Association Between Mind-Body and Cardiovascular Exercises and Memory in Older Adults

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OBJECTIVES: To compare the memory function of older adults who regularly practiced mind-body (MB) or cardiovascular (CV) exercises with that of those who did not engage in regular exercise. Older adults who engaged in both types of exercise were also included to examine the combined effects.

DESIGN: Cross-sectional study between 2002 and 2003.

SETTING: Older adults from a local community in Hong Kong.

PARTICIPANTS: One hundred forty adults aged 56 and older.

MEASUREMENTS: The Hong Kong List Learning Test was used to assess the memory of all participants. It is a clinically validated Chinese verbal-memory test that measures various aspects of memory processing, including learning, retention, and retrieval abilities. MB and CV exercises were defined using three dimensions: motion speed, emphasis on relaxing the mind, and conscious control of movement.

RESULTS: Older adults who practiced MB or CV exercises demonstrated a similar level of memory function, and their learning and memory was better than that of individuals who did not exercise regularly. Those who practiced both types of exercises outperformed all other groups, even after corrected for the total hours of exercise. Although memory change across age was found in older adults who did not exercise, this trend was not observed in individuals who practiced MB exercises.

CONCLUSION: Practicing both MB and CV exercises appears to have a combined effect that might help to preserve memory in older adults. In addition, MB exercises may be considered as an alternative training for older adults who cannot practice strenuous physical exercise. **J Am Geriatr Soc 53:1754–1760, 2005.**

Key words: mind-body exercise; cardiovascular exercise; memory; aging

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Memory decline is a prominent feature in the preclinical stage of dementia because it is often observed before declines in other cognitive domains such as language.[1,2] Therefore, it is usually regarded as an early marker of dementia,[3–5] and identifying factors that can protect against memory decline or development of dementia becomes significant.

With evidence from cross-sectional,[6,7] longitudinal,[8,9] and experimental[10] studies, physical exercise is found to be a significant factor that could facilitate the preservation of cognitive or memory functions in elderly individuals. Although there is some disagreement on the effects of physical exercise,[11] higher physical activity level is generally found to be associated with less-severe cognitive impairment in elderly individuals.[9,12,13] Of various cognitive functions, memory function, especially verbal, is relatively sensitive to the protective effects of physical exercise. A recent study reported a significantly weaker association between age and decline in delayed verbal recall in a physically active elderly sample.[13]

Although the notion that physical exercise protects against memory declines seems to be well supported, most of these findings have been based on studies of cardiovascular (CV) exercises, such as jogging and swimming. The cognitive benefits of mind-body (MB) exercises, another form of physical exercise long used in the East and now increasingly popular in the West, remain unexplored. A unique characteristic of MB exercises is that they emphasize the conscious control of each body movement. To pay attention to each movement, the exercises typically involve slow motion. Moreover, those who perform it are requested to maintain a peaceful and relaxed state of mind. Notwithstanding this, some MB exercises, in common with CV exercises, are classified as moderate-intensity exercise with similar physiological benefits, such as improved pulmonary

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function[14,15] and reduced blood pressure.[16,17] It is conceivable that MB exercises could be an alternative type of physical exercise that might help preserve the memory functions of older adults. To examine whether this is so, the present study compared the memory functions of older adults who regularly practiced MB exercises with those of individuals engaging in CV exercises.

To test the specific effect of exercise on memory function against other functions, language ability was also assessed. In contrast to memory, which is vulnerable to aging, language usually remains relatively well preserved with advancing age.[1,18] Therefore, it was anticipated that physical exercise would have an effect on memory but not on language.

METHODS

Participants

One hundred forty older adults (114 women, 26 men) were selected from a database of approximately 300 participants recruited from the community through advertisements who participated voluntarily in a research project on aging in Hong Kong during 2002/2003. Older adults whose first language was not Chinese and who had a history of psychiatric or neurological problems were excluded. Cognitive ability was determined using the Chinese version of the Mattis Dementia Rating Scale (CDRS);[19] those with the CDRS score below the cutoff score for dementia were excluded. Their ages ranged from 56 to 78, and level of education ranged from 0 to 16 years. The participants were interviewed and assessed individually with written consent, and the clinical research ethics committee of the Chinese University of Hong Kong approved the study.

