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Physical activity and executive functions in the elderly with mild cognitive impairment

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Abstract

The primary goal of the present study was to examine whether in the elderly with mild cognitive impairment (MCI), the effect of physical activity measured directly following treatment, was reflected in an improvement in cognitive functioning in general or in executive functions (EF) in particular. Secondly, this study aimed to compare the effectiveness of two types of intervention, with varying intensities: walking and hand/face exercises. Forty-three frail, advanced elderly subjects (mean age: 86) with MCI were randomly divided into three groups, namely, a walking group ($n = 15$), a group performing hand and face exercises ($n = 13$), and a control group ($n = 15$). All subjects received individual treatment for 30 minutes a day, three times a week, for a period of six weeks. A neuropsychological test battery, administered directly after cessation of treatment, assessed cognitive functioning. The results show that although a (nearly) significant improvement in tasks appealing to EF was observed in both the walking group and the hand/face group compared to the control group, the results should be interpreted with caution. Firm conclusions about the effectiveness of mild physical activity on EF in the oldest old can only be drawn after studies with larger number of subjects.

Introduction

Epidemiological studies provide considerable evidence that the amount of physical activity has a positive relationship with level of cognitive functioning. In one study it was observed that elderly with a low activity level (<1 hour activity per day) are at a two-fold increased risk of deterioration in cognition than elderly who were active for more than one hour per day (Schuit, Feskens, Launer & Kromhout, 2001). In another study, Bunce (2001) examined the effect of physical activity on the vigilance of healthy elderly women. The amount of physical activity per week was determined by means of a self-completion questionnaire. The results indicate that the fittest among the elderly showed the highest level of vigilance under conditions of greater task demands. In addition to cognitive functioning, a negative relation between physical activity and affective states like depression has also been found (Kritz-Silverstein, Barrett-Connor & Corbeau, 2001).

In contrast to the large number of epidemiological studies on the relation between physical activity and cognition in healthy elderly people, such studies have

rarely been carried out in cognitively impaired elderly. In those few studies, similar results to those described above were found. For example, in a prospective cohort study with subjects who had a normal mental status at the onset of a five-year follow-up study, those subjects with a high level of physical activity showed the lowest risk for cognitive impairment, Alzheimer's disease (AD), and other types of dementia (Laurin, Verreault, Lindsay, MacPherson & Rockwood, 2001).

In sum, several epidemiological studies have highlighted the relation between the level of physical activity throughout life and cognitive functioning. From these studies, the interesting question arises whether physical activity could be effective as an intervention in maintaining or enhancing cognitive functions in elderly people. Kramer and colleagues (1999) applied an aerobic (walking) and an anaerobic (toning exercises) exercise program to sedentary cognitively unimpaired elderly (age range 60–75 years). They observed that in contrast to the toning exercises, walking improved the performance of cognitively challenging tasks that are dependent on executive functions (EF). Executive functions

include volition, planning, purposive action, and response-inhibition; functions in which the frontal lobe is particularly involved (Duke & Kaszniak, 2000). Of note is that the frontal lobe is most vulnerable to the aging process (Coffey et al., 1992). The negative effect of ageing on the frontal lobe is reflected in a reduction in its cerebral glucose metabolism (Mielke et al., 1998). Others argue that the frontal lobe is vulnerable to white matter lesions, disconnecting it from other brain areas such as the medial temporal lobe, and causing age-related cognitive impairment (Tisserand & Jolles, 2003).

Even in very old people (mean age 84.5 years) with a normal mental status, an exercise program including stretching, flexibility, general mobility, and, in addition, low intensity aerobic activity showed an improvement in the performance on a verbal fluency task with semantic categories such as colours, animals, fruit, and towns (Stones & Dawe, 1993). The effects were observed directly after the treatment but after a follow-up assessment 30 minutes later, the improvements were reduced. In another study, a significant difference in Category Naming, another verbal fluency task, between the experimental group and control group was observed after a three-month light exercise program (Molloy, Delaquerriere Richardson & Crilly, 1988). Importantly, this difference was not due to an improvement in the experimental group, but to a decline in the control group. No significant differences between both groups were found on other cognitive tasks (Molloy et al., 1988). However, in contrast to the study of Stones and Dawe (1993), neuropsychological testing took place three to seven days after cessation of treatment. The question therefore arises whether the same or other effects could have been observed when assessment had taken place directly after the cessation of treatment (Molloy et al., 1988).

