

Dance-based aerobic exercise may improve indices of falling risk in older women

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Abstract

Objective: to determine the effect of dance-based aerobic exercise on indices of falling in older women.

Design: an exercise intervention trial with participants assigned either to an exercise group or to a control group.

Setting: an exercise hall at a community centre for senior citizens.

Participants: thirty-eight healthy women aged 72–87 years, living independently in the community.

Intervention: twenty women performed dance-based aerobic exercise for 60 minutes, 3 days a week, for 12 weeks. The exercise included single-leg standing, squatting, marching, and heel touching; and targeted balance, strength, locomotion/agility, and motor processing.

Main outcome measures: single-leg balance with eyes open/closed and functional reach as balance, hand-grip strength and keeping a half-squat position as strength, walking time around two cones and 3-minute walking distance as locomotion/agility, and hand-reaction time and foot tapping as motor processing.

Results: at the pre-test, both exercise and control groups performed similarly in all tests. At the end of the intervention, the exercise group showed significantly greater single-leg balance with eyes closed, functional reach, and walking time around two cones. In contrast, there were no significant improvements in any of the test measures in the control group.

Conclusions: dance-based aerobic exercise specifically designed for older women may improve selected components of balance and locomotion/agility, thereby attenuating risks of falling.

Keywords: *balance, locomotion, agility*

Introduction

In recent years, Japan has become the world's most aged society; the longevity rates—77.2 years of age for men and 84.0 years of age for women—are the highest in the world [1]. The percentage of adults aged 65 and over is set to increase to approximately 26.6% by 2025. As the total number of healthy older adults increases, the number of bed-ridden people may also increase. The

number of bed-ridden adults (>65 years of age) has been up to 316 000 in 1998.

Falls are the most frequent cause of a bed-ridden condition, injury-related morbidity, and mortality among older adults [2]. In an attempt to prevent falls, some studies have shown the effects of exercise intervention on older adults. Sherrington and Lord [3] reported the effects of a 1-month home exercise program. In their study, participants who had suffered from hip fractures

were instructed to undertake a weight-bearing exercise with the use of a telephone book as a stepping block. The participants showed significant improvements of quadriceps strength and gait speed. Shaw and Snow [4] applied a weighted vest to older women in their exercise class. The results demonstrated increases in hip abduction, knee extension, plantar flexion, and lateral stability; these were considered to contribute to the prevention of falls. These studies suggest that exercise may increase the physical ability that is required to prevent falls. However, these studies focused only on weight-bearing exercise/resistance training, and aerobic exercise (aerobic dance) has not been examined as a means of exercise intervention.

Aerobic dance could be also an effective exercise to prevent falls, because of its advantages associated with (i) kinesiological factors and (ii) a relatively low incidence rate of injuries. Movement and choreography in aerobic dance included the sagittal step and the straddling step, in which balance and locomotion/agility are needed [5]. A plyometric lunge was also included with the expectation that muscle strength of the lower extremities would improve. The movement was associated with ground reaction forces and included a wide variety of exercises specifically designed to increase muscular strength and power of the lower extremities [6]. This movement was based on the premise that increased eccentric preload on a muscle induces the myotatic stretch reflex and may cause a more forceful concentric contraction.

Powell *et al.* [7] demonstrated that incidence rates per 100 participants for injuries, causing reduced participation in physical activity, were 1.1 ± 0.5 per 30 days for walking, 1.1 ± 0.4 for gardening, and 3.3 ± 1.9 for weight-bearing exercise. It was also reported that there were too few activity-reducing injuries to calculate incidence rates for aerobic dance. Therefore, aerobic dance specifically designed for older persons ('dance-based aerobic exercise') could be an exercise to attenuate the risk of falling, similar to the weight-bearing exercise.

The purpose of this study was to determine the effect of dance-based aerobic exercise on the improvement of indices of falling in older women. This clinical trial would propose a new exercise mode as a means of preventing falls in older persons.

Methods

Participants

Participants were recruited from two community clubs (so-called Silver Clubs) managed by Welfare Organization for the Aged in Tsukuba City, Ibaraki Prefecture, Japan, where our laboratory was located. This organization managed all 32 Silver Clubs in this city, with a membership of 1131, accounting for approximately 5.8% of all older adults aged 65 years

