Creative dance can enhance proprioception in older adults

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Aim. **It has been shown by many authors that proprioception declines with age. However, few studies have examined the effects of exercise interventions on proprioception. The purpose of this study was to investigate the effects of a creative dance program on proprioception of older adults.**

Methods. **Thirty-seven men and women between 55 and 80 years of age, who were not engaged in any exercise program for at least one year, were randomly assigned to an experimental (63.6±5.7 years) or a control group (65.3±7.6 years). The experimental group participated in a creative dance program for 12 weeks with a periodicity of 3 sessions of 90 minutes per week. Measures of knee kinesthesia, knee joint position sense and arm positioning were taken before and after the program.**

Results. **After 12 weeks, knee joint position sense (P=0.005) knee kinesthesia (in flexion) (P=0.04), and arm positioning (P=0.008) significantly improved within the creative dance training group. At 12 weeks follow-up, arm positioning performance was significantly better for the creative dance group when compared with the control group (P=0.043). The control group did not show any significant improvement in proprioception.**

Conclusion. **This study showed that a creative dance program emphasising body awareness can improve proprioception in older adults.**

Key words: Proprioception - Creative dance - Aging.

Proprioception is conveyed to all levels of the central nervous system, where it provides a unique sensory component to optimize motor control.[1]

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Proprioceptive information is provided by specialized sensory receptors called mechanoreceptors - primarily found in muscle, tendon, ligament, and capsule,[2] which are responsible for quantitative transducement of mechanical events occurring in their host tissues into neural signals.[3, 4]

The importance of proprioception to balance, walking stability and trajectory, sit to stand performance, and stair walking ability has been consistently reported in older adults.[5-8] Postural equilibrium requires proprioceptive acuity and precise neuromuscular control.[8, 9] Impaired proprioception increases fall risk in older adults,[8] which have a marked negative impact on older persons´ health, function, and independence.[10, 11]

Most proprioceptive information travels to higher central nervous system levels through either the spinocerebellar tracts or the dorsal lateral tracts.[2] The spinocerebellar tracts are believed to be responsible for “nonconscious proprioception” used for reflexive, automatic and voluntary activities.[12] The dorsal lateral tracts convey the signals to the somatosensory cortex, where proprioceptive information is processed resulting in conscious awareness of movement and position.[4] There are three submodalities of conscious proprioception: joint position sense (JPS), kinesthesia and sense of tension or force.[13]

Many studies reported that proprioception declines with age.[14-18] Ribeiro & Oliveira [19] concluded in a literature review that regular physical activity can attenuate age-related decline in proprioception. However, there is a deficit of experimental designs able to establish a cause-effect relationship between exercise and proprioception.

Creative dance (CD) is a particular form of dance that, unlike other dance forms, does not require years of training and is characterized by an absence of predetermined performance standards.[20, 21] CD stimulates creativity through a positive learning environment resulting from a friendly, informal and open atmosphere.[22] It is believed that the CD expression adds extra dimensions such as an individual self-mastery through allowing the subjects to be consciously in charge of their body.[23] Previous reports suggested that CD could increase mobility, spatial orientation, coordination and balance in older adults.[24, 25] It was also reported that CD can enhance balance in children with disabilities.[26] CD is based in activities that emphasize conscious awareness of body position and movement; the increase of attention directed to proprioceptive cues seems to contain the characteristics of proprioceptive exercise.[4, 27]

Although several studies have concluded that there is a beneficial role of physical activity in the maintenance or improvement of diverse physiological systems among older people, few have examined the effects of physical activity in proprioception. Moreover, to our knowledge, none have examined particularly the effects of CD in the proprioception of older adults, and few have followed a prospective, controlled experiment involving the training of subjects. Therefore, the aim of this study was to investigate the effects of a CD training program on proprioception of older adults.

Materials and methods

Subjects

Participants were recruited in the city of Évora (Portugal) by posted flyers and local newspaper announcements. Forty-four potentially eligible subjects, living independently in the community, responded and sought more information. The exclusion criteria included the presence of any serious cardiovascular or musculoskeletal diseases, having less then 55 years of age, and have been engaged in any exercise program within the previous year. Exercise program was defined as any type of physical activity that is planned, structured and supervisioned, occurring at least one day per week. This information was gathered by means of a questionnaire with a complementary interview concerning exercise participation.

TABLE I.—*Demographic and anthropometric data of the experimental and control group. Data are means (SD).*

Group	N.	Gender	Age (years)	Weight (kg)	Height (cm)
Experimental	19	4M, 15F	63.6 (5.7)	72.3 (13.5)	158.0 (0.1)
Control	15	5M, 10F	65.3 (7.6)	73.0 (14.4)	159.0 (0.1)

M: male; F: female.

