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Analysis of postural control and muscle function performance of older adults participating in a multicomponent exercise program in primary health care

Análise do desempenho do controle postural e da função muscular de idosos participantes de um programa de exercício multicomponente na Atenção Primária à Saúde

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Abstract

Objectives: This cross-sectional study aimed to investigate (1) postural control performance in different postural tasks and (2) muscle strength and power of the hip, knee, and ankle of active vs inactive older adults.
Methods: The sample consisted of 61 healthy community-dwelling older adults, classified into 2 groups: active, consisting of participants of a multicomponent exercise program offered through the Exercise Orientation Service; and inactive. Participants were considered physically active/inactive in the past 3 months. Postural control was assessed using a force plate in 8 postural tasks. Muscle function was evaluated using an isokinetic dynamometer. T-tests were used to compare clinical characteristics between the groups. ANCOVA and MANCOVA were used to compare differences in variables of postural control and muscle function.
Results: Active participants had higher levels of physical activity, clinical balance, and quality of life than inactive participants. The active group had lower values for area (center of pressure) than the inactive group under the following conditions: bipedal stance on an unstable surface with eyes open and with eyes closed, and semi-tandem stance on an unstable surface with eyes open. The active group showed greater muscle power, with higher mean power values for hip abduction and adduction, knee extension, and knee flexion and shorter time to peak torque for hip adduction and ankle dorsiflexion than the inactive group.
Conclusions: Multicomponent exercise programs delivered in primary health care settings contributed to improving postural control and muscle power in this sample of older adults, which can potentially help prevent falls and improve quality of life.
Keywords: aging; exercise; postural balance; muscle strength; Unified Health System.

Resumo

Objetivo: Este estudo transversal visou investigar: (1) o desempenho no controle postural em diferentes tarefas e (2) a força e a potência musculares de quadril, joelho e tornozelo de idosos ativos *vs.* inativos.
Metodologia: A amostra foi composta de 61 idosos comunitários saudáveis, classificados em dois grupos: os ativos, participantes do programa de exercício multicomponente ofertado pelo Serviço de Orientação ao Exercício, e os inativos. Os participantes foram considerados fisicamente ativos/inativos nos três meses anteriores. O controle postural foi avaliado em oito tarefas usando-se uma plataforma de força. A função muscular foi mensurada com um dinamômetro isocinético. Foram utilizados testes *t* para comparar as características clínicas entre os grupos. Análise de covariância e análise multivariada de covariância foram utilizadas para comparar diferenças nas variáveis de controle postural e função muscular.
Resultados: Os participantes ativos apresentaram maiores níveis de atividade física, equilíbrio e qualidade de vida que os inativos. O grupo ativo apresentou menores valores de área (centro de pressão) que o inativo nas seguintes condições: base bipodal em superfície instável com olhos abertos e fechados e base semitandem em superfície instável com olhos abertos. O grupo ativo apresentou maior potência que o inativo, com maior valor de potência média para abdução e adução de quadril, extensão e flexão de joelho, e menor tempo de pico de torque para adução de quadril e dorsiflexão de tornozelo.
Conclusão: Programas de exercício multicomponente ofertados na Atenção Primária à Saúde contribuíram para melhorar o controle postural e a potência muscular nesta amostra de idosos, o que pode contribuir para prevenir quedas e melhorar a qualidade de vida.
Palavras-chave: envelhecimento; exercício físico; equilíbrio postural; força muscular; sistema único de saúde.

INTRODUCTION

The aging process is often characterized by disturbed postural control and impaired muscle activity. In older adults, postural control deteriorates due to structural and functional changes in the sensorimotor system and is particularly impaired in situations involving a reduced base of support, visual and somatosensory disturbances, and dual-task conditions, especially in older adults with cognitive decline.[1,2] Aging also leads to changes in postural strategies, with increased dependence on the hip strategy rather than the ankle strategy for postural control.[3] These changes appear to result from deficits in muscle function, with a decline in peak torque and power in older adults.[4]

As opposed to the aging process, exercise provides benefits in terms of improved postural control and muscle function, thus contributing to preventing falls.[5] Multicomponent exercise is recommended for the older population because it improves postural performance (e.g., by reducing the surface area and amplitude of postural sway) and increases muscle strength and power.[6-10] Multicomponent exercise also appears to contribute to preventing falls and improving quality of life.[11,12] The VIVIFRAIL© multicomponent exercise program is an international reference for the prevention of frailty and falls in older adults and suggests that public interventions are necessary to promote physical activity in this population.[13]

The Exercise Orientation Service (EOS) is a pioneering physical activity program in the Brazilian Unified Health System (SUS, for the acronym in Portuguese), provided by the municipal health department of Vitoria, capital of Espírito Santo state, which aims to contribute to promoting health and quality of life.[14] Previous studies have shown that participation in the EOS program is associated with sufficient levels of physical activity, health promotion, and socialization as well as with balance control benefits.[15-17] However, information on the health benefits of physical activity within SUS programs is still lacking, especially for older adults. To the best of our knowledge, no study has analyzed postural control and muscle function performance in active participants of a multicomponent exercise program in primary health care compared with inactive individuals. In this context, investigating postural balance and muscle activity seems necessary in older adults participating in multicomponent physical activity programs delivered in primary health care settings, such as the EOS program.

Because age-related deterioration of postural control and muscle function is an important risk factor for falls, the number of falls should be considered a control variable in analysis in order to eliminate its influence on the dependent variables "postural control" and "muscle function."[18] This study aimed to investigate:

1. Postural control performance in different postural tasks; and
2. Muscle strength and power of the hip, knee, and ankle of active vs inactive older adults.

