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Original Article

Effect of a psychomotor training program on hand function in nursing home residents: a pilot study

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Abstract
In elderly people, hand and upper limb function are essential to maintain independence in the activities of daily living. Living in nursing homes, due to 24h nursing assistance, reduces the amount of activities autonomously performed by the residents, hence supports the physiological age-related decline of the upper limb and hand function. Benefits of physical activity have been well-documented and are universally accepted; however, to the best of our knowledge, the effect of a structured physical activity on the quality of hand and upper limb function has never been investigated in elderly nursing home residents. Fourteen nursing home residents were recruited and randomly assigned to either a control (CG) or experimental (EG) group. The CG subjects did not modify their current activities and treatments, whereas the EG subjects engaged in a 3-month exercise program (3 sessions per week) focused on improving upper limb and hand function. Before and after the intervention, manual and finger dexterity were assessed by means of the Jebsen-Taylor hand functional test and the Nine-hole Peg test, respectively. After the intervention, manual dexterity significantly improved ($p<0.05$; Wilcoxon test) in both dominant and non-dominant hand of EG participants, whereas manual dexterity of CG and finger dexterity of EG and CG participants did not change ($p>0.05$; Wilcoxon test), regardless of the hand used. Only delta score (i.e. the difference between the results after and before intervention) of non-dominant manual dexterity improved significantly ($p<0.05$; Mann-Whitney U Test) in the EG compared to CG participants. Moreover, each test for both limbs showed improvement trends for EG, whereas CG had mostly either no trend or a decline of performance. Therefore, structured physical activity seems to improve hand and upper limb function of elderly nursing homes residents. However, additional studies with larger sample size are needed to confirm the results of the present study.
Key words Upper limb, aging, psychomotor training, hand dexterity, finger dexterity.

Introduction

Upper limb function is essential to preserve personal and social independence, and its impairment, which is common in elderly, can lead to a lower quality of life.

Aging has degenerative effects on hand function, both in terms of quantity (with a reduction of finger and hand strength) and quality (with a reduction of the ability to control submaximal pinch force and maintain a steady pinch posture, manual speed and hand sensation) (Ranganathan, Siemionow, Sahgal, & Yue, 2001). However, even in elderly individuals exercise programs have been shown to improve the hand function (Ranganathan et al, 2001), as well as pinch strength and fine motor control (Gaetano, 2016, Gaetano, 2012, Di Tore et al, 2016, Federici et al., 2008, Raiola 2017).

Problem and aim Nursing homes provide 24h assistance and play an important role in the society. However, they reduce the amount of activities autonomously performed by the residents, which might promote the physiological age-related decline of the upper limb and hand function (Reid et al., 2013).

To date, to the best of our knowledge no studies assessed the effect of an exercise program, focused on psychomotor skills, on hand movement quality in elderly nursing home residents.

Therefore, our hypothesis is that a structured exercise program focusing on psychomotor skills can positively affect the movement quality of both hand and upper limb, by delaying or limiting the physiological age-related decline.

Methods

Subjects - Twenty-seven elderly volunteers (6 males and 21 females) between 63 and 95 years were recruited in the present study. Participants were randomly assigned to either an experimental (EG) or a control group (CG). Due to age-related diseases and complications and some deaths 13 subjects did not complete the study, hence the

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final study sample was composed by 14 participants: 7 participants in the EG (2 males and 5 females) and 7 participants in the CG (2 males and 5 females).

Experimental design

Recruitment, training and testing were performed within a nursing home. EG participants underwent a 3-month, supervised exercise program focused on the development of psychomotor hand skills (see "*Training program*"), whereas the CG participants were not trained and did not modify their activities and treatments. Before and after the intervention the subjects of both EG and CG performed several tests aimed to assess hand and finger function (see "*Testing procedures*").

Training program

Training program was performed as group sessions, for approximately three months, three times per week (always during the morning) for a total of 36 session. The training program was structured according to the training principle of "progression", with a gradual increase of exercise volume, difficulty and intensity, and it was focused on multilateral development, in order to allow the subjects to transfer the skills acquired to the activity of daily living.

