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Relationships Among Physical Fitness, Cognitive Performance and Self-Concept in Older Adults

Sharna Olfman

A Thesis

in

The Department

of

Psychology

Presented in Partial Fulfillment of the Requirements
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ABSTRACT

Relationships among Physical Fitness, Cognitive Performance and Self-Concept in Older Adults

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Concordia University, 1986

The purpose of this study was to assess relations among physical fitness, cognitive performance, and self-concept in older adults. The participants included one group of athletic older adults (n = 14) and two groups of sedentary older adults; the Exercise (n = 17), and the Control (n = 14) groups. Participants were evaluated at baseline and again 14 weeks later on tests of short-term memory, psychomotor speed, self-concept, and paper and pencil measures of fitness and health. During the 14-week interval, the Exercise group completed an exercise programme which emphasized aerobic fitness training. The Control group completed an adult interest course which served as a control for social and educational gains inherent in the exercise programme. The Athletic group received no intervention. At baseline, the Athletic adults were significantly more physically fit than the members of the other two groups. Despite baseline differences in fitness, there were no differences among the groups in cognitive performance and only a trend favouring the Athletic and Control groups on the self-concept measures. Stepwise regression analyses were conducted with a slightly different sample of subjects (n = 45) for whom actual measures of aerobic fitness were available (Athletic group, Exercise group, pilot subjects, and Exercise dropouts). Physical fitness did not emerge as a predictor of baseline cognitive performance. Physical fitness did, however, emerge as a significant predictor of baseline physical, personal, and social self-concept. When change in performance from baseline to Time 2 was examined, the exercise programme was shown to effect a significant change in the physical fitness of the Exercise Participants but there was no accompanying improvement in their cognitive or self-concept scores. Interviews with the exercise particpants on completion of their programme revealed that 94 percent felt that they had benefitted physically, socially, and educationally from their involvement. At six-month follow-up, 71 percent remained active in exercise programmes. This study confirmed that older adults have the capacity to train and to improve their aerobic fitness. The results support a positive association between physical fitness and self-concept in older adults.

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I would like to thank my parents, Bess and Mitchell Olfman, and my sister Lisa Olfman for their constant support and thoughtfulness. I would also like to thank my friend and fellow student Debra Lean for introducing me to the mysteries of BMDP, and for sharing the rigours of graduate school with me.

I dedicate this thesis to the loving memory of my grandfather, Mr. Yale Leve, who instilled in me the value of education, and who inspired me to pursue research in the psychology of aging.

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It has been well established in the gerontological literature that older adults generally perform more poorly than young adults on cognitive tests of psychomotor speed and memory (Birren, Woods, & Williams, 1980; Botwinick, 1977; Botwinick, 1984; Cerella, 1985; Craik, 1977; Horn, 1982; Madden, 1985; Salthouse, 1984; Salthouse & Somberg, 1982; Spirduso, 1980). Although performance deficits have been established, their cause is still unknown. It remains unclear to what extent these cognitive deficits are an inevitable consequence of biological aging, and to what extent they can be attributed to age-related changes in older people's physical condition, their emotional state and their social situation.

Physical fitness has also been shown to decline in old age (de Vries, 1975; de Vries, 1983; Raven & Mitchell, 1980). The cause of the fitness decline is better understood than is that of the cognitive decline. To a significant extent it reflects 'deconditioning' as a function of a more sedentary lifestyle in old age, which in turn is at least partially the result of stereotyping of older adults as being more physically limited than they in fact are (de Vries, 1975; Raven & Mitchell, 1980). Contrary to the popular stereotype, healthy sedentary older adults have the capacity to train and to improve their physical conditioning (Adams & de Vries, 1973; Dehn & Bruce, 1972; de Vries, 1970; Sidney & Shephard, 1978). Preliminary findings from other laboratories suggest that the decline in cognitive performance in old age and the concomitant decline in physical fitness are related (Birren et al., 1980; Crooks, 1977). These findings also suggest that improvement in physical fitness is related to improvement in cognitive performance in the elderly (Del Rey, 1982; Diesfeldt, & Diesfeldt Groenendijk, 1977; Elsayed, Ismail, & Young 1980; Powell, 1974; Stamford, Hambacher, & Fallica, 1974). However, much of this work was conducted with institutionalized elderly patients and therefore, the extent to which it can be generalized to nonclinical elderly people is debatable.

Older adults may also experience a diminished self-concept as a result of exposure to negative stereotyping, the many significant losses which they face, and the physical changes which accompany the aging process. The stereotype of the elderly suggests that they are greatly impaired intellectually, rigid in their personalities, and no longer useful to society. Many older adults have themselves grown up with these stereotypes and to the extent that they adopt these beliefs about themselves, their self-concept may be greatly affected (Rodin & Langer, 1980). In addition, older adults must often cope with the loss of spouse, family, friends, social status, parental role, employment and socioeconomic status, leading to a diminished sense of self (Barach, 1964; Chen, 1968; Palmore, 1973; Schwartz, 1975). The physical changes which accompany the aging process may have a dramatic effect on the individual's body image and subsequent feeling of self-worth (Wiswell, 1977). Relationships between self-concept and physical fitness have been established in young adults, but this relationship has received minimal attention among older adults (Hanson & Nedde, 1974; Hilyer & Mitchell, 1978; Pauly, Palmer, Wright, & Pfeiffer, 1982).

The purpose of this research was to assess relationships among physical fitness, cognitive performance and self-concept in older adults. The background for the project is outlined in the following sections. The first section presents evidence that healthy sedentary older adults have the capacity to train and to improve their physical fitness. The second section reviews empirical support for the relationship between cognitive performance and physical fitness in older adults. The third section reviews the literature which supports the relationship between self-concept and physical fitness.

Physical Fitness and Aging

In this paper, physical fitness will refer to Physical Work Capacity which has been defined as the maximum level of physical work which an individual is capable of doing (Astrand & Rodahl, 1970; de Vries, 1983; Spirduso, 1980). The best single measure of physical work capacity is Maximal Oxygen Uptake (VO2max), also referred to as aerobic capacity. Maximal Oxygen Uptake is a measure of oxygen consumption per kilogram of body weight per minute (Astrand & Rodahl, 1970; de Vries, 1983; Raven & Mitchell, 1980). Cross-sectional studies have shown that the yearly rate of decline in VO2max is approximately .45 ml/kg/min for men, and .30 ml/kg/min for women after 20 years of age (Raven & Mitchell, 1980). In 1978, the Canadian Public Health Association administered fitness tests to 10,400 employees across Canada between the ages of 17 and 65 years. The typical pattern of decline in aerobic capacity with increasing age was upheld. For example, VO2max for the average Canadian male between 60 and 65 years was estimated to be 30.1 ml/kg/min, as compared to 52.2 ml/kg/min for the average 17 to 19 year old male. Similar results were obtained for women. Predicted VO2 max scores across different age groups of Canadian men and women are presented in Table 1.