We hypothesized that active individuals would perform better in all postural tasks, especially in those involving a reduced base of support and simultaneous visual and somatosensory disturbances, and would have greater muscle strength and power of the hip, knee, and ankle than inactive individuals.

METHODS

This cross-sectional study evaluated healthy community-dwelling older adults aged 60 to 74 years who performed activities of daily living independently and received primary health care in Vitoria, Espírito Santo, Brazil. Participants were recruited from the community by health professionals from the EOS program and primary health care units. The sample was selected using non-probabilistic sampling and classified into 2 groups: active, consisting of older adults who regularly participated in the EOS program, defined as those who attended more than 70% of the multicomponent exercise sessions (sessions of approximately 60 minutes twice weekly, including balance, strength, flexibility, and aerobic exercises as well as socialization and recreational activities) conducted at EOS Modules (transient training centers of primary health care located on beaches, parks, and public squares) for more than 3 months; and inactive, consisting of older adults who were not engaged in at least 150 minutes per week of moderate-intensity physical activity in the past 3 months. Exclusion criteria were neurological, vestibular, or musculoskeletal diseases that could prevent the fulfilment of motor tasks, cancer, severe visual impairment, cognitive deficits, loss of plantar skin sensitivity, use of orthoses or prostheses, use of medication that could affect balance, and body mass index (BMI) > 35 kg/m^2. Written informed consent was obtained from each study participant according to the rules established by the Resolution number 466/2012 of the Brazilian National Health Council. This study was approved by the Research Ethics Committee of Universidade Federal do Espírito Santo (UFES) (approval number 2.061.608).

Data were collected on 2 days: day 1, in the EOS Modules and primary health care units; and day 2, in the Strength and Conditioning Laboratory at UFES Physical Education and Sports Center. On day 1, eligible participants were interviewed for information on sociodemographic characteristics, health status, and history of falls (a fall was defined as an event that results in a person coming to rest inadvertently on the ground or floor or other lower level) and for evaluation of the exclusion criteria. In addition, the modified Baecke questionnaire for older adults was administered to assess the level of physical activity;[19] the mini-mental state examination was used to assess cognitive function;[20] the 36-Item Short Form Health Survey (SF-36) was used to measure quality of life;[21] and the Mini-BESTest was performed to assess clinical balance.[22] On day 2, plantar skin sensitivity, postural control, and muscle function assessments were performed. Plantar skin sensitivity was assessed using the Semmes-Weinstein monofilament test (SORRI Bauru). Postural control was measured by means of a force plate (Biomec 400, EMG System do Brasil), on which a viscoelastic foam was placed to evaluate postural control on an unstable surface. Muscle function was evaluated using an isokinetic dynamometer (BIODEX System 4 Pro, Biodex Medical System).

For postural control assessment, the participants were instructed to maintain the upright stance on a force plate for 30 seconds, with the arms extended along the side of the body and the gaze fixed on a target placed at eye level and 1 m distant, under 8 different conditions:

1. Bipedal stance on a rigid surface with eyes open (BREO);
2. Bipedal stance on a rigid surface with eyes closed (BREC);
3. Bipedal stance on an unstable surface with eyes open (BUEO);
4. Bipedal stance on an unstable surface with eyes closed (BUEC);
5. Semi-tandem stance on a rigid surface with eyes open (SREO);
6. Semi-tandem stance on a rigid surface with eyes closed (SREC);
7. Semi-tandem stance on an unstable surface with eyes open (SUEO); and
8. Semi-tandem stance on an unstable surface with eyes closed (SUEC). Participants performed 3 trials for each postural control condition.

For muscle function assessment, the participants initially performed a warm-up on a cycle ergometer for 5 minutes with self-selected intensity. After the warm-up, the participants were informed of the evaluation procedures, which included the evaluation of movements of the hip (abduction and adduction; flexion and extension), knee (extension and flexion), and ankle (plantar flexion and dorsiflexion). Before the experimental tests, 5 submaximal repetitions were performed for each movement and velocity to allow the participant to familiarize with the protocol. The evaluation consisted of concentric isokinetic tests performed at a predetermined sequence of velocities and repetitions: 60°/s (5 repetitions) and 120°/s (10 repetitions). A 60-second rest was allowed between each trial. Measurements were performed bilaterally, starting with the dominant limb (ie, the leg used to kick a ball). Muscle function and postural control assessments were performed in separate blocks, always starting with postural control. Trials were completely randomized within each block.

The dependent variables used for postural control assessment were area and mean range of center of pressure (COP) displacement in the anteroposterior (COPap) and mediolateral (COPml) directions. The dependent variable used for muscle strength assessment was peak torque normalized to body mass (PT/BM) of the dominant limb at 60°/s. To assess muscle power, time to peak torque (TPT) at 60°/s and mean power (MP) at 120°/s of the dominant limb were analyzed.