So far, the effects of physical activity on cognition have been discussed with respect to elderly without cognitive impairment. However, physical activity as an intervention has also been applied to patients with probable AD. In some studies in which physical activity was applied to cognitively impaired elderly, the dependent variables were functional mobility, balance, and urine control (Jirovec, 1991; Tappen, Roach, Brooks Applegate & Stowell, 2000). With respect to cognition, Palleschi and colleagues (1996) observed that aerobic training on a cycloergometer for more than 20 minutes, three days a week, during a three-month period improved attention and verbal capacity in AD patients. Of note, a control group was lacking in that study. Verbal capacity also improved in moderate-to-severe AD patients over a 30-minute planned walking program and not over a 30-minute conversation program, applied three times a week, for 10 weeks (Friedman & Tappen, 1991). It is unfortunate that the effects of physical activity on cognitive functioning in AD patients were only examined in a few studies. It has been suggested that AD patients rarely participate in studies on exercise, due to low treatment compliance and the apparent irreversibility of AD (Schnelle, 1995; Tappen et al., 2000).

The results of the above-mentioned studies suggest that EF, including verbal fluency (Gurd et al., 2002), measured directly after cessation of treatment, are consistently improved by physical activity, irrespective of its intensity and of the level of cognitive functioning (not demented and demented). Whether physical activity in very old people has a beneficial effect on other cognitive tasks such as episodic memory cannot be answered yet, since the performance on a wide range of cognitive tasks has never been assessed directly after the treatment (Friedman & Tappen, 1991; Jirovec, 1991; Palleschi et al., 1996; Stones & Dawe, 1993; Tappen et al., 2000). Taken together, the effects of physical activity should be examined on a broad range of cognitive functions, preferably in a population who are aware of their more than normal cognitive impairment and are therefore motivated to participate in an activity program.

Elderly, who are aware of a more than normal decline in cognition, predominantly in episodic memory, are those with mild cognitive impairment (MCI) (Petersen et al., 1999). Mild cognitive impairment is a transition state between normal aging and dementia (DeCarli, 2003). Since the neuropathology in MCI is supposed to be less severe than in dementia, its associated cognitive deterioration might be less irreversible and may respond more favourably to treatment (Luis, Loewenstein, Acevedo, Barker & Duara, 2003; Lehmann, Regland, Blennow & Gottfries, 2003). Therefore, the primary goal of the present study was to examine whether in the oldest old with MCI, physical activity, measured directly following treatment, improves cognitive functioning in general or EF in particular.

A second question was related to the intensity of physical activity. In the above-cited studies, both walking and milder exercises appeared to be effective. Therefore, in the present study the effectiveness of two types of interventions, with two levels of intensity, were examined: walking and hand/face exercises. The rationale underlying the hand/face exercises was two-fold: (1) many frail elderly people are unable to perform aerobic exercises like walking (Netz & Jacob, 1994), and (2) motor activity of the hands and face stimulates areas of the frontal lobe, including the anterior cingulate cortex (ACC) (Paus, Petrides, Evans & Meyer, 1993), a structure that is engaged in sensory, motor, and cognitive processes (Davis, Taylor, Crawley, Wood & Mikulis, 1997).

Methods

Subjects

The study sample consisted of 43 frail, elderly subjects with MCI, drawn from a sample of 500 elderly who live in a combined home for the elderly/nursing home. The subjects were randomly divided into three groups: a walking group ($n = 15$: 13 females), a group performing hand and face exercises ($n = 13$: 11 females), and a control group ($n = 15$: 14 females).

