients may be predisposed to a higher risk of mortality from cardiovascular diseases and, as a consequence, greater changes in cardiac autonomic modulation when undergoing hemodialysis treatment[10,11].

Among other reasons, the impact of hemodialysis treatment on autonomic modulation during dialysis may be related to low hematocrit values and long periods of hemodialysis treatment[12]. In addition, reduced autonomic control and blood pressure may be associated with a higher risk of developing hypertension, myocardial infarction and heart failure, greater morbidity and sudden death[13,14,15], linked to an increase in sympathetic modulation and a decrease in parasympathetic modulation, which are important factors in causing mortality in hemodialysis patients[16].

Associated with this, dysfunction of the renin-angiotensin-aldosterone system (RAAS), which is fundamental for regulating blood pressure, can result in over-stimulation of the sympathetic nervous system[17], promoting RAAS dysfunction and leading to hypertension of the glomerular and systemic capillaries, resulting in damage to the vascular and glomerular endothelium. At the same time, aldosterone and angiotensin II can also stimulate pro-inflammatory responses and thus cause damage to the kidneys[17,18].

With the presence of metabolic and muscular alterations in hemodialysis patients, the vast majority of cases are associated with decreased functional capacity and low exercise tolerance[19]. The functional capacity of chronic kidney patients in advanced stages has been pointed out as an important prognostic index in this population, as well as having a possible relationship with the nutritional, biochemical and body composition status of this population[20,21].

Authors have shown that physical exercise can influence autonomic modulation and functional capacity in various populations, such as patients with chronic heart failure, diabetes mellitus and acute myocardial infarction[22]. However, it is still not routinely used among patients with advanced chronic kidney disease[23].

It is therefore necessary to explore treatments that can reduce these risks for this population. In this sense, aerobic training can be an important ally in improving cardiovascular function.

The aim of this study was to analyze the effects of 12 weeks of aerobic training on cardiovascular and autonomic function, body composition, functional capacity and 24-hour interdialytic ambulatory blood pressure in patients with chronic kidney disease.

METHODOLOGY

STUDY DESIGN

This study consisted of a cross-sectional design with a sample size of 28 hemodialysis patients, divided into two groups: Control (n=15) and Exercise (n=13) with aged (years) 42.86 ± 6.81 and 38 ± 13.29, respectively.

ETHICAL STATEMENT

The study was approved by the Ethics and Research Committee of Hospital Universitário do Maranhão with protocol CAAE No.528387167.00005086 and Judgment no. 1450043a. The present study was conducted in compliance with all the recommendations of the 1964 Helsinki declaration.

PARTICIPANTS AND STUDY SETTING

The study was carried out at the Renal Rehabilitation Center of the Presidente Dutra University Hospital, São Luís, Brazil. Hemodialysis patients were invited to take part in the study and those who agreed to participate were interviewed and divided into two groups according to their personal decision to take part in the exercise protocol.

Participants signed an informed consent form and then filled in an anamnesis form asking for data such as name, date of birth, address, telephone number, gender, date of diagnosis, length of time on hemodialysis, length of hemodialysis session, intradialytic complications, intradialytic weight gain, dry weight, type and number of fistulas, medications used and questions about regularity, intradialytic weight gain, dry weight, type and number of fistulas, surgeries, comorbidities, family illnesses, number of hospitalizations after starting dialysis, medications in use and questions about the regularity of the menstrual cycle or the occurrence of menopause (for women).

LABORATORY TESTS

Samples of blood were collected at baseline and after 12 weeks of the exercise protocol, by a technician or nurse on duty in the laboratory. The patients were instructed to maintain 12 hours of fasting before laboratory evaluations. On the same day, the other protocols of the study were not performed so that there was no interference in the results and for the greater comfort of the participants. Then, the samples were taken for automating analysis in ADVIA 2120i Hematology System and ADVIA 2400 Clinical Chemistry System (Siemens Healthcare Diagnostics, Forchheim), where the following parameters were evaluated: concentrations of hematocrit (%) and hemoglobin (mg/dL) in whole blood sample and serum levels of urea (mg/dL), phosphorus (mg/dL), creatinine (mg/dL), blood glucose (mg/dL), potassium (mmol/L), Calcium (mg/dL).

