Effects of Different Kinds of Exercise in the Gait Parameters of Elderly Women

EXERCISE AND SPORTS MEDICINE CLINIC

ORIGINAL ARTICLE

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ABSTRACT

Exercise type, intensity and frequency are important factors to produce changes in gait velocity. The aim of this study was to compare the effects of different exercise types in the gait kinematic parameters in elderly women, whereas anthropometry, functional capacity and physical activity level are considered. Fifty-six elderly women were grouped according to their specific physical activity (practice for more than 6 months): dancing (n = 10), strength training (n = 10), aquatic exercise training (n = 12) and walking (n = 11). In addition, an inactive female older group (n = 13), without engagement in regular physical activity for at least 02 months, participated in the study. The physical activity level (Baecke Questionnaire), functional capacity (AAHPERD battery) and the gait kinematic parameters (gait cycle and step length, gait cycle duration and velocity, cadence and single support phases, swing and double support duration) were measured. The results showed that the physical activity level in the control group was different from the one in the other groups (physically active). In relation to functional capacity, only the strength component was different between groups, indicating that the control group differs from the strength training group. Regarding the gait parameters, the control group was statistically different from the group dancing regarding gait cycle and step length. The results of this study indicate that the functional capacity and gait parameters of active and sedentary elderly females present few differences.

Keywords: physical activity, functional capacity, gait kinematic parameters.

INTRODUCTION

Walking is part of most of the basic and instrumental activities of daily life to the extent of being recommended as an example of physical activity for prevention of falls in the elderly(1). The gait spatial-temporal parameters are modified during the ageing process. There is evidence of decrease in gait cycle and step length, decrease of the distance between the foot and the ground in the swing phase, increase in the gait cycle duration and increase in the duration in double support(2-5), leading to gradual decrease in gait velocity of elderly subjects(3). The ageing process also seems to be associated with unfavorable alterations in the gait pattern, in increase of the time needed to complete a certain distance and in the need to use additional support for dislocation(6,7). Moreover, the alterations in the gait spatial and temporal parameters can be related to the decline in muscular aptitude components derived from the ageing process(8).

Different examples of physical activities have been proposed to this population, among them, aquatic exercise training, dancing, strength training, general gymnastics and walking, and the elderly subject can choose the one which adapts best to his/her lifestyle(9). However, the American College of Sports Medicine(10) points out that walking is the commonest and strength training is recommended to delay sarcopenia.

In an extensive meta-analysis on the effects of exercise on the gait velocity in the elderly, Lopopolo et al.(11) revealed that the type of exercise, intensity and frequency are important factors to produce alterations in the gait velocity. Additionally, studies which try to observe the effects of exercise have included the gait analysis as a way of preventing the risk of falls or functional mobility of elderly subjects(12) and the acute effects of hip flexibility(13). Nevertheless, until the present moment, the gait spatial and temporal parameters have not been widely related to the functional capacity of the elderly and to the type of exercise practiced.

Thus, the aim of this study was to compare the effects of different types of exercise in the gait kinematic parameters of female elderly subjects, considering anthropometric characteristics, functional capacity and level of physical activity.

METHODS

This transversal descriptive study was submitted to and approved by the Ethics in Research Committee of the State University of Paraíba (protocol number CAAE – 0450.0.133.000-08). All information about the research was given to the participants and a Free and Clarified Consent Form was filled out and signed by the elderly women for participation in the study.

Women aged 60 years or older were intentionally recruited in systematized physical activity programs of the Campina Grande city-PB. The elderly women were grouped according to the engagement in the specific practice of an activity (dancing, strength training, aquatic exercise and walking). The inclusion criterion for the elderly groups was the engagement in the specific activity for a minimum time of six months. Moreover, a group of inactive elderly women (control) was also recruited in third age groups. The lack of engagement in regular physical activity program for at least two months was applied as inclusion criterion in the Control group formation.

Exclusion criteria were observed through anamnesis for all groups: history or case of myocardium infarct; angina pectoris and/or cardiac insufficiency; type I diabetes mellitus, insulin-dependent; osteomyoarticular problems which harm locomotion; and regular use of medication which interfere in balance.

The experimental protocol was developed in two non-consecutive days. On the first day, the level of physical activity, the anthropometric characteristics and functional capacity were measured. The evaluation of the gait kinematic parameters was performed on the second collection day.

The Modified Baecke Questionnaire for Older Adults (MBQOA[14]) was used to evaluate the level of physical activity of the participants. The Portuguese version of the MBQOA applied by Carvalho[15] and studied by Mazo et al.[16] was used.

