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Investigating the acute effect of an aerobic dance exercise program on neuro-cognitive function in the elderly

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ABSTRACT

Objective: The present study investigated the types of aerobic dance programs that positively impact cognition, such as executive function, in elderly people.
Design: Randomized controlled trial.
Method: The study compared the effects of acute aerobic dance exercise on cognitive performance using two 40-min aerobic dance programs. Thirty-four elderly participants, aged 65–75 years, were randomly assigned into either free ($N = 17$) or combination ($N = 17$) style workout groups. The free style (FR) workout consisted of several patterns of movement, while the combination style (CB) workout consisted of similar patterns of movement to FR, but the patterns were joined to form a long choreographic routine. Both dance programs were controlled to be the same in exercise intensity, approximately 40% heart rate reserve. Reaction time and correct rates were measured using a task-switching reaction time test to evaluate executive cognitive performance immediately before and after the 40-min dance exercise.
Results: A two-way (dance program × pre-post dance exercise) repeated-measures analysis of variance for switch reaction time increase (switch cost) demonstrated a significant interaction ($p = .006$), showing that the switch cost in the CB group became smaller after the dance exercise than before ($p = .009$).
Conclusion: The results suggest that the executive cognitive network was facilitated in a CB dance workout that has a dual-task nature and induces movement (task) interference with unexpected movement changes.

Introduction

Aerobic dance exercises have typically been developed as an aerobic exercise to improve physical fitness and performance and to improve cardiovascular fitness (Darby, Browder, & Reeves, 1995; Engels, Drouin, Zhu, & Kazmierski, 1998; Holmerova et al., 2010; Hopkins, Murrah, Hoeger, & Rhodes, 1990; Keogh, Kilding, Pidgeon, Ashley, & Gillis, 2009; Shigematsu et al., 2002; Williford, Blessing, Olson, & Smith, 1989; Williford, Scharff-Olson, & Blessing, 1989). Above all, low-impact aerobic dance exercise has been well adapted to keep and improve health in a wide range of the population. Low-impact aerobic dance requires participants to keep one foot on the floor during their dance workout, resulting in fewer jumping and bouncing movements. Therefore, the participants reduce the amount of impact shock thought to be associated with injuries in traditional aerobic dance. Low-impact aerobic dance exercise has been recommended as a beneficial exercise to maintain health, especially in individuals with low fitness or in the elderly population (Engels et al., 1998; Garrick & Requa, 1988; Hopkins et al., 1990; Koszuta, 1986).

There are emerging reports that dance-related aerobic exercise might positively influence psychological aspects of cognitive function as well as mood and well-being in older adults (Engels et al., 1998; Ravelin, Kylma, & Korhonen, 2006). Most participants in an aerobic dance exercise subjectively feel cognitive stimulation or effort in performing the dance, and expect to experience some type of cognitive effect (Kattenstroth, Kolankowska, Kalisch, & Dinse, 2010; Verghese, 2006). Aerobic dance exercises comprise a number of dance elements including different patterns, steps, and movements. Participants are required to pay attention and follow the instructor's lead to learn new dance elements and smoothly switch between these elements throughout the exercise. Therefore, the nature of an aerobic dance exercise might stimulate and improve cognitive function. However, no systematic or scientific

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studies have been reported on an aerobic dance program appropriate to cognitive functioning.

Aerobic dance workouts are usually composed of several short dance routines with varied cadence, high or low-impact, and step and upper body movements. These routines are sometimes sequentially repeated to compose the entire dance workout, which is called a free style (FR) program. On the other hand, the dance routines are sometimes combined as a long choreographic routine to increase the difficulty and enjoyment of performing the dance exercise. This type of program is called the combination style (CB). For the FR program, participants are required to simply follow the instructor's leads, repeating each routine independent of the others. Thus, the FR program has generally been recommended as an introduction to dance exercise for the elderly and for people unfamiliar with dance performances because it is easy to perform. In contrast, in the CB program, participants are required to remember several dance routines and rapidly and skillfully switch between them so as to construct a long, organized choreographic routine according to the instructor's leads. Thus, the CB program may require relatively higher cognitive engagement for the participants to conduct the dance workout. More specifically, the CB program might require more cognitive demands to stimulate related processes, such as executive control and working memory, in contrast to the more basic FR program.