HEART RATE VARIABILITY

Heart Rate Variability was obtained of continuous and non-invasive form, beat-to-beat, through the electrocardiogram. This procedure was performed at baseline moment and after twelve weeks of the protocol, during ten minutes with the participant in the supine position. Participants were instructed to abstain from eating and drinking per four hours before the test, as well as not performed physical exercise on the test day and not drinking alcohol for 48 hours previous to the exam.

The analyzes allow checking parameters of the cardiac autonomic nervous system in the time and the frequency domains. To assess the heart Rate Variability, the temporal series of RR intervals were registered by Wincardio electrocardiogram and analyzed utilizing spectral analysis using the Fast Fourier Transform in portions of five minutes with interpolation four Hz, and overlap in 50%. The software Kubios HRV 2.0 (Biosignal Analysis e Medical Imaging Group, Kuopio, Finland) was used as an automatic filter and then was performed the analysis in the time domain, using the variables: SDNN (standard deviation of the interval of time series NN); RMSSD (square root of the quadratic differences of the mean of the NN intervals).

The measurements of heart Rate Variability in the frequency domain were characterized by Fast Fourier Transform, where the low frequency (LF: 0.04-0.15 Hz) and high frequency (HF: 0.15-0.4 Hz) represent the sympathetic and vagal modulations respectively. The autonomic balance was measured through the LF/HF variable of the time series of the RR-interval.

A symbolic analysis was performed according to the study previously validated. The symbolic analysis and The Shannon entropy was calculated to provide a quantification of the complexity (chaos) in the distribution pattern. The sequences are spread on six levels and all the possible patterns are divided into four groups, consisting of patterns: 1) no variations (0V, three symbols equal, associated with a sympathetic modulation); 2) with one variation (1V, two symbols equal and one different associated with a sympathetic and parasympathetic modulation); 3) with two variations (2V, associated with a parasympathetic modulation);

ANTHROPOMETRIC ASSESSMENT

Weight and height were assessed using a digital scale with attached stadiometer (Welmy, São Paulo, Brazil), with patients instructed to remain in an orthostatic position, and used to determine body mass index (BMI)[24].

BIOIMPEDANCE AND PHASE ANGLE INDEX

Bioelectrical impedance (BIA) was used to determine the percentage of fat and lean mass (Biodynamics BIA 450, bioimpedance analyzer, Seattle, Washington - USA). Measurements were taken on patients in the supine position, with limb abduction, using 4 electrodes (2 placed on the dorsum of the hand and 2 on the dorsum of the foot) on the dominant side25. Resistance and reactance were obtained after passing an electric current of 800 μA at 50 kHz. The phase angle was derived from the tangent arc between the reactance and resistance[25].

In order to carry out the bioimpedance test properly, the participants were instructed not to eat four hours before the test, not to exercise on the day of the test, not to empty their bladders, not to consume alcohol and not to be in their pre-menstrual period. The test was carried out immediately after the hemodialysis session.

The percentage of body fat obtained was classified according to age and gender[26].

6-MINUTE WALK TEST

The test consisted of walking on a flat surface for 6 minutes, with the patient instructed to walk the pre-determined distance of 60 meters marked by signaling cones, being warned to discontinue the test if they presented any limiting symptoms, following the guidelines recommended by the American Thoracic Society.

Before starting the test, blood pressure was checked with a phygmomanometer using the oscillatory method (oscillometric method - Omron 705-IT device, Japan), heart rate (Polar S810), oxygen saturation using a pulse oximeter (digital oximeter CMS-50D - Montserrat), and the subjective feeling of exertion using the modified Borg scale. These same variables were measured at the end of the test and repeated at rest after 5, 10 and 15 minutes (recovery phase). VO2peak was calculated using the formula: VO2peak = 0.03x distance (m) +3.98[27].

24-HOUR BLOOD PRESSURE MONITORING

Patients with chronic kidney disease on hemodialysis, ambulatory blood pressure monitoring should be collected in a period of forty-four hours. This period includes one day without the hemodialysis procedure. Blood pressure was evaluated according to the European Society of Hypertension Position Paper on Ambulatory Blood Pressure Monitoring guidelines. This assessment was performed at the moment baseline and after twelve weeks of the exercise protocol.

