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Intradialytic exercise and postural control in patients with chronic kidney disease undergoing hemodialysis

Exercício intradialítico e controle postural de doentes renais crônicos em hemodiálise

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Abstract

Introduction: Exercise promotes physiological improvements that reflect better quality of life and survival among chronic kidney disease patients. However, little is known about the effect of exercise on postural control of hemodialysis patients. **Objective**: To evaluate the effect of intradialytic aerobic exercise on postural balance in patients on hemodialysis. **Methods**: a pilot study with seven individuals was conducted at the Hemodialysis Center of Bauru State Hospital. The Berg Balance Scale evaluated balance and postural balance was evaluated by the force platform Advance Mechanical Technology Inc. (AMTI - AccuGait). Trunk mean sway amplitude in the anterior-posterior (AP) and medial-lateral (ML) directions and mean velocity in the AP and ML directions were assessed. Secondary outcomes about functional capacity and body composition (DEXA) were evaluated. The aerobic exercise was performed with a ergometric bicycle during the first two hours of hemodialysis session for 50-60 minutes (BORG >12), three times a week for 12-weeks. **Results**: Four men and three women, 52.86 ± 11.08 years, participated in the study. There was no difference between pre and post-test of postural balance outcomes. Although the results were not statistically

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significant, except for the lean body mass and leg lean mass, the presented pilot study suggests improved functional balance and lower limb strength. **Conclusion**: The 12-weeks of aerobic exercise protocol during hemodialysis despite inducing gains in lean body mass and leg lean mass, was not able to promote improvements in postural control of chronic renal failure patients on hemodialysis.

Keywords: Postural Balance. Chronic Kidney Disease. Hemodialysis. Rehabilitation.

Resumo

Introdução: *O exercício promove benefícios fisiológicos que reflete em melhor qualidade de vida e sobrevida do doente renal crônico. Contudo, pouco se sabe sobre o efeito do exercício físico sobre o equilíbrio postural destes pacientes em tratamento de hemodiálise.* ***Objetivo****: Avaliar o efeito do exercício intradialítico sobre o equilíbrio postural de pacientes renais crônicos submetidos a hemodiálise.* ***Métodos****: Sete indivíduos renais crônicos provenientes do Centro de Hemodiálise do Hospital Estadual de Bauru. O equilíbrio foi avaliado pela escala de equilíbrio de Berg e o equilíbrio postural por meio da plataforma de força (AMTI – AccuGait). Para o equilíbrio postural foram consideradas as variáveis amplitude média e velocidade de deslocamento médio ântero-posterior e médio-lateral do centro de pressão. Informações secundárias sobre capacidade funcional e composição corporal (DEXA) também foram avaliadas. O exercício aeróbio foi realizado por 50-60 minutos nas primeiras duas horas da sessão de hemodiálise, três vezes na semana, durante 12 semanas.* ***Resultado****: Quatro homens e três mulheres com 52,86 ± 11,08 anos participaram do estudo. Os momentos pré e pós exercício não apresentaram diferença estatisticamente significativa (p > 0,05) para as variáveis do equilíbrio postural. Contudo, houve ganho massa magra total e de perna. Os resultados sugerem também melhora do equilíbrio através da escala de Berg e força de membros inferiores, contudo sem significância estatística.* ***Conclusão****: O protocolo de doze semanas de exercício aeróbio durante a hemodiálise apesar de promover ganhos na massa magra total e de membros inferiores, não foi capaz de promover melhoras no controle postural de doentes renais crônicos em hemodiálise.*

Palavras-chave: *Equilíbrio Postural. Doença Renal Crônica. Hemodiálise. Reabilitação.*

Introduction

In 2014 the estimated number of patients on dialysis in Brazil was higher then 100 thousand. An annual increase in the number of patients has been observed since 1994, when the number of people on dialysis treatment was about one quarter (24,000) of the current number (1).

Individuals with chronic kidney disease have not only a progressive and irreversible loss of renal function, but a complex syndrome comprised of metabolic changes involving uremia and abnormal electrolyte balance (2), anemia (3), impaired hormonal response (4), cardiopulmonary diseases (5), oxidative stress (6), chronic inflammation and impaired immune system (7). Concomitant to these characteristics, the clinical profile of these patients is also associated with reduced muscle strength and endurance (8). There is a consensus that patients on dialysis have lower exercise tolerance and loss of functional capacity (9, 10).

Recent data have shown that chronic renal failure patients on hemodialysis have lower postural control and balance compared to healthy individuals (11, 12), higher risk of falling incidence than the general population and the elderly (13), and consequently, high risk of fractures, given the high prevalence of osteoporosis in this population (4, 14).