The Shapiro-Wilk test was used to assess the normality of data distribution, and the Levene test was employed to assess the homogeneity of variance. T-tests were performed to compare age, anthropometric data, and clinical characteristics between the groups. Multivariate analysis of covariance (MANCOVA) and repeated-measures ANCOVA were performed to analyze variables related to postural control. The number of falls in the past 12 months was used as a covariate to eliminate its effect on the dependent variables. A 3-way MANCOVA (group [active, inactive] x task [bipedal rigid surface, bipedal foam surface, semi-tandem rigid surface, semi-tandem foam surface] x visual condition [eyes open, eyes closed]) was used to analyze COPap and COPml. A 3-way ANCOVA (group [Active, Inactive] x task [bipedal rigid surface, bipedal foam surface, semi-tandem rigid surface, semi-tandem foam surface] x visual condition [eyes open, eyes closed]) was used to analyze the COP area. Repeated-measures ANCOVA was performed to analyze variables related to muscle function. The number of falls in the past 12 months was used as a covariate. A 2-way ANCOVA (group [active, inactive] x movement [abduction, adduction, flexion, extension]) was used to analyze PT/BM, TPT, and MP. Post hoc Bonferroni correction was applied if necessary. When data sphericity was not confirmed, the Greenhouse-Geisser correction was used. The effect size was computed using eta squared (η^2). The cutoff criteria for effect size (partial eta squared [η^2]) were as follows: small effect ($0.20 \leq \eta^2 < 0.50$), medium effect ($0.50 \leq \eta^2 < 0.80$), and large effect ($\eta^2 \geq 0.80$). Sample size was calculated using G*Power software, version 3.1.9.2 (Universitat Kiel-Germany). To this end, a medium effect or 0.6 based on Cohen classification was considered to determine the effect size f. For the other parameters, an alpha level of 0.05 and a power of 0.90 were used. For a number of groups of 2 (active and inactive) and a number of repeated measures of 2 (task and visual condition) or 1 (movement), a sample size of at least 10 participants per group was necessary. The significance level was set at $p \leq 0.05$ for all analyses.

RESULTS

Of 68 older adults who initially agreed to participate in the study, 3 dropped out and 4 were excluded. Therefore, a total of 61 participants were evaluated, 31 active (27 women and 4 men) and 30 inactive (26 women and 4 men). Regarding the history of falls, both groups had 10 fallers each. Table 1 shows the clinical characteristics of participants in each group. According to t-tests, the 2 groups differed in Baecke scores, Mini-BESTest scores, and SF-36 functional capacity, vitality, social aspects, and mental health subscale scores. The results showed that active participants had higher levels of physical activity, clinical balance, and quality of life than inactive participants.

ANCOVA results for the COP area revealed no main effects of number of falls or group, but interaction effects were revealed between the factors [base, surface, and vision] and [base, surface, vision, and group], with differences between all postural tasks (Table 2). Active participants had a smaller COP area than inactive participants in all postural tasks, except for the SUEC condition, which indicated a better postural control performance in the active group. Post hoc analysis revealed a larger COP area for inactive than active participants in the BUEO, BUEC, and SUEO conditions (Figure 1). MANCOVA results for COPap and COPml revealed a main effect of number of falls. Interaction effects were also observed between the factors [base, surface, and vision] and [base, surface, vision, and group]. ANCOVA results revealed no main effects of number of falls for COPap or COPml. However, interaction effects between the factors [base, surface, and vision] and [base, surface, vision, and group] were observed for both variables (Table 2). Active participants had lower COPap and COPml values than inactive participants in all tasks, except for the SUEC condition, which indicated a better balance control in the active group. Post hoc analysis showed greater COPap values for inactive than active participants in the BUEO and SUEO conditions (Figure 1). The inactive group had greater COPml values than the active group in the BREO, BUEO, BUEC, and SUEO conditions (Figure 1). These results indicated greater postural instability of inactive older adults in the frontal plane, even in the BREO condition, which involved no sensory disturbances. In addition, the values for COP area, COPap, and COPml increased with increasing levels of task complexity, especially in the BUEC and SUEC conditions, which involved simultaneous visual and somatosensory disturbances. The SUEC condition was a complex postural control task for both groups, and no significant differences were observed.

TABLE 1. Sample characteristics with mean values, standard deviation, p-value and 95% confidence interval of age, number of falls, and clinical and anthropometric characteristics of inactive (n=30) and active (n=31) groups.

Sample characteristics	Inactive	Active	95% CI
Age (years)	66.70 (± 4.45)	65.16 (± 4.21)	-0.68 to 3.76
Mass (kg)	68.23 (± 10.50)	66.47 (± 9.63)	-3.40 to 6.93
Height (m)	1.57 (± 0.05)	1.57 (± 0.06)	-0.03 to 0.03
BMI (kg/m^2)	27.54 (± 3.56)	26.87 (± 3.05)	-1.02 to 2.37
Number of falls	0.47 (± 0.73)	0.61 (± 0.92)	-0.57 to 0.28
Mini-mental state examination (score)	27.80 (± 1.40)	27.87 (± 1.67)	-0.86 to 0.72
Modified Baecke questionnaire for older adults (score)	3.88 (± 1.15)	13.95 (± 4.33)	-11.71 to -8.43*
Mini-BESTest (score)	22.07 (± 3.91)	25.03 (± 2.03)	-4.58 to -1.35*
Plantar skin sensitivity right foot (score)	25.10 (± 4.99)	25.84 (± 5.19)	-3.35 to 1.87
Plantar skin sensitivity left foot (score)	25.17 (± 5.17)	25.55 (± 5.18)	-3.04 to 2.27
SF-36 functional capacity (score)	89.67 (± 8.90)	94.68 (± 4.27)	-8.64 to -1.38*
SF-36 functional limitation (score)	80.83 (± 37.53)	91.94 (± 21.78)	-26.98 to 4.78
SF-36 pain (score)	69.20 (±27.65)	80.61 (± 22.53)	-24.37 to 1.55
SF-36 general health status (score)	67.00 (± 15.55)	72.81 (± 10.87)	-12.66 to 1.05
SF-36 vitality (score)	71.00 (± 20.70)	81.45 (± 10.97)	-19.04 to -1.86*
SF-36 social aspects (score)	74.58 (± 27.17)	90.32 (± 17.59)	-27.55 to -3.92*
SF-36 emotional aspects (score)	68.89 (± 46.27)	83.87 (± 37.40)	-36.60 to 6.64
SF-36 mental health (score)	70.27 (± 18.69)	80.00 (± 11.17)	-17.70 to -1.77*

CI: confidence interval; N: number of participants; kg: kilograms; m: meters; BMI: body mass index; *difference between groups ($p \leq 0.05$).

