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Original article

The influence of a protocol of aquatic exercises in postural control of obese elderly

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ABSTRACT

Objective: The objective of this study was to evaluate the effects of a protocol of aquatic exercises in postural control of elderly subjects with overweight and the influence of body mass and body mass index in variables of the center of pressure.
Method: Each participant was positioned on the force platform, without shoes, feet apart on the same alignment of the upper limbs along the body. For the collection, the subjects were instructed to stay on in bipedal support on the force platform with eyes fixed on the bright spot for 60 s.
Results: Results indicated a notable difference in the variables root mean square-mediolateral and COP area after aquatic exercise practice. However, visual condition analyzed indicates significant differences in the variables root mean square-anteroposterior and speed anteroposterior.
Conclusion: Aquatic exercise had positive effects when analyzing the sensory condition suggesting maintenance of postural control. However, when analyzed post aquatic exercise in closed eyes condition and the interaction effects of visual condition did not improve postural stability. In obese elderly, body mass index resulted in a functional adaptation in control of upright stance, suggesting that the balance was preserved in the population studied.

Influencia de un protocolo de ejercicios acuáticos en el control postural de ancianos obesos

Palabras clave:
Ancianos
Obesos
Postura
Equilibrio postural
Ejercicios

RESUMEN

Objetivo: El objetivo de este estudio fue evaluar los efectos de un protocolo de ejercicios acuáticos en el control postural de sujetos de edad avanzada con exceso de peso y la influencia de masa corporaly el índice de masa corporal en las variables del centro de presiones.
Método: Cada participante se posicionó en la plataforma de fuerza sin zapatos, los pies separados con la misma alineación de las extremidades superiores a lo largo del cuerpo. Para el análisis, los sujetos fueron instruidos para permanecer en apoyo bípedo sobre la plataforma de fuerza con los ojos fijos en un punto brillante durante 60 segundos.
Resultados: Los resultados indicaron una diferencia notable en las variables: Media Cuadrática-Mediolateral y el Área descrita por el desplazamiento del centro de presiones, después de la práctica de ejercicio acuático. Sin embargo, la condición visual analizada indica diferencias significativas en las variables: Media Cuadrática Anteroposterior y Velocidad Anteroposterior.
Conclusión: El ejercicio acuático tuvo efectos positivos en el análisis de la condición sensorial sugiriendo el mantenimiento del control postural. Sin embargo, cuando se analizan la condición de ojo cerrado tras

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el ejercicio acuático y los efectos de la interacción de la condición visual no mejoró la estabilidad postural. En obesos de edad avanzada, el índice de masa corporal resultó en una adaptación funcional en el control de la postura vertical, lo que sugiere que el equilibrio se conservó en la población estudiada.

Influência de um protocolo de exercícios aquáticos no controle postural de idosos obesos

Palavras-chave:
Idoso
Obeso
Postura
Controle postural
Exercícios

R E S U M O

Objetivo: O objetivo deste estudo foi avaliar os efeitos do protocolo de exercícios aquáticos no controle postural de idosos com excesso de peso, e a influência de variáveis de massa corporal e índice de massa corporal no centro de pressão.

Método: Cada participante foi posicionado sobre a plataforma de força, sem sapatos, pés alinhados, braços ao longo do corpo. Durante a coleta, os indivíduos foram orientados a permanecer sobre a plataforma de força, com os olhos fixos no ponto brilhante durante 60 segundos.

Resultados: Os resultados indicaram uma diferença significativa nas variáveis: área do centro de pressão e média quadrática-mediolateral, após a prática de exercício aquático. No entanto, a análise da condição visual sugere diferenças significativas nas variáveis: média quadrática anteroposterior e velocidade anteroposterior.

Conclusão: Os exercícios aquáticos tiveram efeitos positivos sobre a análise sugerido pela condição da manutenção do controle postural. No entanto, quando analisados em condição de olho fechado após o exercício aquático e os efeitos da interação da condição visual, não melhoram a estabilidade postural. Em obesos idosos, o índice de massa corporal resultou numa adaptação funcional para controlar a posição vertical, o que sugere que o equilíbrio foi mantido na população estudada.

