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THE EFFECTS OF A THREE-MONTH EXERCISE PROGRAMME ON NEUROPSYCHOLOGICAL FUNCTION IN ELDERLY INSTITUTIONALIZED WOMEN: A RANDOMIZED CONTROLLED TRIAL

Summary

This randomized controlled trial examined the effect of a 3-month exercise programme on neuropsychological function in a population of very elderly institutionalized women. Baseline neuropsychological testing was performed, and following 3 months of exercise or control intervention, subjects were retested 3–7 days after the completion of the study period. Apart from the Word Fluency Test, there was no significant improvement in any of the neuropsychological test scores. This study may not have shown any significant improvement in neuropsychological function because our exercise programme was too light to improve aerobic fitness, or because neuropsychological tests were repeated 3–7 days after exercise was completed and any acute effects of exercise may have disappeared by that time.

INTRODUCTION

In the adult years, activity is at its highest in the 20s and early 30s. Activity and fitness decline as energetic leisure-time pursuits are abandoned, and these remain stable until retirement, when a second major decline occurs [1]. With ageing there also is a decrease in memory [2], perception and intellectual function [3, 4]. This decline in mental function may be related to physical fitness [5–11]. Physically fit elderly scored higher on fluid intelligence tests than age-matched sedentary controls [5, 9]. Molloy et al. [11] and Davey [6] have reported an acute improvement in memory immediately following exercise. People who have completed exercise programmes have shown improvement in physical fitness [10, 12–14] and neuropsychological function [7–10]. This improvement in neuropsychological function correlated with the increase in aerobic fitness and maximal oxygen consumption (mVO_2), that occurred, following regular physical activity [10].

Most of these studies have been performed on normal noninstitutionalized subjects [5, 6, 9–15]. Some of the studies performed on the institutionalized elderly have had poor experimental designs, have studied only small numbers and have shown conflicting results [7, 8, 16–19]. Since the institutionalized elderly differ in many respects from younger community dwellers, it is not possible to assume that conclusions from studies in one group apply to the other.

At present it seems reasonable to conclude that regular physical activity slows some of the age-related changes in the central nervous system, that occur with ageing [5, 7, 9, 10]. However, it is not clear if exercise begun late in life can significantly affect neuropsychological function in the institutionalized elderly. At least part of the mental debility that the elderly institutionalized display may result from inactivity and disuse. If this is so, then it may be possible to reverse part of the mental disability with regular activity, and the stimulation of an exercise programme. On the other hand the institutionalized elderly may be in a phase of life where there is an irreversible loss of reserve, such that exercise may not produce any functional improvement. The majority of previous studies that have examined the effects of exercise on cognitive function in the elderly have used the young elderly. Dustman et al. [10] showed a significant improvement in 'elderly' community-dwelling subjects after a 3-month exercise programme. Their subjects were aged 55–70 years. Powell [7] also reported a significant improvement in cognitive function in institutionalized elderly subjects, following a 4-month exercise programme. Their subjects were aged 59–89 (mean age 69) years. Diesfeldt and Diesfeldt-Groenendijk [8] also found an acute improvement in cognitive function in very elderly institutionalized subjects, who had a mean age of 82 years. Molloy et al. [11] reported an acute improvement in mental performance in elderly subjects aged 60–85 (mean 66) years when cognitive function was assessed immediately after completion of 45 min of exercise. However, no studies have examined the long-term effects of an exercise programme on very elderly institutionalized subjects. The frail elderly may be unable to tolerate enough vigorous activity to increase their level of fitness, and mVO_2, that may be necessary to improve neuropsychological function [10]. Studies that have reported an improvement in neuropsychological function have repeated testing soon after exercise, on the day that patients exercised. Since an acute improvement in memory and neuropsychological function in the elderly immediately following exercise has been documented [6, 7, 11], it is possible that at least part of the improvement that these studies have reported may be an acute effect that is not maintained on days that the subjects do not exercise.

This study compares the effects of a 3-month exercise programme with a control intervention, on neuropsychological function, in a population of elderly institutionalized women. Baseline neuropsychological testing was performed, and then patients were randomized to control or exercise groups. Following 3 months of exercise or the control intervention, subjects were retested 3–7 days after the completion of the study period. In this way, by studying the patients on a day when they were not exercising, we hoped to avoid any acute improvement that exercise may have caused.