Although some of the age-related fitness decline can be attributed to inevitable aging, and degenerative disease processes, it has been hypothesized that decreased physical activity, or 'deconditioning' in old age also contributes significantly to the decline (de Vries, 1983; Kanstrup & Ekblom, 1978; Kasch & Wallace, 1978; Raven & Mitchell, 1980). Kraus and Raab (1961) refer to the effects of the deconditioning process as 'hypokinetic disease' which encompasses a whole spectrum of somatic and mental illness induced by inactivity. An important implication of the deconditioning hypothesis is that the magnitude of the age-associated fitness decline is not fixed or inevitable. Research has supported the deconditioning hypothesis in the following ways: Healthy sedentary older adults have achieved training effects after undergoing exercise programmes, comparable in magnitude to the training effects achieved by younger adults (Adams & de Vries, 1973; de Vries, 1970; Sidney & Shephard, 1978; Souminen, Heikkinen & Parkatti, 1977). Also, athletic adults who maintain the same level of fitness training over many years show a minimal decline in aerobic capacity (Kasch & Wallace, 1977; Pollock, Miller, & Ribisl, 1978). Because physical fitness remains labile in old age, it is possible to entertain the hypothesis that improvement or maintenance of physical fitness in older adults is related to improvement or maintenance of both cognitive performance and self-concept. The studies presented below support the deconditioning hypothesis.

Fitness Training in Sedentary Older Adults. De Vries assessed the physiological effects of participation in an exercise programme on both older men (1970) and women (Adams & de Vries, 1973). In both studies,

Table I

Statistical Analysis of the (Predicted) VO_2 Max Data (ml/kg/min)

	Males					
Age (Yrs.)	17-19	20-29	30-39	40-49	50-59	60-65
Mean	52.2	48.0	42.2	37.5	33.6	30.1
Standard Deviation	5.2	5.0	3.9	3.3	3.4	3.4
Range	21.9	33.1	28.8	25.7	20.4	18.4
N	72	1.625	1.931	1,189	643	118
	Females					
Age (Yrs.)	17-19	20-29	30-39	40-49	50-59	60-65
Mean	38.4	35.7	33.1	29.4	25.0	22.7
Standard Deviation	2.6	2.9	2.9	3.1	3.8	4.7
Range	16.6	26.2	16.7	16.8	23.4	19.4
N	144	1.670	774	475	283	55

Note. From *Standardized Test of Fitness in Occupational Health*, 1978, Canada: Canadian Public Health Association.

participants (54 to 71 years) underwent a three month, three times per week exercise training regime. Each one hour class was divided into a warm-up phase of calisthenic exercises, an aerobic phase which consisted of jogging and walking, and a cool-down phase of static stretching exercises. Pre - post assessments revealed that both the men and women improved their VO2max by approximately 21 percent. De Vries concluded that not only are sedentary men and women 'trainable', but the magnitude of their capacity for training is similar to that of younger individuals if compared on a percentage basis.

Souminen, Heikkenen, and Parkatti (1977) also assessed the capacity of sedentary older men and women (M age = 69 years) to increase their aerobic capacity with fitness training. Their training programme consisted of five, one hour sessions per week for a duration of eight weeks. The sessions included walking/jogging (2x/week), swimming (1x/week), gymnastics (1x/week), and ball games (1x/week). The men improved their VO2max by 11 percent and the women displayed a 10 percent increase. The VO2max scores of the participants before and after fitness training are presented in Table 2.

In 1978, Sidney and Shephard studied a group of healthy sedentary elderly men and women before and after their participation in a 14-week, four times per week exercise programme. Each class consisted of a period of warm-up calisthenics and stretching exercises, a half-hour of brisk walking sequences, and a warm-down period of slow walking. At the end of the 14-week period, the participants' mean gain in VO2max was 3.8 ml/kg/min.

Maintenance of Fitness Training and Aerobic Capacity. Kasch and Wallace (1976) conducted a 10-year longitudinal study to assess the

Table 2

VO_2 Max Scores of Sedentary Older Adults Before and After Fitness Training

	VO_2 Max (ml/kg/min)	
Group	Pre-Training	Post-Training
Men	28.9	32.0
Women	27.9	31.3

Note: From "Effect of Eight Weeks' Physical Training of Muscle and Connective Tissue of the M. Vastus Lateralis in 69 Year Old Men and Women." by H. H. E. Souminen and T. Parkatti, 1977, *Journal of Gerontology, 32*, p. 36.

long-term effects of regular exercise on the aerobic capacity of middle-aged men. The majority of the participants were runners although a few followed a swimming or combination running/swimming programme. On average, they trained three times per week and ran 15 miles each week, at 86% of maximal physical working capacity. The men maintained the same frequency and intensity of training for 10 years. At the beginning of the study (M age = 45 years), their mean estimated VO2max was 43.7 mi/kg/min. Ten years later, their mean estimated VO2max was essentially unchanged at 44.7 ml/kg/min. This group maintained their aerobic capacity during an age span when a nine to 15 percent decline in VO2max is typically reported.

A group of eight middle-aged world class master's runners were studied over a span of five years in order to determine whether they would maintain their aerobic capacity with ongoing fitness training (Pollock, Miller, and Ribisl, 1978). Six of the athletes had a mean age of 43 years at the beginning of the study, and the other two athletes were 55 years of age initially. All of the participants ran approximately 30 miles each week for five years. No substantial declines in VO2max were recorded. The pre and post mean VO2max scores of these athletes are listed in Table 3.

The research conducted by Adams and de Vries (1973), de Vries (1970), Sidney and Shephard (1978), and Souminen et al. (1977) supports the deconditioning hypothesis. These studies are particularly powerful in demonstrating the plasticity of aerobic fitness in old age. They showed that healthy sedentary individuals could begin formal fitness training in old age and achieve a training effect similar in magnitude to that of younger adults. The research of Kasch and Wallace (1976),

Table 3

VO$_2$ Max Scores of Middle Aged and Older Master's Runners Over a Five Year Span.

	VO$_2$ Max (ml/kg/min)	
Group	Initial	Final
43 - 48 years	59.6	57.2
55 - 61 Years	52.9	50.0

Note. From "ACSM Symposium. Former Athletes in Later Life. Effect of Fitness on Aging." by M. L. Pollock, H. S. Miller, and P. M. Ribisl, P.M., 1978, The Physician and Sportsmedicine, August, p. 47.

and Pollock et al. (1978) also supports the deconditioning hypothesis by demonstrating that middle-aged men can maintain their physical fitness by holding constant their level of physical activity. Although these men were atypical because they were much more physically fit than the average adult, this does not negate the significance of these studies. It has been found that professional athletes who become sedentary in middle age display similar and sometimes greater rates of decline in aerobic capacity than more sedentary individuals (Pollack et al., 1978).