Evidence shows that the deficiencies in mobility, balance and increased risk of falls are related, in addition to muscle activity, a complex interaction in sensory information processing of the visual, vestibular and somatosensory system and motor response (15). Thus, it is possible that metabolic alterations caused by renal failure and the treatment of the disease, affecting the neurological and vestibular system, and reduced muscular strength and endurance would promote damage to the postural control of these individuals.

In the last 35 years, exercise and physical activity has been studied in this population. The literature describes physiological improvements that reflect better quality of life and survival among chronic kidney disease patients (16). However, little is known about the effect of exercise on postural control of hemodialysis patients. Besides the improvement in muscle strength and consequently functional capacity (17), exercise can benefit the sensory and motor systems by improving the functioning of sensory channels for the postural control system, as well as effect the conduction velocity of motor fibers (18, 19). The aim of this study was to evaluate the effect of 12-weeks of intradialytic aerobic exercise on postural control and balance of chronic kidney disease patients undergoing hemodialysis.

Methods

This study is part of a larger project involving data from all patients from the Hemodialysis Center located in Bauru/SP, Brazil. The hemodialysis center has capacity to treat ~164 patients, these patients are divided into two groups according to the day of the week (Monday, Wednesday, Friday or Tuesday, Friday, Saturday) and in three shifts according to the time of day (morning, afternoon and evening). However, the sample of the present study was composed only by the morning shift as a pilot trial for postural control analysis. Eligibility criteria included: a) older than 18 years, b) more than three months of hemodialysis vintage, c) under the permission of their nephrologist for exercising, d) no diagnostic for neuropathy diseases, e) agreement to be randomly assigned and undergo study protocols. Patients in wheelchair, presenting disability, or those who had amputation and malformation of the lower limbs, causing impaired walking, and presenting representative blindness were excluded from the study. The procedures used in this study meet the criteria of the Ethics in Human Research according to resolution number 466/12 of the Brazilian Health Ministry and the study was previously approved by the Ethical Research Committee of the Faculdades Integradas de Bauru — FIB (CAAE):02564112.2.0000.5423). All patients provided written consent to partake in the study.

Assessments

Patients underwent the same evaluation protocol initially and at the end of 12 weeks of intervention in an interdialytic day. Data regarding age, sex, hemodialysis vintage and secondary morbidities such as hypertension, diabetes, smoking and perception of dyspnea were assessed by interview and medical records.

Primary outcomes

Berg balance scale

The Berg balance scale assessed functional balance performance based on 14 items common to daily life. The maximum score that can be reached is 56 and each item possesses an ordinal scale of five alternatives ranging from 0 to 4 points. The scale was developed to meet the various proposals in clinical practice and research: monitor the status of the patient's balance, the course of a disease, predict falls, selecting patients suitable to the process of rehabilitation and the patient's response to treatment.

Postural control

The postural control was assessed by the Advance Mechanical Technology Inc. (AMTI – AccuGait) force-plate. This force-plate has four electric sensors that measure the components of the horizontal and vertical forces (Fx, Fy and Fz) and the moments of these forces (Mx, My and Mz). The components measure the ground reaction force that together with their moments are used to calculate the center of pressure (COP) as the center of reaction force. The following dependent variables were obtained: trunk mean sway amplitude (AMP) in the anterior–posterior (AP) and medial-lateral (ML) directions as the standard deviation in direction for the positional data throughout the trial and mean velocity (VEL) in the AP and ML directions using displacement in each direction divided by the time of each trial. Variables were calculated using specific routines written in Matlab (The Matworks Inc., 1998 – version 5).

The participants were asked to stand upright for 30 seconds, positioned 1 m away from a fix target, in two bipedal stance positions (narrow and wide).

During the wide stance condition, the participants positioned their feet comfortably apart, at shoulder width. In the narrow stance condition, they kept their feet parallel and placed together at both the heels and toes. Each participant performed three tries for each postural task.

Secondary outcomes

Dual-energy x-ray absorptiometry (DEXA) was used to measure lean body mass and leg lean mass in kg using a total body scan, following the equipment description — HOLOGIC Discovery Wi (Hologicinc, Waltham, MA, USA). Body composition was assessed after a hemodialysis' day (interdialysis); the time after the previous hemodialysis session did not exceed eight hours before the body composition assessment.

The Six-minutes-walking-test (6MWT) measure the endurance in a 35 meters area, where subjects were instructed to walk their maximum distance in a 6-minute period according to "American Thoracic Society/European Respiratory Society" protocol (20).