Methods

Subjects

Women over 70 years of age who resided at a nursing home were recruited for the study. We selected those who could walk without assistance, who were free of any disability, or disease, such as stroke, Parkinson's disease, or blindness, that compromised their ability to exercise. Each subject was interviewed and examined by a doctor to assess her suitability for exercise before admission to the study. Informed consent was obtained from each subject who was randomly allocated to control or exercise group.

Study Intervention

(a) *Exercise programme*

Women allocated to the exercise programme attended exercise classes three times weekly for 3 months. These classes increased in duration from 10 min at the beginning, to 35 min as the subjects' tolerance improved. Each exercise class was designed to improve balance, co-ordination and muscle strength. The exercises were light, and were not intended to increase aerobic fitness. Few patients experienced increases in heart rates greater than 10–20 beats/min for sustained periods of time. Classes were conducted by a physiotherapist.

(b) *Control group*

Control women carried on with their normal activities during the 3-month study period.

Neuropsychological Testing

All subjects underwent a battery of neuropsychological tests at the start, and after 3 months' exercise or control interventions. They were retested 3–7 days after the completion of the control period or exercise programme. The tester was 'blind' to whether subjects were in the control or exercise group. The battery of neuropsychological tests employed took approximately 30–45 min to complete.

Testing

The following battery of neuropsychological tests was used. It has been found suitable for use with the demented elderly [11, 20, 21].

1. *Colour Slide Test*—This test measures memory, language and visual perception [8]. Slides are projected and the resulting images are so large that the elderly could easily see them. Seven slides of common objects, such as a chair, tree and fruit, were shown four times in the same order, in each case. Two alternative sets of slides were used for each test.

The first time the slides were shown without any instruction to learn them, but merely to check that the subject could recognize and name each object. At the conclusion of this first showing, subjects were asked to name as many of the objects as they could (Immediate Free Recall). During the next three showings (in the same order), the task was set to commit the objects to memory. After each showing the subjects were asked to name as many objects as possible, in any order they chose. This is the Total Recall Test.

Recognition test—At the end of the testing session (30–45 min), the seven slides shown earlier in the Free Recall task were shown later intermixed with three new slides. Subjects were asked to name which slides they had seen before and which were new. The data from these slide tests were analysed as follows:

(a) *Immediate free recall* score. The number of correctly reproduced items after the first trial. Score 0–7.
(b) *Total recall* score. The sum of the correctly reproduced items after the three learning attempts. Score 0–21.
(c) *Recognition test.* The number of pictures subjects recognized as having seen, or not seen previously. Score 0–10.

2. *Digit Symbol* [22]—This is a Wechsler Adult Intelligence Scale (WAIS) subtest. Subjects were given a series of numbered symbols and then asked to draw the appropriate symbols below a list of random numbers. The score was the number of correctly made matches in 1 min.

3. *Digit Span* [23]—This is a WAIS subtest which measures recent memory. The subject's score was the number of digits that she could repeat forwards, plus the number that she could correctly recall in reverse order.

4. *Logical Memory*—This is a Wechsler Memory Scale subtest [23]. The test is intended to measure immediate recall of logical memory. It consists of a passage which was read out to the subject. The subject's score was the number of ideas which she spontaneously remembered from the passage. A different story was used for the re-test.

5. *Word Fluency Test*—This test is similar to Controlled Word Fluency [24] and the Set Test [25] and is part of the Western Aphasia Battery [26]. Subjects were asked to name as many objects within a specific category as they could think of in 1 min.

6. *Mood Test*—This is part of the Multi-focus Assessment Scale for the frail elderly [27].

7. *Geriatric Depression Scale* [28]—This is a scale designed specifically for the elderly to avoid most of the problems associated with the measurement of depression in a geriatric population.

8. The *Mini Mental State Examination* [29]—This is a screening instrument originally developed for use in clinical drug studies. The scale assesses the subject's orientation to time and place, instantaneous recall, short-term memory, ability to perform serial subtractions and constructional capacities and the use of language.