Cognitive Performance and Physical Fitness in Older Adults

Various theorists have suggested a causal relationship between the age related declines in physical fitness and the age related decrements in cognitive performance. For example, Spirduso (1980) hypothesized that physical disuse causes a decrease in metabolic demands on motor and somatosensory brain tissue, which in turn produces a decrease in circulatory blood flow, that may eventually result in neuronal destruction and a permanent decrease in the brain's functional capacity. According to Spirduso, this cycle of decline may be prevented by exercise. Birren et al. (1980) observed that with age, not only may function follow structure, but structure may follow function. In other words, the structural changes observed in the aging nervous system which are responsible for cognitive decline, may themselves reflect an adaptation to the diminished physical activity of the older individual (Birren et al., 1980). The empirical evidence in support of this hypothesized relationship between cognitive performance and physical fitness in older adults is presented below under the following headings: 1.) Cognitive Performance and Fitness in Healthy

Older Adults, 2) Psychomotor Speed and Fitness in Older Adults, and 3) Cognitive Performance and Fitness in Older Patients.

Cognitive Performance and Fitness in Healthy Older Adults. The research in this area falls into two main categories: 1) studies which examine the relationship between cognitive performance and existing level of physical fitness in healthy older adults, and 2) studies which assess the impact of participation in an exercise programme on the cognitive performance of healthy older adults. Studies by Crooks (1976), Ohlsson (1976), and Del Rey (1983), fall into the first category. Crooks (1976) conducted a correlational study to assess the relationship between physical fitness and cognitive performance in healthy older individuals ranging in age from 55 to 89 years. Cognitive measures included Similarities, Digits Forward, Digits Backward, and Block Design subtests from the Wechsler Adult Intelligence Scale (WAIS), and the Bender Gestalt Test. Fitness level was assessed by an Aerobic Activity Interview. Based on a regression analysis, Crooks found that aerobic activity level was a significant predictor of all of the cognitive measures except Digits Forward. He also found that aerobic activity level was a more significant predictor of cognitive performance than was age. This suggests that the relationship which has been traditionally established between cognitive performance and age may be mediated by physical fitness. While the above results support a relationship between cognitive performance and physical fitness, the possibility remains that people who choose a more physically active lifestyle may share other characteristics which predispose them to superior cognitive performance.

In 1976, Ohlsson compared the cognitive functioning of sedentary versus physically active older adults. The members of the active group (M age - 67 years) had been physically active most of their lives and were still taking part in sporting competitions. None of the members of the sedentary group (M age = 72 years) had undergone rigorous fitness training at any time in their lives. Instead, they were involved in various interest courses. Cognitive tests reflecting processes of attention, reaction-time, short-term memory, and speed and accuracy, were administerd to the participants. An analysis of covariance with age as a covariate showed that the active group performed better on all of the above tests, in support of the hypothesized relation between fitness and cognition. The particular physical activities engaged in by the active group were not specified, and no actual fitness measures were taken. Therefore, the active group may have been distinguished from the sedentary group more on the basis of perceived as opposed to actual fitness level.

Del Rey (1983) compared the performance of physically active versus sedentary older women (M age = 65 years) on retention of a timing memory task. The more active participants were members of a three times weekly exercise programme which included flexibility exercises, swimming and stationary bicycle work. In addition, an activity questionnaire revealed that these women were generally more involved in physical activities and sports than were the sedentary women. The participants were tested on retention of the following memory task: They were asked to observe a light moving at one of four speeds through a series of lamps on a runway and to press a button coincident with the arrival of the light at the last lamp. The physically active group recalled the task significantly better than the sedentary group.

The studies reported below by Young (1979), Elsayed, Ismail, and Young (1980), and Dustman, Russell, Shearer, Bonekat, Shigeoka, Wood, and Bradford (1983) assessed the relationship between improvement in physical fitness and improvement in cognitive performance in older adults. Young (1979) tested young men and women (24 to 36 years), and middle-aged men and women (43 to 62 years). All of the participants completed a 10-week, three times weekly exercise programme. The one-hour sessions included a warm-up period, calisthenics, and walking/jogging at 70 percent of maximal working capacity. Fitness and cognitive measures were taken before and after the exercise programme. The cognitive measures included the Digit Symbol and Block Design subtests from the WAIS, the Visual Reproduction and Associate Learning subtests from the Wechsler memory scale, a Trail Making Test, and the Crossing-Off Test. Physical fitness was assessed by submaximal heart rate in response to a 10-minute treadmill walk. When considered as a group, the participants significantly improved their physical fitness upon completion of the exercise programme. They also showed improvement in their performance on the digit symbol, block design, trail making, crossing-off, and associate learning tests. These results suggest that there is a relationship between improvement in physical fitness and improvement in cognitive performance. However, closer examination of the results of the individual groups shows that the improvements in cognitive performance were not related solely to improved fitness. For example, the middle-aged women had a higher mean submaximal heart rate, indicating a decline in fitness level at Time 2, but their cognitive scores improved significantly. The improvement in cognitive performance may be due to a variety of other factors including practice effects, social gains, or expectations rather than improvement in fitness. In the absence of controls for these alternative factors, the findings are essentially uninterpretable.

In 1980, Elsayed, Ismail, and Young compared the cognitive performance of four different groups before and after their participation in an exercise programme: ´high-fit´ young adults (M age = 34 years), ´high-fit´ middle-aged adults (M age = 52 years), ´low-fit´ young adults (M age = 36 years) and ´low-fit´ middle-aged adults (M age = 53 years). The exercise programme consisted of three 90-minute sessions each week for four months. Each session included calisthenics and running activities. Fitness assignment was based on submaximal exercise heart rate, and VO2max. Cognitive measures included the Series, Classification, Matrices, and Conditions subtests of the Culture Fair Intelligence Test, which were considered to be measures of fluid intelligence, and Factor B of the Cattell 16 Personality Factor Questionnaire as a measure of crystallized intelligence. At baseline, the young adults had significantly higher total fluid intelligence scores than did the middle-aged adults. When the groups were collapsed across age, the ´high-fit´ adults had significantly higher total fluid intelligence scores than the ´low-fit´ adults. However, the age by fitness interaction was not statistically significant. The combined four groups were significantly higher at posttest than at baseline on fluid intelligence but there were no significant group by time interactions. The results of this study suggest that cognitive performance is positively related to fitness level and that participation in an exercise programme is positively related to improvement in cognitive performance. However in the absence of a control group, it is impossible to draw any firm conclusions.

