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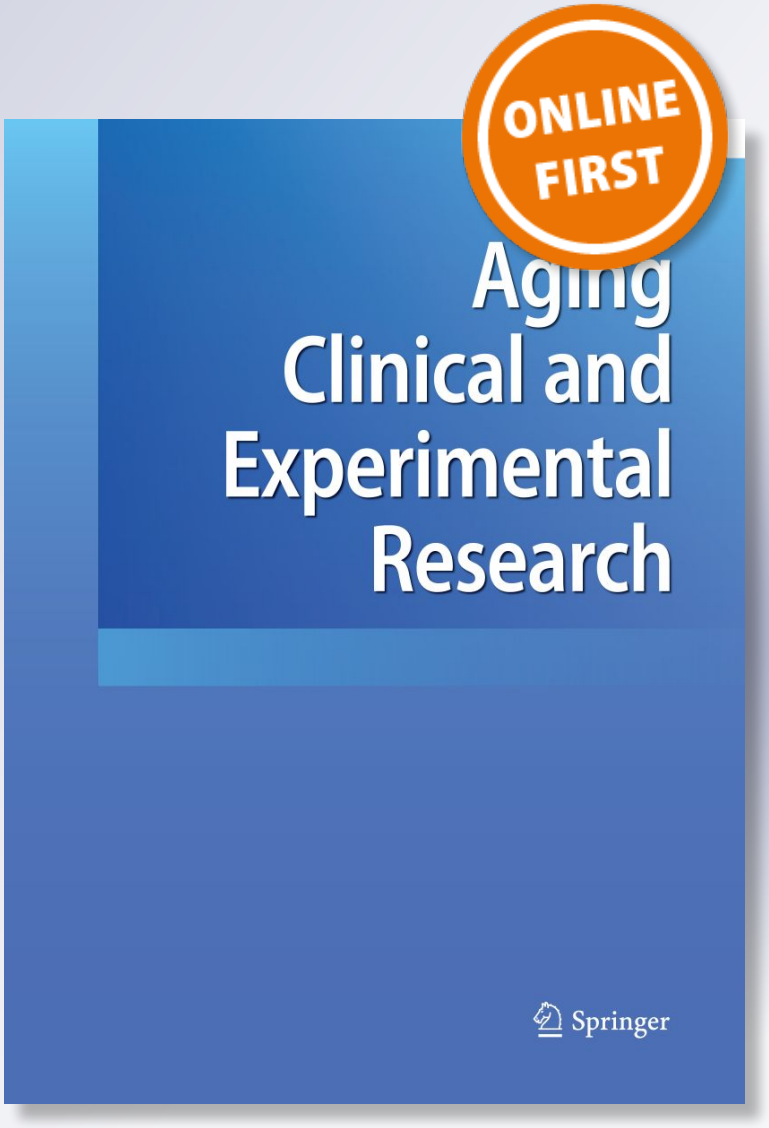

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SHORT COMMUNICATION

Effects of feedback-based balance and core resistance training vs. Pilates training on cognitive functions in older women with mild cognitive impairment: a pilot randomized controlled trial

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Abstract
Background There is limited research about beneficial effects of physical activity in older adults suffering from mild cognitive impairment (MCI).
Aim The aim of the study was to provide preliminary evidence on the effects of two types of non-aerobic training on cognitive functions in older women suffering from MCI.
Methods Twenty-eight participants aged 66–78 years with MCI were randomly assigned to a combined balance and core resistance training group ($n = 14$) or to a Pilates group ($n = 14$).
Results Following completion of the 8-week exercise programme, both groups showed significant improvements in global and specific cognitive domains.
Conclusion Findings suggest that non-aerobic training should be further explored as a beneficial intervention for older adults suffering from MCI.

Keywords Mild cognitive impairment · Cognitive functions · Physical activity · Exercise

Introduction

Research about beneficial effects of physical activity (PA) in older adults suffering from mild cognitive impairment (MCI) is still scarce [1, 2]. In addition, there is also the need to explore whether aerobic component is essential to obtain positive cognitive effects or other exercise modalities may also benefit cognition [1]. The present study seeks to contribute to this area of knowledge by investigating the effects of two types of non-aerobic training on cognitive functions in older adults with MCI.