Therefore, different non-conventional devices, such as elastic bands, soft balls of different dimensions and sticks, were utilized. In addition to general exercises, which aimed to improve and/or recover upper limb and hand functions, specific exercises focused on training motor control, dexterity and sensation were included (see Figures 1, 2 and 3 for some examples of the exercises and their detailed explanations). Exercises mostly involved the execution of predetermined tasks based upon different commands gave arbitrarily by the exercise specialist. Due to subjects difficulties to maintain a standing position, all the exercises and tests were performed in the seated position. This also allowed the participants to focus their attention on upper limbs and hands movements, which are the main objectives of the present study.

Figure 1. Hand and finger control of a soft ball. Soft balls, of different dimensions, were placed on the table in front of the subjects, 13 cm apart from edge of the table. The balls were classified as small, medium and large. The subjects, according to a specific request of the exercise specialist, selected the proper ball then rolled it with the palm of the hand forward and backward for six times, first with the dominant then with the non-dominant hand. The exercise was created to improve and/or preserve hand and finger sensation through the manipulation of the ball that stimulates psychomotor control and hand-eye coordination.

Figure 2. Finger pinch tasks during cube manipulations. The subjects, while sitting with their elbow flexed and hands near the waist, rotated a wooden small cube using the fingers. A different number was written on each cube face. The subjects freely selected the direction of rotation, but they were required to interrupt the cube rotation when the face with the number said by the exercise specialist was in front of them. This exercise aimed to improve and/or preserve fine motor skills of hand movements besides function, sensation and fine control of the hands.

Figure 3. Elbows flexion and extension (biceps curl) with a stick. The subjects, while sitting with the elbows near the trunk, grasped a stick with both hands (supinated grip) with hands 30 cm apart. Hence, they flexed and extended their elbow throughout full range of motion. This exercise focused on strengthening biceps brachii, controlling the posture and preserving elbows' range of motion.

Testing procedures

Hand dexterity and the finger dexterity were evaluated in both dominant and non-dominant arm.

Hand dexterity was assessed by means of *Jebsen-Taylor Hand Functional Test* (JTHFT), which was proposed in 1969 (Jebsen, Taylor, Trieschmann, Trotter, & Howard, 1969) and is still utilized (Hackel, Wolfe, Bang, & Canfield, 1992; Mak, Lau, Tam, Woo, & Yuen, 2015). JTHFT assesses the hand dexterity by means of seven tests that simulate different activities of daily living (see Figure 4). The seven tests have to be completed as fast as possible and performed firstly with the non-dominant then with the dominant hand. The time to complete each test is recorded and the total time for each hand is used as the test result see Jebsen et al. (1969)for more details.

Figure 4. Jebsen-Taylor Hand Functional Test (JTHFT) kit. The kit includes: a pencil to write a sentence composed by 24 letters; cards for simulated page turning; small common objects to pick up; simulated feeding materials; checkers to stack; large and light objects to pick up; large and heavy objects to pick up.

Finger dexterity was assessed by means of Nine-Hole Peg Test (NHPT), which consists of one task repeated three times with each hand starting with the dominant hand (Mathiowetz, Weber, Kashman, & Volland, 1985). The average time, expressed in second, of the three repetitions for each hand is the test result. NHPT task consisted of picking from a container, nine pegs (0.64 cm in diameter and 3.2 cm in length) one at a time and put them into 9 holes (1.3 cm deep and 0.71 cm in diameter), in any order (see Figure 5). Once all the holes were filled, the subjects removed the pegs and returned them in the container, one at a time. The task was complete when all the pegs were in the container, see Mathiowetz et al. (1985) for more details.

Figure 5. Nine Hole Peg Test (NHPT) kit.