Seven subjects were excluded according to the criteria: be engaged in exercise programs (N=2), poor health condition (N=1), or refused to participate (N=4). The remaining 37 subjects were then randomly assigned to either the experimental group (N=19) or the control group (N=18). All thirty-seven eligible participants signed a written informed consent prior to participate in the study. Three women of the control group did not complete the postmeasurements and were excluded from the final analysis. No significant difference was found in gender, age, height, or weight across the two groups (Table I). The minimum age was 55 years in both groups, and the maximum age was 75 and 80 years in the experimental and the control group, respectively.

The present study was approved by the institutional Human Research Ethics Committee. All procedures were followed according to the declaration of Helsinki.

Procedures

LOWER LIMB

Knee proprioception was assessed through JPS and kinesthesia, two important and common evaluation techniques,[13, 28] using a computerized dynamometer, the Biodex System 2 (Biodex Medical Systems, Shirley, New York). The test subjects were seated on the dynamometer at a 105° trunk angle, with the back supported and the knee hanging over the edge of the seat. The axis of rotation of the knee joint was aligned with the axis of rotation of the frame. Subjects were blindfolded to eliminate visual stimuli and during the kinesthesia protocol they additionally wore headphones (containing whitenoise) to eliminate auditory from the testing procedure apparatus. They wore shorts to negate any extraneous skin sensation from clothing touching the knee area. Each person used an inflatable splint to eliminate any sensation cues from skin or ankle position by immobilizing the foot.[29] The inflatable splints were attached to the lever arm of the Biodex. The evaluations were conducted on the dominant leg.

JPS.—The data were collected using similar instrumentation and procedures described by other authors.[29, 30] Each subject had one practice trial to become familiar with the test process, and then perform nine test trials (three for each target angle). During the test trials, the lever arm of the dynamometer was passively moved from 90° (0°=knee fully extended) to 1 of 3 allocated target angles of 20, 45 and 70° of knee flexion, using a speed of $5°\cdot s^{-1}$. Each target position was maintained by the Biodex for 10 seconds. Then the participants' legs were passively returned to the start position (90° of flexion) and, after a 5-second rest, subjects attempted actively to reproduce the previously attained target angle (speed of $5°\cdot s^{-1}$), clicking a button when perceived that they have replicated the angle. The same sequence of test target angles (randomly established by the researchers) was performed by all subjects. No feedback regarding performance was provided during the test. The outcome measurement was an error score calculated as the mean absolute difference between the target and replicated angle (in degrees), and averaged over the 9 target angle replication attempts.

Kinesthesia.—With the subjects' knees in 45° of flexion, the Biodex dynamometer extended or flexed the knees at $0.5°\cdot s^{-1}$. The lever arm motion of the dynamometer was initiated in a random time interval between 2 and 10 seconds. Once each subject detected motion of the leg, they pressed a hand held stop button and confirmed the direction of the motion. The rotation angles of the frame were defined as the threshold of detection for the knee joint. No feedback regarding performance was provided during the test. After one practice trial, subjects completed 6 consecutive test trials, three for flexion and three for extension. The same sequence of extension/flexion trials (randomly established by the researchers) was performed by all subjects. The mean values in degrees were calculated for flexion and extension.

Upper Limb

A linear movement device (Model 31202, Lafayette Instruments, Lafayette, IN) was used to measure arm positioning. During the test the subjects were blindfolded and seated on a chair with the linear positioning device placed directly in front of them. The subjects' task was to attempt to replicate the end point of a passive linear movement by grasping the vertical rod with the dominant hand and moving it from right to left (right handed) or from left to right (left handed). The rod was slowly moved by one of the researchers to the allocated target position, and that position was maintained for 5 seconds. Then the participants' hands (still grasping the rod) were passively returned to the start position. After a 5-second rest, the participants attempted actively to reproduce the previously attained target angle, stopping the arm movement and informing the researcher when perceived that the position had been replicated. One practice trial was performed. The actual test consisted of 4 distances (15, 30, 45, 60 cm) presented to the blindfolded subject, three times each for a total of 12 trials. The same sequence of test target positions (randomly established by the researchers) was performed by all subjects. No feedback regarding performance was provided during the test. The outcome measurement was an error calculated as the mean absolute difference between the target and replicated point (in cm), and averaged over the 12 target replication attempts.

CD Program

After the baseline evaluation, the experimental group participated in the CD program 3 days a week during 12 weeks. Each session took approximately 90 minutes and was conducted by a physical education teacher with specific formation in CD. Warm-up consisted on a general mobilization that intended to activate physiological systems, and introduced some features of CD which were developed further in the main phase. In this phase, the exercise intensity was higher and music was always present, with different rhythms and paces. The intervention program was carefully planned, and the solicited tasks were directed to body communication through movement, emphasising body awareness and postural control. Frequently, particular ideas were proposed to the participants, who creatively translated them to body expression through movement. Finally, the cool-down phase consisted especially on relaxation exercises.