Pilates has positive impact on general health condition in older adults [3]. However, it is still unknown whether this exercise programme is effective in enhancing cognitive performance in older adults with MCI. Recently, it has been shown that a novel feedback-based balance and core resistance training device named HUBER® (LPG Systems, Valence, France) that simultaneously captures balance, core stability and strength, and total body strength successfully improves physical functions in older adults [4]. However, no research has been conducted to determine whether this type of training also benefits cognition. Thus, the main aim of this study was to provide preliminary data on efficacy of both combined balance and core resistance training and Pilates training on cognitive performance in older women with MCI, which might be worth replicating in a subsequent larger study.

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Methods

Participants

Participants were recruited via advertisement in the local newspaper. Fifty women (age 66–79 years) volunteered to participate in the study. All volunteers underwent a pre-participation medical examination and completed a medical history questionnaire. General exclusion criteria for participation were as follows: (1) serious medical condition that prevented safe participation in an exercise programme, (2) use of medications or the presence of symptoms of a disease, and (3) participation in any other structured exercise programme. In addition, volunteers were required to meet the criteria for MCI, defined as a total score in range from 19 to 25 on Montreal Cognitive Assessment (MoCA) [5]. The final sample consisted of 28 woman between the ages of 66 and 78 years (M 70.4, SD 3.93) who were randomly assigned to a combined balance and core resistance training group, i.e. HUBER group (14 participants) or to a Pilates group (14 participants). At enrollment, except for the cigarette consumption which was higher in HUBER group ($p < 0.05$), groups were comparable with respect to cognitive status, age, education, marital status, living arrangement, employment status (all participants were retired), engagement in hobbies or volunteer work, and alcohol consumption.

Procedure

Training in both groups was conducted three times a week through 8 weeks.

HUBER training which included push and pull exercises on the handles in different postures, hand positions, and directions lasted ~30 min per session. The force level ranged from 50% of maximum voluntary contraction (MVC) during the first 2 weeks, over 65% of MVC during the next 3 weeks, to 75% of MVC during the last 3 weeks. The duration of isometric actions ranged from 5 to 7 s, and participants performed between 30 and 60 contractions per session.

Pilates training lasted 1 h per session. Core stability was addressed by the use of abdominal bracing and pelvic tilt. A typical session included supine, side-lying, sitting, and quadruped exercises. The difficulty of these exercises was gradually increased and the focus was maintained on keeping a neutral posture and stable core in different gravity orientations. Every session ended with lower- and upper-limb exercises using elastic bands. Each exercise was performed for 2–4 sets with 15–20 s contraction time (isometric exercise) or 15–20 repetitions (dynamic exercise).

Outcome measure testing

Cognitive functioning at baseline and after the training intervention was measured using MoCA, a brief screening tool developed for the assessment of mild cognitive impairment [5] which consists of seven subscales (Table 1).

Results

Analyses were conducted on an intention-to-treat basis. Missing data from one participant in HUBER and two participants in Pilates group were imputed using expectation–maximization (EM) algorithm.

Pre-intervention testing revealed that total MoCA scores and mean scores for seven cognitive domains, did not differ among groups (Table 1). Following intervention, both groups showed significant improvements in the overall MoCA score, as well as in the cognitive domains of language and abstraction. In addition, in the HUBER group, improvements were also found in the domains of visuospatial/executive functions and orientation, while in the Pilates group significant gains were obtained in delayed recall domain. Following Cohen's criteria [6], the magnitude of most of significant differences could be interpreted as large effect size ($d > 0.8$). No improvements were found in attention domain, or in naming domain which was hampered by a ceiling effect. Between-group analyses of post-intervention outcome measures showed that participants from HUBER group obtained significantly higher scores in visuospatial/executive and orientation domain, as well in the overall MoCA score. The effect size of the last two differences could be interpreted as large.

Discussion

The main aim of the study was to examine whether non-aerobic PA interventions have a beneficial influence on cognitive performance among older women with MCI. The results showed that both combined balance and core resistance training and Pilates training enhanced global cognitive functioning and improved some of the specific cognitive domains.

Significant improvements in visuospatial/executive functions and orientation following intervention were obtained only in HUBER group. Since in HUBER intervention participants had an extra cognitive task, i.e. they had to precisely adjust force applied on the handles by hitting the target area on the screen, it seems reasonable to hypothesize that this additional cognitive stimulus might have also had beneficial influence on cognitive functions [7].