Materials and Procedures

Physical Activities Questionnaire

The participants reported the frequency and duration of the MB (e.g., tai chi chuan) and CV (e.g., dancing and tennis) exercises they practiced. Ten choices of frequencies, ranging from never to once a month to once a day were provided. The frequency and total hours involved per week were then calculated. Based on their reported activities, they were classified into four groups; the MB group practiced MB exercises at least once a month, the CV group engaged in CV exercises at least once a month, the CV+MB group practiced both types of exercises at least once a month, and the NO group did not engage in any physical exercise.

Measures of Physical Conditions

Medical Conditions. Each subject was asked to report all medical conditions, including vision and hearing problems, cardiovascular diseases, and digestive system diseases.

Peak Flow Measure. The Mini-Wright peak flow meter (Model CE 0120, Clement Clarke International Ltd, Essex, United Kingdom) was used to measure pulmonary peak expiratory flow rate. The participants were asked to blow as hard as possible through the meter while standing. The average reading of three trials (in liters per minute) was taken as an index of pulmonary function.

Blood Pressure and Resting Heart Rate. Participants' diastolic and systolic blood pressures and resting heart rates were measured using a blood-pressure monitor (OSIM OS505, OSIM International, Singapore).

Measures of Cognitive Functions

General Mental Function. The CDRS,[19] translated from its original version,[20] was used to assess general cognitive function and to exclude the possibility of dementia. The maximum score is 144.

Memory. The Hong Kong List Learning Test—Form One (HKLLT),[21] a locally validated verbal-memory test,[22,23] was used to assess verbal memory. The test, which consists of a list of 16 two-character Chinese words, was presented orally three times. Participants were asked to recall as many words as possible after each learning trial and after 10-minute and 30-minute delayed-recall trials. They were then orally presented a recognition list of 16 target words and 16 distracters for discrimination. The total learning score, with a maximum of 48 points, was obtained by summing the number of words recalled during three learning trials. The delayed-recall scores, each with a maximum of 16 points, were also analyzed. Discrimination score in the recognition task was calculated using the equation

$$((\text{Correct hits} - \text{False alarms})/16) \times 100$$

Language. A modified Chinese version of the Boston Naming Test (CBNT)[24] was used to assess the language ability. The test consists of 30 line-drawing objects selected from the original 60 items of the BNT[25] according to the cultural relevancy in the local population. The number of correctly named items was analyzed.

Statistical Analyses

Analyses of variances (ANOVAs) using SPSS version 11.0.1 (SPSS Inc., Chicago, IL) were performed to explore group differences in demographic and clinical characteristics. To control for the inflation of the overall type I error because of the multiple comparisons, the Bonferroni correction for the alpha level was adopted. When group differences were found, Tukey honestly significant difference (HSD) post hoc analyses were also performed. Partial etas-squared were computed to measure the effect sizes, which ranged from very small (<0.01) to small (0.01–0.05) to medium (0.06–0.13) to large (≥ 0.14).[26]

To examine any difference on the negative relationship between age and memory by practicing MB or CV exercises, the regression coefficients for each group were computed and compared with those of the control group using regression analyses with dummy coding and *t* tests.[27] The coefficients represented the associated difference in memory scores with a unit increase in age.