Introduction

Aging is associated with several changes in the life style and body composition of the elderly population. Mainly, the loss of balance might reduce the independence. In addition, this condition can be intensified due obesity.[1,2] Furthermore, changes in body composition is connected with aging, including muscle tissue reduction and increase of the fat tissue, especially in the lower limbs.[1,3,4] The association between aging and obesity negatively influence visual acuity, muscle strength, processing and nerve conduction, tactile sensitivity causing a reduction in functional capacity, losses in balance control, and increase the risk for falls.[1,3,4] Thus, the maintenance of body balance in standing position for the obese elderly is challenging task, which requires a complex integration of multiple systems, responsible for maintaining the projection of the center of gravity of the subject on the support base.[5]

We can say that the balance and postural control are terms used interchangeably, and can be defined as the ability to maintain the projection of the center of gravity on the support base limits for static and dynamic positions.[6,7] The assessment of the balance can be estimated by calculating the center of pressure (COP). COP characterized by the application point of the resultant vertical forces acting on the support surface. The COP displacement is a collective result of postural control system and the force of gravity.[8] Some of the changes that occur in postural control as part of the aging process are reflected in COP displacement.[5]

In view of some changes that occur in the elderly, physical activity can be an adjuvant therapy, improving balance control for both elderly and obese subjects. Various types of training are described in the literature and indicate positive effects in the control of these subjects.[9–13] Aquatic exercises may be preferred for this population since they allow these to perform large movements without the risk of falling or injury and assist in maintaining an independent stance. Water has a viscosity that allows movements to be performed slowly and so the subjects have more time to create and develop responses reaction mechanisms. Combinations of training principles lead to an increase in muscle strength, improved flexibility, balance, and consequently reduce the number of falls.[10]

This study hypothesized that overweight elderly subjects could improve postural control after performing a protocol of aquatic exercises, taking into account the physical properties of water in reducing the impact on the joints and in the great movements of accomplishment permission amplitude. Therefore, the aim of this study was to evaluate the effects of aquatic exercise protocol in postural control of elderly subjects with overweight and the influence of body mass and body mass index (BMI) on the COP variables.

Method

Subject

The Ethics Committee of the Federal University of Goiás (UFG) and declaration of Heisinki, under number 093, approved the study. All participants were informed about the research procedures and signed the Informed Consent. The study included ten female subjects (age = 68.90 ± 4.05 years; height = 1.43 ± 0.01 m; mass = 64.43 ± 8.32 kg) and three males (age 70.55 ± 2.40 years; height = 1.53 ± 0.03 m; mass = 67.40 ± 18.90 kg). All subjects were overweight when classified according to the BMI (LIPSCHITZ, DA, 1994). They were recruited from a Family Health Strategy Unit (ESF) in the city of Professor Jamil – Goiás and evaluated in the first half of 2011 and the first half of 2013. Inclusion criteria were having regularly attended the activities in the local from 2011; age or greater than 60; do not have musculoskeletal problems. Participants with high blood pressure and uncontrolled blood glucose, cognitive impairment losses engines (injury or broken hip, knee, ankle and/or foot in the twelve months before the trials) or device

Table 1
Exercise protocol.

Phases	Exercises type	Duration and frequency	Intensity
Warming up	Walk – 10 laps on the swimming pool	10 min 3 times a week	Perceived exertion (level 9–11) Borg scale
Aquatic exercises	-Upper limb: abduction/adduction/flexion with the aid of flotation device; displacement in the transverse plane; -Lower limbs: flexion/extension of the hip and knee; abduction/adduction of the hip; flexion/dorsiflexion plant;	30 min, 3 times per week 3 sets of 8–15 repetitions; A minute average recovery between sets	The increase in the number of repeats was performed according to the subjective perception of the group; Level 13–15 Borg scale
Relaxation	Fluctuation; stretching arms and legs	10 minutes, 3 times per week	Increase of 30 s each month Level (9–11) Borg scale

use auxiliary upright posture or gait were excluded from sample. The data relating to controlled glycaemia or were not collected from medical records

Experimental design

To collect the body mass data and height a digital scale, brand Toledo (2096PP model, Sao Paulo, Brazil) and a stadiometer by Sanny (professional, Sao Paulo, Brazil) were used. To collect kinetic data an AMTI force platform (model OR6-7, Massachusetts, USA) six channels of 50 cm × 50 cm placed on a smooth surface at ground level was used.

