Original Article (short paper)

Supervised dance intervention based on video game choreography increases quadriceps cross sectional area and peak of torque in community dwelling older women

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Abstract — Aims: the purpose of this study was to assess the effects of a supervised dance intervention based on video game choreography on isokinetic concentric and eccentric knee peak of torque (PT), quadriceps and hamstrings cross sectional area (CSA) and functionality in community-dwelling older women. **Methods:** Forty-seven older women were allocated in Control Group (CG, n=25) and Intervention Group (IG, n=22). The IG performed dance based on video game choreography (*Dance Central*, *XBOX 360*®, *Kinect*), during 12 weeks, ~40 minutes, 3x/week, without foam (1-6week) and with foam and visual disturbances (7-12 week). The pretest-training-posttest assessments included: isokinetic concentric and eccentric knee PT and CSA (Magnetic resonance imaging) of quadriceps and hamstrings and functional tests. **Results:** The light-to-moderate-intensity 12-weeks training increased 8.5% the eccentric PT of quadriceps at 60°/s (p=0.04) and 1.3% quadriceps CSA (p=0.02). **Conclusions:** These findings suggest that dance training based on video game choreography can enhance PT and induce hypertrophy in community-dwelling older women.

Keywords: aged, virtual reality, dance training Brazilian Register of Clinical Trials (ReBec) (RBR-8xkwyp)

Introduction

It is well described in literature that muscle strength and power exercises are effective in improving muscle strength, mass and power, and the functionality, components that are closely related to the maintenance of functional independence and the ability to perform daily living activities in older adults[1–3]. However, it is estimated that the number of old participants who frequently practice strength training is less than 10%[4] and the low adherence may be related to the repetitive and tedious characteristics of this type of training, reported by participants[5].

In this way, the practice of exercise using video game, also called as exergames, has been adopted by several studies and classified as fun and motivating by aged[5,6]. This type of training is effective in improving gait and postural control, balance and mobility and reducing fear of falling[7]. Studies verified isometric strength increment after Tai-Chi and Yoga virtual reality-based exercise during 8 weeks, 3 times/week (t/w)[8] and after exergames that involved 3 balance and 5 strength exercises, 3 t/w during 16 weeks[9]. Jorgensen, Laessoe, Hendriksen, Nielsen, Aagaard[6] conducted a 2 t/w training using different balance and strength Wii Fit games, during 10 weeks, and found improvement in maximal leg muscle strength (maximal voluntary contraction and rate of force development) and overall functional performance (Timed Up and Go test, 30-second repeated Chair Stand Test and fear of falling) in community-dwelling older adults. Still, dance based on video game choreography have also been used to improve balance, reaction time and functionality[5].

It is known that increasing muscle strength can promote increases in muscle mass[10]. Studies that performed traditional aerobic and muscle strength and power exercises reported increases in cross-sectional area (CSA) and/or muscle volume after 12 weeks (3-4 t/w) of aerobic exercise on a stationary bicycle[11], 12 weeks (3 t/w) of power exercises (30%-50% 1RM)[12] and 16 weeks (2 t/w)[13] of strength and power exercises. Although studies with virtual games reported an increase in muscle isometric strength[8,9], no one was found investigating the effects of virtual games on muscle mass and concentric and eccentric torque, which are required to perform the activities of daily living. Still, the skeletal muscle remodeling response to concentric and eccentric exercises, as a dance training performed in closed chain, can be different when the concentric and eccentric torque are assessed by an isokinetic dynamometer[14,15].

Nevertheless, there is a lack of evidence of exergames training effects on functionality and muscle function in the aged, that can be explained by the absence of exercise parameters prescription such as: frequency, duration, progression and intensity of video game training and small sample size[16,17].Thus, the aim of this study was to investigate the effects of a supervised dance intervention based on video game choreography on isokinetic concentric and eccentric knee peak of torque (PT), quadriceps and hamstrings cross sectional area (CSA) and functionality in older women. The potential findings can improve the understanding about skeletal muscle responses to different types of exercise, enabling health professionals to choose the one that best suits their population goals.

Methods

Design

This was a non-randomized controlled trial, approved by the Research Ethics Committee of the Health Sciences Division of the Federal University of Parana (UFPR), Brazil (CAAE: 36003814.2.0000.0102) and all participants signed the informed consent.