RESULTS

Demographic Characteristics and Physical Activity Frequency

As shown in Table 1, the four groups were matched in terms of age, education, and physical condition, although significant group differences were found in the frequency and total hours of physical exercises per week. Therefore,

Table 1. Demographic and Clinical Characteristic of Older Adults

Characteristic	No Regular Physical Exercises (n = 35)	Cardiovascular Exercises (n = 35)	Mind-Body Exercises (n = 35)	Cardiovascular and Mind-Body Exercises (n = 35)	F	Degrees of Freedom	P-value
	Mean ± Standard Deviation						
Age	65.37 ± 4.65	66.11 ± 4.57	66.34 ± 5.77	64.94 ± 4.80	0.60	3, 136	.62
Education, years	5.51 ± 4.38	5.91 ± 3.40	5.57 ± 4.27	6.14 ± 2.82	0.22	3, 136	.89
Number of medical conditions	2.26 ± 1.31	1.57 ± 1.09	2.11 ± 1.45	1.43 ± 1.01	3.79	3, 136	.01
Peak expiratory flow, L/min	297.38 ± 90.81	338.45 ± 90.64	319.20 ± 82.21	350.95 ± 87.96	2.48	3, 136	.06
Systolic blood pressure, mmHg	144.87 ± 22.72	138.48 ± 22.61	129.79 ± 17.46	139.48 ± 19.90	2.94	3, 122	.04
Mind-body exercises							
Number of times per week	—	—	6.70 ± 1.00	6.70 ± 1.00	0.00	1, 68	1.00
Total hours per week	—	—	7.74 ± 4.29	7.65 ± 3.41	0.01	1, 68	.93
Cardiovascular exercises							
Number of times per week	—	4.15 ± 2.87	—	4.38 ± 4.71	0.06	1, 68	.81
Total hours per week	—	4.47 ± 4.06	—	4.18 ± 4.66	0.08	1, 68	.78
Total exercise frequency							
Number of times per week	—	4.15 ± 2.87	6.70 ± 1.00	11.08* ± 4.96	38.03	2, 102	<.001
Total hours per week	—	4.47 ± 4.06	7.74 ± 4.29	11.83* ± 5.73	21.10	2, 102	<.001
Mattis Dementia Rating Scale Adjusted score, Chinese version	151.72 ± 9.83	155.95 ± 4.95	154.10 ± 7.43	156.35 ± 5.12	3.09	3, 136	.03
Boston Naming Test score, Chinese version	20.83 ± 4.42	22.14 ± 3.69	21.97 ± 3.72	22.46 ± 3.01	1.26	3, 136	.29

* Significantly different from cardiovascular exercises and mind-body exercise groups.

additional analyses were performed with the groups further matched in total weekly exercise hours.

Cognitive Performance

Global Cognitive Function and Linguistic Performance

Participants' global cognitive function, measured using the CDRS, and language performance on the CBNT were similar (Table 1). This supports the hypothesis that language function is less affected by physical exercise.

Memory Function: Acquisition, Retention, and Recognition

The information processing model is commonly used to perform detailed analyses of memory function, specifically the ability to learn newly presented information and to retain and retrieve it. Analyzing memory function with the information processing model has significant clinical value, given that the different etiologies of brain disorders will affect the various levels of processing.[28,29] In addition, it has been reported that a rapid rate of forgetting is a strong predictor of the future development of dementia in normal elderly individuals.[4]

Acquisition. Table 2 shows details of performances of older adults on the HKLLT. A group- (NO, MB, CV, CV+MB) by-trial (1–3) repeated measures ANOVA was performed to examine the learning abilities, and the main effect of group was significant ($F_{3,136} = 2.97$, $P = .03$). Post hoc Tukey HSD analyses showed that the CV+MB group learned significantly more words than the NO group ($P = .02$). The performances of the CV group and the MB group lay between them and were not significantly different from each other.