Cognition, age, and education. Level of cognitive functioning was assessed by the shortened 12-item version of the Mini-Mental State Examination (MMSE) (Breakhus, Laake, & Engedal, 1992). The 12-item MMSE version (maximum score: 12) evaluates orientation in time and place, registration, recall, attention, calculation, language and praxis, and visuoconstructive abilities (Breakhus et al., 1992). A MMSE-score of 7–10 is indicative for mild/moderate cognitive deterioration whereas subjects with a score of <7 are classified as having serious cognitive disturbances. Subjects were included in the study if they had an MMSE score of 7 or higher. The mean MMSE scores show that cognitive decline of the subjects in the three groups was very mild. Compared to the control group, the MMSE scores of the walking group and the hand/face group did not differ significantly ($t (28) = 0.21$; *ns*, and $t (26) = 1.24$; *ns*, respectively) (for means, range, and standard deviations, see Table I). The subjects with an MMSE score of 11 or 12 were also included in the study since they showed a decrease in performance on the Delayed Recall of the Verbal Learning and Memory Test (VLMT) (Mulder, Dekker & Dekker, 1995), a test for episodic memory (see Table III for means and standard deviations). Besides the mild decline in MMSE scores, the subjects met the MCI criteria as established by Petersen et al., (1999): (1) subjective complaint of memory impairment, supported by a nursing assistant; (2) objective memory impairment measured by the memory items of the MMSE; (3) general cognitive functioning largely unimpaired;

(4) no decline in activities of daily living; and (5) no signs of dementia.

The walking group, the hand/face group, and the control group did not differ in age ($\chi^2 = 44.54$, $df = 34$, *ns*) (for means, range, and standard deviations, see Table I). Education of the subjects was assessed by a seven-point scale: (score 1) uncompleted elementary school; (score 2) elementary school six grades; (score 3) eight grades; (score 4 and 5) three and four years lower general secondary education, respectively; (score 6) pre-university education, technical college, higher vocational education; (score 7) university. No significant differences in education levels were observed between the walking group, the hand/face group, and the control group ($\chi^2 = 8.19$, $df = 10$, *ns*) (for means, range, and standard deviations, see Table I).

Exclusion criteria. Subjects were excluded from participation in the study if they met the NINCDS-ADRDA criteria for probable AD (McKhann et al., 1984), and if they had a history of alcoholism, cerebral trauma, hydrocephalus, neoplasm, epilepsy, disturbances of consciousness, or focal brain disorders.

Characteristics of painful conditions. Painful conditions that might hinder an active participation to or continuation of the walking or the hand/face program included arthrosis/arthritis, postoperative states (e.g., total hip, total knee), and recent fractures (within the last year). There was no significant difference between the three groups with respect to the prevalence of arthrosis/arthritis ($\chi^2 = 4.86$, $df = 4$, $p = 0.30$), postoperative states ($\chi^2 = 4.76$, $df = 4$, $p = 0.31$) and recent fractures ($\chi^2 = 4.18$, $df = 4$, $p = 0.38$).

Comorbidity. In physical activity programs, overall health status is an important variable that might influence treatment outcome. Therefore, the prevalence of specific categories of illness were recorded and compared between the three groups. Specific categories of illness included congestive heart failure, peripheral vascular disease, chronic pulmonary disease, diabetes mellitus, chronic renal failure, tumours, ulcer disease, anaemia, hyper/hypothyroidism, cholecysectomy, urology, hypertension, migraine, diverticulosis, esophagitis, and liver disturbances. For each separate category of illness, comparisons were made between the three groups employing χ^2 tests. Only cholecystectomy occurred significantly more in the hand/face group than in the other two groups ($\chi^2 = 12.86$, $df = 4$, $p = 0.012$). The total number of illnesses did not differ significantly between the three groups ($\chi^2 = 10.61$, $df = 10$, *ns*). The goal and the procedure of the

Table I. Demographic characteristics and values of the Mini-Mental State Examination (MMSE).

	Walking group		Hand/face group		Control group	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age, years	84	6.38	89	2.40	86	5.05
(range)	(76–94)		(85–92)		(78–93)	
Education	2.60	1.06	2.85	1.14	2.73	1.67
(range)	(1–5)		(2–5)		(1–7)	
MMSE	9.73	1.94	9.23	1.30	9.87	1.41
(range)	(7–12)		(7–11)		(8–12)	

study were extensively explained to the subjects, after which written informed consent was obtained.