The devices were programmed in 15/15 minutes for the wake and night period respectively. The patients were instructed to complete a daily report regarding the activities performed from the moment the patient awakens in the morning until bedtime. The measures evaluated during the examination were: systolic blood pressure and diastolic blood pressure.

MAXIMAL TREADMILL TEST

The Maximum treadmill test was performed in a room properly prepared for the security of the patients with oxygen, emergency drugs, and a defibrillator using the technique previously. The patients used an aneroid sphygmomanometer on the right arm for measurements of blood pressure before, during and after the test. Rest electrocardiograms of the patients were performed in sitting and standing positions, before and after the hyperventilation, and were used as a baseline for changes occurring during and after exercise.

Posteriorly, the patient starts the test walking in a treadmill with a fixed incline of 10% during three min to a velocity 1.7 mph; then two minutes at 3 mph; two minutes at 4 mph and finally, three minutes at 5 mph. Blood pressure and electrocardiogram were recorded in intervals of 1 min during exercise and for eight minutes after the test. This test was performed at the moment baseline and after twelve weeks, and the variables used to assess functional capacity were Metabolic Equivalent of Task and Maximum Oxygen Uptake and Maximum Heart Rate.

EXERCISE TRAINING PROTOCOL

The aerobic exercise protocol lasted 12 weeks, and was performed on a horizontal cycle ergometer (Vision Fitness R2250). During the first three weeks, the patients exercised at an intensity of approximately 60% of the HRmax obtained from the exercise test. The intensity was also controlled through the participant's subjective perception of effort, using the Borg scale (relatively easy - slightly tiring). The duration of the exercise was 20 minutes at the start and extended to 30 minutes as tolerated. In weeks 3 to 5, the duration of the exercise was increased to 40 minutes while maintaining the intensity.

Over the next 7 weeks, the duration of the exercise was maintained and the intensity increased, as tolerated, until 80% of HR_{max} was reached. At the end of all the sessions, 5 minutes of cooling down were carried out.

STATISTICAL METHODS

Data were analyzed in GraphPad Prism 5 software (La Jolla, California, USA). The Shapiro-Wilk test was used to test the normality of the data, presented in mean and standard deviation. For possible statistical differences, the Student's paired T-test was used for variables with normal distribution and the Wilcoxon test for non-parametric variables. Two-way ANOVA and post-hoc Student Newman-Keuls were used to compare the groups. A significance level of $p<0.05$ was adopted.

RESULTS

No significant differences were found in the Control vs. Exercise groups comparison regarding age (years) (42.86± 6.81 vs. 38 ±13.29, p=0.40), and interdialysis weight (kg) (2.42 ± 0.97 vs. 2.66 ± 0.40, p= 0.55).

Regarding the time of chronic kidney disease and hemodialysis therapy, in months, there was observed, respectively, mean values 73.33±66.66; 84.30±45.02 (p=0.62), when comparing between groups Control vs. Exercise.

Also, we observed associated comorbidities, such as hypertension in the Control group and Exercise group (71.42 % and 85.71%, respectively), and Systemic lupus erythematosus observed in two patients, one in each of the groups (Control and Exercise).

The drugs used by the patients both groups were, respectively, Angiotensin-converting enzyme inhibitor or Angiotensin receptor blockers (26% vs. 53%); Beta-blockers (33% vs. 53%); Calcium channel blockers (6% vs. 7%); Furosemide (6% vs. 15%); Erythropoietin (46% vs. 46%); Sevelamer (6% vs. 38%); Calcitriol (26% vs. 38%) and Prednisone (13% vs. 15%), with no significant differences in the comparison between Control vs. Exercise in chi-square test (p=0.94).

Table 1 shows body composition and functional capacity data for both groups. The body mass index (kg/m^2) showed lower values in the post moment of the Exercise group, and, higher values in the post moment of Control group (p<0.05). Fat mass (kg and %) decreased in the post moment of the Exercise group and increased in the Control group (p<0.05). No differences in Lean Mass (kg and %) were found.