Retention. A group-by-delay (10-minute and 30-minute delayed-recall trials) repeated-measures ANOVA was performed to examine the verbal retention after short and long delays. Again, the main effect of group ($F_{3,136} = 5.93$, $P = .001$), was significant. Post hoc comparisons showed that, on average, the CV+MB group recalled significantly more words than the CV ($P = .005$) and NO ($P = .001$) groups. The CV+MB group retained about 30% and 36% more words than the CV and NO groups in the delayed-recall trials, respectively. Although the MB group tended to retain fewer words than the CV+MB group, the difference was not statistically significant. Because the number of words learned during three learning trials affected the delayed-recall scores, their retention abilities were also assessed with the rate of forgetting. Specifically, the rate of forgetting was determined using the formula

$$((\text{Number of words recalled in the delayed trial} - \text{number of words learned in learning trial 3})/\text{number of words learned in learning trial 3}) \times 100\%$$

A group-by-delay (10-minute, 30-minute) repeated-measures ANOVA was conducted on the rates of forgetting over the short and long delays. The results showed that the main effect of the group was marginally significant ($F_{3,136} = 2.26$, $P = .08$), and the effect size was approaching medium. Although the greatest difference was again observed between the CV+MB group and the NO group, the performances of the CV group and the MB group again were not significantly different. Specifically, although the

MB group forgot approximately 16% of learned materials after 10 minutes, the CV group forgot about 18%. The NO group forgot approximately 20% of the learned materials, and the CV+MB group forgot only approximately 7% of them. Similarly, under the long-delay condition, the MB group forgot approximately 21% of the words learned, and the CV group forgot approximately 24%. Although the NO group recalled 28% fewer words than they learned in trial 3, that information loss was only 14% for the CV+MB group. These results seem to support the hypothesis that the NO group had a relatively faster forgetting rate than the CV+MB group.

Retrieval. To determine whether group differences in the recall trials were attributable to differences in retrieval ability, further analyses were conducted on the recognition task of the HKLLT.

Correct Hits. The results of ANOVA on the number of correct hits revealed significant group differences ($F_{3,135}$ = 6.09, P = .001). Further comparisons using Tukey HSD showed that the three groups performing physical exercise (MB (P = .006), CV (P = .02), and CV+MB (P = .001)) identified significantly more correct responses than the NO group.

False Alarms. ANOVA on the number of false-alarm errors also revealed significant group differences ($F_{3,135}$ = 5.33, P = .002). Post hoc results revealed that the CV group committed more false-alarm errors than the CV+MB group (P = .001).

Discrimination Score. Considering that the number of correct hits might overestimate the participant's ability to distinguish the target items from the distracters, a discrimination score was calculated that also took into account the number of false-alarm errors to correct possible bias. ANOVA revealed significant group differences ($F_{3,135}$ = 5.79, P = .001). Post hoc analyses suggested that the CV+MB group had significantly higher discrimination scores than the CV group (P = .01) and the NO group (P = .001). Taken together, these results suggested that their lower retrieval abilities might not have totally explained the relatively poorer recall performances of the NO and CV groups because, on the recognition task, which requires minimal retrieval abilities, their performances continued to be poorer.

Relationship Between Total Hours of Exercises per Week and Verbal Memory

The results suggested that older adults practicing both MB and CV exercises outperformed all other groups, but given that the CV+MB group had significantly more total hours of exercise than the CV and MB groups, it is unclear whether these results are attributable to differences in the hours spent in exercises. To examine this, a subset of 17 individuals, matched in total exercise hours spent per week, was selected from the original sample (Table 3).

The group differences in verbal memory were generally consistent with the above analyses. Medium to large effect sizes, some statistically significant, were observed in the CV+MB group in their verbal learning ($F_{3,64}$ = 1.27, P = .29), 10-minute delayed recall ($F_{3,64}$ = 4.21, P = .009), 30-minute delayed recall ($F_{3,64}$ = 1.64, P = .19), and recognition scores ($F_{3,64}$ = 4.69, P = .005). The NO group tended to have lower verbal retention and recognition scores than the CV+MB group. The difference between the MB and CV groups was more obvious, especially in their recognition scores, on which the MB group correctly discriminated 15% more target words than the CV group. These analyses suggest that the total hours of exercise per week did not have significant effects on the difference in memory performance between the groups.

