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Neuromotor training, mobility and fear of falling in older women living in long-term care setting

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Abstract

The study aimed to identify the direct and indirect effects of physical neuromotor training on mobility function, fear of falling and restriction of activities of daily living (ADL) in a group of ageing women living in the long-term care setting. Thirty-five older women (mean age 84.18, SD = 5.92 years) participated in the study; 20 in the intervention group and 15 in the control group. The neuromotor training programme was based on concepts from motor control and motor learning, and performed for 4 months. Data on mobility function, fear of falling and ADL restriction were collected before and after the intervention. The intervention group showed steady and significant improvements in fear of falling, mobility function and ADL restrictions after the intervention, whereas the control group did not exhibit significant changes. Moreover, mediation analysis showed the role of mobility function as mediator between participation in physical training and fear of falling.

Keywords: ageing women, physical activity, exercise

In advancing age, the deterioration of physical function because of disease progression and impaired physical fitness (e.g. musculoskeletal function, cardiovascular function and balance) can impact a person's functional abilities[1] and activities of daily living (ADL),[2] such as walking, stair climbing and rising from a chair and increase in the risk of mobility decline. Especially, mobility function defined as the ability to move independently in the environment[2] is often the first symptom of the inability to perform ADL and may lead to a requirement for assistance and an increased risk of falling, disability and institutionalisation.[3]

In addition, in advancing age, mobility impairments are associated with the fear of falling.[4] Fear of falling was found to be associated with factors, such as female gender and higher age,[5-8] along with several adverse outcomes, including mobility decline,[9, 10] restriction of activities,[11, 12] increased risk of falling,[13] institutionalisation.[14] Therefore, older adults with impaired mobility may have a fear of falling and the fear of falling may conversely cause a reduction in the gait pattern or possibly ADL.[15] This can potentially lead to a debilitating vicious circle, eventually resulting in loss of independence, falling accidents, fear of falling and functional decline.[13, 16]

The relationship between mobility impairment and fear of falling is probably reciprocal, but this can be positively influenced through effective physical training programmes.[10] Indeed, engaging in a physical training programme may be the first step to avoid mobility impairment, fear of falling and functional decline.[17] This can contribute to 'successful' ageing,[18] especially in particularly vulnerable persons, such as older women. As suggested by the American Collage of Sport Medicine (ACSM),[1] an effective physical training programme, including progressive resistence, balance and functional training can improve the mobility function, ADL and the general quality of life in older adults living in the long-term care setting.[19-26] Futhermore, evidence-based research supports physical intervention programmes being the first step to prevent and decrease the fear of falling and related consequences.[17, 27] Most of the exercise programmes were based on balance training,[17] balance training with virtual-reality systems,[28] ankle-strengthening and walking exercises,[29] training with video games[30] and Tai Chi.[31] Moreover, few researches tested other approaches in older adults living in the long-term care setting. As the fear of falling is often related to mobility issues,[9, 16] our study was based on physical neuromotor training upon a cognitive neuroscientific approach to motor control, which implies that several cognitive and motor control processes can be distinguished during the preparation and execution of functional motor tasks, such as the processing of motor task related information, action planning and initiation.[32, 33] Our training was directed at stimulating the proprioceptive, vestibular and visual systems, so that older adults would learn to integrate sensory information into adequate motor responses. Moreover, the training aimed to increase motor competence by teaching functional motor skills, such as balance, coordination and gait, and also necessary skills for moving independently in the environment and related mobility functions.[2] On the basis of ACSM,[34, 35] we hypothesised that this particular physical intervention would benefit older adultsand useful among older adults living in the long-term care setting.

The purpose of the study was therefore to identify the direct and indirect effects of physical neuromotor training on mobility and fear of falling in a group of women living in the long-term care setting. The primary aim was to evaluate the effect of neuromotor training on mobility function. The secondary aim was to evaluate the effect of the intervention related to the fear of falling and restriction of ADL. Finally, the tertiary aim of the study was to assess the effects of engagement in physical training on the fear of falling through the related change in mobility function.

Design and Methods

The experimental research design included two groups, i.e., one intervention and one control group, which were used to determine the effects of training on mobility function, fear of falling and ADL restriction. The intervention group participated in the training for 16 weeks, whereas the control group received routine residential/medical care, went on with their lives as usual, specifically not performing any type of programmed physical training. All participants were assessed before and after the 16-week training period. The study was conducted from January to June 2013 in Turin, Italy.