Statistical analysis

The time effect was assessed, within each group, using paired sample Wilcoxon tests between the results before and after intervention, separately for EG and CG. Additionally, delta scores (i.e. the difference between the scores after and before intervention) were computed and compared between groups using U of Mann-Whitney tests. The significance level was set at $p<0.05$.

Results

After the three months interventions, manual dexterity significantly improved in the EG, hence JTHFT was completed faster, in both dominant and non-dominant hand, whereas no differences were observed in the CG. Finger dexterity, measure by NHPT, was not significantly different before and after intervention regardless the group or hand used (see Table 1). Between group differences of delta scores were statistically significant in non-dominant hand but not in the dominant one for JTHFT and were not different in both hands during the NHPT (see Table 2).

Table 1. Descriptive statistics, by group and hand, before and after the intervention, with inferential statistics.

		Dominant hand			Non-dominant hand		
		PRE-intervention	**POST-intervention**	***p***	**PRE-intervention**	**POST-intervention**	***p***
JTHFT	**EG**	73 ± 24	55 ± 17	0.028	95 ± 31	62 ± 24	0.018
	CG	99 ± 61	95 ± 30	0.31	94 ± 38	100 ± 35	0.499
NHPT	**EG**	44 ± 17	36 ± 12	0.225	55 ± 21	46 ± 20	0.173
	CG	61 ± 30	68 ± 38	0.237	60 ± 35	67 ± 37	0.398

Note: Data are absolute values in seconds (mean ± SD). JTHFT, Jebsen-Taylor Hand Functional Test; NHPT, Nine-Hole Peg Test; EG, experimental group; CG, control group; *p*, level of statistical significance (Wilcoxon test between before and after intervention).

Table 2. Descriptive statistics, by group and hand, of the delta scores (i.e. difference between the post- and pre- intervention results), with inferential statistics.

	Dominant hand			Non-dominant hand		
	EG	**CG**	***p***	**EG**	**CG**	***p***
JTHFT	-18.1 ± 27.3	-4.4 ± 47.5	0.097	-33.1 ± 16.7	5.8 ± 39.4	0.038
NHPT	-7.5 ± 13.9	7.5 ± 16.2	0.073	-8.2 ± 16.0	7.0 ± 17.7	0.128

Note: Data are absolute values in seconds (mean ± SD). JTHFT, Jebsen-Taylor Hand Functional Test; NHPT, Nine-Hole Peg Test; EG, experimental group; CG, control group; *p*, level of statistical significance (U of Mann-Whitney tests between the delta score of the two groups).

The trends over time of the four tests are shown in Figures 6 to 9.

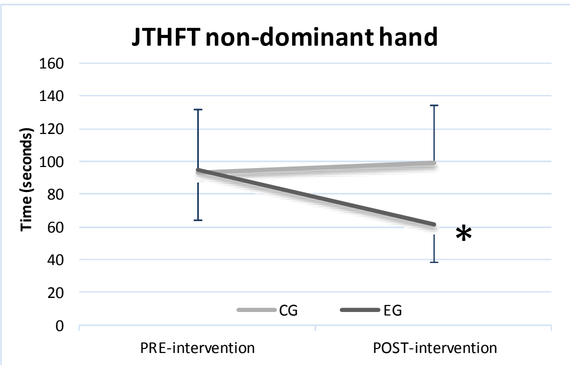

Figure 6. Hand dexterity of the non-dominant hand. JTHFT, Jebsen-Taylor Hand Functional Test; CG, control group; EG, experimental group; *, p<0.05 (U of Mann-Whitney test between group delta scores).

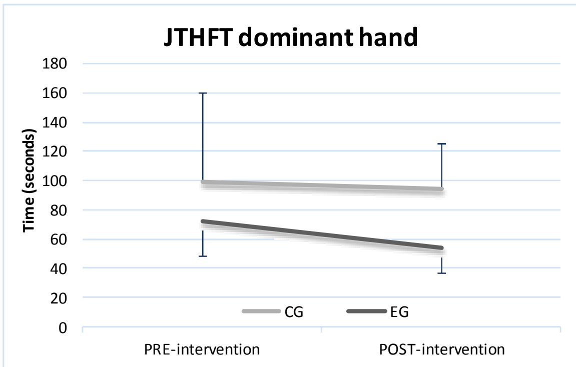

Figure 7. Hand dexterity of the dominant hand. JTHFT, Jebsen-Taylor Hand Functional Test; CG, control group; EG, experimental group.