Dustman et al. (1983) also assessed the effects of aerobic exercise training on cognitive functioning in older adults. Healthy sedentary older adults (55 to 79 years) were randomly assigned to two groups; an aerobic exercise group and an exerise control group. A third group of older volunteers which did not participate in an exercise programme was also tested. Participants in the aerobic exercise group met three times a week for four months. Their exercise programme focussed on aerobic conditioning through brisk walking and jogging. The exercise control group also took part in a four-month exercise programme with a focus on strength and flexibility exercises. The third group received no intervention. All three groups were tested at baseline and four months later after completion of the exercise programme on the following cognitive measures: 1) Critical Flicker Fusion Threshold, 2) Culture-Fair Intelligence Test, 3) Digit Span and Digit Symbol subtests of the WAIS, 4) Dots Estimation, 5) Simple and Choice Reaction Time, and 6) the Stroop Colour Test. Pre - post VO2max tests of the two exercise groups, showed that the aerobic exercise group improved their VO2max scores by 27 percent, whereas the exercise control group only improved by 9 percent. The aerobically trained group demonstrated significant improvement on Critical Flicker Fusion, Digit Symbol, Dots Estimation, Simple Reaction Time, and the Stroop Test, whereas the exercise control group and the no intervention control group improved significantly on only one test each: respectively, Dots Estimation, and the Culture Fair Intelligence Test.

Because actual fitness measures were taken, and the exercise control programme offered all of the social and educational benefits inherent in the aerobic exercise programme, this study lends strong support to the hypothesis that improvement in aerobic fitness is causally related to improvement in cognitive functioning in older adults.

It is difficult to integrate the findings of the investigators cited in this section because of their wide-ranging selection of cognitive measures. The rationale for selection of their test-batteries is often unclear. The findings of Crooks (1976), Ohlsson (1976), and Del Rey (1983) all suggest that there may be a relationship between cognitive performance and physical fitness in healthy older adults. However, no causal inferences can be made. Individuals who are physically fit may differ systematically in other significant ways from sedentary adults. For example, they may be more competitive, or self-confident, and consequently more proficient in test taking situations. Also, three of the four studies cited above did not include actual fitness measures. Therefore perceived rather than actual fitness level may be the most salient characteristic differentiating the subject groups. The research of Young (1979), Elsayed et al. (1980), and Dustman et al. (1983) support the relationship between improvement in physical fitness and improvement in cognitive performance in healthy older adults. Because Dustman et al.'s (1983) research design included random assignment to groups and controls for factors other than physical fitness, their study constitutes the only strong support for a causal link between improvement in fitness and improvement in certain aspects of cognitive performance.

Psychomotor speed and fitness in older adults. Psychomotor speed refers to the speed with which an individual can perform a task which involves responding motorically to an environmental stimulus (Spirduso, 1980). Reaction time measures are often used to tap psychomotor speed. While certain of the studies already cited incorporated reaction time measures, the studies cited below were specifically designed to investigate a relationship between psychomotor speed and physical fitness in healthy older adults.

Botwinick and Thompson (1968) compared the reaction time speed of young athletes, young non-athletes, and older adults. The older adults had significantly slower reaction times than did the young athletes, but no significant differences were found between the reaction times of the older adults and the young non-athletes. Botwinick and Thompson therefore concluded that physical fitness may be a factor in psychomotor slowing with age.

In 1978, Spirduso and Clifford studied the effects of chronic physical exercise on the reaction time of young and old adults. They tested two groups of older active men involved in running or racket sports, older inactive men, young active men involved in running or racket sports, and young inactive men. The older groups were between 50 and 70 years of age, and the younger groups were between 20 and 30 years of age. No significant differences were found in reaction time between the young inactive group and the older active groups. As well, the older active groups had faster reaction times than did the older inactive group. The young active men did however have faster reaction times than the older active men. The results of this study suggest that as well as age, a lifestyle of physical activity may play an important role in determining psychomotor speed. Because the studies cited above were correlational, the possibility that individuals who choose an active lifestyle may have inherently faster reaction times cannot be ruled out. In addition, self-report as opposed to actual fitness measures were taken.

Cognitive performance and fitness in older patients. While the above studies were concerned with the healthy elderly, the following studies assessed the effects of participation in an exercise programme on the cognitive performance of elderly mentally disturbed patients. Powell (1974) randomly assigned geriatric mental patients (M age = 69 years) to three groups. One group was enrolled in an exercise programme which included walking, calisthenics, and rhythmical movements. The second group took part in ´social therapy´ which consisted of art, social interaction, music, and games. This group served as a control for attention and change of routine. The above programmes entailed five one-hour sessions per week for a duration of 12 weeks. The third group of patients served as a no-treatment control group. The following pre - post cognitive measures were administered to the participants: the Wechsler Memory Scale, Raven´s Progressive Matrices Test, and Graham and Kendall´s Memory for Designs Test. The exercise group showed significant improvement on the Wechsler Memory Scale, and the Progressive Matrices test. No significant changes were found in the performance scores of the other two groups. Powell therefore concluded that exercise per se, and not attention or social interaction was responsible for an improvement in cognitive performance. Because no pre - post fitness measures were taken, a training effect from the exercise programme can only be surmised, leaving open the possibility that a factor other than improved fitness may have been responsible for the improved performance of the exercise group.

Stamford, Hambacher, and Fallica (1974) also assessed the effects of exercise on the cognitive performance of a group of hospitalized elderly mental patients (M age = 68 years). Their study included pre and post fitness measures in addition to cognitive measures. The patients were randomly assigned to an exercise group and a control group. The exercise group took part in an exercise programme which consisted of 6 to 20-minute treadmill walks at 70 percent of predicted maximal heart rate five times per week for a duration of 12 weeks. A control group followed a similar regime but their treadmill walks were too brief (one minute) to induce a training effect. Physical fitness was assessed by heart rate in response to a fixed workload. As anticipated, only the exercise group showed a significant improvement in physical fitness. Cognitive measures included a Draw-a-Person Test, the WAIS Digit Span Subtest, the WAIS General Information Questionnaire, and a second General Information Questionnaire based on well established hospital routine. The exercise group demonstrated significantly improved performance on the two general information questionnaires, whereas the control group showed no change on any of their performance scores. The results of this study support the hypothesis that an improvement in aerobic fitness leads to improved cognitive performance.

Diesfeldt and Diesfeldt-Groenendijk (1977) assessed elderly patients who were suffering from organic brain syndromes (M = 82 years). Patients were randomly assigned to an exercise group which participated in one month of light gymnastics and a no-treatment control group. Cognitive measures administered before and after the one-month period were: Immediate Free Recall (immediate recall of seven slides), Total Recall (the sum of the scores of three immediate free recall trials), a Recognition Test (10 minutes after the last recall trial, each of the seven slides was shown in conjunction with three novel slides, and the patient was asked to recognize the slide he had seen before), and a Posting-Box Test (a box with geometric slots and five blocks with corresponding shapes; the patient was asked to fit the blocks into the matching slots). Results of the study are mixed. Both groups significantly improved their scores on the immediate free recall test, suggesting the presence of a practice effect. Only the exercise group significantly improved its total recall performance. While the exercise group exhibited no change on the recognition test, scores of the control group significantly declined. This could be interpreted to mean that the exercise programme offset a similar decline in cognitive performance in the fitness group. This study has a number of weaknesses in design. No actual fitness measures were taken, and no controls were available for social interaction, attention, or change of routine. As well, the second set of cognitive measures was administered immediately after the last fitness class. Therefore acute versus chronic effects of physical fitness are confused.