or over. The leader of one randomly selected Silver Club was contacted and asked to participate in this study as an exercise intervention group. More information was provided to the leader and club members by means of a leaflet and verbal instructions at the community centre. The eligibility criteria included (a) aged 70 or older, (b) living independently in a community, (c) being without contraindications to cardiorespiratory fitness assessment (i.e., unstable angina, uncontrolled ventricular arrhythmia, resting diastolic blood pressure > 115 mm Hg, resting systolic blood pressure > 200 mm Hg) [8], and (d) not having a regular exercise habit. Twenty-two older Japanese women from the Silver Club, aged between 72 and 87 years, agreed to participate in this study. None of the participants had ever smoked. Two people did not meet the above criteria and were excluded: one suffered from cerebrovascular disease, and the other had regularly played competitive gateball (gateball is similar to the sport ground golf). The mean age of the twenty women was 78.6 ± 4.0 years. All participants scored 100 points in the Barthel index [9], which meant they were highly physically independent. Four participants suffered from essential hypertension (World Health Organization stage I) and were taking medications including calcium blockers, ACE inhibitor blockers, or beta-receptor blockers. Two participants suffered from cardiac arrhythmia and were taking calcium blockers. One had type 2 diabetes mellitus with diet control. Controls ($n=18$, 79.8 ± 5.0 years) were collected from a different Silver Club; that was also randomly selected from the other 31 Silver Clubs in the same city. Informed consent from all the subjects was obtained. This study was approved by the Human Ethics Review Board of Tsukuba Health Fitness Research Group in Higashi Toride Hospital.

Measures

Participants completed comprehensive cardiorespiratory fitness (medical check-up, Day 1) and functional fitness (Day 2) assessments prior to the exercise intervention. Each assessment was conducted on two separate days within a 7-day period at the participants' convenience. Data were collected by technicians at two sites (a division of cardiology, Higashi Toride Hospital and a hall at the community centre for senior citizens).

Cardiorespiratory fitness assessment (Day 1)

To assess the exercise intensity and to stratify risks during the dance-based aerobic exercise, participants performed a symptom-limited graded exercise test [8]. This test collected volume of oxygen uptake, heart rate (HR), and blood lactate level through resting to maximum exercising. The details were reported in the study of Takeshima *et al.* [10].

Functional fitness assessment (Day 2)

In a prospective study, Nevitt and colleagues [11] contacted 325 older community-living adults, who had fallen in the year before the onset of the study. The authors ascertained falls and determined the circumstances and consequences of falls. Multiple analyses of these falls revealed that a previous fall history with fracture, a slower Trail Making B time (test of cognitive function), being Caucasian, and using stairs and steps were independent variables associated with the risk of injury. In addition, the risk of injury was higher in persons having a slower hand-reaction time and decreased handgrip strength. A case-controlled study of Chu *et al.* [12] demonstrated that lower limb weakness and poor tandem-walk ability emerged as two significant predictive factors among the multiple clinical and functional falling risk factors identified. Gehlsen *et al.* [13] had reported that results in functional fitness in those with a history of falls were lower than those with no history of falls. In that study, functional fitness items included static balance (one-leg balance test), dynamic balance (backward-walking test), hip, knee, and ankle joint strength, and hip and ankle flexibility tests.

From these studies, we tentatively assumed balance, strength, locomotion/agility, and motor processing as elements of functional fitness related to the risk of falls. Also, in the present study, nine functional fitness items were selected in order to match each element. *Balance* included single-leg balance with eyes open, single-leg balance with eyes closed, and functional reach. *Strength* included hand-grip strength, and keeping a half-squat position. *Locomotion/agility* included walking around two cones, and a 3-minute walk. *Motor processing* included hand-reaction time, and foot tapping. Details of measurement of these fitness items have been reported in a previous study [14].

Exercise intervention

The 3-month exercise program was designed to increase balance, strength, locomotion/agility, and motor processing. Exercise classes were held three times a week with at least 1 day of rest between classes. Each 60-minute class began with 10 minutes of warm-up activities consisting of calisthenics and stretching. The class was followed by 35 minutes of dance-based aerobic exercise, finishing with 10–15 minutes of cool-down activities. In the first 2 weeks of exercise, participants were initiated to the basic movements and choreography of dance-based aerobic exercise. After the initiation of the program, the exercise intensity during the dance-based exercise was set at the individual's HR (± 15 b/min) and rating of perceived exertion [15] corresponding to the lactate threshold. This intensity was considered as targeting cardiorespiratory fitness [10], although the change in this fitness was not measured. HR monitoring equipment (Accurex plus, Polar Electro Oy, Finland) was

used to monitor and keep records during exercise. Most of the activities were accompanied by music played on a cassette player that could change tempos. In order to continue dance-activities, the tempos were arranged for participants. A hall at the community centre for senior citizens that was the nearest to the participants' residences was selected in order to keep high attendance rate to the exercise. The area of this hall was approximately 150 m² with Japanese tatami mats that were made of rush. These mats could absorb the excessive shock of the gravitational impact of the participants' lower body. An exercise specialist, whose areas of expertise were exercise gerontology and aerobic-dance instruction, conducted the exercises. Throughout the 3-month trial, movements and choreography were effectively modified for participants with the aid of this instructor.

