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Effects of intradialytic exercise on sleep quality and cardiac autonomic modulation

Efeitos do exercício intradialítico sobre a qualidade do sono e a modulação autonômica cardíaca

Efectos del ejercicio intradialítico sobre la calidad del sueño y la modulación autonómica cardíaca

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ABSTRACT

Objective: to evaluate the effects of an intradialytic resistance exercise program on sleep quality and cardiac autonomic modulation in hemodialysis patients. **Method:** non-randomized clinical trial, carried out between February 2019 and October 2020, with 52 individuals with chronic renal failure on dialysis, divided into an intervention group (IG; n=32) and a control group (CG; n=20). The IG performed 12 weeks of intradialytic physical training, three times a week. Indices of sleep quality and cardiac autonomic modulation were measured. **Results:** there was an increase in the standard deviation indices of beat-to-beat intervals (SDNN) (ms) (p=0.0004), square root of the mean square of adjacent beat-to-beat intervals (RMSSD) (ms) (p<0. 0001), standard deviation 1 (SD1) (ms) (p=0.03) and standard deviation 1/standard deviation 2 (SD1/SD2) ratio (p=0.0003). There was no improvement in sleep quality. **Conclusion:** Intradialytic resistance exercise is able to improve cardiac autonomic modulation in patients with chronic kidney disease.

Descriptors: Renal Insuficiency, Chronic; Renal Dialysis; Exercise; Sleep Quality; Autonomic Nervous System.

RESUMO

Objetivo: avaliar os efeitos de um programa de exercício resistido intradialítico sobre a qualidade do sono e a modulação autonômica cardíaca de pacientes em hemodiálise. **Método**: ensaio clínico não randomizado, realizado entre fevereiro de 2019 e outubro de 2020, com 52 indivíduos renais crônicos dialíticos, alocados em grupo intervenção (GI; n=32) e grupo controle (GC; n=20). O GI realizou 12 semanas de treinamento físico intradialítico, três vezes por semana. Foram mensurados índices de qualidade do sono e modulação autonômica cardíaca. **Resultados**: houve incremento nos índices desvio padrão dos intervalos batimento a batimento (SDNN) (ms) (p=0,0004), raiz quadrada da média do quadrado dos intervalos batimento a batimento adjacentes (RMSSD) (ms) (p<0,0001), desvio padrão 1 (SD1) (ms) (p=0,03) e razão desvio padrão 1/desvio padrão 2 (SD1/SD2) (p=0,0003). Não houve melhora da qualidade do sono. **Conclusão**: O exercício resistido intradialítico, é capaz de melhorar a modulação autonômica cardíaca em pacientes com doença renal crônica.

Descritores: Insuficiência Renal Crônica; Diálise Renal; Exercício; Qualidade do Sono; Sistema Nervoso Autônomo.

RESUMEN

Objetivo: evaluar los efectos de un programa de ejercicios de resistencia e intradialíticos sobre la calidad del sueño y la modulación autonómica cardíaca en pacientes en hemodiálisis. **Método:** ensayo clínico no aleatorizado, realizado entre febrero de 2019 y octubre de 2020, junto a 52 individuos en diálisis con insuficiencia renal crónica, divididos en grupo intervención (GI; n=32) y grupo control (GC; n=20). El GI realizó 12 semanas de entrenamiento físico intradialítico, tres veces por semana. Se midieron índices de calidad del sueño y modulación autonómica cardíaca. **Resultados:** hubo un aumento en los índices de desviación estándar de los intervalos entre latidos (SDNN) (ms) (p=0,0004), raíz cuadrada del cuadrado medio de los intervalos entre latidos adyacentes (RMSSD) (ms) (p<0,0001), desviación estándar 1 (DE1) (ms) (p=0,03) y relación desviación estándar 1/desviación estándar 2 (DE1/DE2) (p=0,0003). No hubo mejoría en la calidad del sueño. **Conclusión:** el ejercicio de resistencia intradialítico puede mejorar la modulación autonómica cardíaca en pacientes con enfermedad renal crónica.