Participants

The inclusion criteria were: community-dwelling older women living in Curitiba and its metropolitan area, Parana, Brazil; independent older women [according to Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL)][18,19]; > 65 years; low to moderately activity level [Human Activity Profile (HAP)][20]; without cognitive impairment [Mini-Mental State Examination (MMSE)][21]; without severe symptoms in hip and knee [Lequesne's Algofunctional Questionnaire][22] accepting scores between 0 (no impairment) to 7 (moderate, mild involvement); without neurological disease and/or trauma, orthopedic fixation or prosthesis, and metallic or non-metallic implants. Volunteers also should not have uncontrolled diseases (cardiac, respiratory, kidney, liver, osteoporosis, hypertension, diabetes I and diabetes II and endocrine); do not use medications that affect balance (benzodiazepines and neuroleptics); have normal visual acuity, even with use of contact lenses or glasses (score of Snellen: <20/70 (ICD-10 - International Classification of Diseases)]. Participants who did not take part in training sessions and/or did not participate in post 12 weeks' evaluations were excluded from the analysis.

Initially, older women from senior groups and public health care ambulatories in Curitiba, PR, Brazil and its metropolitan area were invited to take part of this study from March to May of 2015. Besides, flyers explaining this study and inviting older women were handed out in many places at Curitiba such as: churches, universities, hospitals and public health care ambulatories. Then, senior women interested in participating to our study underwent the screening assessments, applied by Physical Therapists and Physical Trainer, and then were evaluated by Geriatrician doctor in July of 2015.

Fifty-two participants were included and submitted to musculoskeletal assessments, before and after 12 experimental weeks (August to November of 2015). Afterward the pre-assessment, participants choose to take part into Intervention Group (IG, n= 23) or Control Group (CG, n=29).

The IG performed supervised dance intervention based on video game choreography, 3t/w, during 12 weeks and the CG committed not to modify their lifestyle during this period. After allocation 3 subjects from CG withdrew and 1 participant from IG dropped out due to hospitalization during the experimental period, and after the finals evaluations, one CG participant was excluded from analysis because had insufficient data. Therefore, 25 older women from CG and 22 from IG completed the study (Figure 1).

Outcomes

The primary outcomes were quadriceps (Q) and hamstrings (H) concentric and eccentric isokinetic PT and cross sectional area (CSA). Isokinetic PT was evaluated by a Physical Therapist, using Biodex System 4 Dynamometer (Biodex Medical Systems, Shirley, New York) in Center of Motor Behavior Studies at Federal University of Parana. The CSA was assessed using Magnetic Resonance Imaging (MRI) equipment (Siemens Magnetom Avanto 1.5T) at Diagnóstico Avançado por Imagem (DAPI) in Curitiba, Parana, Brazil.

For the isokinetic PT evaluations, all participants were tested in the dominant lower leg after answering the question "*which leg would you use to kick a ball?*"[23,24].