Treatment

The 'walking' treatment involved self-paced slow walking with an aid. With respect to the hand/face exercises: the hand exercises included, among other things, bending and stretching the fingers, and sliding a wooden club through the hand by moving the fingers. Facial activity consisted of producing seven different facial expressions, an exercise used with rehabilitation following paralysis of the facial nerve.

All subjects of the two experimental groups received individual treatment for 30 minutes a day (30 minutes walking and 15 minutes each for the hand/face exercises), three times a week, for a period of six weeks. With respect to the subjects of the control group, they were divided into two subgroups: in one subgroup eight subjects received social visits as a 'treatment', while in the other subgroup the remaining seven subjects continued their normal social activities. The social visits were meant to control for the positive influence of an intensified contact on subjects' well being (Hicks, 2000), a contact that is also part of the walking and hand/face exercises program. Although the majority of the subjects in the latter two groups were glad that a period of rest followed the activity program, the subjects in the control group only faced the ending of an intensified social contact. It is known that terminating an intense social interaction might negatively influence the post-treatment scores (Planavsky, Mion, Litaker, Kippes & Mehta, 2001). To level out the positive and negative influence of social interaction and its termination, respectively, only eight out of 15 subjects were visited during the treatment-period. Combining both subgroups into one control group ($n = 15$) was justified as follows. Analysis of variance showed no significant difference between both subgroups on any of the neuropsychological tests (means, standard deviations, and analysis of variance are presented in Table II). Furthermore, paired *t*-tests showed no significant difference between the pre- and post-treatment scores of the neuropsychological tests within each subgroup.

Assessment of cognitive functions

The following neuropsychological tests aimed at assessing executive functions (EF) and memory were administered:

Executive functions (EF). Each participant was given two frontal executive functioning tests, namely, the Category Naming (Snijders & Verhage, 1983) and Trail-making A and B (Reitan & Wolfson, 1985).

The former test measures the subjects' ability to retrieve familiar information from semantic memory by asking them to name as many animals and occupations as possible, each during one minute. Elderly with a mean age of 85 years have an average score of 21 ($t = 50$). The latter task involves complex visual scanning, speed, and attention. Norms for the oldest old are lacking but for elderly with an age ranging from 70–79 years, a score of 276 seconds falls within the 50th percentile.

Memory. Digit Span from the Wechsler Memory Scale—Revised (WMS-R) (Wechsler, 1984) was used to assess patients' verbal short-term memory abilities. For elderly with an age ranging from 70–74 years a score of 12 lies between the 46th and 48th percentile. No norms exist for elderly with an age of 75 or above. Visual Memory Span from the WMS-R (Wechsler, 1984) can be considered as a nonverbal equivalent of the Digit Span test. Similar to Digit Span, for elderly with an age ranging from 70–74 years, a score of 13 lies between 44th and 62nd percentile. The Verbal Learning and Memory Test (VLMT): List A (Mulder et al., 1995) is a Dutch version of the California Verbal Learning Test (Delis, Kramer, Kaplan & Ober, 1987). The subtests Direct Recall (max. score: 80), Delayed Recall (max. score: 16), and Recognition (max. score: 44) measure the subjects' episodic memory. Face Recognition from the Rivermead Behavioural Memory Test (RBMT) (Wilson, Cockburn, & Baddeley, 1987) provides a measure of visual, nonverbal long-term memory (max. score: 20) whereas Picture Recogniton from the RBMT provides a measure of visual, verbal long-term memory (max. score: 40) (Wilson et al., 1987).

Administration of the tests. An investigator blind to the treatment condition administered all tests directly before (pre-treatment: T_1) and directly after a six-week period (post-treatment: T_2), and again after six weeks without treatment (delayed: T_3).

Statistical analysis

The pre-treatment scores were submitted to *t*-tests in order to determine if the groups differed at the start of the experiment.