RESULTS

Fifty women were admitted to the study and were randomly assigned equally to the two groups; 45 completed the study. In the exercise group, one subject lost interest and one was too busy to attend exercise classes. In the control group, one participant became ill, one was depressed, and another refused to be retested. The results for the other 45 patients—22 controls and 23 exercisers—are reported here. The exercise and control groups were similar in age. The mean age was 82.0 years in the exercise group (range 73–90 years) and 83.3 years in the control group (range 73–90 years). On average, the proportion of classes attended was 71% (range 31% to 94%). The results of the neuropsychological tests are illustrated in the Table. The results of eight tests were analysed. The pre-exercise and pre-control values for each test were compared, using unpaired t tests (two-tailed). These scores were different for the digit span, and word fluency tests ($P<0.01$) but similar for all the other tests. The difference in the pre- and post-exercise scores was compared to the differences between the pre- and post-control scores for each test using unpaired t tests. The differences between pre- and post-exercise scores and pre- and post-control scores were statistically significant for the word fluency test ($P<0.025$). The total scores for each subject were computed by adding the results for all the neuropsychological tests together. There was no statistically significant difference between the total scores, when the difference in scores for the pre- and post-exercise (-5.0 ± 9.8) and the difference for the pre- and post-control (-6.8 ± 7.5) scores were compared.

Table. Means ± standard deviation of scores from neuropsychological testing at baseline (pre-) and after 3 months of exercise or control (post-)

Test	*Exercise*			*Control*		
	Pre-	*Post-*	*Difference*	*Pre-*	*Post-*	*Difference*
Immediate recall	4.3±1.3	3.9±1.5	−0.4±1.4	4.1±1.4	3.9±1.7	−0.2±1.3
Total recall	15.8±3.1	14.6±4.5	−1.1±2.6	17.1±4.3	16.7±4.8	−0.4±1.9
Recognition test	9.7±1.0	9.9±0.5	0.2±1.1	9.3±1.6	9.4±1.4	−0.1±1.3
Digit symbol	12.2±6.7**	11.2±6.1	−1.0±4.8	15.5±7.9**	15.2±9.7	−0.3±3.7
Logical memory	6.9±4.8	5.3±3.7	−1.6±3.4	9.0±5.1	6.1±3.4	−2.9±2.9
Digit span	10.5±2.1	10.3±2.1	−0.2±2.2	12.8±4.3	12.3±3.9	−0.5±1.9
Word fluency	11.6±4.9**	11.3±4.3	−0.3±2.7*	15.0±5**	12.6±5.0	−2.4±3.[illegible]
Mini mental	24.7±4.8	24.1±4.8	−0.6±2.6	24.9±4.4	24.7±5.7	−0.2±2.[illegible]

Significant difference *$P<0.025$; **$P<0.01$.

DISCUSSION

This study compared the effects of a 3-month exercise programme and control intervention on neuropsychological function in elderly institutionalized women (mean age 82 years). It is not clear at present if part of the disability that the institutionalized elderly demonstrate is due to disuse and inactivity and can be reversed with therapy or interventions such as exercise programmes. Exercise programmes have clearly been shown to be an effective method of improving fitness and neuropsychological function in younger, noninstitutionalized subjects [7, 9, 10, 12–14]. The elderly institutionalized, however, may be in a phase of life where there is an irreversible loss of reserve such that exercise cannot produce any amelioration in their disability and impairment.

Many studies that have examined the effects of exercise programmes on neuropsychological function have repeated testing on the day on which the subjects have exercised [8, 10, 16]. We have shown that exercise improved neuropsychological function acutely in a younger, fitter group of elderly (aged 60–85; mean 66 years), when repeated testing was performed immediately after exercise [11]. This confirmed the findings of Davey [6] who reported an immediate improvement in short-term memory in young students following physical exercise. It is not clear how long this acute improvement lasts, or if any improvement persists on the days that subjects do not exercise.