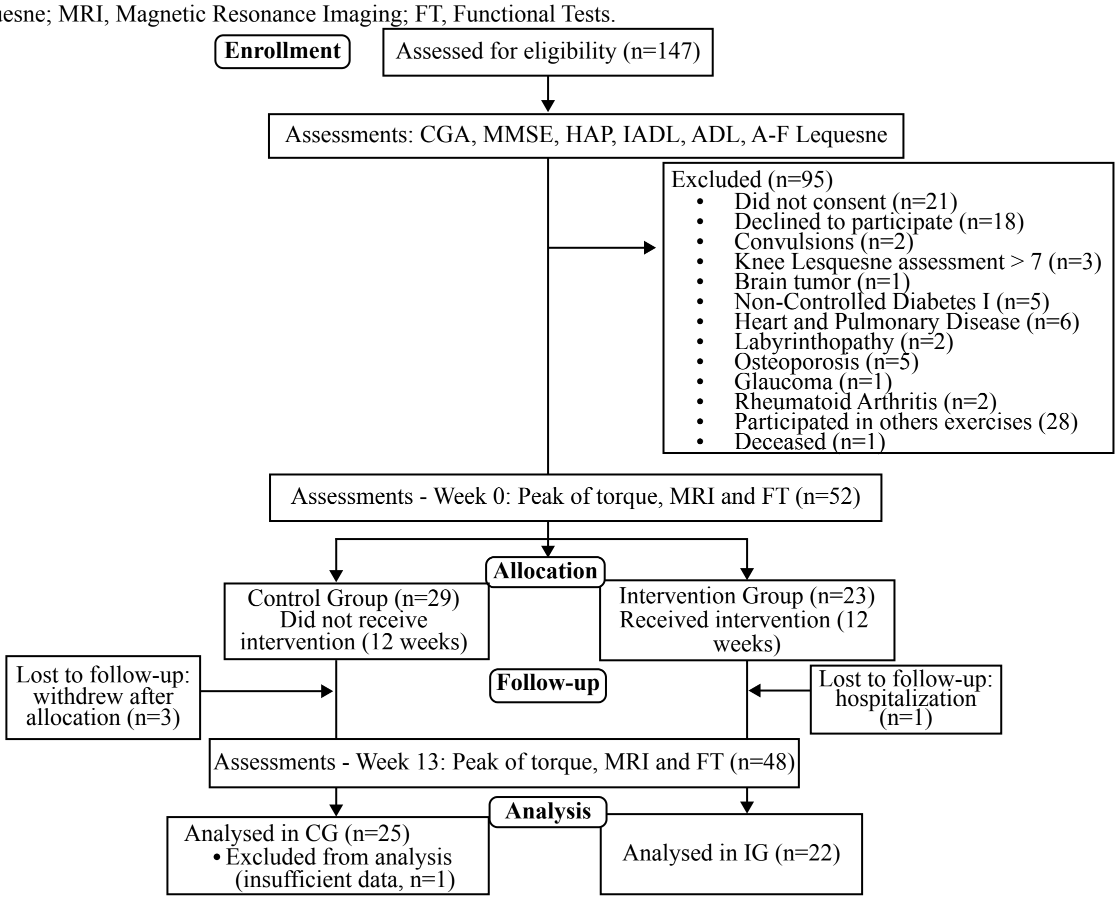
Before starting the test, the subjects completed a warm-up [walking throw a 30 meter straight corridor until reaching the target heart rate (HR) for warming-up (40% to 60% of HR reserve)][25]. The average time obtained for warm-up was 2 minutes. Once they reached the target HR, the participants sat on the dynamometer chair (chair back angle of 85°) secured by adjustable straps in the trunk, waist and thigh, and with the input shaft of the dynamometer aligned with their knee axis of rotation. To get familiarized with test protocol, participants performed 2-4 passive repetitions followed by 1 set of 4 submaximal continuous repetitions. Then, 1 set of 3 maximal continuous voluntary flexion-extension were performed and considered for analysis. This process was done to evaluate knee concentric and eccentric strength, at 60°/s and 180°/s, with 2 minutes of rest among the tests[23,26,27], and 60º of range of motion (ROM)[26]. Participants received verbal encouragement in order to reach the maximal strength through the full available ROM at every trial[26,27]. After the tests the subjects performed 2 repetitions of 30 seconds stretching exercises for extensor and flexor knee joint at orthostatic position.

The MRI axial images of quadriceps and hamstrings muscles were assessed by a specialist in radiology. The images were obtained from the dominant leg, with 9 mm thickness, 1 mm gap, 20 ms of echo time and a 442 ms repetition time, in a 256 x 256 pixels matrix. An initial axial T1 image was captured to determine the perpendicular distance from greater trocanter of the femur to the inferior femur condyle border. The muscle images were obtained at 50% of this distance[13], with participant in supine position and most relaxed as possible[28,29].

The CSA was analyzed using the Image J software (Version 1.46r, National Institutes of Health, Bethesda, MD, USA). The external borders of the quadriceps and hamstrings were outlined, excluding bone, subcutaneous and intermuscular fat. The quadriceps and hamstrings muscle CSA areas (measured in cm^2) were automatically calculated by summing pixels of the indicated tissues and multiplied by the pixel surface area[30]. Each muscle group was measured three times by the same researcher and the average value of the three measurements was considered for the analysis[28,29].

The secondary outcomes were functionality assessed by functional mobility test (Timed Up and Go - TUG)[31], Gait Speed (GS) of 10 meters test[32,33] and Five Times Seat to Stand Test (FTSS)[34]. All these tests were assessed by Physical Therapists and Physical Trainer in the Prevention and Functional Rehabilitation Unit and Metabolic Unit at Clinics Hospital/Universidade Federal do Paraná.

Figure 1. Design and Flow of Participants Throw the Trial. CGA: Comprehensive Geriatric Assessment; MMSE, Mini-Mental State Examination; HAP, Human Activity Profile; IADL, Instrumental Activities of Daily Living; ADL, Activities of Daily Living; A-F Lequesne, Algofunctional index of Lequesne; MRI, Magnetic Resonance Imaging; FT, Functional Tests.