Relationship Between Physical Exercise and Memory Performance Across Age

Further analyses were performed to explore the relationship between age and memory performance. The decreases in the memory scores associated with 1-year increases in age were greatest in the NO group, ranging from 0.3 to 1.7 units per year. Less change in memory performance across age was found in the MB group (10-minute delayed-recall, t = 2.68, P = .008; 30-minute delayed-recall, t = 2.97, P = .004; and recognition scores, t = 1.99, P = .049) than in the NO group, and the decrease ranged from 0.0 to 0.2 units with incremental change in age. The trend demonstrated by the CV and the CV+MB groups was not significantly different from the NO group. Hence, the results appear to support the hypothesis that, for the MB group, there was less decrease in verbal memory performance with age than for the other three groups.

DISCUSSION

The present findings revealed a significant association between practicing MB and CV exercises and better memory in older adults. Specifically, performance on the verbal memory test of older adults who regularly practiced MB exercises was not statistically different from that of their counterparts who regularly performed CV exercises. Their performance was similar in all dimensions of memory processing, including learning, retention, and retrieval. This similarity suggests that exercise, whether MB or CV, might help older adults preserve their ability to learn, as well as their ability to retain newly learned information.

Whereas previous studies reported that elderly Americans who regularly exercised performed better on memory tests than those who did not,[10,13] the present findings reveal the positive effects of CV exercises on late-life memory preservation in a Chinese population, whose diet, living habits, and social structure differ greatly from those of the American population. Hence, it seems that older adults with different cultural backgrounds benefit from physical exercise. In addition, given that the present findings suggest that MB exercises produce an effect similar to that of CV exercises, MB exercises can be considered as an alternate model of physical exercise for older adults who cannot exercise vigorously to lower the risk of sports-related injuries and cardiac hazards.

Leisure, but not physical, activities have been found to be associated with a reduced risk of dementia in a recent study.[11] The current results were in some way consistent with this. Although elderly individuals who did not exercise regularly and those who practiced CV exercises demonstrated a similar change in memory performance across age, this change was significantly lower in the individuals who practiced MB exercises. Although a causal relationship cannot be inferred at this stage, these findings suggest that

Table 2. Comparisons of the Memory Profiles on the Hong Kong List Learning Test

Memory Profile	NO (n = 35)	CV (n = 35)	MB (n = 35)	CV+MB (n = 35)	F	Degrees of Freedom	*P*-value	Post hoc	Effect Size[†]
	Mean ± Standard Deviation								
Acquisition									
Trial 1	4.49 ± 1.87	4.97 ± 1.42	4.89 ± 1.75	5.09 ± 2.09	0.74	3, 136	.53		0.02[‡]
Trial 2	7.09 ± 2.58	7.89 ± 2.00	7.71 ± 1.95	8.66 ± 1.81	3.30	3, 136	.02		0.07[§]
Trial 3	8.37 ± 2.64	8.91 ± 2.57	9.11 ± 2.51	10.11 ± 2.18	3.02	3, 136	.03		0.06[§]
Total learning	19.94 ± 6.25	21.77 ± 5.05	21.71 ± 5.32	23.86 ± 5.28	2.97	3, 136	.03		0.06[§]
Retention									
Trial 4*	6.86 ± 3.14	7.09 ± 2.31	7.66 ± 2.70	9.29 ± 1.95	6.39	3, 136	<.001	CV+MB> CV, MB, NO	0.12[§]
Trial 5*	6.26 ± 3.46	6.60 ± 2.60	7.20 ± 2.79	8.60 ± 2.17	4.78	3, 136	.003	CV+MB> CV, NO	
									0.10[§]
10-minute forgetting rate	−20.07 ± 25.32	−18.27 ± 23.55	−16.46 ± 24.16	−6.84 ± 15.15	2.43	3, 136	.07		0.05[‡]
30-minute forgetting rate	−28.68 ± 30.11	−23.50 ± 32.70	−21.03 ± 27.20	−14.38 ± 14.63	1.69	3, 136	.17		0.04[‡]
Retrieval									
Correct hits*	12.88 ± 2.52	14.20 ± 1.49	14.34 ± 1.55	14.60 ± 1.54	6.09	3, 135	.001	CV+MB, CV, MB>NO	0.12[§]
False alarm*	1.06 ± 1.65	1.91 ± 2.03	1.11 ± 1.47	0.46 ± 0.61	5.33	3, 135	.002	CV>CV+MB	0.11[§]
Category-related errors	0.21 ± 0.48	0.31 ± 0.63	0.17 ± 0.45	0.11 ± 0.40	1.00	3, 135	.40		0.02[‡]
Sound-related errors	0.65 ± 0.81	1.09 ± 0.85	0.80 ± 0.90	0.40 ± 0.60	4.50	3, 135	.005	CV>CV+MB	0.09[§]
Unrelated errors	0.21 ± 0.69	0.54 ± 0.95	0.26 ± 0.51	0.17 ± 0.71	1.88	3, 135	.14		0.04[‡]
Discrimination score*	73.90 ± 20.15	76.79 ± 17.78	82.68 ± 13.05	88.39 ± 10.30	5.79	3, 135	.001	CV+MB>CV, NO	0.11[§]