Subsequently, an anthropometric evaluation of the following aspects was performed: stature and body mass for acquisition of the body mass index (BMI); and tricipital skinfold (TSF) for the fat percentage obtained with 1mm Lange calipers. The measurement technique adopted was suggested by Lohman et al.[17]. Regarding the anthropometric parameters evaluation, the elderly women were grouped according to age range (60-69 years, 70-79 years and 80 years or older). These anthropometric variables were classified and presented in percentile (P5, P10, P25, P50, P75, P90 and P95) according to Menezes and Marucci[18]. The anthropometric data were analysed by a physical evaluation software (BIO-SYSTEM, Campina Grande-PB), containing databank for files managing and performance of all calculation procedures and involved formulas.

The functional capacity levels were evaluated through agility and dynamic balance, coordination, strength endurance, flexibility and general aerobic endurance motor tests, proposed by the battery of motor tests by the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) and described by Gobbi et al.[19].

In order to assess gait, each participant was invited to complete an eight-meter distance. After the researcher command, the participant walked at her favorite velocity until the end of the walk in five trials. Rest intervals were given whenever asked by the participant. The kinematic data were recorded through eight passive markers made with adhesive reflexive film of 15 mm of diameter which were attached on the following anatomic points: a) right lower limb on the great femoral trochanter, lateral tibial condyle, fibular malleolus, calcaneus lateral process and lateral process of the fifth metatarsal head; b) left lower limb of the tibial malleolus, medial process of the calcaneus and medial process of the first metatarsal head.

A digital camera (Samsung, SDC173U) was positioned perpendicular to the center of the completed distance in order to film the right sagittal plane of the participants to visualize all the markers and record an intermediate gait cycle of the path of the right lower limb. The image acquisition frequency was of 60Hz. The recorded images were taken by a video board (Pinnacle brand name, model Studio DV, version 1.05.307) connected to a computer. Subsequently, the markers were automatically digitalized in a gait cycle (interval between two consecutive initial contacts of the right foot), with the use of the program Digital Video for Windows – DVIDEOW (Laboratory of Instrumentation in Biomechanics – Unicamp[20]).

After digitalization and still using the DVIDEOW program, the x and y coordinates of each marker were transformed to the metric system using a bidimensional reference system with four control points and with 1m x 1m dimensions, length and height, respectively. The acquired data were filtered with a Butterworth second-order filter with the use of the Matlab 6.5 program (The Mathworks, Inc.). The filter frequency was defined by residual analyses suggested by Winter et al.[21].

The gait dependent variables considered in this study were: gait cycle length (m), step length (m), gait cycle duration(s), gait cycle velocity (m/s), cadence (gait cycle/s) and duration of the single support, swing and double support in the gait cycle phases (%). The variables were analysed with the Matlab 6.5 software.

Statistical analysis initially verified the data distribution of each variable (Kolmogorov-Smirnov test) and homogeneity of variances (Levene test). The data indicated that the variables level of physical activity (punctuation in the Baecke Questionnaire) and coordination (AAHPERD) did not fulfill these criteria and therefore, were treated by non-parametric statistics by the Kruskal-Wallis and U by Mann-Whitney tests, with significance level corrected by the number of comparisons in $p = 0.05$.

For each of the remaining dependent variables, ANOVAs and Tukey test were applied for comparison between groups. Multiple regression analyses (stepwise) were applied to verify among the variables related to the level of physical activity, to the functional capacity and to the anthropometric characteristics, which ones were predictors of the gait cycle length and step length. The collected data received statistical treatment through the computer system SPSS 13.0 for Windows. The significance level of 0.05 was considered in all parametric analyses.

RESULTS

Table 1 presents the characterization of the participants per group. The groups were similar for the age, stature, weight, BMI and fat percentage variables.

Concerning the level of physical activity, there was difference between groups ($X^2_4 = 33.567$; $p \leq 0.001$). As expected, the Control group was statistically different from the remaining groups, which are equal (Control x Strength training: $Z = -4.045$, $p \leq 0.001$; Control x Walking: $Z = -4.255$, $p \leq 0.001$; Control x Aquatic Exercise: $Z = -4.156$, $p < 0.001$; Control x Dancing: $Z = -3.984$, $p \leq 0.001$).

Table 1. Participants' characterization.

Group	Age		Stature		Weight		BMI		% g triceps	
	Mean	σ	Mean	σ	Mean	σ	Mean	σ	Mean	σ
Control (n = 13)	68.85	4.22	1.48	0.06	63.63	10.86	29.10	4.31	19.31	6.65
Strength training (n = 10)	67.20	5.20	1.53	0.08	63.83	8.63	27.55	4.13	21.50	4.22
Walking (n = 11)	66.83	5.65	1.50	0.04	63.03	9.70	28.06	3.86	24.27	5.10
Aquatic exercise (n = 12)	70.73	5.97	1.51	0.04	65.33	12.83	28.46	5.29	21.67	4.64
Dancing (n = 10)	69.80	7.27	1.54	0.05	72.29	13.95	30.53	6.29	20.20	6.20

n = number of participants, BMI = body mass index, % g triceps = triceps fat percentage, σ = standard deviation.