The research conducted by Powell (1974), Stamford et al. (1974), and Diesfeldt et al. (1977), suggest that participation in an exercise programme is significantly related to improvement in the cognitive performance of elderly mentally ill patients. However, the studies of Powell (1974) and Diesfeldt et al. (1977) did not include actual fitness measures. Diesfeldt et al.'s (1977) study also lacks a control for social and educational gains inherent in participation in an exercise programme. In addition, the precise nature of the patients' illness is not well defined in any of these studies.

The literature which was reviewed suggests that there is a positive association between physical fitness and cognitive performance in older adults, and that improvement in physical fitness is positively related to improvement in the cognitive performance of older adults. These conclusions remain tentative for the following reasons: First, several of the investigators assigned their subjects to athletic and sedentary groups on the basis of self-report measures, and therefore, perceived rather than actual fitness level may have been the most salient characteristic differentiating the groups. Second, the majority of studies which assessed the effects of participation in an exercise programme on cognitive performance did not include pre and post fitness measures. As a result, a training effect from the exercise programme can only be surmised, leaving open the possibility that factors other than improved fitness may have been responsible for the changes which were observed in cognitive performance. Third, many of the studies did not include a control group for social, and educational gains inherent in participation in an exercise programme. Finally, the investigators selected large and wide-ranging cognitive test batteries. The theoretical rationale underlying the selection of tests was often not specified, and the implications of the different patterns of change observed within the test batteries for conclusions about relationships between physical fitness and cognitive abilities was often not addressed.

Self-Concept and Physical Fitness

Self-concept is the totality of the individual's thoughts and feelings about him or herself (Rosenberg, 1979). A positive self-concept is widely agreed to be essential to mental health (Coopersmith, 1967; Jahoda, 1958; Rosenberg, 1979). A possible relationship between self-concept and physical fitness has been examined in young adults (Hanson & Nedde, 1974; Hilyer & Mitchell, 1979; Pauly, Palmer, Wright, & Pfeiffer, 1982). It has been hypothesized that changes in the body as a result of fitness training tend to alter one's body image and consequently affect self-concept (Folkins & Sime, 1981; Zion, 1965). Although a self-concept - fitness relationship has been studied in young adults, there is a distinct absence of research on the relationship between self-concept and physical fitness in older adults. This lack of research is particularly striking given that it is the older adult for whom a diminished self-concept may be a far more tangible concern (Barach, 1964; Chen, 1968; Palmore, 1973; Rodin & Langer, 1980; Schwartz, 1975; Wiswell, 1979). A review of research which assesses the relationship between self-concept and physical fitness in young adults is presented below.

Hanson and Nedde (1974) examined the relation between self-concept and physical fitness in eight sedentary young women (_M_ age = 28 years) who participated in an eight month aerobic exercise programme. Classes were conducted five times per week, and they included both warm-up calisthenics, and running or cross-country skiing. Fitness and self-concept measures were administered before the programme began, at four months, and at eight months. Fitness level was determined by a wide variety of cardiovascular and respiratory measures including submaximal exercise heart rate and submaximal oxygen uptake. Self-concept was measured by the following subscales of the Tennessee Self-Concept Scale (TSCS); self-criticism, self-satisfaction, physical self, personal self-worth, social self, total conflict in self-perception, and the total positive score reflecting overall level of self-esteem. The women significantly improved their level of physical fitness at four-months, and again at eight-months. There was also a significant change in six of the seven self-concept subscale scores after eight months. Only the self-criticism subscale remained unchanged. Hanson and Nedde therefore concluded that there is a relationship between improvement in physical fitness and enhanced self-concept. Because there were no control groups in this study, it is impossible to determine what aspect of the fitness programme was related to the rise in self-concept scores. Possibilities include improvement in cardiovascular fitness, attention, social gains, subjective perception of fitness improvement, and expectations. It is interesting that although fitness level improved significantly after four months, significant improvements in self-concept scores were found only after the eight-month interval.

Relationships between self-concept, and both actual and perceived fitness level were assessed in both male and female college students who participated in a 10-week, twice weekly aerobic jogging programme (Leanardson & Garguilo, 1978). Actual fitness level was measured with Cooper's 12-minute run test (distance covered in 12 minutes). A self-rating scale of perceived physical fitness was also administered. Self-concept was measured with a semantic differential scale. A significant correlation between self-concept and perceived fitness was found ($\underline{r}$ = .53) at baseline, but there was no significant correlation between self-concept and actual fitness level. Only actual fitness level improved after the 10-week programme. There was no concomitant change in self-concept or perceived physical fitness. This study indicates that the self-concept - fitness relationship established in other studies may be a function of the extent to which perceived and actual fitness level are correlated. The authors did not elaborate on the nature of their self-concept measure, so it is difficult to relate their findings to those of other researchers.

Heaps (1978) tested the hypothesis that the relation between self-concept and physical fitness is a function of the individual's cognitions about his or her fitness level. He tested male university students. Actual physical fitness was measured by Cooper's 12-minute run test. A physical fitness self-estimate designed to measure perceived fitness level was also administered. Self-concept was measured by a Self-Acceptance Inventory. Participants ran the 12-minute fitness test with a confederate and they were given two types of false information about their level of fitness; social feedback and physical feedback. In the social feedback condition, the confederate ran much better or worse than the student and then praised or put down his performance. In the physical feedback condition the student was told that he was in good or poor condition based on a rigged heart rate and oxygen consumption measure. The participants' perceived fitness levels were significantly influenced by altering the social and physical information given to them. Participants' perceptions of their fitness levels were significantly positively related to self-concept (r = .32), but actual fitness levels were not significantly related to self-concept. Therefore, Heaps concluded that a relationship between fitness level and self-concept will exist to the extent that an individual's actual and perceived fitness levels are congruent with each other.

In 1979, Hilyer and Mitchell assessed relationships between self-esteem and physical fitness in male and female university students. Level of self-esteem was determined by the total positive score of the TSCS, and fitness level was measured by Cooper's 12-minute run test. The students were divided into low and high self-esteem groups based on their initial self-esteem scores. Six groups were then established: high self-esteem fitness only, low self-esteem fitness only, high self-esteem fitness and counselling, low self-esteem fitness and counselling, high self-esteem no treatment control, and low self-esteem no treatment control. The fitness only groups participated in a 10-week (three times per week) exercise programme which consisted of running and flexibility exercises. The fitness and counselling groups took part in both the exercise programme, and a one-hour weekly counselling session in which they were given a progress report, and the benefits of the exercise programme were clarified. All of the students who participated in the exercise programme significantly improved their physical fitness. The two low self-esteem fitness groups significantly improved their self-esteem scores as well. At posttest, the low self-esteem counselling students had self-esteem scores two and a half times greater than the low self-esteem fitness group, and four times greater than the low self-esteem control group at posttest. These results support the hypothesis that one's cognitions with regard to fitness are important in mediating the relationship between self-concept, and physical fitness.