Statistical Analyses

Kolmogorov-Smirnov test showed that the data did not present a normal distribution. The Mann-

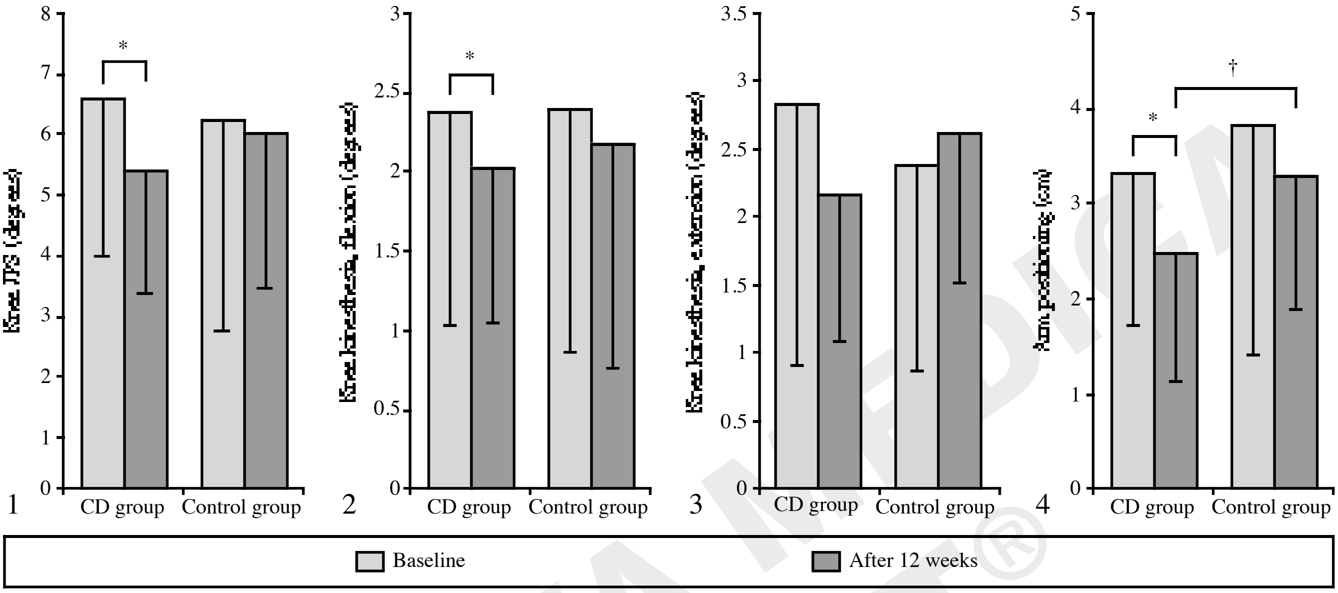

Figure 1.—Mean (SD) knee JPS at baseline and after 12 weeks. *P<0.01 compared with baseline values. Figure 2.—Mean (SD) knee kinesthesia in flexion at baseline and after 12 weeks. *P<0.05 compared with baseline values. Figure 3.—Mean (SD) knee kinesthesia in extension at baseline and after 12 weeks. Figure 4.—Mean (SD) arm positioning at baseline and after 12 weeks. *P<0.01 compared with baseline values; †P<0.05 between groups after 12 weeks.

Whitney test was used to examine the differences between the values from both the groups. Wilcoxon signed-rank test was used to compare the values within each group before and after CD intervention. Significance level was set at 0.05 (P<0.05). Statistical analysis was carried out using SPSS 15.0 (SPSS, Chicago, IL).

Results

Measures of proprioception at baseline and after 12 weeks are presented in Figures 1-4.

Inter-group analysis

At baseline there were no significant differences between the experimental and the control groups in any proprioception variable studied: Knee JPS (P=0.354); knee kinesthesia in flexion (P=.835); knee kinesthesia in extension (P=0.415); arm positioning (P=0.607).

At week 12 follow-up, arm positioning performance was significantly better (P=0.043) for the experimental group (2.5±1.4 cm) when compared with the control group (3.3±1.3 cm). At the same moment, despite the lack of statistical significance, knee JPS (P=0.471), knee kinesthesia in flexion (P=0.732), and knee kinesthesia in extension (P=0.147) were better in the experimental group (5.4±2.1°; 2.0±1.0°; 2.2±1.1°, respectively) than in the control group (6.0±2.6°; 2.2±1.4°; 2.6±1.1°, respectively).