ANCOVA results for hip, knee, and ankle PT/BM revealed no main effects of number of falls or group, nor interaction effects (Table 3, Figure 2A). ANCOVA results for hip and ankle revealed only a main group effect. An interaction effect was observed between movement and group for ankle TPT (Table 3). Post hoc analysis showed differences between the groups for TPT in hip adduction and ankle dorsiflexion (Table 3, Figure 2B). The active group had a shorter TPT than the inactive group, which indicated higher hip and ankle muscle power in the active group (Figure 2B). ANCOVA results revealed a main group effect only for hip and knee MP (Table 3). Post hoc analysis showed differences between the groups for MP in hip abduction and adduction as well as in knee extension and flexion, which indicated greater muscle power in the active group than in the inactive group (Figure 2C).

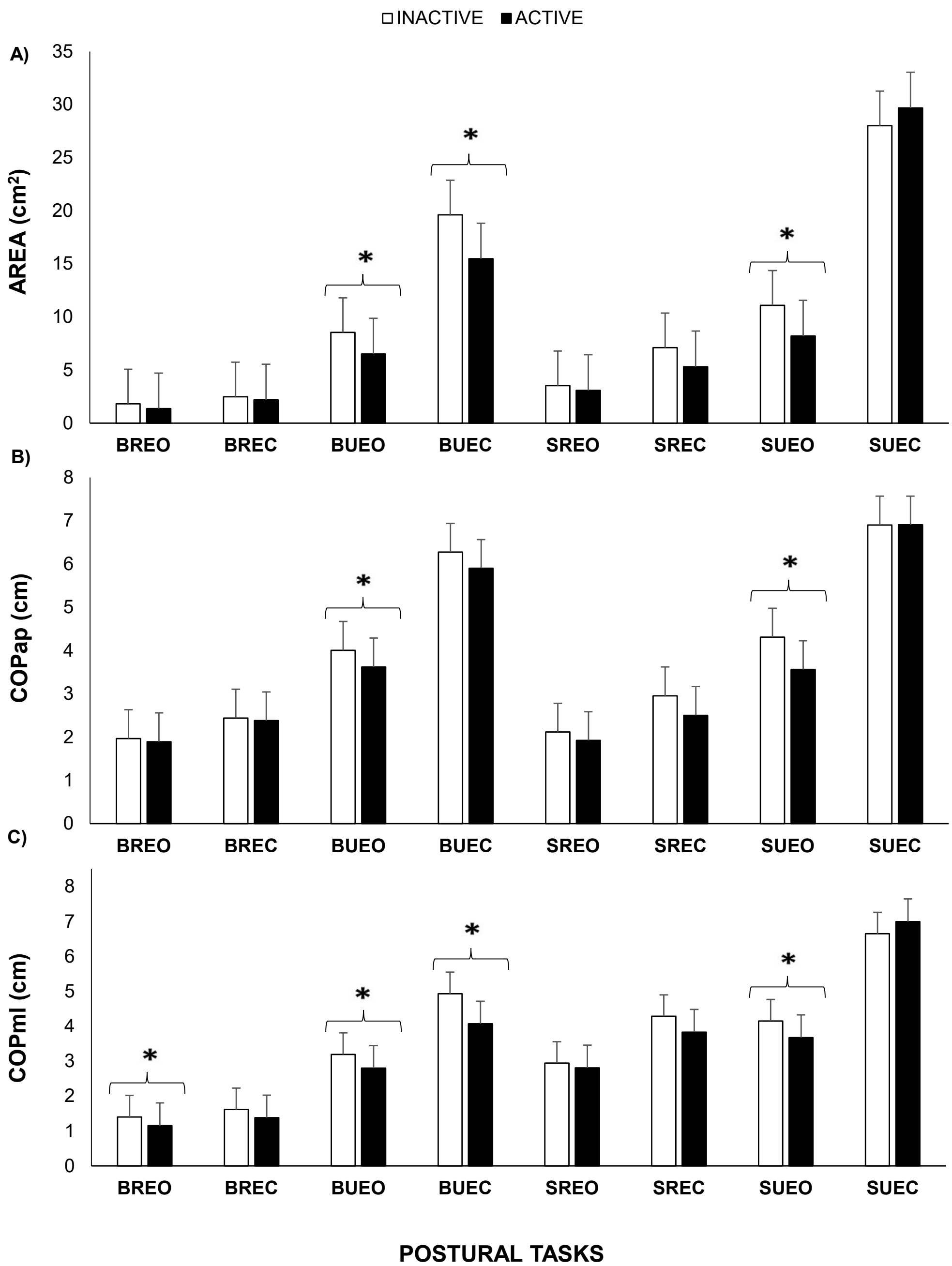
DISCUSSION

This study investigated postural control performance in different postural tasks as well as muscle strength and power of the hip, knee, and ankle of active vs inactive older adults. Regarding clinical tests, the active group had higher Mini-BESTest scores, which indicated better performance in static and dynamic balance tests compared

TABLE 2. F, p-values, η^2 and 95% confidence interval for the main effect (falls and group) and interaction (base * surface * vision; base * surface * vision * falls; base * surface * vision * group) from MANCOVA and ANCOVA for the area of center of pressure (AREA) and mean range of displacement in the anteroposterior and mediolateral directions of the center of pressure and p-values and 95% confidence interval of post hoc Bonferroni's correction.