The 30s sit-to-stand (ST30s) test measured the lower-body extremity muscle strength. Patients were instructed to stand up and sit down as quickly as possible for 30 seconds in a chair, with their arms across the chest.

Exercise intervention

Aerobic exercise was conducted with a mini ergometer cycling (Mini Bike E5 *Acte Sports*) attached to the patient chair. At first, we proposed three levels of workout load: 1) no load, 30-45 minutes of intercalated workout, 2) no load, 50-60 continuous exercise, and 3) 50-60 minutes of continuous workout with increased load. However, we did not find problems to start the intervention at the level three (all patients started exercising for 50-60 minutes continually with load incensement). Patients were instructed to maintain the workout effort between 12 and 16 of Borg scale, in accordance with The Life Options Rehabilitation Advisory Council: Exercise for the Patient Dialysis recommendation (21). Thus, the workload was adjusted when necessary during the exercise session, according to the perceived effort made by the patient.

The heating was held at ergometer for 5 minutes without load and prior to exercise in order to follow the progression exercise load cycle and the cooling was accomplished by decreasing exercise load. Two sessions were set to equipment adaptation, so patients could report any uncomfortable position and to find out in which of the three levels (above described) he could cycle.

Stretching of the upper limbs and trunk was performed before hemodialysis session, and legs' stretching was performed after exercise, during the hemodialysis session. Blood pressure, heart rate and perceived exertion were recorded before, during and after activity.

Statistical analysis

All data were verified by Shapiro-Wilk test and homogeneity test. Data are shown as mean and standard deviation. The analysis of variance (ANOVA 2x2) with stance (narrow and wide) and (time) pre and post-test treated as a repeated measures factor was performed. Secondary outcomes were compared by paired Student t test. The analysis was conducted using the software SPSS, version 17.0, and the level of significance used was $p < 0.05$. Effect size (ES) was calculated using Hedge's g formula.

Results

From nine patients selected to participate, seven patients (four man), mean age 52.86 ± 11.08 years, enter the final analysis. One patient received transplantation just before the exercise intervention initiates and one was not reassessed, despite finishing the 12-weeks exercising. The general characterization is presented in Table 1.

Regarding the exercise program, patients compete on average 76.4 ± 17.7% of the exercise sessions (total = 36 sessions) and exercised on average for 56.03 ± 6.18 minutes in each session. The BORG scale reported was 12.7 ± 1.37. There was no intercurrence related to exercise during the sessions.

After 12-weeks of exercise there was no significant differences between the moments for the variables evaluated (Table 2). As expected, the ANOVA showed effect of stance on postural control [AMPAP ($F_{1,6} = 8.65$, $p = 0.032$, partial eta$^2 = 0.63$), AMPML

($F_{1,6}$ = 37.40, p = 0.002, partial eta^2 = 88.0), VELAP = 13.16, p = 0.015, partial eta^2 = 0.73) VELML ($F_{1,6}$ = 25.16, p = 0.004, partial eta^2 = 0.83)], patients on narrow stance showed higher body sway. However, there was no interaction between time (pre and post-test) and stance (narrow and wide) (Table 2).

However, the group showed gains in lean body mass and leg lean mass (p < 0.05) with small ES, and although with no statistical significance, a trend of improvement in sit-to-stand test (ES = 0.57) and functional balancing test (ES = 0.83) could be observed (Table 3).

Table 1 - Sample characterization

Variables	N = 7
Hemodialysis vintage (months)	31.43 (7.63)
Skin color	
With/black	5 (71.4)/2 (28.6)
Gender N(%)	
Male/Female	4 (57.1)/3 (42.9)
Currently working N(%)	
Yes/No	5 (71.4)/2 (28.6)
Chronic kidney disease etiology N(%)	
Hypertension	1 (14.3)
Glomerulonephritis	2 (28.6)
Unknown	4 (57.1)
Biochemical values	
Kt/V	1.29 ± 0.18
Sodium (mEq/L)	137.83 ± 3.25
Potassium (mEq/L)	4.85 ± 0.82
Hemoglobin (g/dL)	11.13 ± 1.76
Phosphorus (mg/dL)	6.40 ± 2.33
Creatinine (mg/dL)	9.77 ± 4.57
Calcium (mg/dL)	8.70 ± 0.55

Table 2 - Mean and standard deviations of body sway, pre and post-exercise and narrow and wide stance