Table 1. Characteristics of body composition and functional capacity at Pre and Post moments of the Control and Exercise groups.

	Exercise (n=13)		**Control (n=15)**	
	Pre	Post	Pre	Post
Body mass (kg)	51.65 ± 4.58	50.64 ± 3.12	58.04 ± 5.85	61.20 ± 7.93
Fat mass (kg)	15.07 ± 4.40	13.69 ± 3.05	19.67 ± 5.0	22.70 ± 4.94*
Lean Mass (kg)	34.21 ± 4.02	35.53 ± 2.96	36.84 ± 5.72	36.90 ± 1.85
Fat mass (%)	30.64 ± 3.12	25.33 ± 4.35	32.63 ± 6.47	39.53 ± 2.31*
Lean mass (%)	69.43 ± 8.14	72.43 ± 6.45	67.38 ± 6.47	61.80 ± 0.91
Phase Angle (%)	6.17 ± 0.8	6.82 ± 0.8*	6.85 ± 0.93	5.82 ± 0.63$^{\#*}$
6-MWT (m)	489 ± 81	607 ± 84*	478 ± 54	466 ± 26$^{\#}$*
VO_2peak (ml/kg/min)	17±3	23±3*	16±2	16±2*#

6-MWT, Six-minute walk test; *p < 0.05 intergroup analysis: post vs. post, $^{\#}$p < 0.05 pre vs post.

The Phase Angle (%) increased in the post moment of the Exercise group and was lower in the Control group. The results also show an increase in the distance covered in the Six-minute walk test and Vo_2peak in the post moment of the Exercise group. Also, when comparing the post moments between Exercise and Control groups, the Exercise group showed higher values in Phase angle (%) Vo_2peak and Six-minute walk test.

Table 2 shows the Biochemical variables of both groups. No significant difference was found between Control and Exercise groups, except for Blood glucose (mg/dL), showing higher values in the post-Control group, when compared to the post Exercise group.

Table 3 shows the results of heart rate and cardiac autonomic modulation in the time and nonlinear domain of Exercise and Control groups. The results show a decrease in heart rate in the post moment of the Exercise group when compared to the post moment of the Control group ($p<0.05$). Additionally, the 0V (%) showed a reduction in the post moment of the exercise group, and no changes in the control group. Also, we observed an increase in the 2V (%) (standard with two different variations), in the post moment of the Exercise group when compared with pre moment and post a moment of the control group.

Table 2. Biochemical analysis of Exercise and Control groups, at Pre and Post moments.

		Exercise (n=13)		**Control (n=15)**	
Data	***References***	Pre	Post	Pre	Post
Blood glucose (mg/dL)	60 – 90	82.25 ± 10.0	83.66 ± 12.88	84.5 ± 7.14	100 ± 8.38*#
Hemoglobin (g/dL)	11.3 -16.3 Female 12.8 – 17.8 Male	12.78 ± 0.83	12.12 ± 2.67	10.8 ± 2.27	12.8 ± 6.48
Hematocrit (%)	36 - 48 Female 40 – 54 Male	39.72 ± 3.21	38.27 ± 7.87	33.68 ± 7.40	33.08 ± 3.16
Urea (mg/dL)	36 - 48 Female 40 – 54 Male	96.4 ± 41.76	128.75 ± 27.75	112 ± 29.89	149.5 ± 22.9
Potassium (mmol/L)	3.5 – 5	4.6 ± 0.48	4.94 ± 0.47	4.88 ± 0.74	5.35 ± 0.65*#
Calcium (mg/dL)	9 – 10.5	9.34 ± 0.69	9.29 ± 0.58	8.76 ± 0.53	9.02 ± 0.59
Phosphorus (mg/dL)	3.0 – 4.5	4.94 ± 0.49	5.72 ± 0.45	4.42 ± 0.66	5.07 ± 1.0

#$p < 0.05$ intergroup analysis: post vs. post, *$p < 0.05$ pre vs post.

Table 3. Behavior of cardiac autonomic modulation in the pre-post between groups.