The primary goal of the study was to answer two questions. In the first place, we wanted to investigate whether physical activity, irrespective of its nature (walking or hand/face exercises), improved EF in particular or cognitive functioning in general. Therefore, both types of treatment were combined and compared with the control group. In the second place, it was examined which of the two types of intervention, in comparison with the control group, was most effective with respect to EF or cognitive

Table II. Means, standard deviations and analysis of variance for the control group with and without social visits.

Neuropsychological tests	Control group without social visits						Control group with social visits						ANOVA pre-post		
	Pre		Post		Del		Pre		Post		Del				
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	F	df	p
Executive functions															
Category naming	23.25	8.78	21.75	9.39	21.17	6.91	19.71	8.60	18.57	10.10	22.00	9.18	0.49	1, 13	ns
Trail-making A + B	280.67	111.61	331.60	134.90	267.00	136.33	140.67	53.58	188.83	139.08	122.17	46.64	3.23	1, 9	ns
Memory															
Digit span	11.00	2.73	11.75	2.61	11.00	3.90	10.57	3.41	10.00	2.65	11.43	3.21	1.74	1, 13	ns
Visual memory sp.	10.75	2.49	11.71	2.98	11.60	4.04	10.14	3.29	10.71	3.64	11.43	4.43	0.38	1, 12	ns
RBMT faces	12.25	5.06	14.57	6.60	9.20	4.15	13.43	5.13	11.71	5.09	12.29	5.35	0.43	1, 12	ns
RBMT pictures	31.50	9.43	36.33	4.46	30.80	10.83	34.29	4.82	32.86	6.41	32.29	8.44	1.19	1, 11	ns
VLMT															
Direct recall	29.00	14.84	31.50	15.09	31.67	20.62	28.43	14.58	35.43	19.03	34.14	17.90	0.17	1, 13	ns
Delayed recall	3.63	3.78	4.88	5.06	4.83	5.74	2.71	4.65	3.57	5.16	3.00	5.83	0.56	1, 13	ns
Recognition	34.29	7.50	35.50	4.14	35.00	8.00	33.29	7.43	34.57	6.08	36.14	6.99	0.16	1, 13	ns

VLMT, Verbal Learning and Memory Test; Visual memory sp., Visual memory span; RBMT, Rivermead Behavioural Memory Test.

functioning in general. To answer these two questions, an analysis of test scores from T_1 and T_2 (pre/post) is required. For this purpose, a one-factor analysis of covariance (ANCOVA) was applied for each neuropsychological test, with the post-treatment scores (T_2) as dependent variable and the pre-treatment scores (T_1) as covariate. A related question was whether effects, if any, last over a period of six weeks without further stimulation. For this question, an ANCOVA was used for each test, with the delayed scores (T_3) as the dependent variable and the pre-treatment scores (T_1) as covariate. As the distributions of the dependent variables were highly skewed, a square root transformation was performed on all variables to obtain a nearly normal distribution. *Post-hoc* statistical tests, for which hypotheses were formulated, were one-tailed. Significance was set at 0.05. Effect sizes (η^2) were calculated, that is, small <0.01, medium <0.06, and large ≥0.14. The data were analysed by means of the SPSS-PC program (Norusis, 1992).

Results

Comparison of the pre-treatment scores of the neuropsychological tests between the control group and the two treatment groups revealed that the walking group and the hand/face group were significantly slower than the control group for Trail-making $A + B$: (t (23) = 2.55; $p = 0.018$) and (t (25) = 2.14; $p = 0.042$), respectively. Moreover, compared to the control group, the walking group performed significantly better on the VLMT/Delayed Recall (t (28) = 2.59; $p = 0.015$), and the VLMT/Recognition (t (26) = 2.20; $p = 0.037$). To control for these differences, pre-treatment scores were used as covariates in the analyses of variance.