Diesfeldt and Diesfeldt-Groenendijk [8] reported a significant improvement in immediate recall on the Colour Slide Test, within 1 month of commencing an exercise programme, in elderly patients (mean age 82 years) in a psychogeriatric nursing home. We did not find any significant improvement in any parameter of the Colour Slide Test measured following a 3-month exercise programme, in a similar population. However, the difference in results may be accounted for by the difference in duration between completion of exercise, and the timing of retesting ('very shortly after' versus 3–7 days in our study). Diesfeldt and Diesfeldt-Groenendijk [8] may have been measuring the acute effects of exercise, whereas we noted no change 3–7 days after the exercise programme was completed. Clarke et al. [17] and Cherry [19] did not show any significant improvement in total daily activity levels, self care, neatness, or independence in activities of daily living, in institutionalized geriatric patients, when the effects of a 3-month [17] or 4-week exercise programme [19] was compared to a control intervention. Dustman et al. [10] and De Vries [13] reported the effects of exercise programmes on physical fitness in healthy community-dwelling subjects. Their subjects underwent vigorous physical activity aimed at improving aerobic fitness, which resulted in a mean increase in maximal oxygen uptake (mVO_2) of 27% in Dustman and colleagues' [10] and 30% in De Vries' [13] subjects. De Vries [13] has reported that the exercise intensity threshold required to improve cardiorespiratory fitness may be met by vigorous activity for 30–60 min daily aimed at maintaining the heart rate between 100 and 120 beats/min. Dustman et al. [10] have shown that the improvement in neuropsychological function correlated strongly with the improvement in physical fitness and mVO_2. They studied younger community dwellers, aged 50–70 years, who could tolerate such vigorous activity. Powell [7] reported a significant improvement in cognitive function in elderly institutionalized geriatric patients following a 12-week exercise programme compared to control or social therapy. The mean age of their subjects was 66.1 years, and their exercise programme was more vigorous and aerobic than our subjects were able to tolerate. Their programme included brisk walking, callisthenics, and rhythmical movements, while our exercise programme was aimed primarily at improving strength and balance. Our subjects were very elderly, and able to tolerate only light exercise. They experienced small increases in heart rate, 0–10 beats/min, which was not sustained throughout the period of activity. It is unlikely that this quantity of exercise resulted in any significant increase in mVO_2 or physical fitness. This may be the reason why there was no significant sustained improvement noted in neuropsychological function, in our subjects.

We did note a significant improvement in the Word Fluency Test ($P<0.025$) in the exercise group compared to the control group. The Word Fluency Test is similar to the Set Test [24] which was originally devised as a simple, rapid test of mental function in the elderly. It measures motivation, attention, concentration, and retrieval from long-term memory. It correlates well with scores from other neuropsychological tests [25]. However, we found no significant change in any other neuropsychological test score or in the total score of neuropsychological tests. Brinkman and Gershon [30] reviewed the results of studies performed using cholinergic drugs in normal adults and in-patients with dementia of the Alzheimer type, to assess the sensitivity of assessment procedures in the measurement of drug effects. They found that word list learning tasks and visual recognition tasks were the most useful tests and results in this study suggest that these tests may be more sensitive to change than other neuropsychological scores. However, it is not clear at present if changes in a single test, as we have reported, have any clinical significance in elderly patients. It is unlikely that a change in this single test represents any significant clinical improvement in mental function.

Our failure to show any sustained improvement may have occurred for two main reasons:

1. Our exercise programme was light, and specifically designed to improve strength and balance. It is unlikely that there was any improvement in physical fitness, or increase in mVO_2 in our group. Dustman et al. [10] have shown a strong correlation between the increase in aerobic fitness and improvement in cognitive function. It may be necessary to improve aerobic fitness in order to improve neuropsychological function. The very elderly institutionalized may not be able to exercise vigorously enough to improve physical fitness, and increase mVO_2, and so may not be suitable candidates for this type of intervention.
2. We repeated neuropsychological testing 3–7 days after completion of the exercise programme, by that time, the acute improvement in neuropsychological function which occurs immediately following exercise may have disappeared. This may account for the difference between our results and those of some previous studies [8].

We conclude that a light exercise programme, for very elderly institutionalized women, did not cause a significant improvement in neuropsychological function. It is not appropriate at present to recommend exercise for this group as a means of improving neuropsychological function.

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