Participants

Study subjects were recruited from a private long-term care facility linked to the Public Health Service of Turin. The care facility accommodated 249 older adults. Subjects were included if they were females, aged >75 years, and able to give informed consent. Subjects were excluded from participation if they were unable to walk 6 m independently with or without a walking aid and if their cognition, as judged by the staff of the residential care facility, was so impaired that they would not be able to process the information provided during the testing and training sessions.[36] In addition, the general practitioner of each participant judged whether there was a medical contraindication for participation. Individuals with severe psychiatric disorders or a clinical diagnosis of depression or anxiety at the moment of the evaluation were not enrolled in the study.

Afterwards, participants were informed that participation in the study was voluntary and confidential. Participants gave their informed written consent to participate in the study, in accordance with the local medical ethics committee and complying with the ethical standards provided in the 1964 Declaration of Helsinki. The Consolidated Standards of Reporting Trials (Figure 1) summarises the recruitment process and attendance information of the study population.

< Insert Figure 1>

Sociodemographic characteristics of the intervention and the control group are presented in Table 1. A total of 35 older women with an average age of 84.18 years [standard deviation (SD) = 5.92 years] were recruited. The intervention group consisted of 20 women (mean age 85.31 years, SD = 5.55 years) and the control group of 15 women (mean age 82.69 years, SD = 6.7 years). During the course of the 16 weeks, two women in the control group dropped out of the study because of falling accidents.

< Insert Table 1>

Neuromotor Training

The neuromotor training was composed of 2 sessions a week, with each session lasting 60 min, and went on for 16 consecutive weeks. The training was conducted by graduates in Physical Activity and Sport Sciences, specialising in physical activity training for the elderly.

According to ACSM,[34] the key components of neuromotor fitness training involves combinations of balance, coordination, and gait exercises. The exercise session began with a 10-min warm up, including mobilising exercises, such as neck rotation, trunk rotation, lateral and forward flexion, upper and lower limb exercises, and breathing exercises. Exercises included progressively difficult postures (e.g. tandem stand, semi-tandem stand, standing with the feet together with open and closed eyes and one-legged stand with/without support), dynamic movement, disturbances the centre of gravity (e.g. walking along a straight line on toes with/without support, tandem walk and circle turn), and stressing postural muscles with reduction of sensory inputs (e.g. standing on heels, toe stand with/without support, toe of one foot beside the heel of the other foot, alternate standing on toes and heels with support and shifting weight from one leg to the other). During the training, each exercise was demonstrated by the instructors and subsequently executed by the participants. Moreover, at the end of each exercise, feedback was given to the participants. The exercise session ended with a 5-min cool-down which included breathing exercises. The exercises had various levels of progression in complexity and were tailored according to individual capability and according to the level of performance.

The training provides exposure to the motor and neurophysiological stimuli in ways that can potentially promote durable adaptations in motor performance; most basic to this is the high number of repetitions. This corresponds to a fundamental requirement for motor control, namely practice through repetition.[33] During our task-oriented training, this relates to the high attentional requirements that walking imposes on people with mobility deficit, as well as the motivational aspects of setting and achieving progressively higher goals. Again, this occurs in a context of practicing a more desirable gait pattern through imposing greater biomechanical symmetry and sensorimotor activation.

Measures

Demographic data were obtained by the staff of the residential care facilities. Baseline assessments on the fear of falling, ADL and mobility functions were recorded; similar assessments were performed at the completion of the 16-week training period.

Mobility function was assessed by the Timed Up and Go Test (TUG)[37] which measures the time taken by a subject to stand up from a chair (height 46 cm, arm height 67 cm) without leaning forward from the back support of a chair, walk a distance of 3 m, turn around a cone and to walk back to the chair, and sit down.[37] The TUG test is proven to have a high validity for assessing mobility[34, 37] and with a test–retest reliability of 0.95.[38] A stopwatch was used to time the performance (in seconds).

The secondary outcome of the study was the fear of falling measured by means of the Short Falls Efficacy Scale.[39, 40] The Short Falls Efficacy Scale is a seven-item shortened version of the Falls Efficacy Scale. The questionnaire contains seven items scored on a four-point scale (1 = not at all concerned to 4 = very concerned), with a total score ranging from 7 to 28.The test–retest reliability estimate was 0.92 and the intra-class coefficient 0.83.[39]

Finally, the outcome of ADL restriction was assessed by using the Katz ADL scale.[41] The Katz ADL scale includes six items of essential activity for an individual’s self-care (eating, walking from bed to chair, walking, using the toilet, bathing and dressing) and reflects the ability to perform typical ADL without assistance. The six items are scored with either 0 (unable to perform the activity) or 1.0 (able to perform the activity without any help). A total score ranging from 0 to 6 was given for each participant. A high score indicated independence in ADL.