Prior to the experimental procedure, height and body mass was measured according to protocol defined by Lohman et al.[12] Each participant was positioned on the force platform, without shoes, feet apart on the same alignment of the upper limbs along the body. The distance between the feet was self-selected. The subject in this position kept his eyes on a bright point positioned 1.5 meters apart and 1.7 m high. A beep indicated the beginning of each subject collection. For the first collection, the subjects were instructed to stay on in bipedal support on the force platform with eyes fixed on the bright spot for 60 s. Three samples were performed with an interval of 1 min between them. Then were held collections without the visual stimulus (eyes closed) following the same procedures of collection with visual stimulus. Participants were reassessed after two years of exercises.

The data were stored on a personal computer via Universal Serial Bus (USB), acquired at a frequency of 100 Hz through the Balance Clinic software, designed for data acquisition in the three orthogonal axes (x component, y, z). After all collections data were exported to a file ASCII. A data analysis involved comparison of the main stabilizing measures, including oscillation range and the length of the COP of the way with their directional subcomponents: anteroposterior (AP) and mediolateral (ML). To perform these analyzes environment in routine Matlab® was developed. A COP area (AREA) was estimated at 95% of the ellipse and expressed in cm^2. The root mean square (RMS), the series time COP was calculated according to the formula:

$$\text{rms\_dir} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(\text{CP}_{\text{dir}}(i) - \overline{\text{CP}_{\text{dir}}(i)})^2} \quad (1)$$

where N is the number of sample and CP_{dir} the direction of COP (AP or ML).

The average speed of the COP was measured along the axis ML and AP expressed in cm/s.[2,5] The calculation was performed based on the following formula:

$$\text{vel}_{\text{dir}} = \sum_{i=1}^{N-1}\sqrt{\frac{(\text{CP}_{\text{dir\_ajust}}(i+1) - \text{CP}_{\text{dir\_ajust}}(i))^2}{N/\text{Fs}}} \quad (2)$$

where vel_{dir} is the speed of the COP. $\text{CP}_{\text{dir\_ajust}}$ is the centralized setting in relation to the first data captured in AP or ML directions; N is the sample number and Fs is the sampling frequency of collection.

The last variable analyzed was the total displacement (DTOT) of the COP. For this measurement, the following formula was used:

$$D_{\text{tot}} = \sum_{i=1}^{N-1}\sqrt{(\text{CP}_{\text{MI}}(i+1) - \text{CP}_{\text{MI}}(i))^2 + (\text{CP}_{\text{Ap}}(i+1) - \text{CP}_{\text{Ap}}(i))^2} \quad (3)$$

where D_{tot} is the displacement of the COP; N is the number of sample; CP_{MI} is the direction of mediolateral COP; CP_{Ap} is the anteroposterior direction of the COP.

Participants performed two years of exercises with a frequency of three times a week, for about 50 min. The exercise protocol was performed with 10-min warm up, 30 min of exercises and ten minutes of relaxation. Table 1 lists the exercises performed during the two years of the study. The exercises were performed in a heated pool (25–29 °C), covered with dimensions of 15 m × 7 m × 1.50 m. Participants performed the exercises with the water level between the nipple line and the waist. The protocol by the subjects consisted of stretching, and relaxation class. All activities were carried out in the pool and supervised by a trained professional.