	Moment		Time		Time*Stance	
Stance	**Initial**	**Post-test**	***f***	***p-value***	***f***	***p-value***
Mean amplitude AP (cm)						
Wide	0.067 ± 0.021	0.068 ± 0.021	0.122	0.741	1.144	0.334
Narrow	0.084 ± 0.032	0.078 ± 0.023				
Mean amplitude ML (cm)						
Wide	0.036 ± 0.015	0.034 ± 0.015	0.150	0.715	0.023	0.885
Narrow	0.076 ± 0.030	0.076 ± 0.023				
Mean velocity AP (cm/s^2)						
Wide	0.248 ± 0.084	0.257 ± 0.094	0.320	0.596	3.122	0.596
Narrow	0.302 ± 0.109	0.278 ± 0.096				
Mean velocity ML (cm/s^2)						
Wide	0.132 ± 0.050	0.132 ± 0.051	0.961	0.372	0.885	0.390
Narrow	0.290 ± 0.115	0.312 ± 0.126				

Note: *p*-value for ANOVA repeated measures (2x2).

Table 3 - Secondary outcomes pre and post-exercise

	Initial	Post-test	*p-value*	Effect-Size
BMI (kg/m^2)	27.18 ± 4.11	27.92 ± 4.66	0.064	0.16
Lean body mass (kg)	46.64 ± 10.22	49.30 ± 11.68	0.021	0.23
Leg lean mass (kg)	14.69 ± 3.58	15.48 ± 3.90	0.004	0.20
Six-minutes walking test (m)	566.17 ± 98.62	579 ± 74.92	0.388	0.14
Sit-to-stand test (repetitions)	13.17 ± 3.76	15.17 ± 2.79	0.247	0.57
Balance scale (score)	52.43 ± 3.55	54.71 ± 0.76	0.156	0.83

Note: *p*-value for paired t test.

Discussion

The 12-weeks of intradialytic aerobic exercise did not promote changes in postural control of hemodialysis patients, however promoted gains in lean body mass, and tendency to better results in functional capacity test and functional balance. To our knowledge, this study is the first to evaluate the effect of intradialytic exercise in hemodialysis patients on postural control.

The literature describes that patients with chronic kidney disease who perform aerobic exercise improves functional capacity, muscle strength, agility (22, 23), and promotes gains in muscle size (24), concerning these variables, our results corroborates with the literature. However, regarding the postural control and balance the effects of exercise have not yet been elucidated.

Evidence has shown that deficiencies in mobility, balance and high risk of falls are related, in addition to muscle activity, to a complex interaction in the processing of sensory information (visual system, vestibular and somatosensory) (25) and the motor response (26). Consequently, it is suggested that the metabolic alterations caused by renal failure and its treatment (dialysis), all well described in this population, such as malfunctions in peripheral neurological system (27), clinical manifestations of vestibular system disorders (28) and impaired cognitive capacity (29), have greater impact on the loss of postural control of these individuals, as well as the reduced muscle strength and endurance (8).

Although not completed elucidated the mechanisms associated with the type of exercise used in the rehabilitation and prevention of postural control and balance, the effects of exercise on postural control in other populations, especially the elderly, have been reported through in various protocols (30, 31). However, studies in the elderly have pointed out that, in general, a physical activity program to improve balance should include besides aerobic exercises of low intensity, resistance exercises to stimulate the maintenance of muscle strength, flexibility and specific balance training (32).

Thus, it is possible that despite promoting gains in lean body mass and tendency of better results on functional testes, corroborating data in the literature, the protocol proposed in this study did not cause effective stimulus to promote changes in the postural control. Also, the short period of intervention has to be considered (12-weeks) as inefficient to promote changes in other systems associated to the postural control. Yet, it has also been suggested that although important in the performance of body balance, the lower-extremity force is not sufficient condition for the maintenance of balance (28).

Therefore, it is possible as well that the characteristic and progression of the disease, which goes beyond declines seen in senescence, and years on hemodialysis procedure, overcome the benefits observed through exercises intervention when regarding postural control, since it controls involve others important systems (visual system, vestibular and somatosensory) among renal patients. Then, it is necessary that more studies to explore possible change resulting from improvement on the sensory systems through the exercise protocols, motor control and cognitive capacity, and the relationship between them, assessing the postural control of chronic renal patients undergoing hemodialysis. The assessment of postural control through force platform assists in understanding the changes that the chronic renal patient undergo, submitting they to a higher risk of falling, and provides information in order to better target rehabilitation in these patients.

Conclusion

The 12-weeks of intradialytic aerobic exercise fallowed by stretching promoted gains in lean body mass, and tendency to better results in functional capacity test and functional balance, however it did not promote significant changes in postural control of hemodialysis patients assessed by force-plate.

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