Executive functions

Category naming. Analyses of covariance (ANCOVA) with the pre-treatment scores (T_1) as covariate comparing the combined treatment group (walking and hand/face groups) with the control group indicated a significant better performance (T_2) in the treatment group than in the control group (F (1,40) = 5.12; $p = 0.03$) $\eta^2 = 0.11$, medium effect size). *Post-hoc* contrasts comparing the separate treatment groups with the control group revealed that the performance on Category Naming after treatment (T_2) was significantly better in the walking group (F (1,27) = 5.02; $p = 0.02$) and in the hand/face group (F (1,25) = 3.27; $p = 0.04$). The effect-sizes η^2 were 0.16 and 0.12, respectively (large and medium-large, respectively). The results of the pre-delayed (T_1-T_3) analyses revealed no significant difference between the control group and the walking group (F (1,17) = 0.57; *ns*) and between the control group and the hand/face group (F (1,12) = 0.55; *ns*). These findings suggest that the treatment effect

could not be maintained in the period without treatment. For means and standard deviations, see Table III.

Trail making $A + B$. Analyses of covariance (ANCOVA) with the pre-treatment scores (T_1) as covariate comparing the combined treatment group (walking and hand/face groups) with the control group revealed a trend of a better performance (T_2) in the treatment group than in the control group (F (1,40) = 3.26; $p = 0.08$) $\eta^2 = 0.075$, medium effect size). *Post-hoc* contrasts of the separate treatment groups with the control group revealed a trend of a better performance (T_2) in the walking group than in the control group (F (1,23) = 2.45; $p = 0.07$). The effect-size η^2 was 0.10 (medium). In addition, compared to the control group, the performance of the hand/face group after treatment (T_2) was significantly better (F (1,21) = 5.03; $p = 0.02$). The effect-size η^2 was 0.19 (large). The results of the pre-delayed (T_1-T_3) analyses revealed no significant differences between the control group and the walking group (F (1,15) = 0.47; *ns*) and between the control group and the hand/face group (F (1,10) = 0.002; *ns*). These findings suggest that the observed treatment effects declined during the treatment-free period. For means and standard deviations, see Table III.

Memory

The performance of tests measuring short-term and long-term memory (Digit Span, Visual Memory Span, RBMT Faces and Pictures, and the VLMT) did not differ between the three groups after treatment (for means and standard deviations, see Table III).

Discussion

The goal of the present study was two-fold. In the first place, it was examined whether physical activity in elderly with MCI had a beneficial influence on cognitive functioning in general or on EF in particular. Secondly, since many frail elderly people are unable to walk, this study examined whether very mild physical activity like hand and face exercises yielded the same positive effects as walking.

It is a very important finding that physical activity, irrespective of its intensity and/or nature, improves EF such as cognitive flexibility, set-shifting, planning, and purposive action (Category Naming and Trail-making $A + B$), in the oldest old with MCI. Although the elderly with MCI who participated in the present study live in a combined home for the elderly/nursing home, a large number of elderly with MCI still live at home. The onset of dementia and hence the moment of institutionalization could be postponed by maintaining or improving the level

Table III.   Means and standard deviations of the various neuropsychological tests of the walking group, the hand/face group and the control group.

Neuropsychological tests	Walking group						Hand/Face group						Control group					
	Pre		Post		Del		Pre		Post		Del		Pre		Post		Del	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Executive functions																		
Category naming	22.60	9.68	24.80	11.37	22.29	8.88	24.62	9.26	25.69	8.14	23.00	6.25	21.60	8.58	20.27	9.51	21.62	7.89
Trail-making A+B	378.00	242.05	339.67	207.41	415.64	278.58	349.92	147.62	273.15	139.85	296.33	176.30	210.67	110.96	253.73	150.03	180.10	114.13
Memory																		
Digit span	10.47	3.04	10.80	3.10	10.07	2.70	9.54	2.82	10.31	2.78	10.56	2.70	10.80	2.96	10.93	2.69	11.23	3.40
Visual memory sp.	11.80	3.78	11.60	3.23	12.36	4.48	10.62	1.81	11.46	2.40	11.22	3.35	10.47	2.80	11.21	3.24	11.50	4.08
RBMT faces	13.33	6.13	15.20	5.39	14.57	5.29	11.62	6.42	12.46	5.11	14.67	3.32	12.80	4.95	13.14	5.86	11.00	4.94
RBMT pictures	36.93	7.29	36.93	6.45	36.14	11.67	35.85	9.00	36.00	3.65	34.67	7.48	32.80	7.51	34.46	5.67	31.67	9.06
VLMT																		
Direct recall	34.95	13.22	41.00	15.14	43.57	17.91	36.23	15.47	37.00	18.21	41.67	19.96	28.73	14.19	33.33	16.53	33.00	18.41
Delayed recall	7.53	4.75	7.67	4.92	7.64	4.96	4.62	4.96	5.85	5.64	5.44	6.21	3.20	4.07	4.27	4.96	3.85	5.63
Recognition	36.33	12.40	36.67	11.56	35.86	13.23	33.23	8.24	34.23	11.78	33.56	7.54	33.79	7.19	35.07	4.96	35.67	7.09