The dance-based aerobic exercise involved continuous movement of the legs and trunk and intermittent movement of the arms. These included movements that extend, flex, abduct, adduct, and rotate the leg and foot, such as side-stepping, fast walking, forward and backward stepping, leg lifts, placing foot to the front, side, and behind, knee bends, forward and side-lunging, and heel rises. The attendance of participants was recorded at each exercise class. Participants in the exercise group were provided with written exercise instructions for times when they were absent from a class. The control group was instructed not to attend the exercise classes.

Statistical analysis

Data were analysed using SPSS version 9.0J statistical software packages (SPSS Inc., Japan). Results are given as the mean \pm standard deviation. Repeated measure analyses of variance were used to examine any changes during the 3 months. The paired *t*-test was performed to help ensure that the HR during the dance-based aerobic exercise (HR_{EX}) was not significantly different from the HR_{LT} within individuals. The HR_{EX} in each participant was defined as the mean of HR during the dance-based aerobic exercise. A *P* value of less than 0.05 was considered statistically significant.

Results

The baseline characteristics of the exercisers were very similar to those of the control group (Table 1). Balance, strength, locomotion/agility, and motor processing measures were comparable at the onset of the study (Tables 2–5). Average attendance to the exercise program was 78.8% (± 15.3 , range=43–80%). No participants terminated participation in the program. One woman had a relatively low attendance rate (43%). This woman had knee pain before entry to the program, and the progression of classes increased the symptomatology.

Table 1. Baseline physical characteristics

Measures	Exercise group (<i>n</i> = 20)	Control group (<i>n</i> = 18)
Age (yr)	78.6 ± 4.0	79.8 ± 5.0
Height (cm)	144.2 ± 5.3	144.8 ± 3.8
Weight (kg)	51.3 ± 7.7	50.7 ± 5.8
Percent fat ¹ (%)	35.7 ± 4.5	34.8 ± 5.6

¹Bioelectrical impedance analysis was performed [18].

Table 2. Balance measurements pre and post 3-month intervention or control period

Measures	Pre	Post
Single-leg balance with eyes open (s)		
Exercise group	23.1 ± 18.1	24.6 ± 17.3
Control group	17.9 ± 13.8	16.6 ± 15.8
Single-leg balance with eyes closed (s)		
Exercise group	2.8 ± 1.2	4.1 ± 2.0 ¹
Control group	6.1 ± 10.2	5.3 ± 5.3
Functional reach (cm)		
Exercise group	23.7 ± 4.5	26.1 ± 3.6 ¹
Control group	24.1 ± 8.8	23.3 ± 7.6

¹Significantly different from the pre-value (*P* < 0.05).

Table 3. Strength measurements pre and post 3-month intervention or control period

Measures	Pre	Post
Keeping a half-squat position (s)		
Exercise group	33.1 ± 18.9	30.8 ± 17.7
Control group	37.6 ± 20.7	34.9 ± 20.4
Hand grip strength (kg)		
Exercise group	22.0 ± 2.7	21.4 ± 2.9
Control group	19.1 ± 3.9	19.5 ± 3.6

Table 4. Locomotion/agility measurements pre and post 3-month intervention or control period

Measures	Pre	Post
Walking around two cones (s)		
Exercise group	31.8 ± 7.3	25.7 ± 5.0 ¹
Control group	32.4 ± 8.4	33.6 ± 9.0
3-minute walk (m)		
Exercise group	212.4 ± 27.9	193.9 ± 39.5
Control group	204.6 ± 16.8	212.0 ± 16.1

¹Significantly different from the pre-value (*P* < 0.05).

However, she continued the exercise program on a chair, performing the movements of arms and legs (e.g., flexing/extending elbows, shrugging shoulders, lifting legs), so as to put less stress on her knees. Our interview with each participant confirmed that the

Table 5. Motor processing measurements pre and post 3-month intervention or control period

Measures	Pre	Post
Hand reaction time (cm)		
Exercise group	29.4 ± 5.5	28.1 ± 5.3
Control group	28.7 ± 5.9	29.6 ± 7.4
Foot-tapping (n/10s)		
Exercise group	40.5 ± 9.0	37.5 ± 5.3
Control group	35.4 ± 9.4	34.4 ± 7.9

amount of physical activity except exercise classes during the study did not change significantly in either the exercise group or control group. Compliance among the control group was 100%.

The mean of HR_{LT} was 98.9 b/min (± 12.6, range = 80–116 b/min). The peak HR, defined as the maximum value observed during the cardiorespiratory fitness assessment, was 131.6 b/min (± 13.7, range = 101–146 b/min). The means of oxygen uptake at peak loading ($\dot{V}O_{2peak}$) and at LT ($\dot{V}O_{2LT}$) were 19.5 ± 2.4 and 11.5 ± 1.2 (ml/kg/min), respectively. During the dance-based aerobic exercise, the HR_{EX} averaged 99.4 b/min (± 11.0 b/min); this was not statistically different from HR_{LT}.