Descriptores: Insuficiencia Renal Crónica; Diálisis Renal; Ejercicio; Calidad del Sueño; Sistema Nervioso Autónomo.

INTRODUCTION

Patients on hemodialysis have a decrease in their physical capacity, reduced conditioning, low tolerance for physical activity, with less than half of the individuals presenting conditions to perform a physical fitness test[1,2]. Studies show that an exercise program for these patients contributes to better control of blood pressure, functional capacity, heart function and muscle strength[3-6].

Strength training, also known as resistance training, is made up of exercises that work the body's resistance and are usually performed with weights, elastic bands or against resistance[7], being considered one of the most effective methods to improve functional performance, as it promotes improvement in strength, speed, power, endurance, balance and coordination[8].

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Several authors report that, in addition to the benefits related to the cardiovascular system, performing intradialytic exercises brings secondary benefits, as it breaks the monotony of the procedure, improves adherence and can increase the effectiveness of dialysis[5,9].

One of the effects that regular physical activity produces on the cardiovascular system is the ability to modify cardiac autonomic balance, decreasing sympathetic activity and increasing parasympathetic activity[10]. The knowledge that heart rate variations reflect an interaction between the sympathetic and parasympathetic nervous systems has offered a window into the study of cardiac autonomic control[11], since patients with impaired sympathetic modulation have more cardiovascular complications[12].

The prevalence of sleep disorders is present in up to 70% of individuals with chronic kidney disease (CKD)[13,14]. With the progression of kidney disease, variations in the antidiuretic hormone level and the absence of a physiological drop in systolic and diastolic blood pressure are the main agents that cause sleep-related changes, often leading these individuals to develop increased stress, reduced physical conditioning, among other harmful physical and mental consequences for the individual[15,16].

Thus, the aim of this study to assess the effects of an intradialytic resistance exercise program on sleep quality and cardiac autonomic modulation in hemodialysis patients is considered important.

METHOD

This is a non-randomized clinical trial, carried out in the city of São Luís (Maranhão, Brazil), from February 2019 to October 2020.

The population consisted of 200 patients with chronic kidney disease who were undergoing hemodialysis at a university hospital and at a Nephrology Center. The sample was non-probabilistic, with 52 eligible individuals.

Participants were allocated into two groups. Those who chose to undergo the physical training protocol were directed to the Intervention Group (n=32) and those who did not accept to undergo the physical training were directed to the Control Group (n=20). There was a sample loss of 11 participants, due to recurrent hypoglycemia (n=1), catheterization (n=1), death (n=2), transfer to another unit (n=2), unstable angina (n=1) and withdrawal (n=4).

Chronic kidney disease patients on hemodialysis, aged 18 years or older, on dialysis treatment for more than three months and who had the cognitive capacity to understand the research process were included. Those who had diseases or some type of musculoskeletal disability that would make assessments and the exercise protocol impossible, dialysis through temporary vascular access, neurological and behavioral alterations that somehow made it impossible to understand the research, patients with acute or untreated cardiovascular and pulmonary diseases and patients who already regularly exercised were excluded.

In addition, criteria for interruption/suspension of the program were considered: frequency less than 75% of the sessions, manifestation of severe cardiovascular symptoms, systolic blood pressure greater than or equal to 160 mmHg and diastolic blood pressure greater than or equal to 100 mmHg, recurrent in three sessions, and acute systemic infection.

The training program comprised four stages: initial assessment, physical training for patients in the intervention group (IG), follow-up for patients in the control group (CG) and reassessment for both groups.

Participating individuals underwent sleep quality assessment through the Pittsburgh Sleep Quality Index[17] and electrocardiogram (ECG) at rest for analysis of heart rate variability (HRV).

Then, the IG performed the physical training program, which consisted of 36 sessions, for 12 consecutive weeks, with a frequency of three times a week on alternate days. The sessions lasted an average of 30 minutes and took place during the first two hours of hemodialysis, supervised and conducted by the professional physiotherapist.