Intra-group analysis

Within the experimental group, significant enhancements were shown in proprioception variables after 12 weeks of the CD program: knee JPS improved 18.4% (P=0.005), knee kinesthesia in flexion 14.4% (P=0.04) and arm positioning 25.0% (P=0.008). Knee kinesthesia in extension was enhanced (23.2%), but not with statistic significance (P=0.059).

Regarding the control group, proprioception did not show any significant improvement between the pre- and post-measurements: knee JPS (3.2%, P=0.842), knee kinesthesia in flexion (9.2%, P=0.363) and arm positioning (13.6%, P=0.733). Knee kinesthesia in extension showed a deterioration of 9.7% (P=0.053).

Discussion

Few studies have examined the effects of exercise on proprioception of older adults. The present study demonstrates that a CD training program is capable of improving proprioception, namely knee JPS, knee kinesthesia (in flexion), and arm positioning. These findings are encouraging, considering the importance of proprioception to optimize motor control, and its relevance to the postural control system.

It is difficult to compare the results from this study with relevant literature about CD, since, to our knowledge, there have not been similar investigations using this form of physical activity. However, previous studies have evidenced the role of other types of physical activity in the attenuation of age-related declines in proprioception. For instance, Petrella *et al*.[16] measured knee JPS in 16 young subjects (19-27 years) and 24 elderly subjects (60-86 years). Elderly group was separated into active and sedentary subgroups based on their level of activity during the previous year. Significant differences were observed in the absolute angle error between active-old and sedentary-old subjects ($P<0.03$), with the first group showing better results. Gauchard *et al*.[31] have studied the influence of regular proprioceptive (yoga or soft gymnastics) and bioenergetic physical activities (swimming, jogging or cycling) on the balance control of elderly women (over 60 years), and concluded that proprioceptive exercise appears to have a good influence on balance regulation.

The effects of Tai Chi in proprioception have been investigated. It was demonstrated that elderly people (mean age 66.1 years) who regularly practiced Tai Chi showed better proprioception at the ankle and knee joints than sedentary controls, and also better ankle kinesthesis than swimmers/runners.[9] Tsang and Hui-Chan [32] showed that long-term Tai Chi practitioners (mean age 69.4 years) improved knee joint proprioception and expanded their limits of stability during weight shifting in stance. Another study concluded that both long Tai Chi practitioners (1-3 years of practice; participants mean age 53.8 years) and short-term Tai Chi practitioners (3 months of practice; participants mean age 52.9 years), have significantly improved their knee JPS.[33]

A study conducted to analyse the differences in the hip JPS between young (mean age 21.7 years) and older adults (mean age 75 years), also supported the positive impact of exercise on proprioception.[17] Curiously, contrary to what could be expected, no significant differences in proprioception were found between young and older adults. The authors suggested that this could be related to the high level of exercise participation that characterized the older group (mean 10 hours each week), and its possible role in maintaining or enhancing hip proprioceptive acuity.

However, despite some studies reporting benefits of physical activity in proprioception, there have been difficulties in concluding that prescribed exercise can improve proprioception. First of all, there is a lack of experimental studies capable of establishing that beneficial effect, whilst other studies have failed to improve proprioception following a training program.[34] On the other hand, while exercise seem capable of increasing coordination and balance, these cannot be compared to proprioception in terms of the two classic proprioceptive modalities: accuracy of JPS or the threshold for detecting joint movement.[27]

The present study gives evidence that a physical activity program, which emphasises conscious awareness of body position and movement, can contribute to develop proprioception. Both central and peripheral levels have been pointed out to mediate the improvements in proprioception that results from the practice of physical activity. With respect to the peripheral level, great importance has been attributed to morphological alterations in muscle spindle, the peripheral receptor whose gain can be modulated by the central nervous system.[19, 27] Regarding the central mechanisms, it is possible that proprioceptive exercises increase the attention paid to proprioceptive cues by the brain; early in the training at the conscious level, then later, after further training, at the autonomous level.[27, 35] Also, at a central level, physical activity might modify proprioception by inducing plastic changes in the central nervous system,[19, 27] such as an increased strength of synaptic connections and/or structural changes in the organization and number of connections among neurons.[36]

Conclusions

In the present study, after 12 weeks of CD practice it was possible to achieve significant improvements on proprioception of older adults, namely in arm positioning, knee JPS and knee kinesthesia in flexion. Knee kinesthesia in extension did not show a significant gain as a result of the participation in the CD program; however, it is important to point out that the experimental group showed marked progressions along the intervention while the control group deteriorated compared to the baseline level. It is reasonable to expect further improvements if the CD program had been extended in time.

In conclusion, this study showed that a CD program emphasising body awareness and communication through movement, can promote improvements on proprioception in older adults.

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