Table 1 Baseline characteristics of subjects by intervention condition and effects of different training programmes on cognitive functions

Variable	Effects of intervention within HUBER group				Effects of intervention within PILATES group				Baseline comparison between groups		Comparison between groups after the intervention	
	Before M ± SD	After M ± SD	$t(13)^a$	d^b	Before M ± SD	After M ± SD	$t(13)^a$	d^b	$t(26)^c$	d^b	$t(26)^c$	d^b
Visuospatial/executive	3.00 ± 1.66	3.50 ± 1.23	1.99*	0.34	2.29 ± 0.73	2.57 ± 1.16	0.84	0.30	1.47	0.59	2.06*	0.78
Naming	2.93 ± 0.27	2.93 ± 0.27	0.00	0.00	3.00 ± 0.00	3.00 ± 0.00	n/a	n/a	−1.00	−0.26	−1.00	-0.26
Attention	5.64 ± 0.50	5.50 ± 0.65	−0.56	−0.25	5.79 ± 0.43	5.43 ± 0.76	−1.44	−0.58	−0.82	−0.32	0.27	0.10
Language	2.50 ± 0.65	2.93 ± 0.27	2.12*	0.86	2.36 ± 0.50	2.86 ± 0.36	3.61*	1.15	0.65	0.24	0.59	0.22
Abstraction	0.93 ± 0.83	1.57 ± 0.51	2.59*	0.93	1.00 ± 0.68	1.43 ± 0.65	2.12*	0.65	−0.25	0.09	0.65	0.24
Delayed recall	3.36 ± 0.93	3.64 ± 1.01	1.00	0.30	3.07 ± 1.07	3.93 ± 0.92	2.60*	0.86	0.75	0.29	−0.78	-0.30
Orientation	4.93 ± 0.48	5.64 ± 0.63	3.24*	1.28	4.93 ± 0.48	4.79 ± 0.89	−0.56	−0.20	0.00	0.00	2.93*	1.12
Total score	23.43 ± 1.70	25.79 ± 1.53	5.21*	1.46	22.71 ± 1.64	24.29 ± 1.98	2.19*	0.87	1.13	0.43	2.25*	0.89

n/a T test could not be computed because the standard error of the difference is 0

*$p \leq 0.05$

[a]One-tailed significance tests of the difference between post- and pre-intervention data

[b]Cohen's *d* effect size measure

[c]Two-tailed significance tests of the difference between HUBER and Pilates group at baseline and after intervention

Contrary to our expectations, the HUBER group showed no significant progress in attention or in delayed recall. Nonetheless, due to a considerable difference in duration of our intervention compared to the one in a previous study (8 weeks vs. 6 months) [8], it could be assumed that the training programme may not have been performed for long enough to enhance these cognitive functions. A similar explanation may hold for the Pilates group in which observable changes in attention were also not detected.

Both exercise interventions had positive effect on general cognition, language, and abstraction. Our findings support the recently emerging indication that non-aerobic exercise interventions may also have beneficial effects on cognitive performance [9].

Significant improvement in short-term memory recall task was obtained only in the Pilates group, indicating that different exercise programmes might have distinct influence on specific cognitive functions, what should be further explored in future studies.

Following intervention, participants from the HUBER group obtained significantly higher scores in visuospatial/executive and orientation domain, as well in the overall MoCA score, what may be due to the qualitative differences in exercise task demands, higher exercise intensity in HUBER group, or both.

The results of this preliminary study should be interpreted within the context of the following limitations. First, the lack of control group and the small sample of only female participants restrict the generalizability of the findings. Second, the specific way of operationalization of the concept of MCI may differ from the MCI diagnosis provided in rigorous clinical settings [10]. The assignment of MCI subtypes (amnestic or non-amnestic) and domains (single or multiple) may provide a better understanding of the relationship between non-aerobic training and cognitive functions in older adults with MCI.

Although additional studies are required before these findings could be used in clinical practice, our study provides important preliminary evidence about beneficial potential of non-aerobic interventions on cognitive performance in those at risk for dementia.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of human and animal rights The study was approved by the university's ethics committee.

Informed consent Informed consent was obtained from all individual participants included in the study.

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