MANCOVA	**COPap and COPml**		
Main effect			
Falls	Wilk's Lambda = 0.87; $F_{2,57}$ = 4.43; p = 0.02*; η^2 = 0.13		
Group	Wilk's Lambda = 0.95; $F_{2,57}$ = 1.66; p = 0.20; η^2 = 0.06		
Interaction effect			
base * surface * vision	Wilk's Lambda = 0.86; $F_{2,57}$ = 134.58; p = 0.01*; η^2 = 0.14		
base * surface * vision * falls	Wilk's Lambda = 0.95; $F_{2,57}$ = 1.64; p = 0.20; η^2 = 0.05		
base * surface * vision * group	Wilk's Lambda = 0.78; $F_{2,57}$ = 8.10; p = 0.001*; η^2 = 0.22		
ANCOVA	**AREA**	**COPap**	**COPml**
Main effect			
Falls	$F_{1,58}$ = 0.25; p = 0.62; η^2 = 0.004	$F_{1,58}$ = 1.30; p = 0.26; η^2 = 0.02	$F_{1,58}$ = 0.16; p = 0.69; η^2 = 0.003
Group	$F_{1,58}$ = 2.09; p = 0.15; η^2 = 0.15	$F_{1,58}$ = 2.57; p = 0.12; η^2 = 0.04	$F_{1,58}$ = 3.38; p = 0.07; η^2 = 0.06
Interaction effect			
base * surface * vision	$F_{1,58}$ = 31.89; p < 0.001*; η^2 = 0.36	$F_{1,58}$ = 5.40; p = 0.02*; η^2 = 0.09	$F_{1,58}$=7.69; p = 0.007*; η^2 = 0.12
base * surface * vision * falls	$F_{1,58}$ = 2.63; p = 0.11; η^2 = 0.04	$F_{1,58}$ = 0.69; p = 0.41; η^2 = 0.01	$F_{1,58}$=3.30; p = 0.08; η^2 = 0.05
base * surface * vision * group	$F_{1,58}$ = 10.89; p = 0.002*; η^2 = 0.002	$F_{1,58}$ = 5.92; p = 0.02*; η^2 = 0.09	$F_{1,58}$=15.29; p < 0.001*; η^2 = 0.21
Post hoc	**AREA**	**COPap**	**COPml**
Bonferroni's correction	**95% CI**	**95% CI**	**95% CI**
BREO	-0.01 to 0.90	-0.18 to 0.33	0.03 – 0.47*
BREC	-0.58 to 1.16	-0.35 to 0.47	-0.05 to 0.52
BUEO	0.48 – 3.57*	0.00 – 0.76*	0.02 – 0.76*
BUEC	0.18 – 8.08*	-0.35 to 1.01	0.26 – 1.47*
SREO	-0.31 to 1.18	-0.03 to 0.42	-0.24 to 0.50
SREC	-0.16 to 3.74	-0.01 to 0.92	-0.17 to 1.08
SUEO	0.78 – 5.02*	0.29 – 1.21*	0.08 – 0.87*
SUEC	-8.66 to 5.32	-0.96 to 0.96	-1.23 to 0.53

COP: center of pressure; COPap: center of pressure anteroposterior; COPml: center of pressure mediolateral; CI: confidence interval; BREO: bipedal stance on a rigid surface with eyes open; BREC: bipedal stance on a rigid surface with eyes closed; BUEO: bipedal stance on an unstable surface with eyes open; BUEC: bipedal stance on an unstable surface with eyes closed; SREO: semi-tandem stance on a rigid surface with eyes open; SREC: semi-tandem stance on a rigid surface with eyes closed; SUEO: semi-tandem stance on an unstable surface with eyes open; SUEC: semi-tandem stance on an unstable surface with eyes closed; *difference between groups (p ≤ 0.05).



AREA: mean and standard error for area; COPap: center of pressure anteroposterior; COPml: center of pressure mediolateral; BREO: bipedal stance on a rigid surface with eyes open; BREC: bipedal stance on a rigid surface with eyes closed; BUEO: bipedal stance on an unstable surface with eyes open; BUEC: bipedal stance on an unstable surface with eyes closed; SREO: semi-tandem stance on a rigid surface with eyes open; SREC: semi-tandem stance on a rigid surface with eyes closed; SUEO: semi-tandem stance on an unstable surface with eyes open; SUEC: semi-tandem stance on an unstable surface with eyes closed.