Statistical analysis

The results were expressed as mean, standard deviation, frequency and graphics. To verify the normality of the data, we used the Shapiro–Wilk test. Analysis of variance (ANOVA) two-way repeated measures was used to test the effects of aquatic exercise in visual condition (Open eyes [EO] and Closed eyes [EC]) and the interaction between them. The association between the independent variables, body mass and BMI with the COP variables were evaluated using Spearman's correlation coefficient. The significance level was 0.05. Statistical analysis was performed using SPSS software (Statistical Package for Social Sciences).

Results

The mean pre-assessment body mass was 65.11 ± 10.63 kg (95% CI: 59.31–70.79) and after 24 months was 65.59 ± 10.73 kg (95% CI: 59.92–71.21). When subjects were classified by BMI values, on both occasions, according Lipschitz,[1] all were in the overweight range (>27 kg/m^2).[1] For BMI pre and post average were 30.87 ± 4.96 kg/m^2 (95% CI: 28.23–33.56 kg/m^2), 31.18 ± 4.86 kg/m^2 (95% CI: 28.54–33.68 kg/m^2), respectively. There were no significant differences in body weight and BMI after the monitoring of individuals ($p = 0.49$; $p = 0.64$, respectively).

When assessing the effects of aquatic exercise on the COP variables, RMS-ML ($F = 5.49$, $p = 0.04$) and AREA ($F = 11.80$, $p = 0.005$), these had increased after 24 months. The effects of the visual condition were recorded RMS-AP (root mean square antero-

Table 2
Cop parameters according to sensory condition and pre training and post (two year after) for total group: mean (SD).

	EO pre	EO post	EC pre	EC post
RMS-AP (cm)	0.38 (0.12)	0.38 (0.12)	0.43 (0.12)	0.45 (0.14)†
RMS-ML (cm)	0.20 (0.08)	0.23 (0.10)	0.22 (0.10)	0.24 (0.10)*
AREA (cm^2)	1.45 (0.93)	1.84 (1.10)	1.43 (0.82)	2.19 (1.43)*
VEL-AP (cm/s)	0.88 (0.32)	0.75 (0.19)	1.10 (0.48)	1.11 (0.39)†
VEL-ML (cm/s)	0.44 (0.16)	0.45 (0.18)	0.48 (0.19)	0.51 (0.18)
DTOT (cm)	63.80 (21.97)	57.34 (15.83)	77.63 (31.54)	78.96 (26.78)†

RMS-AP: root mean square anteroposterior; RMS-ML: root mean square mediolateral; VEL-AP: velocity anteroposterior; VEL-ML: velocity mediolateral; DTOT: total displacement; EO: Open Eyes; EC: Closed Eyes.
* $p < 0.05$ to difference between pre and post training.
† $p < 0.01$ to sensory condition.

posterior) ($F = 9.19$, $p = 0.01$), SPD-AP (displacement of the COP anteroposterior) ($F = 22.95$, $p < 0.001$) and DTOT (total displacement of the COP) ($F = 19.50$, $p = 0.001$) (Table 2). The ANOVA results for two-way repeated measures indicated no interaction between activity and the visual condition of the variables of the COP.

Fig. 1 shows the values before and after the aquatic exercise for each subject of the variable speed pressure center anteroposterior-(VEL-AP) (Fig. 1A and B) and speed pressure center mediolateral (VEL-ML) (Fig. 1C and D), and the average values for the condition of open eyes (OE) and closed eyes (OC) (Fig. 1E). There was a 14.8% reduction and a small increase of 1% for VEL-AP values between the EC and OE conditions, respectively. For the VEL-ML variable the increase was 2.3% for OA and 6.2% for OC. When performed the association between body mass, BMI and the variables of the COP these were not significant when analyzed before and after 24 months of aquatic exercises.