Table 2 shows the changes in balance measurements in the exercise and control groups throughout the 3-month period. The results in the exercisers showed significant increases from 2.8 ± 1.2 to 4.1 ± 2.0 s in single-leg balance with eyes closed (*P* = 0.03) and from 23.7 ± 4.5 to 26.1 ± 3.6 cm in functional reach (*P* = 0.01) at 3 months. Table 4 shows the changes in locomotion/agility measurements that indicated a significant decrease from 31.8 ± 7.3 to 25.7 ± 5.0 s in walking around two cones (*P* = 0.03). However, any changes in either strength or motor processing measurements were not statistically significant (Tables 3 and 5). No significant changes were observed in the control group.

Discussion

Results reported herein demonstrate improved balance (single-leg balance with eyes closed and functional reach) and locomotion/agility (walking around two cones) after 3 months of dance-based aerobic exercise. The positive change in the single-leg balance with eyes closed was significant, resulting from the repetition of various stepping movements in the main part of the exercise. The result is in agreement with static balance results reported by Gehlsen *et al.* [13]. They also assumed that static balance reflected postural stability, demonstrating a significant difference in this test score between fallers (persons with any falling experiences) and non-fallers. The functional reach that was also included in the

balance category improved significantly. The body movement required in this test was a forward shift of upper-body while the heels touched the ground. Thus, the improvement indicated the maximization of the stability skills in the exerciser. Weiner *et al.* [16] reported the improvement in functional reach after physical therapy in older adults. This change was correlated significantly with the change in mobility skills that involved 'ascending stairs, step over step', 'rising from the chair without upper extremity support', and so on. It is possible that improved neural mechanisms accounted for some of this change in functional reach, although this factor was not measured.

The change in walking around two cones was also statistically significant. Rikli and Jones [17] had proposed a test item (8-ft up-and-go) that was very similar to walking around two cones, evaluating the locomotion/agility. Both tests had a similar movement that mimics daily activities: standing from a chair, walking straight and around the cone, and sitting on the chair. The positive change in this test indicated that participants in the exercise group acquired much lower-body muscular power and agility.

We hypothesized that strength and motor processing would also improve due to the present exercise program. Knee bends, forward/side lunging (including plyometric lunge), and heel raising must have afforded greater lower-extremity loading in the exercisers. However, it is probable that the amount of these activities was insufficient to observe strength changes. Witzke and Snow [6] demonstrated the improvement in isokinetic strength of the leg extensors in adolescent girls who participated in plyometric jump training. Participants in that study performed more than 100 jumps a class, three classes a week, although participants in the present study performed approximately only 20 jumps a class, because of avoiding accumulating fatigue. The fewer jumps may be one reason for the non-statistical improvement.

Certain limitations of the study are acknowledged. First, our intent in this study was to prevent falls; however, it has not been definitely determined to what extent functional fitness contributes to the prevention of falls. Furthermore, we have not measured the numbers of fallers or falls *per se*. A second limitation is that the level of functional fitness of the participants was comparatively high. Participants of the present study seemed not to be at high risk for falls, indicating that each of them was physically independent with high Barthel index score. Many studies focused on risk of falls, treated the 'high risk' older adults [11, 12]. However, those who were physically independent, as well as those who were physically dependent, also require the maintenance of a functional fitness level because their fitness would significantly decrease with aging. This became part of the rationale behind the use of physically independent participants. However, further research on this type of dance-based aerobic exercise should be

conducted in order to determine whether the results obtained from this study could be applicable to older persons with severe balance problems or low functional fitness level.

A primary goal of the present exercise intervention was to determine the effect of dance-based aerobic exercise on the improvement of indices of falling. Our results demonstrated that some test items of risk of falls were favourably altered by the exercise program. Previous studies using resistance exercise for older persons have indicated improvements in dynamic balance [4] and walking velocity [3]. Our results using aerobic exercises were not much different from these results using resistance exercises. Furthermore, the attendance level of participants to dance-based aerobic exercise classes was high because dancing movements are more enjoyable than resistance exercise movements for most older adults. Another factor was the use of folk music and the practice of arranging the music tempos in order to allow the participants to continue their dance-activities. In conclusion, it appears that dance-based aerobic exercise would effectively decrease selected risks of falling in older women living independently in the community. This exercise could be recommended as a practical means for preventing falls in older persons.

Key points

- Dance-based aerobic exercise specifically designed for older women may improve selected components of balance and locomotion/agility, thereby attenuating falling risk.
- Improvements on balance were found in single-leg balance with eyes closed, and functional reach. Improvement on locomotion/agility was found in walking around two cones.

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