FIGURE 1. Mean and standard error for area (Figure 1A), mean range of displacement in the anteroposterior (Figure 1B) and mediolateral (Figure 1C) direction of the center of pressure for inactive and active older adult groups in the following postural tasks: bipedal stance on a rigid surface with eyes open; bipedal stance on a rigid surface with eyes closed; bipedal stance on an unstable surface (foam) with eyes open; bipedal stance on an unstable surface (foam) with eyes closed; semi-tandem stance on a rigid surface with eyes open; semi-tandem stance on a rigid surface with eyes closed; semi-tandem stance on an unstable surface (foam) with eyes open; semi-tandem stance on an unstable surface (foam) with eyes closed. *difference between groups ($p \leq 0.05$).

with the inactive group. These results are consistent with a previous study showing that gymnastics and yoga classes offered through the EOS program provided balance control benefits for older adults.[17]

Analysis of posturography data revealed that, overall, active participants had lower values for COP area, COPap, and COPml than inactive participants. These results indicated better performance in postural control for active than

TABLE 3. F and p-values F, p-values, η^2 and 95% confidence interval for the main effect (falls and group) and interaction (movement * falls; movement * group;) from ANCOVA for peak torque normalized to body mass, time to peak torque, and mean power of muscle function of hip (abduction, adduction, flexion, extension), knee (flexion, extension), and ankle (plantar flexion, dorsiflexion) and p-values and 95% confidence interval of post hoc Bonferroni's correction.

ANCOVA	**PT/BM HIP**	**PT/BM KNEE**	**PT/BM ANKLE**
Main effect			
Falls	$F_{1,58}$ = 0.50; p = 0.48; η^2 = 0.01	$F_{1,58}$ = 1.46; p = 0.23; η^2 = 0.03	$F_{1,58}$ = 0.22; p = 0.79; η^2 = 0.001
Group	$F_{1,58}$ = 1.66; p = 0.20; η^2 = 0.03	$F_{1,58}$ = 2.09; p = 0.15; η^2 = 0.04	$F_{1,58}$ = 0.57; p = 0.32; η^2 = 0.02
Interaction effect			
movement * falls	$F_{1,58}$ = 0.59; p = 0.62; η^2 = 0.01	$F_{1,58}$ = 0.11; p = 0.74; η^2 = 0.002	$F_{1,58}$ = 0.90; p = 0.35; η^2 = 0.02
movement * group	$F_{1,58}$ = 0.520; p = 0.67; η^2 = 0.01	$F_{1,58}$ = 3.77; p = 0.06; η^2 = 0.06	$F_{1,58}$ = 0.37; p = 0.55; η^2 = 0.01
ANCOVA	**TPT HIP**	**TPT KNEE**	**TPT ANKLE**
Main effect			
Falls	$F_{1,58}$ = 1.00; p = 0.32; η^2 = 0.02	$F_{1,58}$ = 0.39; p = 0.53; η^2 = 0.01	$F_{1,58}$ = 0.400; p = 0.53; η^2 = 0.01
Group	$F_{1,58}$ = 5.18; p = 0.03*; η^2 = 0.08	$F_{1,58}$ = 0.09; p = 0.77; η^2 = 0.001	$F_{1,58}$ = 4.51; p = 0.04*; η^2 = 0.07
Interaction effect			
movement * falls	$F_{1,58}$ = 0.46; p = 0.71; η^2 = 0.01	$F_{1,58}$ = 0.01; p = 0.93; η^2 = 0.000	$F_{1,58}$ = 0.04; p = 0.85; η^2 = 0.001
movement * group	$F_{1,58}$ = 0.91; p = 0.44; η^2 = 0.02	$F_{1,58}$ = 2.08; p = 0.16; η^2 = 0.04	$F_{1,58}$ = 5.26; p = 0.03*; η^2 = 0.08
ANCOVA	**MP HIP**	**MP KNEE**	**MP ANKLE**
Main effect			
Falls	$F_{1,58}$ = 2.93; p = 0.09; η^2 = 0.05	$F_{1,58}$ = 2.81; p = 0.01; η^2 = 0.05	$F_{1,58}$ = 0.65; p = 0.43; η^2 = 0.01
Group	$F_{1,58}$ = 4.45; p = 0.04*; η^2 = 0.07	$F_{1,58}$ = 5.69; p = 0.02*; η^2 = 0.09	$F_{1,58}$ = 2.09; p = 0.15; η^2 = 0.04
Interaction effect			
movement * falls	$F_{1,58}$ = 0.04; p = 0.99; η^2 = 0.001	$F_{1,58}$ = 3.020; p = 0.09; η^2 = 0.05	$F_{1,58}$ = 0.070; p = 0.79; η^2 = 0.001
movement * group	$F_{1,58}$ = 0.89; p = 0.45; η^2 = 0.02	$F_{1,58}$ = 3.61; p = 0.06; η^2 = 0.06	$F_{1,58}$ = 0.68; p = 0.41; η^2 = 0.01
Post hoc Bonferroni's correction	**PT/BM**	**TPT**	**MP**
	95% CI	**95% CI**	**95% CI**
Hip abduction	-16.03 to 3.22	-56.00 to 358.71	-17.45 to -0.48*
Hip adduction	-27.69 to 1.74	52.65 – 280.87*	-19.07 to -0.66*
Hip flexion	-18.37 to 6.98	-191.74 to 172.70	-16.80 to 3.19
Hip extension	-26.12 to 13.67	-70.41 to 446.85	-27.85 to 0.54
Knee extension	-28.07 to 1.26	-159.65 to 57.68	-30.31 to -2.75*
Knee flexion	-14.13 to 7.04	-47.87 to 165.91	-17.76 to -0.65*
Ankle plantar flexion	-13.04 to 5.27	-38.41 to 32.05	-6.64 to 1.48
Ankle dorsiflexion	-3.91 to 1.45	16.99 – 219.23*	-2.90 to 0.43

PT: peak torque normalized; BM: body mass; TPT: time to peak torque; MP: mean power; *difference between groups ($p \leq 0.05$).

inactive participants. Therefore, it is reasonable to assume that the EOS multicomponent exercise program may promote a number of adaptations that contribute to preventing age-related decline in postural control performance. As for the sensory system, these adaptations may be related to a decreased dependence on the visual system and increased contribution of proprioceptive, vestibular, and skin information. They may also be associated with improved sensorimotor integration in the central nervous system. In addition, improved postural control may be explained by greater muscle strength and power and better coordination of muscle synergies involved in postural control in active individuals.