	Exercise (n=13)		Control (n=15)	
	Pre	Post	Pre	Post
Time-domain				
Heart Rate (bpm)	77.14 ± 9.08	69.86 ± 7.53	74.14 ± 5.52	74.71 ± 3.30#
Men RR (ms)	777.50 ± 107.90	810.5 ± 105.10	758.60 ± 51.92	754.88 ± 43.14
SDNN (ms)	16.15 ± 7.80	17.64 ± 7.92	17.17 ± 8.13	14.43 ± 8.80
RMSSD (ms)	11.30 ± 5.49	13.31 ± 9.02	11.93 ± 6.45	9.18 ± 4.98
Symbolic analysis				
0V (%)	24.85 ± 8.99	16.2 ± 12*	27.23 ± 8.61	26.6 ± 8.15
1V (%)	44.92 ± 12.0	40.95 ± 16.55	45 ± 8.37	47.27 ± 5.17
2V (%)	29.1 ± 5	43 ± 5*	28.2 ± 8	28.0 ± 5#

#$p < 0.05$ intergroup analysis: post vs. post; *$p < 0.05$ intragroup analysis: pre vs. post.

Figure 1 evidences the cardiac autonomic modulation in the frequency domain of both groups. The results show a decrease of sympathetic modulation by LF (%) component and LF/HF parameters in the post moment of the Exercise group when compared with pre-exercise and Post moment of the control group. The parasympathetic modulation increased in the post moment of exercise evidenced by increase in HF (%) component group when compared with pre-exercise and Post moment of Control group.

Figure 2 shows the 24h-blood pressure monitoring in interdialytic period. We showed a reduction in the post moment of the Exercise comparing to the pre moment, and versus the post moment of the Control groups during the night-time. Also, we observed a reduction of 24h-systolic blood pressure during the night-time in the post moment of the Exercise group when compared to the pre moment of the Exercise and post a moment of the Control group in the interdialytic period.

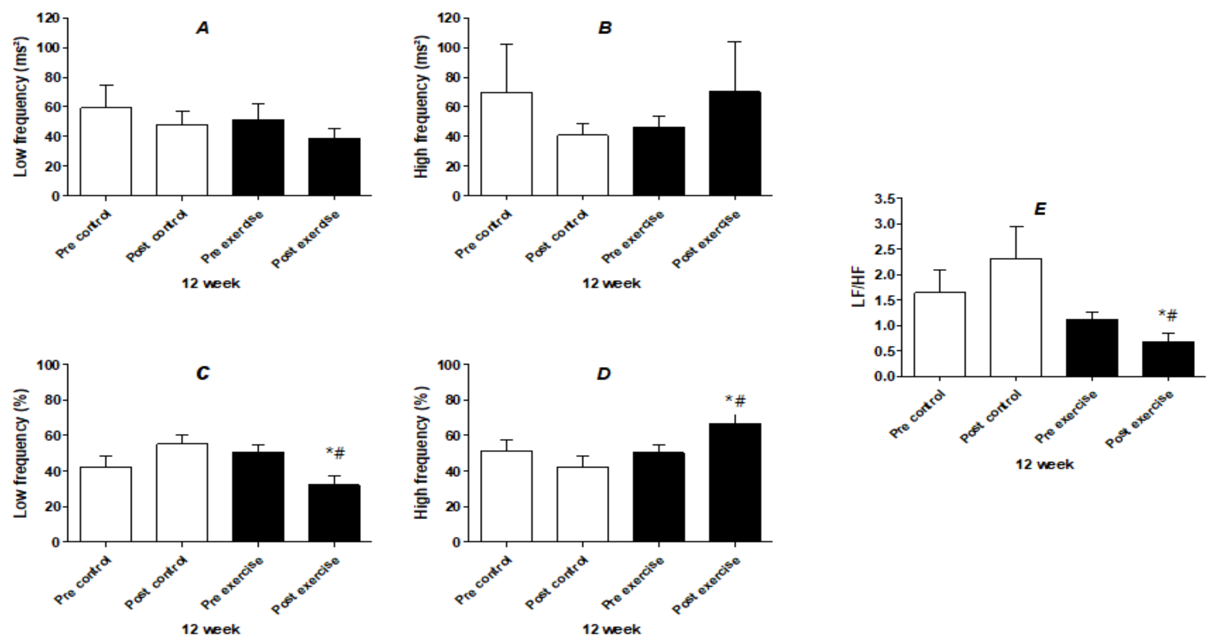

Figure 1. Cardiac modulation autonomic in frequency domain of groups.