Pauly et al. (1982) assessed the relationship between self-concept and physical fitness in a group of men and women (18 to 59 years) before and after their participation in a 14-week exercise programme. Classes were held three times per week, and they included calisthenics and aerobic exercise. Self-concept was assessed by five of the subscales on the TSCS: physical self, moral-ethical self, personal self, family self, and social self. Fitness level was assessed by a wide variety of measures which tapped cardiovascular and respiratory functioning, including VO2max. Upon completion of the exercise programme, the participants significantly improved their physical fitness, and their scores on the personal, social, and physical self-concept subscales. However, the improvement in self-concept was not correlated with frequency of participation or improvement in VO2max, suggesting that something in addition to, or other than improvement in cardiovascular fitness was mediating the improvement in self-concept. In the absence of a control group, there was no means of detecting potential non-physiological mediators of self-concept that may have been inherent in the exercise programme. Although there was a wide age range among the participants, the investigators did not assess relations among age, self-concept, and physical fitness.

Support for a relationship between self-concept and physical fitness in young adults is mixed. The research of Hanson and Nedde (1974), Hilyer and Mitchell (1979), and Pauly et al. (1982), indicates that improvement in physical fitness is positively related to improvement in self-concept. Hilyer and Mitchell's study suggests that the relationship was mediated by change in perception of fitness level, and expectation of benefits. Because Pauly et al. did not find a linear relationship between improvement in self-concept and physical fitness, it seems that something other than actual fitness improvement mediated the improvement in self-concept. Possibilities include change in perceived fitness level, expectations and social gains. The research of Leanardson (1978), and Heaps (1978), did not support a relationship between self-concept and physical fitness. Their studies did however establish a relationship between self-concept and perceived fitness level. Only one of the studies reviewed used a control group. Therefore, interpretation of results is speculative.

The investigators cited above worked primarily with healthy young adults who probably were not suffering from a poor self-concept. Perhaps therefore, they were encountering ceiling effects. It may be more meaningful to examine the relation between self-concept and fitness in older adults who are experiencing a diminished self-concept as a result of exposure to negative stereotyping, the many significant losses which they face, and the physical changes which accompany the aging process (Barach, 1964; Chen, 1968; Palmore, 1973; Rodin & Langer, 1980; Wiswell, 1977).

Statement of the Problem

The previous literature has suggested that there is a relation between physical fitness and cognitive performance in older adults although this conclusion is only tentative because of methodological weaknesses in most of the studies cited. The literature has also suggested that there may be a relation between physical fitness and self-concept in young adults. However this association has not been explored among older adults.

The present study was designed to examine the interrelations among physical fitness, cognitive abilities and self-concept in both sedentary and athletic older adults. The experimental manipulation was a 14-week aerobic fitness programme specifically designed for older adults.

Four hypotheses were tested in this study. The first two hypotheses deal with baseline relations among physical fitness and psychological functioning in older adults. The second two hypotheses consider relations between improvement in fitness and improvement in psychological functioning in older adults. The hypotheses are as follows:

1) There is a positive association between cognitive performance and physical fitness in older adults.

2) There is a positive association between self-concept and physical fitness in older adults.

3) Improvement in physical fitness is associated with improvement in cognitive performance in older adults.

4) Improvement in physical fitness is associated with improvement in self-concept in older adults.

In order to test these hypotheses more adequately, certain features that had been absent in some of the previous studies were incorporated into the present experimental design:

1) Objective physiological fitness measures were used in addition to self-report measures in order to assess both actual and perceived

fitness level.

2) Both pre and post fitness measures were taken in order to establish that there was a training effect as a result of the fitness intervention.

3) A control group was used in order to tease out physical versus social and educational gains inherent in the exercise programme.

4) The cognitive test battery was selected to represent certain cognitive functions which typically show decline with age, and which have received some empirical support for their association with physical fitness.

Method

Subjects

The participants were two groups of sedentary older adults; the Exercise group, and the Control group, and one group of athletic older adults: the Athletic group. All were 60 years of age or over, living in or near Montreal. The majority in each group were female. It was made clear that participation was strictly voluntary, and that it was permissible to leave the study at any time.

Because participants assigned themselves to treatment groups, the groups were compared on background measures of age in years, socioeconomic status (SES), years of education, and verbal intelligence. Blishen's (1967; Blishen & McRoberts, 1976) Socioeconomic Index for Occupations in Canada was used to assess SES. The index ranks occupations of the male labour force according to income level, educational status, and prestige on a scale from one to six, one representing high SES, and six representing low SES. The majority of women in this study were supported by their husbands. Women were therefore ranked according to their husband's current or former occupations unless they had never married or were established in a profession of superior status to that of their husband. Intelligence was assessed with the Vocabulary Subtest of the Stanford Binet Intelligence Scale (Terman & Merrill, 1972). Vocabulary tests have been identified as the best single measures of both verbal and general mental ability (Lezak, 1983). Because all of the psychological dependent measures were language based, it was important to assess the groups on this aspect of intelligence. The mean values on background variables of age, intelligence, SES, and education for the three groups is presented in Table 4. Analyses of variance (ANOVAS) revealed that the groups differed significantly on intelligence only $\underline{F}(2, 42) = 4.5$, $\underline{p} < .02$. Post hoc Scheffe tests showed that the Control group had a significantly higher mean intelligence score than the Exercise group $\underline{F}(2, 42) = 9.1$, $\underline{p} < .05$.

Exercise group. The Exercise group was comprised of sedentary older adults ($\underline{n}$ = 14 women, 3 men) who agreed to participate in a 14-week exercise programme, and undergo psychological and fitness testing. This group was recruited primarily through newspaper advertising. The advertisements specified the following: 1) the exercise programme was designed for sedentary adults 60 years of age or over who wanted to make a serious effort to improve their physical conditioning, 2) fitness assessments and psychological interviews would be conducted before and after the programme, 3) the programme was not open to individuals with high blood pressure, diabetes, or a history of cardiac illness, and 4) there would be a nominal fee of

Table 4

Age, Intelligence, SES, and Education Comparisons for the Treatment Groups based on One-Way ANOVAS

	Experimental Group			
Background Variables	Exercise (*n* = 17) *M* (*SD*)	Control (*n* = 14) *M* (*SD*)	Athlete (*n* = 14) *M* (*SD*)	*F*(2, 42)
Age				
Years	66.0 (4.8)	68.2 (3.2)	66.5 (4.5)	1.1
Intelligence				
Vocabulary Subscale–Stanford-Binet	31.1 (5.1)	36.1 (2.5)	33.1 (5.4)	4.5*
SES				
Blishen	3.1 (1.6)	2.4 (1.2)	2.4 (0.9)	1.8
Education				
Years	11.8 (2.6)	13.6 (2.7)	12.6 (2.6)	1.8

* $p < .05$.