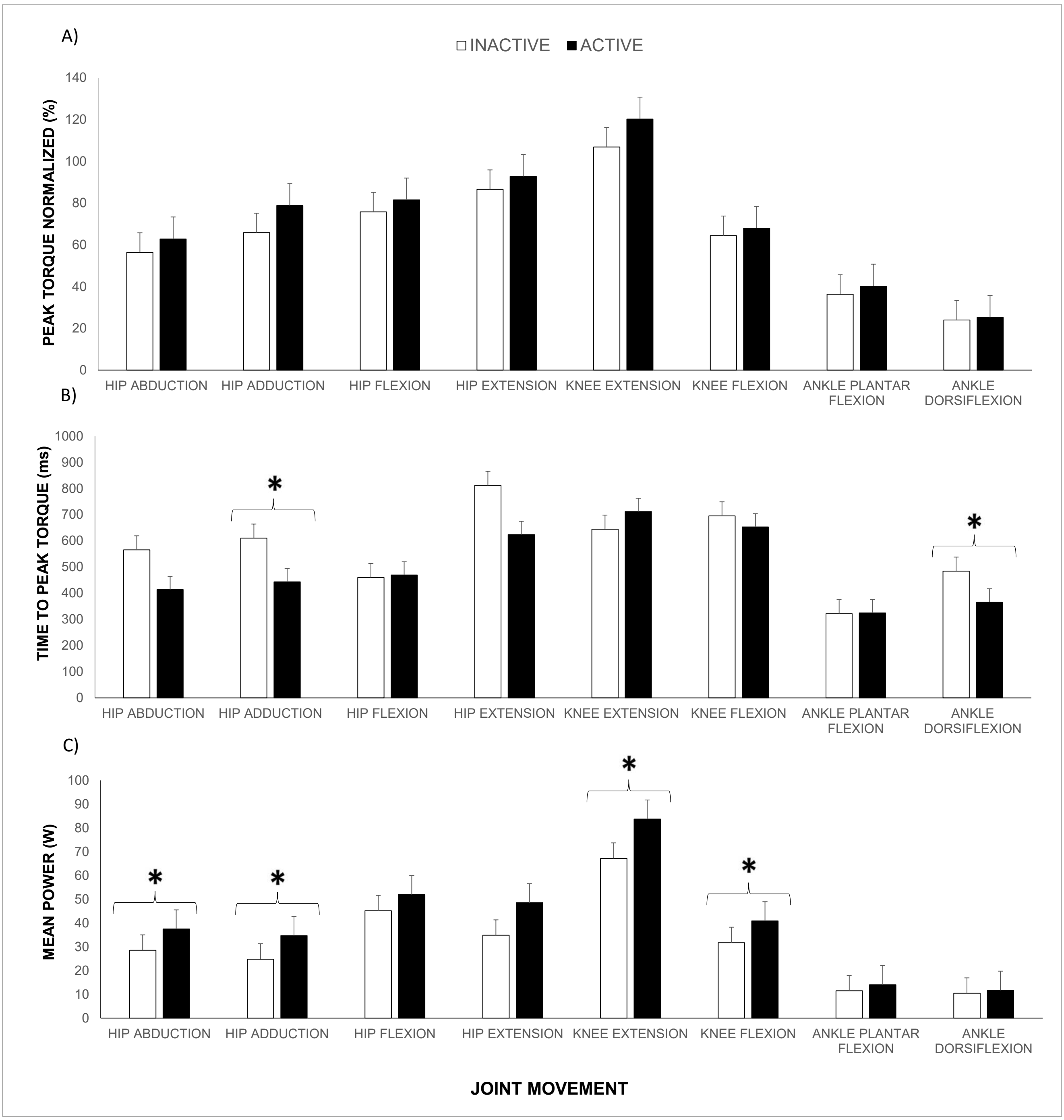


FIGURE 2. Mean and standard error for peak torque normalized to body mass (Figure 2A), time to peak torque (Figure 2B), and mean power (Figure 2C) of muscle function of hip (abduction, adduction, flexion, extension), knee (flexion, extension), and ankle (plantar flexion, dorsiflexion) of inactive and active older adult groups. *difference between groups ($p \leq 0.05$).

A gradation of task instability was observed, as disturbances were introduced first in the visual system and then in the somatosensory system, with tasks in semi-tandem stance being more unstable than similar tasks in bipedal stance. Greater postural sway in tasks that involved visual and somatosensory disturbances may be related to the limited ability of the central nervous system to re-weight sensory information in order to control balance. It may also be attributed to the fact that the vestibular system was unable to provide adequate information of the body in space. The greater sway observed in semi-tandem stance appears to be related to postural strategies, as these tasks demand higher hip torque generation and result in faster and larger displacements of the center of mass than those in bipedal stance. These results are consistent with the literature which reports that multicomponent exercise programs promote a decrease in postural sway in older adults.[7-9] However, other studies have reported no differences in postural sway between active older adults participating in multicomponent exercise programs and inactive older adults.[10,23] Therefore, a relevant result of the present study was that older adults engaging in multicomponent exercise training offered through a public physical activity program in primary health care performed better than inactive older adults in different postural tasks, especially in those with higher levels of instability. Postural control assessment during tasks with different levels of instability was another important aspect of the study as it fills some gaps in the literature on the benefits of multicomponent exercise programs. Previous studies had limitations in terms of the conditions for postural control assessment.