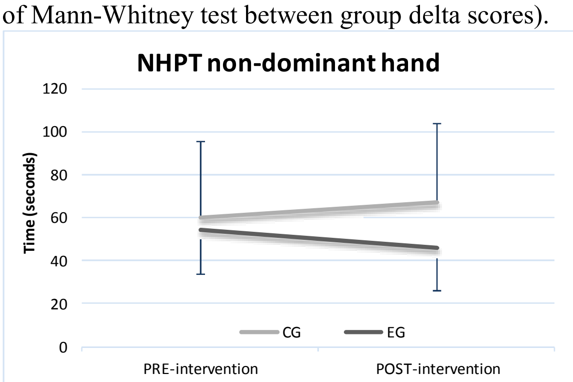

Figure 8. Finger dexterity of the non-dominant hand. NHPT, Nine-Hole Peg Test; CG, control group; EG, experimental group.

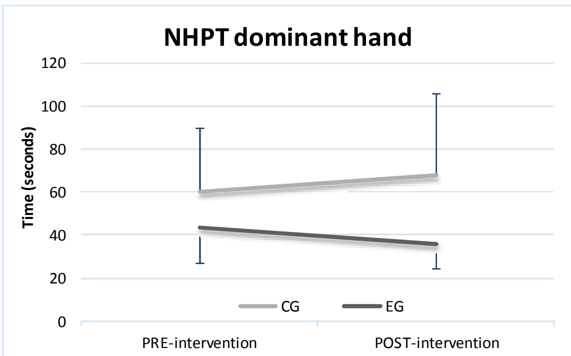

Figure 9. Finger dexterity of the dominant hand. NHPT, Nine-Hole Peg Test; CG, control group; EG, experimental group.

Discussion and conclusions

The present study aimed to assess if a specific exercise program, which was focused on the training of psychomotor skills, was able to improve hand function in elderly nursing home residents. The results showed how the exercise protocol performed in EG compared to the CG was able to improve the manual dexterity (i.e. JTHFT) in the non-dominant hand, whereas there were no differences between groups on the other values. Nonetheless, the trends over time of both hand and finger dexterity suggest a positive effect, which means the subjects completed the tests in less time, in EG compared to the CG (see Figure 6, 7, 8 and 9).

Moreover, after the interventions, EG showed an improvement of the manual dexterity (i.e. JTHFT) of both dominant and non-dominant hands, opposed to CG that did not improved their performance. Therefore, the lack of statistical significance seems to be caused by the small sample size at the end of the study, hence low statistical power, and not by the lack of efficacy of the training protocol. Noteworthy, except the results from the JTHFT performed with the dominant hand (in which, however, the variability was high), the performance in both manual and finger dexterity decreased in CG participants (who were not engaged in any training program). This is in line with the generic physiological age-related decline, which has been proved to be particularly rapid for the tasks that require dexterity (Bowden & McNulty, 2013; Desrosiers, Hebert, Bravo, & Rochette, 1999).

The present study seems to confirm the hypothesis that the physiological age-related decline of dexterity, even in elderly individuals living in nursing home, can be slowed down undertaking an exercise program focusing on specific training of psychomotor skills. Therefore, the movement quality, hence the hand function and especially hand dexterity, could be improved in elderly patients with psychomotor activities. Actively using the upper limb could thus exploit the skills potential of elderly individuals, by slowing down the natural age-related decline and preserving individuals' personal and social independence, which will consequently improve the life quality on the functional, physical, social and emotional dimensions. Therefore, the present pilot study highlights the importance and necessity of additional studies, with a broader sample size, to investigate the topic.

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