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DANCING AT AN AMATEUR LEVEL IMPORVES STABILITY AND SYNCHRONISATION CAPABILITY DURING GAIT IN HEALTHY ELDERLY POPULATION

DANZARE A LIVELLO AMATORIALE FAVORISCE LA STABILIA' LE ABILITA' DI SINCRONIZZAZIONE DURANTE IL CAMMINO IN UNA POPOLAZIONE ANZIANA SANA

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Abstract

Rhythmic acoustic stimulation promotes an improvement in postural stability during walking in healthy elderly people by enhancing synchronisation processes in the brain. Similarly, dance-based movement therapies have been shown to embellish motor skills including stability, coordination, joint mobility, and muscle strength in elderly people in both healthy and pathological conditions. In the present study, we investigated the ability of 13 healthy elderly people, who practice dance at an amateur level twice a week, to synchronise their gait to a rhythmic acoustic stimulation. Our aim was to assess, through 3D gait analysis, whether the years of dance practice would affect the subjects' motor performance and specifically their synchronisation ability. Our results highlighted that elderly people who have been dancing for a longer time showed a better ability to synchronise with the acoustic stimulus and displayed a better dynamic stability during gait.

La stimolazione ritmico acustica, garantisce un miglioramento della stabilità posturale durante il cammino in persone anziane sane enfatizzando i processi di sincronizzazione del cervello. Analogamente è stato visto che, terapie del movimento basate sul ballo favoriscono una conservazione delle capacità motorie come la stabilità, la coordinazione, la mobilità articolare e la forza muscolare nelle persone anziane sia in presenza che in assenza di condizioni patologiche. Nel presente lavoro, abbiamo analizzato la capacità di tredici soggetti anziani senza alcuna patologia, che praticano ballo a livello amatoriale due volte alla settimana, di sincronizzare il loro cammino ad una stimolazione ritmico acustica. Il nostro obiettivo, attraverso la 3D gait-analysis, è stato quello di stabilire se gli anni di pratica di ballo influenzassero la performance motoria dei soggetti e in particolar modo le loro capacità di sincronizzazione. I nostri risultati hanno messo in evidenza che i soggetti anziani sani che praticano ballo da più tempo manifestano una migliore abilità di sincronizzare il loro cammino allo stimolo acustico rivelando anche una migliore stabilità durante il cammino.

Keywords

Elderly, Physical Activity, Rhythmic acoustic stimulation (RAS), Dance therapy, Synchronisation

Anziani, Attività Fisica, Stimolazione ritmica acustica, Danza-terapia, Sincronizzazione

Introduction

Ageing represents a physiological process in which the human body undergoes a progressive overall functional decline due to several factors including muscle atrophy, osteoporosis, asthenia and reduced joint mobility (Baumgartner, 2000). Consequently, elderly face a loss of their motor efficiency that often lead to a reduction of static and dynamic balance resulting in higher risk of falling (Muir et al., 2010). Nowadays, it is widely recognized the contribution of physical activity in improving the quality of life (Drewnowski & Evans, 2001). Indeed, according to the American College of Sports Medicine (ACSM) a daily-moderate exercise training (comprehensive of resistance, strength and flexibility exercise) significantly reduce the risk of developing diseases such as stroke, cancer, diabetes mellitus II and injuries from falls (Chodzko-Zajko et al., 2009). Similarly, it has been observed that physical activity plays a fundamental role in management and prevention of cognitive impairment (Larson et al., 2006). Among the different types of physical exercise that are recommended for older people, dancing represents a multi-faceted activity able to contemporary improve several aspects of human well-being. Indeed, it has been shown that extended dance-based training (at least 8 weeks) improves mobility and balance functions ensuring enhanced stability and reducing the risk of falls in the elderly (Borges et al., 2012; Britten et al., 2017) as well as improving their endurance performance and gait (Liu et al., 2021). Dancing requires the ability to follow the rhythm of the music that is, in turn, the ability of the brain to synchronise to an external stimulus. To this regard, note that the human brain activity is entirely based on the presence of "neural oscillations" which are defined as the "pattern" that reflects the rhythmic activity of the human brain (Buzsaki, 2006). The presence of neural oscillation allows the synchronisation between different brain regions suggesting the idea that cognitive, sensory, and motor processes could result from the activity of synchronised brain network (Buzsáki & Draguhn, 2004). By exploiting this property of the human brain, several strategies, based on the sensory stimulations, have been developed to improve static and dynamic balance (Bella et al., 2017; Rhea & Kuznetsov, 2017; Wittwer et al., 2013). Specifically, rhythmic acoustic stimulation (RAS) exploits the physiological effects of the rhythm on motor function in order to improve the postural stability in both patients with significant walking deficits (Bella et al., 2017; Thaut et al., 2015) and healthy elder people (Minino et al., 2021). RAS may involve the use of fixed frequencies which, according to some authors, allow better synchronisation of movement (Olmo & Cudeiro, 2005), or of modulated frequencies based on the average cadence of each subject under examination (Yu et al., 2015).
In the present study, we investigated the ability of 13 healthy elderly people, who practice dance at an amateur level twice a week, to synchronise their gait to a RAS. Our hypothesis is that the years of dance practice would affect the subjects' stability as well as their ability to synchronise to the acoustic stimulus.