Another interesting finding of this study was that the postural task involving simultaneous visual and sensory disturbances combined with a reduced base of support was considered the task at the highest difficulty level by both groups. Perhaps these conditions were simply not part of the activities of daily living and exercise training of the participants. These results indicated the importance of increasing the instability of balance exercises in order to increase postural stability for preventing falls. Postural tasks in semi-tandem stance produce improved postural sway compared with tasks in bipedal stance, and a reduced base of support promotes the combination of different motor abilities involved in hip and ankle strategies to maintain postural control.[24] Age-related decline in muscle function may limit the generation of adequate torque to maintain balance during tasks with a higher level of postural instability.

Regarding muscle function, our results indicated that the EOS multicomponent exercise program may improve performance in muscle power of the hip, knee, and ankle. No differences were observed in muscle strength. In general, the EOS activities focus on recreation and socialization, which may explain the lack of benefit in specific components of physical fitness. Possibly, the greater performance in muscle power observed in the active group could be explained by the characteristics of the multicomponent exercise program, which, overall, consists of moderate-intensity dynamic activities. Compared with the inactive group, the greater ability of the active group to produce power was a relevant result of the study, as muscle power is known to decline earlier and more rapidly than muscle strength with advancing age and is more closely related to the functional capacity of older adults.[25] These results are consistent with previous studies that also demonstrated the effectiveness of multicomponent exercise programs for muscle power gain in older adults.[10,26] In addition, previous studies also showed no differences in muscle strength in older adults engaging in multicomponent exercise training.[23,27]

The number of falls did not affect the variables related to COP or muscle function in the statistical model analyzed in this study. Falls have a multifactorial etiology,[18] but in this study, they were not associated with postural control or muscle function deficits. A previous study showed that postural control performance differed between fallers and non-fallers only when fallers were over 70 years of age and had recurrent episodes of falls.[28] Therefore, our sample profile of low mean age and small number of falls may have influenced the results. Despite the known association between decline in muscle function and falls, there seems to be no consensus on the main muscles involved in falls. In this context, this study attempted to conduct a more comprehensive analysis of the influence of falls on the performance of lower-limb muscle function.

Furthermore, although quality-of-life assessment was not an objective of the study, our results revealed that older adults participating in the EOS multicomponent exercise program had higher scores in the functional capacity, vitality, social aspects, and mental health domains of the SF-36, indicating a better quality of life compared with inactive older adults. These differences in quality-of-life scores between the groups can be attributed to a higher level of physical activity in the active group, given the well-known positive association between physical activity and quality of life.[29] Another possible explanation is that the characteristics of the activities offered through the EOS program favor the development of bonding and sociability between participants and health professionals,[16] and these aspects may have contributed to greater adherence and quality of life among the participants.

The demographic transition caused by population aging is a global phenomenon associated with changes in the epidemiological profile and an increase in health-related problems. Thus, healthy aging has become an important and challenging public health issue. Physical activity has been positively associated with healthy aging.[30] In this context, exercise should be recommended in primary health care to improve postural control and muscle function performance, both of which can contribute to preventing falls and to improving the functional capacity and quality of life of older adults.

Multicomponent exercise programs appear to be a feasible and efficient option to promote physical activity among older adults in primary health care, as the activities can be performed in groups, require inexpensive equipment, and can be adapted to local characteristics. Furthermore, primary health care programs should minimize barriers to physical activity promotion. Although recommendations from the literature should be considered in exercise programs for older adults, they may occasionally create barriers to the development of the interventions.[6] Yet, socialization and recreational activities seem to be an essential component to enhance adherence among older adults and should be incorporated into multicomponent exercise programs.

An important aspect of this study was to show that multicomponent exercise programs delivered in primary health care settings seem to be a useful strategy to provide benefits in terms of postural control and muscle power performance for older adults. Multicomponent exercise programs for older adults should include balance exercises with different levels of instability, especially those involving a reduced base of support and simultaneous visual and somatosensorial disturbances.

A limitation of the study is the low mean age of the participants and the small number of fallers, which seems to have influenced some of the results. However, the sample was selected based on the characteristics of the EOS program's participants. Another limitation of the study is the lack of a training protocol within the EOS program. However, variations in exercises are a characteristic of the EOS activities that contribute to enhancing adherence of older adults to the program. Finally, although a randomized controlled trial is considered to be the optimal study design for evaluating the effects of physical activity programs, our results allow us to infer that the EOS multicomponent exercise program has a positive influence on postural control and muscle power performance in older adults.

CONCLUSION

Multicomponent exercise programs delivered in primary health care settings, such as the EOS program, contribute to improving both postural control performance in tasks with different levels of postural stability and muscle power performance in older adults, which can potentially help prevent falls and improve quality of life.

Conflict of interest

The authors declare no conflicts of interest.

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Authors' contribution

LAV: Conceptualization, data curation, formal analysis, investigation, methodology, writing – original draft, writing – review & editing. JLC: Data curation, formal analysis, investigation, writing – original draft. MR: Formal analysis, investigation, writing – original draft. NMR: Conceptualization, formal analysis, investigation, project administration, methodology, supervision, writing – original draft, writing – review & editing.

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