A: Low frequency (ms²); B: High frequency (ms²); C: Low frequency (%); D: High frequency (%); F: LF/HF. *$p<0.05$ intergroup analysis: post vs. post; # $p < 0.05$ intragroup analysis: pre vs. post.

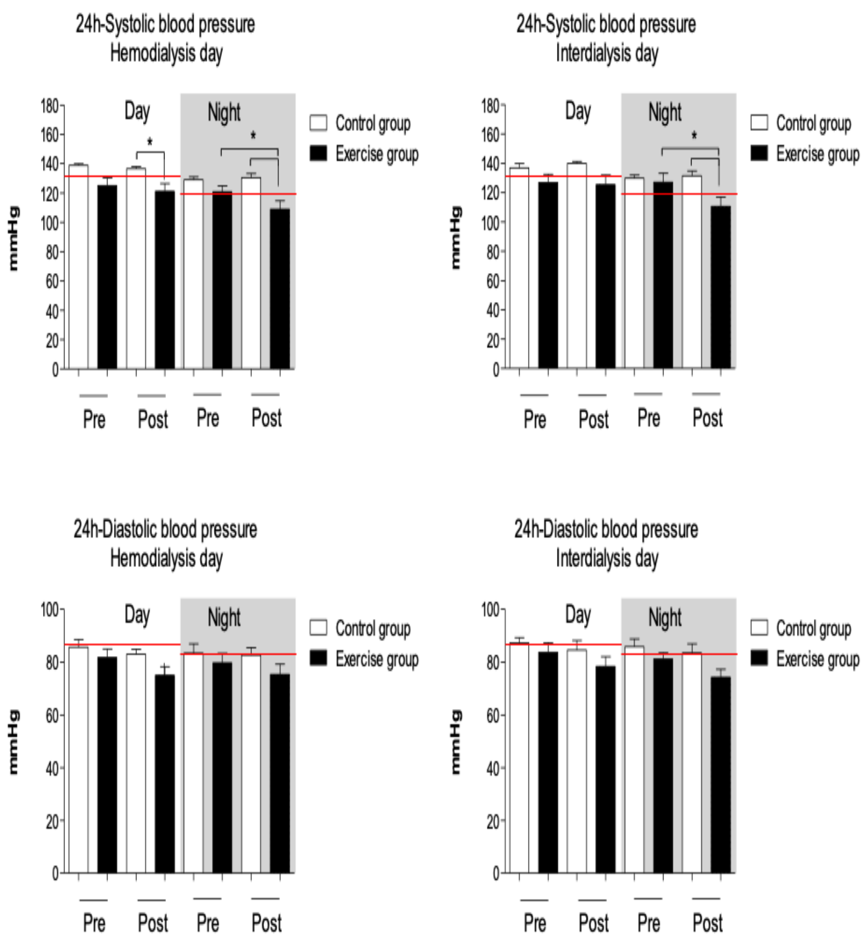

Figure 2. 24-hour blood pressure monitoring in interdialytic day.

*$p<0.05$; red lines indicate 24h-blood pressure cutoffs for hypertension, according to the American Heart Association (Systolic 135mmHg for the day, 120mmHg for the night; diastolic 85mmHg for the day, 70mmHg for the night).

DISCUSSION

The study aimed to analyze the impact of aerobic training over 12 weeks on autonomic modulation, 24-hour blood pressure and functional capacity in patients with chronic kidney disease on hemodialysis. Following a literature search, this is the first study to evaluate the effect of aerobic exercise training on 24-hour blood pressure interdialysis.

The main findings of this study suggest that after aerobic training for 12 weeks in chronic renal failure patients undergoing hemodialysis, there is an increase in parasympathetic autonomic modulation, an improvement in body composition, functional capacity and metabolic components, and a reduction in 24-hour systolic blood pressure in the interdialytic period.