1. Materials and Methods

Participants

Thirteen elderly healthy subjects (6 males, 7 females) were recruited from a day care centre for healthy elderly people according to the following inclusion criteria: (1) age ranging from 65 to 85 years old; (2) no skeletal, muscular and neurodegenerative disorders; (3) no hearing impairment. The cohort's characteristics are summarised in table 1.

Table 1: Cohort description
Data are reported as mean ± standard deviation (when needed); m = male; f = female; bpm = beat per minute.

Participants' characteristics	**Mean (± standard deviation)**
Sample size	13
Age (years)	73.4 (±5.7)
Gender (m/f)	6/7
Education level (years)	11.6 (±4.8)
Dance practice (months)	18 (±5.7)
Mean cadence (bpm)	110.13 (±9.4)

Gait analysis assessment

The 3D gait analysis was carried out in the Motion Analysis Laboratory of the University of Naples "Parthenope". Gait kinematic data were acquired through a stereophotogrammetric system, equipped with eight infrared cameras (ProRefex Unit-Qualisys Inc., Gothenburg, Sweden). In agreement with the modified Davis protocol (Davis et al., 1991), 55 passive markers were positioned on participants' anatomical landmarks of feet, lower limb joints, pelvis and trunk, as well as on upper limb joints and head. The RAS was emitted by a metronome (MA-1 Solo Metronome, Korg—UK). Participants were recorded four times: (1) while walking at their self-selected speed, in order to calculate the individuals' average cadence, (2) with a RAS frequency equal to the individual average cadence, (3) with a RAS frequency corresponding to +10% of each participant's mean cadence, and (4) with a RAS frequency corresponding to -10% of subjects' mean cadence. Then, we calculated the cadence divergence of our participants, which represents the measure of how much the individual was *unable* to synchronise his/her cadence to the acoustic stimulus. Specifically, the cadence divergence score was obtained as follows: for each subject we calculated the difference between the actual cadence (step per minute) when walking with RAS and the RAS itself (expressed as beat per minute); then we summed up the three differences (during RAS at average cadence, +10% and -10%), to obtain the cadence divergence score, representative of the overall ability to synchronise to a given RAS. Moreover, we calculated the coefficient of variability (CV) of several spatio-temporal parameters (stance time, swing time, cycle time, double limb support time, stride width, and stride length) during uncued gait, representative of dynamic stability (the higher the variability the lower the stability). Coefficients of variability were calculated as the ratio between standard deviation and average value of a given spatio-temporal parameter, multiplied by 100.

Statistical analysis

Statistical analysis was carried out in MATLAB 2021a. We used the Spearman's correlation to explore a possible relationship between duration of dance practice (expressed in months) and both (1) the participants' stability during uncued gait and (2) the synchronization level of each subject while walking with the acoustic stimulus.

2. Results

We explored the effects of dance practice on stability during gait in a healthy elderly population. Specifically, we found a significant negative correlation (r = -0.590; p = 0.033) between the duration of dance practice (expressed in months) and the cadence divergence (measured including all the cued walking trials), which represents how much each subject was unable to synchronise his/her cadence to the acoustic stimulus (figure 1A). Subjects who practiced dance for longer showed a better ability to synchronise to an acoustic stimulus and therefore displayed a lower cadence divergence. Moreover, we found a significant negative correlation (r = -0.590; p = 0.033) between the duration of dance practice and the stride length CV (figure 1B). The greater the months of dance practice, the lower the variability coefficient of stride length.