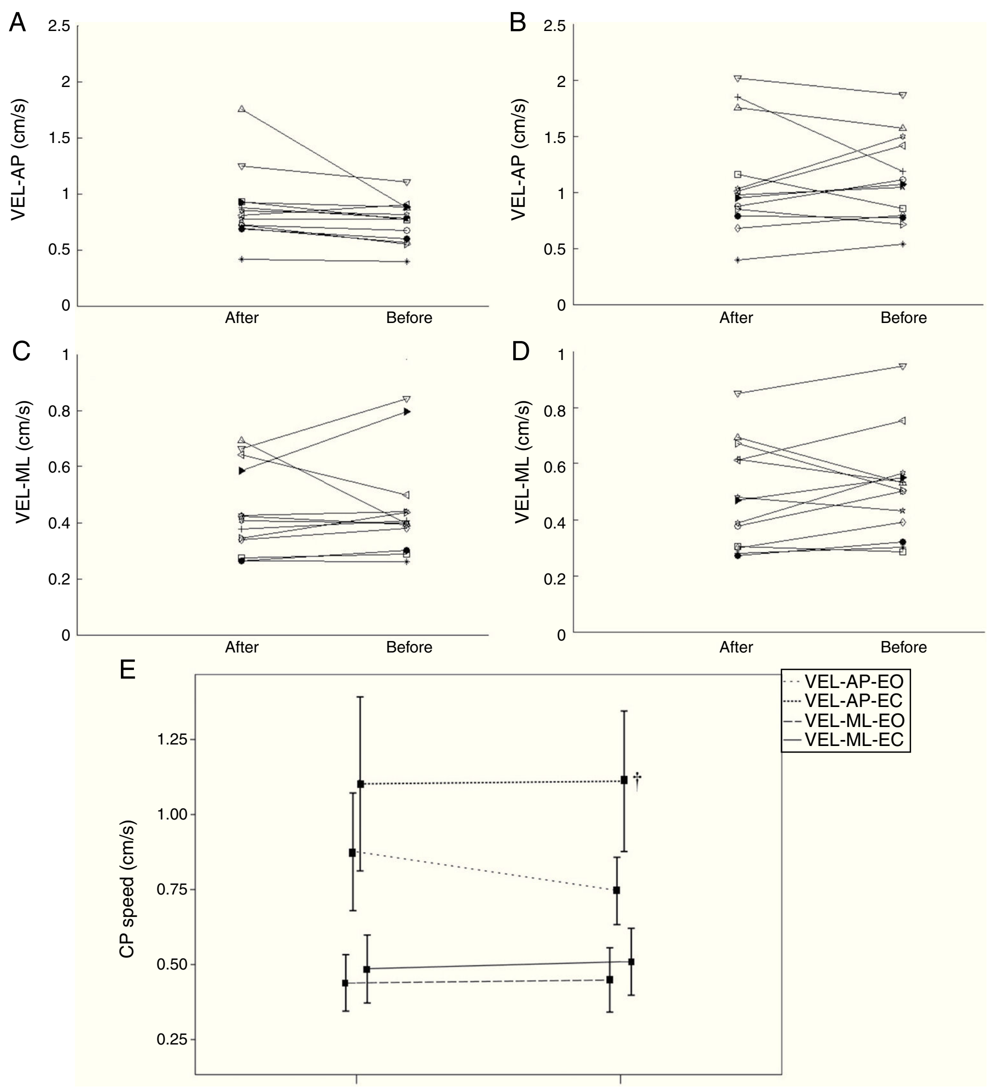

Fig. 1. Individual values for the VEL-AP variables, OE and OC (A and B) and VEL-ML, EO and (C and D) before and after aquatic exercise. (E) Average values and the standard deviation visual (EO and EC) before and after aquatic exercise. †Effects of visual condition on COP speed ($p < 0.001$).

Discussion

This study aimed to evaluate the effects of a protocol of aquatic exercises in postural control of elderly and obese subjects beyond the influence of body mass and body mass index (BMI) of variables of the COP. The results indicated that after aquatic exercise, the RMS-ML variables and the AREA differ significantly. When the effect of visual condition was analyzed, the only variables that showed significant differences were RMS-AP, VEL-AP and DTOT. In addition, associations were found between body weight, BMI and the variables of the COP.