The covariates were falls and anthropometric data (weight, height and body mass index - BMI). About the fall history, the participants answered if they had experienced a fall during the last 12 months[35].

Intervention Protocol

The dance training based on video game choreography was performed in a group of 19 older women on average per training session, 3 times per week, ~ 40minutes per session, during 12 weeks. The control group did not take part in any intervention protocol and was instructed to maintain their lifestyle during the experimental period.

The Dance Central game and XBOX 360® with Kinect motion sensor were used. All the training sessions started with warm-up (10 minutes) in which the dance movements that would compose the choreography of that training session were taught by the Physical trainer, at first without music. Then the "*perform it*" game mode was played once, in which the participants could perform the choreography with all the movements learned before, with music and the game avatar. At the main session part (20 minutes), the "*dance battle"* mode, in which the whole choreography was repeated twice, without interval, was performed four times and then, the training session finished with relaxation and breathing exercises (10 minutes). Six dance rhythm musics were selected: *Funkytown, Galang' 05, Down, Brick House, Jungle Boogie, Days Go by*, and all of them were played only in the easy level. A different song was danced every week until the seventh week, when they were repeated in the same sequence, as described in Box 1.

The selected music and their order of execution in the training protocol were based on the American College of Sports Medicine[36] recommendations for neuromotor training that include exercises as follow: " 1) progressively difficult postures that gradually reduce the base of support (e.g., two-legged stand, semi tandem stand, tandem stand, one-legged stand), 2) dynamic movements that perturb the center of gravity (e.g., tandem walk, circle turns), 3) stressing postural muscle groups (e.g., heel stands, toe stands), or 4) reducing sensory input (e.g., standing with eyes closed)". Thus, the sequence of choreographed songs chosen increased progressively the difficulty of movements, from bipedal support to one standing leg movements; movements at the same support basis to movements with lateral and forward displacement; plantar flexion, jumps and squat movements. Besides, to increase the training complexity, the participants performed the exercises with low lighting from the 7th to 12th week, on a 19m^2 of polyurethane foam with 5cm of thickness[37]and 33 of density which supports 70 – 100kg. From the 10th to 12th week colorful and flashing lights were added to promote visual inputs perturbation.

Box 1. Summary of the Dance Based on Video Game Choreography Protocol.

Dance Central - XBOX 360 - *Kinect*												
	Weeks											
Musics	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Funkytown	X						X					
Galang' 05		X						X				
Down			X						X			
Brick House				X						X		
Jungle Boogie					X						X	
Days Go by						X						X
Training Progression	Exercise without Foam						Low Light			Colorfull and flashing lights		
							Exercise on the Foam					

The game was projected on a white wall and the sound amplified, facilitating the viewing and the hearing by all participants. All the sessions were supervised by Physiotherapists and led by a Physical Trainer. Their functions were: implement the training and give all the necessary orientations, ensure the safety of participants mainly regarding to the risk of falling, prevent the incorrect movements, give feedback to participants on their performance, note their HR, rating perceived exertion (RPE) and their presence at each session.

The Physical Trainer was the person captured by Kinect system. The intervention was performed in group, however the Kinect system captured only one player, i.e., the physical trainer. So, participants danced following the avatar projected on a white wall, but the performance feedback given by the Kinect system was related to the Physical Trainer who conducted the dance exercises. However, the participants received verbal stimulus and positive feedback from professionals during the dance training.

To control training intensity, the HR was collected at pre and post each session and after the warm-up (moment 1), 10th (moment 2) and 20th (moment 3) minutes of dance training in each session. The percent of HR Reserve (%HRR) were considered to calculate the intensity of training using the exercise HR response at moment 1, 2 and 3. For the %HRR the equation was [%HRR =((HR achieved - HR rest)/HRR) x 100][25,38]. And to evaluate the perception of effort during exercise, participants answered about their perceived both cardio respiratory and muscle RPE[39] using the Borg 6 -20 scale, after the warm-up (moment 1), 10th (moment 2) and 20th (moment 3) minutes of dance training.