A previous meta-analysis study suggests that simple aerobic exercise such as walking strongly influences executive cognitive control sustained by comprehensive higher cognitive abilities, which include coordination, inhibition, scheduling, planning and working memory (Colcombe & Kramer, 2003). The task-switching reaction time test has been used as a suitable method for evaluating executive cognitive function (Cepeda, Kramer, & Gonzalez de Sather, 2001; Davidson, Amso, Anderson, & Diamond, 2006; Kramer, Hahn, & Gopher, 1999). However, effects of the aerobic exercise were unclear in perceptual-motor speed, automatic processing, and discrimination ability which have been estimated with tapping, simple and choice reaction time tasks, respectively (Blumenthal et al., 1991; Colcombe & Kramer, 2003; Hill, Storandt, & Malley, 1993). Based on these previous studies, it can be surmised that aerobic dance exercise might significantly influence executive function rather than other cognitive abilities. Thus, the present study examined executive function using a task-switching RT test to investigate the effects of dance programs on cognition. The main purpose of the study was to determine whether the acute impact of aerobic dance exercise on executive function would be greater under the CB program than under the FR program in older adults.

Method

Participants

Healthy older adults aged 65–78 years residing in residential areas participated in this study. On the basis of their annual medical examination, all participants were confirmed to be free of chronic conditions that might limit their ability to engage in physical activity. People who had engaged in habitual exercise routines within the last three years, such as strength training, jogging, swimming, or dance, were excluded from the present study. The details of this study were explained before the study began, and informed written consent was obtained from all participants. This study was approved by the ethics committees of Tokyo Denki University.

Thirty-four participants were randomly assigned, using a random number generated with computer software (Microsoft Excel 2007), into two aerobic dance exercise programs: the FR program ($N = 17$, male = 7, female = 10), or CB program ($N = 17$, male = 7, female = 10). The study was conducted in a gymnasium at Tokyo Denki University located in Inzai, Chiba Prefecture, Japan.

Dance exercise programs

The participants, who were unfamiliar with dance exercise, experienced two aerobic dance sessions supervised by a well-trained dance instructor. The instructor had 10 years of experience and was familiar with teaching low-impact aerobic dance exercise to older adults. A single instructor delivered both dance programs to eliminate potential biases or differences in teaching skills depending on instructors. The instructor had extensive experience in teaching these two dance programs and was able to adapt the routines to fit the experimental design. The aerobic dance exercise was conducted for 40 min and was formally structured to include a 10-min warm-up, a 20-min aerobic dance workout, and a 10-min cool-down period. The goal for peak intensity of the aerobic dance workout was for participants to achieve at between 40 and 50% heart rate reserve (HRR; defined by Karvonen formula (Karvonen, Kentala, & Mustala, 1957)). The music selection for the warm-up was 100 beats/min. For the main workout (the low-impact dance exercise), the music tempo was set at 120 beats/min using a CD player with a speed controller.

The FR and CB programs consisted of short dance routines that were identical between the two programs in cadence (120 beats/min), impact (low-impact), and upper body/limb movements (e.g., putting the hands on the waist, or natural motions in the arms and head simultaneously while stepping). The two dance programs required participants to perform four common dance elements (Fig. 1): A) marching with toe or heel touch on every 4th count; B) knee bend and side slide with knee bend; C) side jack and step touch; and D) lunge up and lunge leg curl. Each of these dance elements was 32 counts in length. The FR program comprised four dance elements, each of which was repeated 16 times (approximately 5 min each) in order of the dance element A, B, C, and D. On the other hand, participants in the CB program had to build up a long choreographic routine by performing four routines of combined dance elements. In the CB program, the combined routines were A, AB, ABC, and ABCD. Each of the routines was repeated eight times and comprised approximately 2-, 4-, 6-, and 8-min time sequences, respectively.

The 34 participants were randomly assigned into four classes of group-exercise with 10 attendees maximum. Two classes were held in April and June, and the other two were held in May and July. The first two classes were administered so that one class was the CB program and began at 09:30, while the other class was the FR program and began at 10:20. The latter session reversed the order of the FR and CB classes. Participants' heart rates were assessed during exercise; cognitive performance was measured within 10 min immediately before and after the exercise session. In each class, no more than five participants actually received assessments because of technical limitations of the measuring devices used. Those who were not assessed at this time were assessed in the second session two months later.

Assessment of heat rate during aerobic dance exercise

To confirm the intensity of the dance exercise, heart rate was recorded during the exercise. Heart rate variability (R–R intervals) was detected by a wireless heart rate monitor (S810 HRM, Polar Electro Oy) with an elastic electrode belt (T61, Polar Electro Oy). The electrode belt was placed just below the chest muscles. The HRM signal was transferred to the Polar Precision Performance Software (release 3.00; Polar Electro Oy) and R–R intervals were exported under ASCII format. The heart rate was monitored continuously during the exercise session for 40 min.