Several studies have demonstrated the positive effects of aquatic exercise on various physiological and biomechanical parameters in the elderly. Among these are the increases in VO_{2max}, walking speed, motor coordination and balance.[10,14] Aquatic exercises increase muscle strength and stable posture independently in the elderly and generate the realization of large movements without increasing the risk of falls and consequential injuries.[15] In addition, the viscosity of the water allows slower movements and thus provides a longer time for the elderly to create and react to stimuli data during the exercises. The combination of frequency and speed of motion can cause an increase in strength and improvement in flexibility.[16]

When the COP variables (RMS-ML, RMS-AP and AREA), pre- and post-aquatic exercises were compared with the study results of Suomi and Koceja,[16] they showed higher values. Two factors may explain these differences: First, the population studied in the present study was elderly with BMI greater than 27 kg/m^2 (patients with orthopedic problems were not excluded) and the study used for comparison, the target was elderly with clinical condition of rheumatoid arthritis and osteoarthritis, and not the body composition. The collection time on the platform can also have affected the comparison of the values found. Today there is still no standardization for this type of collection, and the researcher's discretion the best way for your study. Studies show different times in the acquisition of kinetic data for the best static postural control in the standing posture.[3,17–19]

The results of the associations of body mass, BMI and the COP variables are different from those found in the literature.[3,19] Studies indicate that increased BMI and body mass may indicate changes in the individual's ability to maintain balance. This fact must be taken into account, since the postural stability is a prerequisite for daily activities.[3,19] However, there is evidence in the literature that increased body mass results in a functional adaptation to control the upright posture, the fact characterized by a reduction in postural sway, suggesting that postural balance is preserved. Already, in obese subjects with BMI greater than 40 kg/m^2 can happen substantial deterioration in AP stability.[20]

It should be emphasized that age influences the functional abilities of individuals, due to the decline of voluntary physical activity is associated with reduced aerobic capacity, muscle strength and balance control.[4] Thus, even if there are adjustments with increasing body mass, individuals would not be free from suffering the aging losses that may at some point be characterized by various clinical conditions, including various aspects, including the musculoskeletal. These are related sarcopenia, which is pronounced in the soleus muscle, which plays an important role in the postural control and suffers from the aging of collagen and fat infiltration and intensifies the obese subject.[21] In addition, the peripheral and axial mechanical changes, which are expressed by the degeneration of articular cartilage, reducing the thickness of the subcondral bone, bone remodeling with osteophytes formation and sub articular bone cysts. When these degenerative changes are severe pain can limit the activities of daily living and impair postural control.[21]

The present study showed that the longer duration of treatment might influence postural control. The type of activity performed in the aquatic environment is recommended for obese patients to minimize the impacts of the exercises performed on the ground, by allowing a range of motion in different bases of support, which leads to an improvement of balance, and reducing the risk of falls.

Some factors were limiting to be able to generalize the results. The small number of individuals, low compliance of males, and the absence of a control group and other methods, such as electromyography, to detect changes in muscle components and their association with the variables of the COP. Another factor to consider is the long period between the collections. Since this is a group of elderly time can interfere considerably in the analyzed variables.

The findings of this study indicate differences in postural stability obese subjects when evaluated after aquatic exercise in closed eyes condition. Regarding the effect of sensory condition there was no difference in displacement and AP speed, and the total COP displacement. In obese subjects BMI resulted in a functional adaptation in control of upright stance, this suggests that the balance was preserved in this sample.

The results also indicate that aquatic exercises were efficient when analyzing the sensory condition with open eyes since there were no differences after training, then suggesting maintenance of postural control. However, when analyzing the closed eyes condition and the effect of visual condition these results were not significant in improving stability.

Finally, after two years of intervention in this group the effects of maintaining balance indicate that the improvement was effective, thinks seen the range of ratings. In two years, the effects in the elderly are considerable when it comes to body stability.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

Conflicts of interest

The authors declare that there are no conflicts of interests.

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