* Significant at the adjusted alpha of 0.004. The performance of the mind-body exercises group (MB) was not statistically different from that of the cardiovascular exercises (CV) group in learning, retention, and retrieval.
[†] Partial eta-squared was used to compute effect size: [‡]small, [§]medium. CV+MB = cardiovascular and mind-body exercises; NO = no regular physical exercise.

Table 3. Demographic Characteristics of the Elderly Subgroups After Matching the Weekly Amount of Physical Exercise of the Exercising Groups

Characteristic	NO (n = 17)	CV (n = 17)	MB (n = 17)	CV+MB (n = 17)	F	Degrees of Freedom	*P*-value	Effect Size*
	Mean ± Standard Deviation							
Age	64.88 ± 4.91	66.94 ± 4.31	65.76 ± 5.64	65.47 ± 5.90	0.47	3, 64	.71	0.02‡
Education, years	5.82 ± 4.39	5.53 ± 3.48	5.82 ± 4.54	5.71 ± 2.57	0.02	3, 64	1.00	0.00†
Exercise, hours per week	—	7.48 ± 4.00	7.38 ± 4.06	7.82 ± 1.81	0.08	2, 48	.93	0.00†

* Partial eta-squared was used to compute effect size: †below small, ‡small. The number of total hours spent on physical exercise per week was matched in the cardiovascular exercise (CV), mind-body exercise (MB), and cardiovascular plus mind-body exercise (CV+MB) groups.

MB exercises may be a protective factor for dementia. Because MB exercises emphasize mindfulness and less-vigorous movements, they may share some characteristics (e.g., less vigorous, require more cognitive processing) with leisure activities. Therefore, MB exercises, similar to leisure activities, may be associated with a lower risk of dementia, although further investigation with empirical studies is needed to explore this speculation.

Older adults who practiced both types of exercises (CV+MB) performed significantly better than the other groups on verbal memory. Furthermore, the pattern of group difference remained unchanged after adjusting for age, education, and duration of exercise. It is interesting that although the CV+MB group performed better on tests than the MB group, the latter group demonstrated less change in memory with age. Therefore, different exercise patterns may have different effects on memory function (e.g., enhancement vs protection).

Although the findings from the present study are encouraging, several limitations should be addressed. First, the data on the frequency and duration of exercise relied on participants' self-reports, which might have affected the validity of the data. Moreover, information on their exercise histories was not available to evaluate possible factors in explaining the exercise preferences of the participants. Finally, because it was a cross-sectional study, the findings cannot reveal a causal relationship. Therefore, further longitudinal or experimental studies are needed to test the possible causal effects of these cross-sectional observations and explore the potential of practicing MB exercises as a form of protection against cognitive decline and dementia.

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