Resistance training consisted of exercises for the upper limb (without arteriovenous fistula) and for the lower limbs. Dumbbells, shin guards and manual balls were used. All exercises were performed on the dialysis chair with the patient in a sitting or lying position.

Exercises for the upper limbs consisted of front elevation of the shoulder; elbow flexion and extension; shoulder abduction and adduction; ball exercises.

Exercises for lower limbs included knee extension in a sitting position at 90º; hip flexion with leg elevation; unilateral hip, knee and ankle flexion and extension; hip abduction and adduction; hip circumference with extended leg.

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For training intensity and load progression, the subjective perception of effort scale for resistance exercise (OMNI-RES) was used, which ranges from 0 (minimum effort) to 10 (maximum effort). From the first to the fourth week, the participants performed a series of 15 repetitions, with a load adjustment of 4 to 5 on the OMNI scale. From the fifth to the eighth week, participants performed two sets of ten to 12 repetitions with a load to an effort of 6 to 7 on the OMNI scale. And, from the ninth to the 12th week, they performed three sets of eight to ten repetitions with a load adjusted to an OMNI of 8 to 9. One minute of rest was allowed between sets. The increase in load occurred progressively, session by session, so that the perception of effort was within the expected range and that the patient was able to perform the predetermined number of repetitions. No adverse events were recorded during the sessions.

At the end of the 12 weeks, participants in both groups underwent a final reevaluation.

As for data analysis, the Shapiro-Wilk test was used to test the normality of the data, which were presented as mean, standard deviation, absolute numbers and percentages. All data were analyzed using Past® 3.0 for Windows software. The chi-square-$\chi 2$ test was used to verify possible associations between qualitative variables. For comparison between groups, one-way ANOVA of repeated measures and Tukey's post-hoc were used. A significance level of $p<0.05$ was adopted. The indices obtained by HRV were analyzed using the Kubios HRV software, version 2.0 (Biosignal Analysis and Medical Imaging Group, Kuopio, Finland).

All procedures were submitted, along with the research protocol, for approval by the Research Ethics Committee of the institutions involved. Only patients who agreed to be volunteers and signed the free and informed consent form participated in this study.

RESULTS

Table 1 describes data related to sleep quality in the control (CG) and intervention (IG) groups.

TABLE 1: Sleep quality of hemodialysis patients before and after 12 weeks of intradialytic resistance physical exercise. Sao Luis, MA, Brazil, 2020.

		Control Group (n=19)				Intervention Group (n=22)				
		Pre		Post		Pre		Post		p-value
	Category	N	%	N	%	N	%	N	%	
Subjective Sleep Quality	Very good	5	26%	3	15%	4	18%	5	22%	0.33
	Good	6	31%	13	68%	16	72%	13	59%	
	Bad	5	26%	2	10%	1	4%	3	13%	
	Very bad	3	15%	1	5%	1	4%	1	4%	
Sleep Latency (minutes)	≤ 15	6	31%	8	42%	10	45%	15	68%	0.08
	16 to 30	6	31%	0	0%	5	22%	2	9%	
	31 to 60	3	15%	6	31%	4	18%	2	9%	
	> 60	4	21%	5	26%	3	13%	2	9%	
Sleep duration (hours)	> 7	13	68%	11	57%	13	59%	14	63%	0.82
	6-7	2	10%	4	21%	7	31%	5	22%	
	5-6	3	15%	2	10%	1	4%	1	4%	
	< 5	1	5%	2	10%	1	4%	1	4%	
Sleep Efficiency (%)	> 85	15	78%	16	84%	20	90%	21	95%	0.43
	75 - 84	2	10%	2	10%	0	0%	0	0%	
	65-74	2	10%	1	5%	1	4%	0	0%	
	<65	0	0%	0	0%	1	4%	1	4%	
Sleep Disorders (events/week)	None	0	0%	4	21%	4	18%	4	18%	0.19
	< 1	12	63%	14	73%	14	63%	16	72%	
	1-2	6	31%	1	5%	4	18%	2	9%	
	3	1	5%	0	0%	0	0%	0	0%	
Use of sleeping medication (events/week)	None	10	52%	7	36%	13	59%	14	63%	0.13
	<1	0	0%	0	0%	3	13%	0	0%	
	1-2	1	5%	1	5%	0	0%	1	4%	
	3	8	42%	11	57%	6	27%	7	31%	
Daytime dysfunction	None	9	47%	12	63%	11	50%	13	59%	0.92
	Small	8	42%	6	31%	10	45%	8	36%	
	Moderate	2	10%	1	5%	1	4%	1	4%	
	A lot	0	0%	0	0%	0	0%	0	0%	
Score -Sleep Quality	Good (0-4)	7	36%	6	31%	9	40%	15	68%	0.20
	Bad (5-10)	9	47%	11	57%	10	45%	7	31%	
	Sleep disorder (>10)	3	15%	2	10%	3	13%	0	0%	