Statistical differences were observed in the parameters LF (%), HF (%), LF/HF 1V (%) and 2V (%) (standard with two different variations) in the Post-exercise group when compared to the Pre-exercise and Post-control groups. These indices show a significant improvement in the sympathovagal balance and parasympathetic tone of chronic kidney patients, thus making it possible to reduce the risk of lethal arrhythmias and mortality in this population[28,29].

Other authors have shown that physical exercise can increase vagal tone and reduce sympathovagal balance in hemodialysis patients, improving the stability of electrical and cardiac activity and providing greater neural control[30]. In addition, studies report that physical exercise improves baroreflex sensitivity and vagal tone, reducing vulnerability to malignant arrhythmias, especially myocardial ischemia[30].

Linked to this, the results also show a reduction in heart rate after the aerobic training protocol, which can be explained by the mechanism responsible for the probable increase in vagal modulation at rest with a consequent decrease in heart rate due to the increased sensitivity of adrenergic receptors to noradrenaline, and changes in nerve conduction and ionic concentrations in the sinus node[31].

With regard to secondary outcomes, we found that the phase angle index values were higher in the post-exercise group, thus resulting in a lower risk of mortality in hemodialysis patients[32]. Furthermore, according to Ikizler et al.[33], interventions in dialysis patients should be individualized, with nutritional support and individually prescribed physical exercise with the appropriate volume and intensity for each case, in order to bring about possible improvements in the body component of this population[33].

Previous publications have shown that after weeks of long-term interdialytic training there was an improvement in the lipid profile, less need for antihypertensive drugs and a lower rate of hospitalization for cardiovascular causes in the trained group[34].

Another important variable that improved was the distance covered in the 6MWT by the post-exercise group compared to the pre-exercise and post-control groups. These results corroborate other studies on chronic kidney disease patients[35,36,37,38,39,40]. It is important to note that the distance covered in the six-minute walk test, when less than 350 meters, has a significant correlation with a higher risk of mortality[41,42]. In addition, the significant VO2 peak values in this study may suggest that these patients can tolerate higher levels of physical stress after undergoing an aerobic training protocol of at least 12 weeks[40,46,44,45,46].

Another important clinical finding is that, after the exercise program, the patients showed a reduction in 24-hour blood pressure below the American Heart Association's cut-off points for hypertension, both during the day and at night[47].

We observed a decrease in systolic blood pressure 24 hours post-exercise when compared to the pre-exercise and post-control groups during the night, in the interdialytic period. This finding may be reinforced by the effects of aerobic training on peripheral vascular resistance[48], with direct action on the autonomic nervous system, due to aerobic exercise stimulating vagal tone, observing an improvement in baroreflex sensitivity due to greater control of blood pressure[49].

It is important to interpret these results given the presence of some limitations, such as the fact that systolic volume was not assessed and the food recall was not applied. These data could provide more information on the behavior of cardiac autonomic modulation and a better understanding of body composition values.

PRACTICAL IMPLICATIONS

Participants in the post-exercise group showed improvements in cardiorespiratory and autonomic aspects, representing a lower risk of cardiovascular events, hypertension and malignant arrhythmias, consequently reducing the incidence of mortality in this group. There is also a lower number of hospitalizations of these patients due to complications resulting from chronic kidney disease and, therefore, a greater reduction in health care costs. These data show that aerobic training is a non-pharmacological treatment option, reducing the adverse effects of treatment.

Therefore, through the results of this study, we hope to demonstrate not only the importance and efficiency of aerobic training in combating the deleterious effects of advanced chronic kidney disease, but also to encourage the inclusion of this type of intervention in hospitals and hemodialysis clinics around the world. In addition, it is necessary to emphasize that the prescription and supervision of physical training should be carried out by exercise professionals.

CONCLUSION

After 12 weeks of moderate-intensity aerobic training, cardiovascular risk parameters such as systolic blood pressure, lipid profile, six-minute walk test and autonomic modulation improved in these patients with advanced chronic kidney disease undergoing hemodialysis.

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