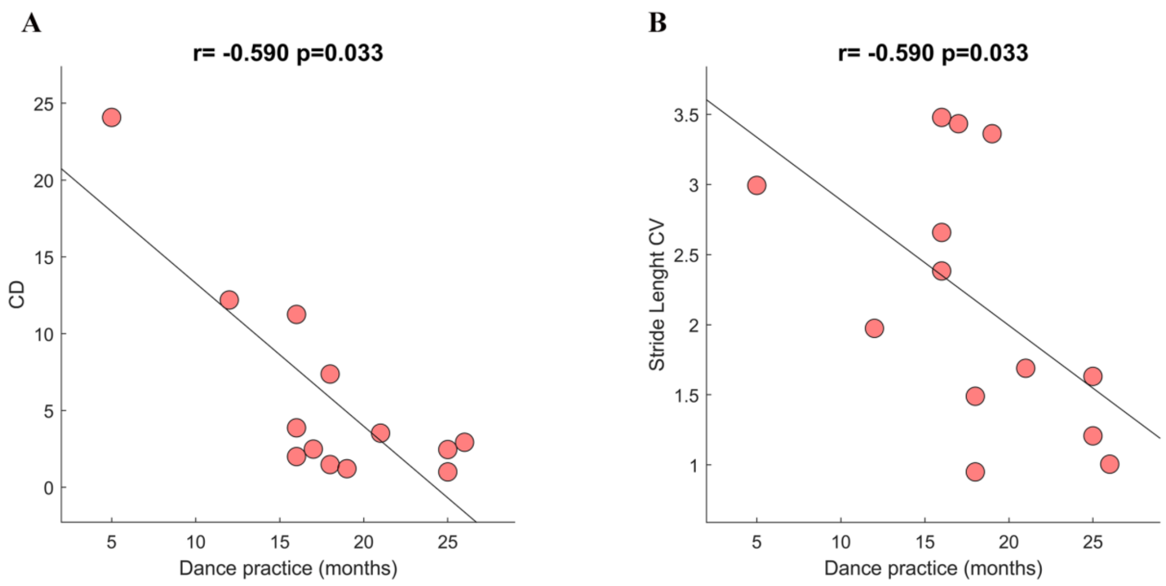

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Figure 1: (A) Spearman's negative correlation between duration of dance practice (in months) and cadence divergence (CD); (B) Spearman's negative correlation duration of dance practice and the variability coefficient (CV) of stride length.

3. Discussion

Through a 3D gait analysis we investigated the effects of dance practice on synchronisation capability and stability during walking in a healthy elderly population. Our expectation embraced the idea that longstanding dance-based therapies would help elderly people to increase their motor performance during walking by enhancing the brain synchronisation capability to an external stimulus. As previously stated by Damm L. et al., listening to a periodic stimulus enhances the synchronisation between the sensory and motor cortical areas leading to an improvement of the oscillatory-based motor activities such as walking and running (Damm et al., 2020). In addition, Jin et Al., shown that competitive ballroom dancers exhibited better finger tapping synchrony compared to non-dancers (Jin et al., 2019). Our results are in agreement with previous statements that highlighted a better motor and synchronisation performance as consequence of rhythmic based training. Indeed, we pointed out the negative correlation between months of dance practice and cadence divergence (i.e., the measure of how much each subject did not synchronise to the RAS). We showed that subjects who have been dancing for longer time display a better synchronisation performance. Dance is based on music, and music is based on rhythm. Hence, we might speculate that a training based on dance can serve as "learning factor" since it improves the sensorimotor plasticity (Karpati et al., 2015) since it improves the sensorimotor plasticity leading to structural and functional connectivity changes (in the sense of enhanced activation) in the brain. Hence, it can be considered a useful tool which can provide a pattern of activity able to reduce the movement variability. Indeed, several evidence confirm the benefit of dance training on the elderly's postural stability. Granacher U. et al., found that prolonged (at least 8 weeks) salsa-dance training improve gait stability in elderly people since participants displayed increased stride velocity and stride length and decreased stride time (Granacher et al., 2012). Moreover, another study performed by Dennis et al., showed the effect of dancing program in reducing variability in gait and fall risk in elderly population (Dennis et al., 2015). This is in line with our results since we found a negative correlation between months of dance practice and stride length CV. In fact, individuals who displayed greater stability during gait (i.e., a lower CV) are those who danced for a longer time.

Conclusions

Our results support the use of dance-based training to reduce gait variability and, as consequence, improve stability. Furthermore, focusing our attention on the neural mechanisms underlying this phenomenon, we highlighted the significant role of synchronisation process, and its relationship with rhythm-based training. Further investigations should deepen our results in order to develop preventive intervention protocols to help the elderly to gain greater stability during walking and consequently to reduce the risk of falling.

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