Statistical Analyses

For all data, means and standard deviations were calculated, including the percentage in change for all outcome variables in both groups. The distribution of the data was examined using the Shapiro-Wilk's test. After having confirmed the assumption of normality for the outcome variables in the different groups ($p > 0.05$), a *t*-test analysis was performed for age and each outcome variable to exclude significant mean differences at the baseline between the intervention and control groups. A repeated measure analysis of variance for each group was performed for each dependent variable. Differences between treatment groups over the time were determined by significant group × time interactions. In addition, as in our previous study,[18] we tested the effect size (Cohen's *d*) of walking training to quantify the effectiveness of an intervention.[42] Finally a mediation analysis according to the approach by Baron and Kenny [43] was carried out to investigate the mediation role of mobility function on the relationship between participation in neuromotor training and the fear of falling. First, we evaluated the direct effect of the predictor (participation in neuromotor training) on the outcome (fear of falling). If the relationship was significant, we included the mediator in the model. Second, we verified the main effect between the independent variable (participation in neuromotor training) and the mediator (mobility function). Third, we checked the mediating effect of mobility function on the relationship between the independent variable and the outcome. Finally, we checked the mediation model with regard to the dependent variable. We used the Sobel test to test the mediation model.[43] The Statistical Package for Social Sciences (SPSS 20.0 for Windows) was used for all statistical analyses. The statistical significance level was set at $p < 0.05$.

Results

As presented in Table 1 there were no baseline differences between the two groups with respect to age [t (35) = −1,306, p = 0.201], TUG test [t (35) = −0.781, p = 0.822], Short Falls Efficacy Scale [t (35) = −0.781, p = 0.411], and Katz ADL scale [t (35) = 0.453, p = 0.654].

< Insert Table 2>

All participants attended at least 90% of the total possible workouts. Mean scores and standard deviations for the intervention and control groups at before and after intervention are displayed in Table 2. With regard to the effects of the intervention, the difference between the intervention and control groups was statistically significant for mobility function [TUG test, F (1, 31) = 15.66, $p < 0.0001$, $\eta^2 = 0.336$] with a large effect size ($d = -1.04$). In fact, mobility decreased between the before and after intervention in the control group [from 28.82 to 30.34 s; F (1, 12) = 0.385, $p = 0.546$ partial $\eta^2 = 0.675$], whereas it increased in the intervention group [from 28.24 to 25.31 s; F (1, 19) = 3.407, $p < 0.0001$, partial $\eta^2 = 0.675$].

With regard to the fear of falling, the difference between the intervention and control groups was statistically significant [Short Falls Efficacy Scale, F (1, 31) = 26.631, $p < 0.0001$, $\eta^2 = 0.332$] together with a very large effect size ($d = 1.15$). A small increase between before and after intervention was observed in the control group [from 18 to 19 points; F (1, 12) = 0.101, $p = 0.756$ partial $\eta^2 = 0.008$]. However, the fear of falling decreased in the intervention group [from 20 to 15; F (1, 19) = 60.09, $p < 0.0001$, partial $\eta^2 = 0.760$].

Finally, the difference between the intervention and control groups in terms of ADL was statistically significant [Katz ADL scale, F (1, 31) = 11.595, $p < 0.0001$, $\eta^2 = 0.272$] with a medium effect size ($d = 0.74$). The control group showed a decrease in ADL [from 3 to 2 points; F (1, 12) = 1.157, $p = 0.303$, partial $\eta^2 = 0.088$], whereas the intervention group's activity score increased [from 3 to 4 points; F (1, 19) = 24.511, $p < 0.0001$, partial $\eta^2 = 0.563$].

Table 3 and Figure 2 show the mediation model. The main effect of the predictor (participation in neuromotor training) on the outcome (Short Falls Efficacy Scale) was statistically significant ($\beta = -0.496$, $p < 0.05$), and the mediator had a positive effect on the Short Falls Efficacy Scale ($\beta = 0.540$, $p < 0.05$). After introducing the mediator (TUG test), we noticed a decrease in the coefficient between the predictor and the outcome ($\beta = -0.242$, $p > 0.05$), whereas the coefficient between the mediator and the outcome was significant (β = 0.470, $p < 0.05$). The Sobel test indicated that the mediation model was fully mediated (z = −2.20 significance $p < 0.05$).