$8.00. After individuals expressed interest in joining the programme, they were then screened by a cardiologist to ensure that they did not have cardiovascular or other conditions which interfered with their capacity to train and/or contraindicated their participation in the programme. The screening procedure included a complete physical examination, as well as stress testing on a bicycle ergometer with ECG monitoring. Forty-two adults responded to the advertisements. Of these, 15 were excluded from the study because of cardiovascular problems found on screening by the cardiologist. Seventeen of the remaining 27 participants completed the exercise programme. Of the 10 who left the programme, three developed the flu, two sustained physical injuries (unrelated to the programme), two lost interest, one could not continue to arrange transportation, one had a flare up of arthritis, and one person got a job with conflicting hours.

Control group. The purpose of the second group of participants (n = 12 women, 2 men) was to serve as a control for social and educational gains inherent in the exercise programme. This group was selected from a registration list for an adult education programme offered at Concordia University. The programme enabled adults over 60 years of age to audit certain university courses at a nominal fee. The courses offered were primarily English, Philosophy and History. Only individuals who were taking one course, and were registering in that subject for the first time were considered in order to match this group with the Exercise group on time commitment and novelty of experience. An effort was made to match the groups on age and sex as well. Participants in the Control group were solicited by telephone and asked to take part in psychological and fitness interviews at the beginning and the end of their course. Of the 22 adults who initially agreed to participate, 14 remained for the duration of the study. The eight individuals who left had dropped out of their respective courses due to disinterest, illness, or injury, and were therefore ineligible to continue in the study.

Athletic group. This group was comprised of older adults (n = 10 women, and 4 men) who were involved in regular vigorous aerobic exercise, primarily running and swimming, and had been active for several years. They were recruited from various running clubs and athletic organizations in the Montreal area. They were asked to take part in fitnesss testing as well as two psychological interviews. Of the 14 individuals who agreed to participate, all completed the first interview, 12 completed the second interview, and nine underwent fitness testing.

Materials

Participants were assessed on Cognitive, Self-Concept, and Physical Fitness measures. The Exercise group also took part in Semi - Structured interviews upon completion of their exercise programme.

Cognitive performance. Participants were tested on both Short-Term Memory and Psychomotor Speed. Short-term memory was assessed with the Memory Span for Digits Forward and Backward, and the Associate Learning Subtests of the Wechsler Memory Scale (Wechsler & Stone, 1945). The Digit Span Subtest requires the testee to repeat successively longer series of numbers (presented at one-second intervals) immediately after they are presented, in the original or reversed sequence. The Associate Learning Subtest consists of 10 paired associates which the participant is required to learn in three trials. The Wechsler Memory Scale subtests were administered and scored according to the original directions specified in the 1945 manual. Test items were presented on tape in order to standardize the quality of presentation. Because hearing loss in the high frequency range is more common in old age, the test items were recorded by a male speaker.

The choice of the Wechsler Memory Scale was based on several considerations. The Wechsler Memory Scale has been widely used with older adults (Cauthen, 1977; McCarty, Siegler, & Logue, 1982; North & Vlatowska, 1981). The Backward Digit Span and Associate Learning Subtests have been shown to decline with age (Cauthen, 1977; McCarty et al., 1982). Also, there is some empirical support for a relationship between physical fitness and these particular measures in older adults (Crooks, 1977; Young, 1979). In contrast, Forward Digit Span was included as a ´hold test´ (Craik, 1977; Horn, 1982; Lezak, 1983). It does not tend to show decline with age (Cauthen, 1977) and a relationship between digits forward and physical fitness has not been established (Crooks, 1977).

Psychomotor speed was measured with the Clerical Speed and Accuracy Test from the Differential Aptitude Series (Bennett, Seashore, & Westman, 1974). The Clerical Speed and Accuracy test is intended to measure speed of response in a simple perceptual task. The participant is required to attend to a two-digit letter and/or number combination which is marked in the test booklet, and then underline the same combination embedded in a group of four similar combinations on a seperate answer sheet. Participants are asked to complete as many items as they can within two three-minute time limits. Scores are based on the number of correctly completed items. The test and answer sheets were retyped in larger print for use in this study, to make them easier to read for an older sample.

The primary reasons for including a test of psychomotor speed were because this function has been shown to decline with age (e.g. Cerella, 1985; Spirduso, 1980), and because there is some preliminary support for a relationship between psychomotor speed and physical fitness in older adults (Botwinick & Thompson, 1968; Spirduso & Clifford, 1978). Although the Clerical Speed and Accuracy Test has not been widely used with older adults, it was selected for the following reasons. Participants were often tested in their homes, and the test battery was lengthy. Therefore a test which 1) did not require bulky equipment, 2) was easy for the testee to understand and 3) brief to administer, was desired. The Clerical Speed and Accuracy test meets the above criteria. Alternate-form reliability coeffecients for a student sample were found to be approximately .86 (Bennett et al., 1974).

Self-Concept. The Tennessee Self-Concept Scale (TSCS) was used to assess self-concept (Fitts, 1965). The TSCS has 100 self-descriptive statements on which participants assess themselves on a five - point rating system from completely true to completely false. An overall self-esteem score is derived from 90 statements. The 90 statements can be classified into five subscales measuring Physical Self, Moral - Ethical Self, Personal Self, Family Self, and Social Self. Physical self refers to the person's view of his/her physical appearance, state of health, and sexuality. Moral - Ethical self reflects the person's feelings of being a 'good' or 'bad' person, as well as satisfaction with one's religion or lack of it. Personal Self reflects the individual's sense of personal worth. Family self is related to feelings of worth as a family member. Social self reflects one's sense of adequacy and worth in interactions with other people. Based on a sample of college students, Fitts (1965) reported a two-week retest reliability of .92 for overall self-esteem and a range of .80 to .90 for the five subscales. Construct validity was confirmed in that the TSCS was able to discriminate between a normal sample and both a psychiatric sample, and a group of individuals who are unusually high in personality integration (Fitts, 1965). The TSCS has been adopted widely for use with older adults (Bretyspraak & George, 1979).

Physical Fitness. All participants were assessed on the Minnesota Leisure Time Physical Activity Questionnaire (LTA) (Taylor, Jacobs, Shucker, Knudsin, Leon, & Debacker, 1978), which is a paper and pencil estimate of cardiovascular fitness. It was necessary to include at least one paper and pencil estimate because not all participants were able to undergo actual fitness testing. The LTA is made up of a list of leisure time physical activities, which are graded according to intensity. The intensity code is an estimate of the ratio of metabolic rate during the specified activity to basal metabolic rate. Intensity codes were established experimentally by the developers of the test based on the rates of oxygen consumption of a sample of middle-aged men as they performed the various physical activities. In completing the LTA, participants are asked whether they engage in each of the activities listed, and if so for what duration of time, how often each month, and during how many months each year. The total LTA score is based on the sum of the duration x frequency x intensity for each activity. The LTA is divided into three subscales based on the intensity of the activities. The subscales are ´LTA light´, ´LTA moderate´, and ´LTA heavy´. Activities included in the calculation of the LTA heavy score involve an intensity of effort greater than 50 percent of VO2max. Because improvement in cardiovascular performance requires a physical effort of a minimum of 50 percent of VO2max, it is the LTA heavy score which reflects cardiovascular fitness. Therefore, the LTA heavy score was selected for use in this study. As a test of validity, a group of sedentary middle-aged men completed both the LTA, and treadmill testing (Taylor et al., 1978). The LTA heavy score was shown to be significantly related to VO2max as determined by treadmill performance.