Only the moments 2 and 3 of HR and RPE were considered for analysis, because these were the moments when the cardiovascular and neuromuscular systems were more required. The cutoffs for intensity of training according to %HRR (bpm) and RPE (score) were respectively: very light (<30; <9); light (30-39; 9-11); moderate (40-59; 12-13); vigorous (60-89; 14-17); near maximal to maximal (≥90; ≥18)[25]. To compare the training intensity with and without foam, only the 3rd session of the 1st, 6th and 12th were considered for analysis

The Blood pressure was checked in accordance with the 6thBrazilian Hypertension Guidelines[40]by the stethoscope method, using a sphygmomanometer (Premium) and stethoscope (Premium) prior to the beginning of each testing session and immediately after the cool down.

Data analysis

The sample size calculation was based on a distribution assuming two independent groups. For this, the GPower 3.1.9 program was used considering an effect size of 0.8 (large), an error type I of 0.05 and power analysis of 0.78, estimating 52 people for the sample size. Along the intervention and after post assessment, there was a sample loss of 5 individuals, which guaranteed the analysis, in a post-hoc evaluation, a power equivalent to 0.74 for a sample size of 47.

The data was tested for normality distribution using the Kolmogorov-Smirnov and Lilliefors. The median and interquartile range were used to demonstrate the data at the baseline characteristics. To compare the variables at baseline Mann Whitney U Test was used for IADL, ADL and Algofunctional index of Lequesne for knee and hip; number of falls through Chi^2 of k proportion test and the others baseline variables analyzed by the independent student t-test. The primary and secondary outcomes were described as mean difference and 95% confidence intervals. The comparisons between IG and CG were adjusted by age using is Analysis of Covariance (ANCOVA) and Bonferroni post hoc test in case of statistical significance ($p \leq 0.05$). To compare the intensity of the training among the 3rd sessions of the 1st, 6th and 12th week the General Linear Models ANOVA repeated measures, assuming Gaussian distribution, followed by post hoc Tukey was used for RPE and HR. The Intraclass Correlation Coefficient (ICC) was calculated to verify the intra-rater reliability to the CSA's measures. It was considered the intra-rater concordance among the 3 measures in the first day and 3 measures after 1 month. The Standard Error of the Measurement (SEM) was estimated to verify the reliability of intra rater score differences to measure the CSA, considering SEM equal to the SD (standard deviation of the measurements) multiplied by the square root of one minus the ICC.

The SPSS (version 20; SPSS, Inc., Chicago, IL) was used to calculate the ICC. The 7.0 Statistic (Stat Soft Inc 7.0) was used to the others analysis. In all statistical tests, significance was set at ≤0.05.

Results

Baseline characteristics

Considering the baseline characteristics, there was difference between the groups only in the height. The average age of the sample was 70.2 years-old. The CG and IG were classified as independent, normal weight by BMI, without cognitive alterations and as moderately active. Seventeen subjects (36%) from both groups reported falls in the previous 12 months. About the lower limb joints functional capacities the participants showed mild symptoms (Table 1).

Feasibility and safety of the intervention

Considering 12 weeks of supervised dance training based on video game choreography performed 3 times per week totaled 36 sessions, the participants performed an average of 31 interventions sessions, representing about 86% of adherence rate and 96% of adherence to the training period. No serious advent related to the intervention was reported and in all the sessions, the participants were overseen by Physiotherapists and a Physical Trainer.

Effects of the intervention

The eccentric PT of quadriceps at 60°/s and the quadriceps CSA increased 8.5% and 1.3% in IG, respectively. There were no significant differences between groups (p>0.05) in the other variables.

Table 1. Participant characteristics at baseline.

	CG (n=25)	IG (n=22)	p value
Age (years)	69 (67 - 73)	68 (67 – 70)	0.22
Height (m)	1.60 (1.50 – 1.60)	1.50 (1.50 – 1.60)	0.05*
Weight (kg)	69.0 (60.9 – 70.6)	62.1 (56.9 – 71.6)	0.10
BMI[a] (kg/m²)	27.3 (25.7 – 28.1)	27.8 (24.8 – 30.3)	0.54
MMSE[b] (score)	27 (26 – 29)	28 (27 – 29)	0.16
HAP[c] (score)	56.0 (41.0 – 64.0)	59.5 (50.3 – 63.8)	0.41
ADL[d] (score)	6 (6 – 6)	6 (6 – 6)	0.76
IADL[e] (score)	21.0 (20.0 – 21.0)	21.0 (20.3 – 21.0)	0.54
A-F Hip[f] (score)	0.0 (0.0 – 0.5)	0.0 (0.0 – 1.8)	0.29
A-F Knee[f] (score)	0.0 (0.0 – 1.0)	0.0 (0.0 – 1.5)	0.06
Falls (number/%)	11 (44%)	6 (27%)	0.234