The levels of functional capacity, separated by component and by group, are presented in table 2. Only the strength component presented differences between groups ($F_{4,51} = 2.546$; $p < 0.05$), where only the Control group is different from the Strength Training group ($p < 0.025$).

Table 2. Means and standard deviation (σ) of the functional capacity components per group.

Group	Flexibility		Coordination		Agility		Strength		Endurance	
	Mean	σ	Mean	σ	Mean	σ	Mean	σ	Mean	σ
Control (n = 13)	53.00	9.04	24.45	7.75	31.28	6.38	15.00	2.95	9.55	1.06
Strength training (n = 10)	52.75	8.76	19.52	6.16	28.98	5.44	20.00	3.23	10.40	1.43
Walking (n = 11)	57.00	9.56	24.28	5.47	29.92	4.18	17.00	4.02	9.20	0.93
Aquatic exercise (= 12)	54.00	11.18	19.37	2.98	31.31	3.03	16.00	2.30	10.09	1.13
Dancing (n= 10)	53.00	9.02	19.21	4.41	33.73	4.27	15.00	4.34	10.31	0.99

Regarding the gait variables, the groups were different in the step length ($F_{4,51} = 3.009$; $p < 0.026$) and in the gait cycle length ($F_{4,51} = 2.85$; $p < 0.033$). The Control group was statistically different from the Dancing group both in the step length ($p < 0.016$; figure 1a) and in the gait cycle length ($p < 0.022$; figure 1b). The remaining variables dependent on the gait were similar between groups (table 3).

All anthropometric variables, including age, functional capacity, level of physical activity and walking, except for gait cycle length to step length and vice-versa, were included in the multiple regression model to determine the predictor variables of step length and of gait cycle length. The gait cycle velocity, gait cycle duration, coordination and body weight variables were identified as predictors for the step length ($R^2 = 0.856$; $p < 0.001$); and the gait cycle velocity, gait cycle duration and cadence variables were identified as predictors for gait cycle length ($R^2 = 0.970$; $p < 0.001$), observed in tables 4 and 5.

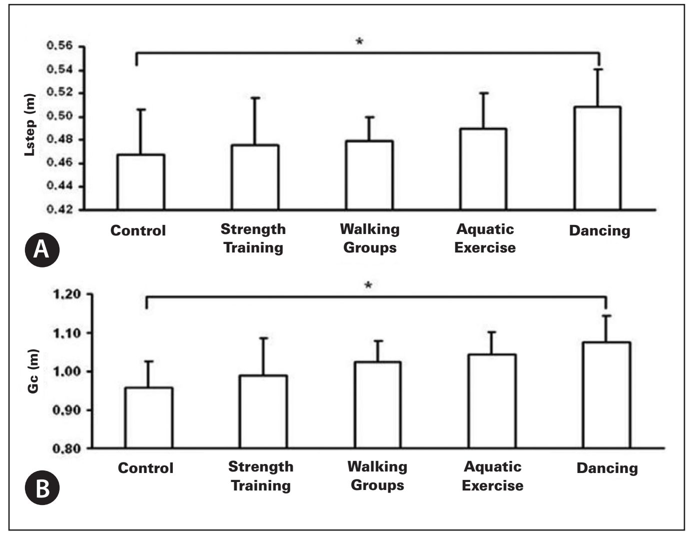

Figure1. Means and standard deviations of the step length (Lstep; a) and of gait cycle (Gc; b). * represents the statistically significant difference between the Control group and the Dancing group.

Table 3. Means and standard deviations of the gait variables per group.

Variables	Control		Strength training		Walking		Aquatic exercise		Dancing	
	Mean	σ	Mean	σ	Mean	σ	Mean	σ	Mean	σ
Dgc (s)	1.06	0.09	0.99	0.06	1.03	0.07	1.03	0.08	1.09	0.07
Vgc (m/s)	0.94	0.12	1.00	0.12	0.99	0.11	1.01	0.10	0.99	0.10
Cad (pass/s)	0.94	0.08	1.01	0.05	0.97	0.06	0.97	0.08	0.92	0.11
Dgcs (%)	39.39	1.70	40.15	1.67	40.36	1.73	40.00	2.30	39.46	1.56
Dgcss (%)	39.88	0.95	40.77	1.37	40.58	1.63	40.48	1.20	40.48	2.84
Dgcds (%)	20.53	2.33	19.67	2.55	19.54	3.02	19.38	2.94	19.95	2.74

Dgc= gait cycle duration; Vgc = Gait cycle velocity; Cad = cadence; Dgcs= gait cycle swing phase duration; Dgcss = gait cycle single support duration; Dgcds = gait cycle double support duration; σ = standard deviation.