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The results were described by frequency of distribution and relative percentage. It is noted that in the control group, 15% of the participants had sleep disorders (n=3), and in the intervention group, only 13% (n=3), at the beginning of the program.

It is observed that, before and after 12 weeks of resistance physical training, both in the control group and in the intervention group, there was no significant change in any of the seven components of the Pittsburgh Sleep Quality Index, or in its total score; however, when we divided the patients into good sleep quality (group 1) and poor sleep quality and sleep disturbances (group 2), it can be seen that in the control group there was no change in the sleep quality score, but in the intervention group there was an increase in patients with an improvement in the sleep quality score from 40.9% to 68.1% and the component that seems to have influenced this improvement is sleep latency.

The results of the statistical analysis in Table 2 indicate the indices of heart rate variability (HRV) in the time domain and non-linear methods, through mean and standard deviation

TABLE 2: Cardiac autonomic modulation before and after 12 weeks of intradialytic resistance exercise. São Luís, MA, Brazil, 2020

	Control group (n=19)		Intervention group (n=22)	
Variables	**Pre**	**Post**	**Pre**	**Post**
Time Domain				
Mean RR (ms)	768.7±124.2	768.6±92.69	729.6±91.41	764.3±97.90
SDNN (ms)	16.10±4.89	14.20±3.40	12.38±1.98	22.29±7.19 *†
RMSSD (ms)	10.68±7.60	9.59±5.39	8.01±4.05	18.08±4.65 *† ¶
Non-linear methods				
SD1 (ms)	4.88±2.48	5.64±2.75	4.62±3.67	8.37±4.83 *¶
SD2 (ms)	16.72±9.71	16.88±9.46	17.07±9.24	12.94±7.33
SD1/SD2	4.08±3.42	3.29±1.81	4.36±2.32	1.83±1.06 *¶

Caption: Mean RR: mean of the R-R intervals; SDNN: standard deviation of R-R intervals; RMSSD: Mean square root of adjacent R-R intervals; SD: standard deviation. * $p < 0.05$ pre x post intragroup difference. † $p < 0.05$ post x post intergroup difference. ¶ $p < 0.05$ pre x post intergroup difference.

The SDNN(ms) (p=0.0004), RMSSD(ms) (p<0.0001), SD1(ms) (p=0.03) and SD1/SD2 ratio (p=0.0003) indices showed significant improvements after the resistance exercise program, demonstrating an increase in parasympathetic predominance and an improvement in total cardiac autonomic modulation in the intervention group.

There was an intergroup difference post x post in the SDNN(ms) (p=0.02) and RMSSD(ms) (p=0.0002) indices, similarly there was an intergroup difference pre x post with an increase in RMSSD(ms) (p=0.001) and SD1(ms) (p=0.04) and a decrease in the SD1/SD2 ratio (p=0.02).

The mean values RR(ms) and SD2(ms) did not show significant differences.

DISCUSSION

One of the complications faced by individuals with RD is sleep disorders14,25. In a cross-sectional analysis, the presence of poor sleep quality or sleep disturbance was observed in approximately 70% of adult individuals in the final stage of CKD, that is, more than half of the analyzed sample[18].