Results are median (interquartile range). **BMI**, Body Mass Index; **MMSE**, Mini-Mental State Examination; **HAP**, Human Activity Profile; **IADL**, Instrumental Activities of Daily Living; **ADL**, Activities of Daily Living. **A-F**: Algofunctional Index of Lequesne. [a]SABE, 2003;[b]Bertolucci et al. (1994); [c]Souza et al.(2006);[d]Katz et al. (1963); [e]Lawton et al. (1982); [f] Marx et al. (2006); *p≤0.05 (independent student t-test and Mann Whitney U test). Falls were compared by Chi² of k proportion test.

Table 2. Quadriceps and Hamstrings Isokinetic Peak of Torque and Functional Tests.

	CG (n=25)	IG (n=22)		
	Δ Mean Difference (95%CI)	Δ Mean Difference (95%CI)	R²	p value
CON Q 60°/s (Nm)	1,42 (-2.24 to 5.08)	3,69 (0.44 to 6.94)	0.020	0.644
CON H 60°/s (Nm)	1,25 (-0.91 to 3.41)	3,49 (0.86 to 6.11)	0.073	0.189
CON Q 180°/s (Nm)	1,30 (-1.60 to 4.20)	4,85 (2.21 to 7.50)	0.071	0.198
CON H 180°/s (Nm)	1,46 (-0.86 to 3.77)	3,80 (1.08 to 6.52)	0.048	0.342
ECC H 60°/s (Nm)	-0,04 (-3.77 to 3.68)	1,94 (-2.45 to 6.32)	0.038	0.426
ECC Q 60°/s (Nm)	0,57 (-7.44 to 8.58)	10,68 (4.79 to 16.56)	0.146	0.031*
ECC H 180°/s (Nm)	-0,74 (-3.95 to 2.48)	3,02 (-0.91 to 6.95)	0.051	0.318
ECC Q 180°/s (Nm)	4,28 (-2.91 to 11.47)	7,97 (1.81 to 14.13)	0.030	0.517
FTSS (s)	0,04 (-0.52 to 0.60)	-0,59 (-1.33 to 0.14)	0.048	0.336
TUG (s)	-0,20 (-0.63 to 0.23)	-0,48 (-0.96 to 0.00)	0.019	0.654
GS (m/s)	0,00 (-0.05 to 0.06)	-0,02 (-0.08 to 0.04)	0.061	0.250

CG, Control Group; **IG,** Intervention Group; Δ, delta; **CON,** Concentric; **ECC,** Eccentric; **Q,** Quadriceps; **H,** Hamstrings; **Nm,** Newton meter; **FTSS,** Five Times Sit to Stand; **TUG,** Timed-Up and Go**; GS,** Gait Speed; **s,** seconds**; m/s,** meters per second. **CI**, confidence intervals; **R²**, determination coefficient of ANCOVA; *p≤0.05, ANCOVA, Bonferroni post hoc test.

Table 3. Cross Sectional Area.

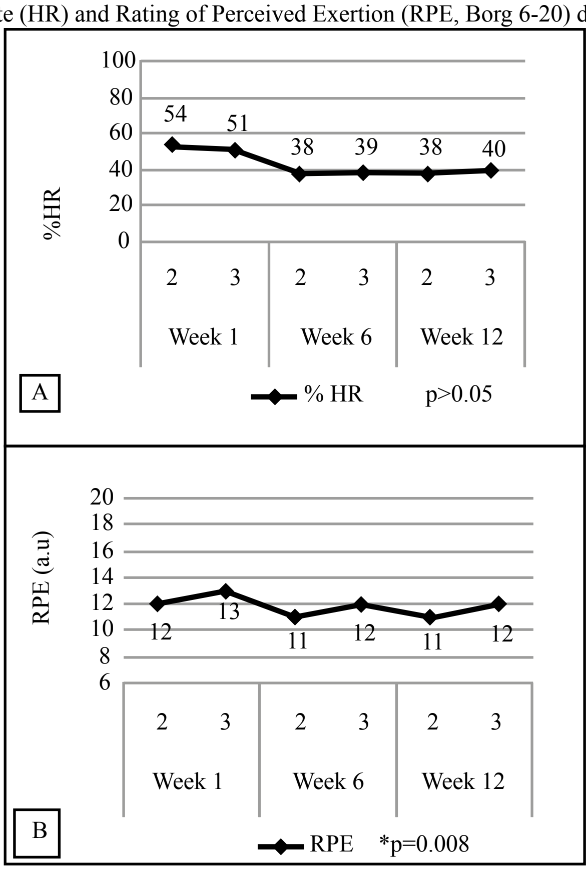
	CG (n=25)	IG (n=22)				
	Δ Mean Difference (CI 95%)	**Δ Mean Difference (CI 95%)**	**R^2**	**p value**	**ICC**	**SEM**
CSA Q (cm²)	-0.42 (-0.85 to 0.01)	0.62 (-0.20 to 1.44)	0.123	0.05*	0.99	0.49
CSA H (cm²)	-0.20 (-0.73 to 0.32)	0.53 (-0.01 to 1.06)	0.086	0.139	0.98	0.53