<Insert Table 3>

<Insert Figure 2>

Discussion

The general aim of this longitudinal intervention study was to investigate the direct and indirect effect of physical intervention according to neuromotor training on mobility and fear of falling in a sample of older women living in the long-term care setting. We investigated mobility function as the primary outcome, and fear of falling and basic ADL were secondary outcomes. The main finding of our study was that neuromotor training may improve mobility function, decrease the fear of falling and strengthen independence in basic ADL . These findings suggest that neuromotor training that includes combinations of balance, coordination, and gait exercises may be useful to improve well-being in older adults living in the long-term care setting.

Moreover, considering mobility function, the results underline the positive effect of the training. Compared with baseline mobility function scores, the data of the intervention group showed a relative increase of 11.5%, whereas the control group showed a relative decrease of 5%. As a result, we found an improvement in functional mobility, which is an important issue in the independency of older adults and in relation with the ADL restrictions.[2] This finding was consistent with previous studies on older adults living in long-term care setting that underlined multi-component exercise[44] improving functional mobility. This result demonstrated, in accordance with ACSM,[34] that neuromotor training may benefit the physical function of the elderly, including those living in the long-term care setting.

With regard to the secondary aim of the study, we found that, over time, the fear of falling in the intervention group decreased by 25% compared with baseline, whereas that in the control group increased by 5.5% compared with baseline. Balance exercises similar to the one used in this study [17] as well as balance training with virtual-reality system[28] or Tai Chi intervention[31] may decrease fear of falling in older adults living in long-term care facilities. This result may have an important implication because the fear of falling leads to a greater decline in ability to perform ADL over time,[14] and it is a predictor of declining physical function[45] in ageing women.[5-7]

Furthermore, we observed that neuromotor training improves independence in ADL. In accordance with previous findings showing that combined training may be conducive to ADL and related functional performance,[18, 19] we found an increase in score of 33% compared with baseline in the intervention group, whereas a relative decrease in control group (33%) was seen. Our result suggested that neuromotor training can be useful to improve the independence in older adults living in the long-term care setting. This may be crucial for developing independence in multiple everyday tasks, which previously was limited. Thus, we think that this result may have important consequences in terms of limiting the decrease in activity restriction linked to fear of falling, confirming the idea that physical exercise can play a protective role in older adults living in the long-term care setting.[19, 24]

Lastly, the mediation analysis also demonstrated that the mobility function played a mediation role in the relationship between participation in neuromotor training and the fear of falling. Older women who performed the training reported lower fear of falling, but these direct effects were mediated by the improvement in mobility function. Regained mobility function might decrease the fear of falling by means of combinations of balance, coordination, and gait exercise in this specific population.

Several potential limitations have to be considered in this study. The subjects were not randomly allocated to the exercise intervention. However, the baseline characteristics of the two groups were almost identical. Moreover, because many residents did not meet the inclusion criteria, the relatively small sample size did not allow us to generalise our results to a larger population. In addition, we used only the TUG test, the Short Falls Efficacy Scale and the Katz ADL scale to measure mobility function, fear of falling and the related activity restriction; therefore, no other outcomes were used to better understand the effect of the intervention. Finally, the assessment of the effect of training was limited to baseline and after 16 weeks, and no follow-up was performed to evaluate the maintenance of the benefit of the intervention over time. Although long-term effects were not studied, we found a positive effect in the intervention group.

Despite these limitations, the data obtained in our study may have important practical consequences. We know that the fear of falling, the related activity reduction, and the decline of physical function are important predictors of falling incidents, especially in ageing females,[16] potentially leading to a vicious circle. The mediation effect of mobility on the fear of falling suggested that our neuromotor training may contribute to the reduction in the fear of falling through an improvement in mobility function. This finding may have important consequences and implications. Physical training may decrease the relative negative outcome linked with mobility impairment in a specific population, such as older adults living in the long-term care setting.

Conclusion

We think that the results of this study have important implications. Neuromotor training may be sustainable by individuals living in the long-term care setting and may help to preserve the independence of ageing people. Our findings suggest that a training programme based on concepts from motor control and motor learning is conducive to improve mobility function and ADL along with a decreased fear of falling, with potentially significant implications for the well-being of ageing people. We think that the identification of specific programmes could improve efforts to prevent the elderly from ending up in a vicious circle as described. However, further studies with larger sample sizes, or studies using different physical programmes are needed to expand on this idea and to investigate the effects of the specific intervention programme on physical function and the fear of falling in older adults living in the long-term care setting.

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