Studies report a higher prevalence of sleep disorders in patients with CKD undergoing hemodialysis compared to people without renal impairment[19,20]. We found the presence of poor sleep quality in 45% of the chronic renal dialysis individuals participating in the study, and after 12 weeks of resistance physical training and follow-up, 43% still had poor sleep quality, which disagrees with the results of other authors, who found improvement in sleep quality, inflammatory markers and muscle strength of men who performed intradialytic resistance exercise for three months[20], however, it corroborates a French study, which did not show improvement in sleep quality after 12 weeks of intradialytic exercise[21]. The fact that our physical training was carried out at the beginning of the night shift may have disturbed sleep induction; in addition to other factors such as the type of exercise applied (resistance), the duration of the sessions and the total training period; and psychosocial and clinical components, such as anemia.

The constancy of a non-restorative sleep can lead patients to develop indisposition and discouragement for the practice of physical activity and even for the activities of daily living[15].

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Studies that have investigated the effect of intradialytic resisted physical exercise on the autonomic nervous system of renal patients on hemodialysis are rare. In this research, the statistical differences between the pre- and post-intervention period and between the control group and the intervention group in the SD1 and SD1/SD2 indices, characterized an improvement in the cardiac autonomic modulation with a predominance of the parasympathetic system in the group that underwent intervention through physical exercise. This behavior, verified by other authors who evaluated the effects of resistance physical training in other populations, such as hypertensive women, in post menopause and older adults with poor sleep quality, reporting an increase in vagal tonus and reduction in sympathetic activity, with an increase in RMSSD and SD1 indices[22-24]. In this sense, a systematic review with meta-analysis described the effects of resistance training on cardiac autonomic control, describing significant differences in the RMSSD and SD1 indices between healthy and sick individuals and concluding that physical training has minimal or null effects on the autonomic control of healthy individuals, but can lead to improved cardiac autonomic control in sick individuals[18].

In the present study, an increase in the SDNN (standard deviation of the R-R intervals) and RMSSD (root mean square of the square of the adjacent R-R intervals) indices was observed, which modulate the HRV in the time domain, demonstrating that there was an improvement in the autonomic response, in the sense of increased parasympathetic activity, leading to a greater sympathovagal balance. A recent publication described that intradialytic physical training, performed for 3 months, was effective in improving quality of life and heart rate variability, with an increase in SDNN, RMSSD, SD1 and SD2 indices, which corroborates our findings[25].

A previous study carried out with 30 patients, who performed resistance exercises for ten months during HD sessions, also proved to be efficient in improving parasympathetic tonus, with an increase in the SDNN index in the time domain, with no significant changes in the control group[26]. Another study carried out with 44 chronic renal patients (age 46.3±11.2 years), submitted to an intradialytic resistance training protocol for 1 year, showed a significant increase in SDNN indices in 58.8% and RMSSD in 68.1%, with consequent improvement in cardiac autonomic modulation[27]. A cross-sectional study carried out with 27 Tunisians with chronic kidney disease on dialysis, through a 24-hour electrocardiogram and HRV analysis, the presence of ANS dysfunction was observed, characterized by hyperactivation of the sympathetic nervous system associated with a decrease in parasympathetic activity[28].

Another complication faced by individuals with CKD is sleep disturbances[14,29]. In a cross-sectional analysis, the presence of poor sleep quality or sleep disturbance was observed in approximately 70% of adult individuals in the final stage of CKD, that is, more than half of the analyzed sample[29].

CONCLUSION

The present study demonstrated that intradialytic resistance exercise in patients with CKD, after three months, improved cardiac autonomic modulation, increasing parasympathetic modulation and total cardiac modulation, also improving the survival of these patients, since indicators of increased parasympathetic modulation were associated in other studies with a lower risk of cardiovascular events. However, no significant changes in sleep quality were observed before and after the exercise program.

We found, therefore, that intradialytic resistance exercise can be used as a supporting measure for the clinical improvement of these patients and as a guide for creating strategies aimed at maintaining peripheral muscle strength and increasing survival of patients.

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