CG, Control Group; I**G,** Intervention Group; Δ, delta; **ICC**, Intraclass Correlation Coefficient intra-rater; **SEM**, Standard Error Measurement; **CSA**, Cross Sectional Area; **Q**, Quadriceps muscle; **H**, Hamstrings muscle; **R^2**, determination coefficient of ANCOVA; *p≤0.05, ANCOVA, Bonferroni post hoc test.

Intensity of training

The intensity was light-to-moderate and there was no significant difference of HR comparing the moments 2 (10^{th} minute) and 3 (20^{th} minute) ($p > 0.05$) and comparing weeks 1, 6 and 12 ($p > 0.05$), i.e., when the exercises were performed with and without foam. There was no significant difference in RPE comparing weeks 1, 6 and 12 ($p > 0.05$), however, RPE increased at moment 3 in relation to 2 in all weeks ($p = 0.008$) (Figure 2). Considering these data the video game dance training protocol was performed in a light-to-moderate intensity.

Figure 2.Percentage of Reserve Heart Rate (HR) and Rating of Perceived Exertion (RPE, Borg 6-20) during the dance training protocol.



A, Percentage of Reserve Heart Rate (%HR). **B,** Rating of Perceived Exertion (RPE), a.u, arbitrary unit. The numbers 2 and 3 correspond to moment 2 (10 min) and 3 (20 min). Week 1, 6 and 12 are related to the training protocol.*p=0.008 represents the statistical increase in RPE at moment 3 in relation to 2 at all training weeks.

Discussion

The supervised dance intervention based on video game choreography, performed in a light-to-moderate intensity, improved muscle function, detected by the 8.5% increase in eccentric PT of quadriceps at 60°/s and the 1.3% increase in quadriceps CSA.

Studies have found increase in isometric strength in lower limbs after virtual reality training based on unsupervised balance and strength exercises during 16 weeks with training progression increasing the task's difficulty and the number of sets, weight or repetitions[9] and based on game's movements of Tai chi and Yoga, carried out for 8 weeks[8]. The increase in isometric strength found in both studies is due to the balance exercise and the loads used during the training[9] and the Tai chi and Yoga exercises performed which demand isometric strength to stay in the positions[8], further, the older adults were not stratified by sex. In contrast, in our study, the training was carried out with female older indicating the specific gain for women. There was no use of extra load and even so the dance training based on video game choreography increased 8.5% in the eccentric PT of quadriceps at 60°/s, probably due to the dynamics movements required to perform the dance training in our study.

Furthermore, performing exercises on the foam may have stimulated the knee semi-flexion to adjust the stability during exercise and this has promoted increase in eccentric PT of quadriceps, probably in consequence of the changes the dance promoted in the support basis, direction and speed that required concentric and eccentric contractions[14]. And, considering dance exercise is performed in a closed kinetic chain, at standing position, it may have promoted co-contraction of the quadriceps and hamstring muscles to maintain the joints stability[41], also enhancing lower limbs strength.

The increase in eccentric PT of quadriceps at 60 °/s may have contributed to the quadriceps CSA increment in this study. Eccentric actions have greater effect on muscle hypertrophy because the increase in the active tension developed by the contractile elements particularly collagen in extracellular matrix and titin. It is theorized that the hypertrophic superiority of eccentric exercise is a result of a reversal of the size principle of recruitment, resulting in selective recruitment of fast-twitch fibers. Besides, eccentric contractions result in additional recruitment of previously inactive motor units, promoting the muscle hypertrophy[10].