Visual memory sp., Visual memory span; RBMT, Rivermead Behavioural Memory Test; VLMT, Verbal Learning and Memory Test.

of autonomy of the elderly with MCI. Particularly in this group of elderly, pharmacological treatment could be most effective in stabilizing cognitive functioning (Lehmann et al., 2003). The findings of the present study suggest that also non-pharmacological interventions like mild physical activity have a beneficial influence on EF. These results imply that elderly with MCI, particularly those who are sedentary, should be encouraged to initiate daily physical activity. Interestingly, the improvement in verbal capacity was observed in previous studies with elderly with a normal mental status (Stones & Dawe, 1993) and with AD patients (Friedman & Tappen, 1991; Palleschi et al., 1996).

The present findings further show that neither type of physical activity had a beneficial influence on episodic memory processes. Molloy and colleagues (1988) also failed to observe positive effects of a mild exercise program on memory. The difference between that study and the present one is that assessment took place 3–7 days after the final treatment whereas in the present study neuropsychological assessment followed directly after the last treatment. The differential effect of physical activity on cognition pleads against a more general effect, for example, an increase in arousal and/or motivation. Instead, by means of for example, increased cerebral blood flow (Hawkins, Kramer & Capaldi, 1992), physical activity such as walking particularly improves performance on tasks appealing to EF and associated with frontal lobe functioning (Emery, Schein, Hauck & MacIntyre, 1998). Indeed, in patients with cardiovascular risk factors, such as hypertension, only impairment in the frontal-executive functions, not memory and visuospatial function, were associated with the cardiovascular risk factors (Pugh, Kiely, Milberg & Lipsitz, 2003). With respect to hand/face exercises, this type of activity is strongly associated with frontal lobe functioning (Coan, Allen & Harmon-Jones, 2001; Kawashima et al., 1996).

The question arises whether, on the basis of the present findings, it is justified to conclude that physical activity has a 'selective' effect on cognition, that is, only improvements in EF (Category Naming, Trail-making $A + B$) were observed. With respect to Category Naming, the improvement after walking and hand/face exercises seems to be rather small at first sight. On the other hand, the effect sizes are large ($\eta^2 = 0.16$) and medium-large ($\eta^2 = 0.12$), respectively. In addition, after cessation of treatment, the beneficial effects disappeared during the treatment-free period, which could be considered as a pro for a real treatment effect. Similar considerations are valid concerning the scores on Trail-making $A + B$. The observed improvement had a medium-large effect size in the walking group ($\eta^2 = 0.10$) and a large effect size in the hand/face group ($\eta^2 = 0.19$). Moreover, the performance on both tests vanished after the treatment-free period.

A related question is whether the observed improvements in EF were also of clinical relevance. After all, one might expect an improvement in autonomy considering its strong relation with EF (Workman et al., 2000). A nursing assistant who knows the participant the best but is not informed about the purpose of the study would be the most obvious person to establish such a clinical effect. However, due to a chronic shortage of nursing staff, the nursing assistants work on various wards and may therefore fail to notice changes in the participant's behaviour. Together with the large wastage among the nursing staff, a reliable clinical assessment is hardly possible. Nevertheless, in future studies the evaluation of the clinical relevance of the treatment effect should be a key issue.

In sum, the present findings must be interpreted with great caution. More studies with larger samples are needed before firm conclusions with respect to the effectiveness of mild physical activity on EF in the oldest old with MCI can be drawn.

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