Table 4. Prediction variables of the step length, with the respective beta and significance values.

Prediction variables	Beta	Sig
Vs (m/s)	1.308	0.001
GC (s)	0.977	0.001
Coord (s)	–0.223	0.001
Weight (kg)	0.158	0.005

Table 5. Prediction variables of the gait cycle, with the respective beta and significance values.

Prediction variables	Beta	Sig
Vs (m/s)	1.541	0.001
GC (s)	0.789	0.001
Cad (steps/s)	–0.145	0.032

DISCUSSION

The similarity between groups observed in table 1concerning the age, stature, weight, BMI and fat percentage variables reveals the careful application of the inclusion and exclusion criteria. This similarity also eliminates the interference of these characteristics in the obtained results.

The aim of this study was to compare the effects of different types of exercise in the gait kinematic parameters of elderly women, considering anthropometric characteristics, functional capacity and the level of physical activity. The results found in this study for level of physical activity revealed that the Control group was different from the remaining groups which practiced physical activities. This fact was already expected, since the literature shows that the participation in regular physical activity programs during 12 weeks improves functional aptitude of elderly women[22]. Furthermore, it shows that the participants from the Control group were really inactive, meeting the inclusion criterion.

Concerning functional capacity, only the strength component presented differences between groups, indicating hence that the Control group is different from the Strength Training group. Training programs may increase strength in individuals of all ages[23] and muscular strength training in elderly subjects promotes improvement in the muscle contractile properties, as well as in the contraction strength and velocity[24]. However, this result should be carefully considered, since the dancing, aquatic exercise training and walking activities develop lower limbs strength and the strength test applied in the study involved upper limbs.

Concerning the gait variables, the Control group was statistically different only from the Dancing group both in the step length and gait cycle length. This result does not corroborate the findings in other studies. Arantes et al.[25], when comparing aquatic exercise and strength training practitioners, found better performance in the gait spatial and temporal performance for the elderly women who practiced strength training. Moreover, Persch et al.[26] observed that strength training was efficient in reverting the ageing effects in the gait parameters. Vieira and Rabelo[27] showed that the gait velocity was higher in elderly women who participate in aquatic exercise and gymnastics when compared to the participants of senior dance.

On the other hand, dancing, besides being a well-accepted physical activity by the elderly, allows acquisition of new abilities and helps in the improvement of motor capacity, allowing the performance of more complex movements[28,29], especially concerning the motor coordination both of upper and lower limbs[30]. Additionally, dancing positively influences body balance and muscular strength[31], besides preventing cognitive decline[32] and decreasing the risk of falls[30,33].

Dancing, in some situations and specific regions, is part of an important cultural manifestation, highlighted in its gestures and festivities[32]. The positive results of the gait pattern found in the Dancing group may be explained by the characteristics of the rhythms practiced, in its majority forró and xaxado. These rhythms involve cadenced movements in many directions, with spins, dislocations and alterations in the base of support. Moreover, forró and xaxado may be characterized as fast rhythms and, as they require that the dislocations follow the imposed rhythm, the feet move with small ankle range of motion. This requirement may have incremented the strength levels of the quadriceps muscles to raise the lower limb from the ground and provided increase both in step length and gait cycle length in comparison with the Control group.

In the analysis to determine the predictor variables of step length and gait cycle length, all anthropometric variables, age, functional capacity, level of physical activity and gait parameters, except gait cycle length to step length and vice-versa, were included in the model. For the step length, the gait cycle velocity, gait cycle duration, coordination and body weight variables were identified. For the gait cycle length, the gait cycle velocity, gait cycle duration and cadence variables were identified as predictors. The combination of these varialbes reveals the intricate relationship between gait spatial and temporal parameters.

Regarding the step length, the presence of the coordination and body weight variables as predictors indicates that, besides the gait parameters, components of the functional capacity and anthropometric characteristics also interact to predict the step length variability. The step length is considered a predictor of gait velocity, since it determines the space completed during the swing phase[34,35]. Increase in step length can also explain increase in the gait velocity, since further distances can be reached in a shorter time period[3].

The present study presents some limitations. The non-inclusion of male participants was due to the facts that few elderly men perform activities such as aquatic exercise and dance and that there are differences between sexes in the muscular adaptations in strength training[10]. However, the main limitation of this study is related to the control of the training specificities in each of the compared activities (exertion intensity, frequency and duration of the sessions), which can only be eliminated in intervention studies.

The results of the present study concluded that: a) functional capacity presents few differences between active and sedentary elderly; b) practice of regional dance (forró and xaxado) alters gait spatial parameters; and c) there is strong correlation between gait spatial and temporal parameters of elderly women.

All authors have declared there is not any potential conflict of interests concerning this article.

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