One study followed 1678 well-functioning older men and women over 5 years and found the thigh CSA decline 3.2% in female older (n=865) and 4.9% in male older (n=813), representing 0.64% and 0.98% over a year, respectively[42]. Comparing to our results, the light-to-moderate dance training based on video game choreography performed 12 weeks enhanced 1.27% in the quadriceps CSA that overcame 2 years of muscle mass loss. Another study[43] also found decline of 16.1% in quadriceps CSA and 14.9% hamstrings CSA in the same older men (n=9), with initially 65.4 old over 12 years, representing a loss of 1.34% in quadriceps and 1.24% in hamstrings over one year. It could be hypothesized that the increase in quadriceps CSA found in our study is equivalent to the value of annual loss, but the authors have assessed the CSA in male, limiting this comparison. However, the dance protocol performed in this study may be prescribed to increase quadriceps CSA in community older women.

In relation to the intensity of training, it was light-to-moderate in our study considering both the HR and the RPE. Other studies[38,44] using Nintendo Wii Fit, the intensity of training was moderate assessed by HRR parameters, light intensity using RPE[38] or did not present significant differences[44]. It might be as a result of the game's type because in our study the participants performed the dance training based on video game choreography developing large movements in different positions not only standing on the balance board as using Nintendo Wii Fit games.

We found that the HR remained stable during the training while the RPE increased at the moment 3 (20th minutes of training), when the cardiovascular and neuromuscular systems were more required. Another study found similar behavior and the authors reported that the RPE increase occurred from the middle to the end of exercise session and it is not correlated to HR, that can be explained by the psychobiological model, which postulates perception of effort is the conscious awareness of the central motor command sent to the active muscles, independent of peripheral afferent feedback signals[45]. Thus, the RPE can increase even when the HR is stable and can be used to monitor the exercise intensity and to detect the exercise tolerance[45].

The motivation of older people is difficult to maintain in exercise training carried out 3 times a week[5,38]. Studies reported 97.5% of adherence in 12 weeks of training, 2 times a week[44] and 97% of adherence in 6 weeks, 2 times a week[7]. Despite these, results had indicated that lower frequency (2x/week) or lower training period (6 weeks) the exercise adherence may be higher. In our study, the adherence was 96% which could be explained by the type of exercise, supervision during the training and also the training session performed in group. This outcome agrees with Kim, Son, Ko, Yoon[8] that reported video game based training encourages participation and increases concentration and continuity in the exercise. In addition, supervised exercise can improve adherence to exercise and safety for individuals[25]. Moreover, the social network must be considered as an important factor that can increase adherence when the training sessions are performed in group as reported by other authors[47].

Regarding the functionality, there were no significant changes after the dance training in our study. Chen, Wei, Hsieh, Cheen, Chen, Kao[48] found improvement in TUG and FTSS after 6 weeks of video-game-based power training (based on squat exercises with virtual interface) in community older adults, 2 times a week for 30 minutes. However, at baseline the results of the TUG (IG: 17.15; CG: 15.98) and FTSS (IG: 17; CG: 1.17) at baseline were higher than the values obtained in this study TUG (IG: 8.8; CG: 8.1) and FTSS (IG: 9.6; GC: 9.3), demonstrating that the better the initial levels of functionality are, the more difficult it is to promote modifications in functionality.

The outcomes of the present study contribute to the prescription of dance intervention based on video game choreography to improve skeletal muscle function. However, this study presents some limitations as absence of sample randomization; absence of blinded evaluations; lack of evaluation of the primary and secondary outcomes after 6 weeks of training, to compare the results with and without foam; and the absence of muscle electrical activity analysis.

Conclusions

The light-moderate-intensity dance intervention based on video game choreography performed with and without unstable ground and visual disturbance improved quadriceps eccentric torque and induced hypertrophy. Moreover, the dance training protocol promoted a high attendance and adherence of community-dwelling older women. As a clinical application the dance training based on video game choreography can be prescribed to increase musculoskeletal function and muscle mass of aged community women.

For future research, we suggest the conduction of randomized control trials that investigate the reaction time and the myoelectrical activity to elucidate the neuromuscular aspects that might be involved in the response of skeletal muscle mass and torque to the supervised dance intervention based on video game choreography. It is also required the investigation about the skeletal muscle function after unsupervised dance intervention based on video game choreography in community-dewlling older women.

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