The Exercise group and nine of the participants in the Athletic group were stress tested on a Monark 668 bicycle ergometer by a cardiologist. Heart rate was monitored by a chest electrocardiogram (Cambridge VS4). Because the initial stress test for the Exercise group was also being used as a screen for cardiovascular illness, the testing protocol was adapted from the cardiologist´s clinical stress testing procedure. This involved monitoring the patient at progressively higher workloads on the bicycle ergometer. Participants started out at a workload of 150 Kilopond Metres (KPM), and workloads were increased by increments of 150 KPM. Participants were required to sustain each workload for approximately two minutes before progressing to the next workload. The test was stopped when patients reached their maximum workload. For the purposes of fitness testing the cardiologist documented Heart Rate at a Workload of 375 KPM, and Maximum Sustained Workload. The workload of 375 KPM was selected because it was one which all of the participants could achieve regardless of whether they were athletic or sedentary. Therefore it offered a basis of comparison across groups. Participants were asked not to eat, smoke, or drink anything but water for a minimum of two hours prior to fitness testing.

Perceived Fitness was measured with a modification of Schonfield's (1973) Triscale. Participants were asked to rate their own level of physical fitness relative to that of other adults their age on a scale from one to nine. One represented someone who was extremely unfit and nine represented someone in excellent physical condition.

A measure of perceived health was also included in light of its hypothesized relationship with psychological well-being in old age (Jarvik, 1983). This measure was also based on Schonfield's Triscale. Participants rated their health relative to that of other older adults on a scale from one to nine; low scores representing extremely poor health, and high scores representing excellent health.

Semi-Structured Interview. Upon completion of the exercise programme, each member of the Exercise group was interviewed individually. They were asked whether they felt they had benefitted from the programme, and if so in what way. After responding spontaneously, participants who expressed that they had benefitted, were then asked to rank order physical, social, and educational benefits.

Procedure

General. Participants were tested at baseline on all of the background, fitness, and self-concept measures itemized above, with the following exception: only the members of the Exercise group, and nine of the 14 Athletic older adults were stress tested by the cardiologist. Participants were tested again 14 weeks later on the same battery of cognitive, self-concept and fitness measures. Only the Exercise group was stress tested at Time 2, and this group also received the semi - structured interview. Alternate forms of the Wechsler Memory Scale and the Clerical Speed and Accuracy Test are available, and different versions of these tests were used at each test session in counterbalanced order. All the cognitive and personality measures, as well as the paper and pencil fitness measures were administered in one testing session. Participants were tested individually, and they were given the option of being seen in their home or at the university. Test sessions took between one and two hours. Stress testing took place in the cardiologist's office during his working day.

During the 14-week interval, the Exercise group took part in a 14-week exercise programme, and the Control group completed an adult education course of similar duration in order to serve as a control for social and educational gains inherent in the exercise programme (see Subjects section). The Athletic group received no intervention. Table 5 summarizes the research design. The tests completed by each of the groups at the two test sessions are itemized in Table 6. Nine of the 17 participants in the Exercise group, and 8 of the 14 participants in the Control group took part in programmes which ran from January to April 1984. The remaining participants in these groups took part in programmes from September to December, 1984. All of the athletes were tested between September and December, 1984.

Exercise programme. After they had been screened by the cardiologist but before beginning the exercise programme, participants were asked to sign a waiver form releasing the instructors and people involved in the study from liability for injuries or illness incurred

Table 5

Research Design

Group	Time 1	Intervention	Time 2
Athletes	Pre-Test	No Intervention	Post-Test
Exercise*	Pre-Test	Exercise Programme	Post-Test
Control*	Pre-Test	Interest Course	Post-Test

* Sedentary Older Adults

Table 6

Measures Completed at Baseline and Posttest

Measures	Baseline	Posttest
Socioeconomic Index	***	---
Stanford-Binet Vocabulary	***	---
Digits Forward (WMS)	***	***
Digits Backward (WMS)	***	***
Associate Learning (WMS)	***	***
Clerical Speed and Accuracy	***	***
Tennessee Self-Concept Scale	***	***
Minnesota LTA	***	***
Perceived Fitness	***	***
Perceived Health	***	***
Heart Rate at 375 KPM	**	*
Maximum Sustained Workload	**	*
Semi-Structured Interview	---	*

*** Administered to all three groups.

** Administered to the Exercise and Athletic groups only.

* Administered to the Exercise group only.

during the course of the programme.

The exercise programme was developed with the assistance of an exercise physiologist who specialized in fitness and aging. The programme was 14 weeks in duration, and one-hour classes were given three times per week. Each class included the following components: 1) a warm-up period, 2) aerobic exercise, 3) strength and flexibility exercises, and 4) a cool-down period. The focus of the class was the 20-minute aerobic exercise. During this period participants maintained their heart rates elevated at between 60 to 80 percent of their age predicted maximal heart rates (220 - age) (Astrand, 1970) through continuous brisk walking and dance exercises. Participants were instructed in taking their pulse, and heart rate was monitored at the beginning, middle, and end of the aerobic period to ensure that they were working out with sufficient intensity to achieve a training effect, but at the same time, not so vigorously as to endanger their health. Heart rate was also checked at the end of each class, and participants were encouraged to remain after class until their heart rate had returned to a resting level. Classes were taught by three experienced fitness instructors who were trained in CPR. The first exercise programme (January to April, 1984) was housed at the Golden Age Association in Montreal. The second programme (September to December, 1984) which was identical in format, was housed at a YMHA in Montreal.

Results

The results are organized in terms of their relevance to the following four relationships: 1) the relationship of baseline cognitive performance to baseline physical fitness in older adults, 2) the relationship of baseline self-concept to baseline physical fitness in older adults, 3) the relationship between improvement in physical fitness from baseline to posttest and improvement in cognitive performance from baseline to posttest in older adults, and 4) the relationship between improvement in physical fitness from baseline to posttest and improvement in self-concept from baseline to posttest in older adults.

A number of preliminary data analyses were conducted including correlational analyses across and within groups. Based on these preliminary results, analysis of covariance and stepwise regression analysis were selected as being the most appropriate methods to evaluate the relationships being examined in the study. All comparisons of the treatment groups were made with analyses of covariance because random assignment to groups was not possible, and available samples were not large enough to match groups on all relevant confounding variables. In these analyses, age was selected as a covariate because of its well established relationship with physical fitness, cognitive performance, and self-concept (see Introduction). Intelligence was selected as a covariate because there were baseline differences in intelligence among the groups (see Method section). Stepwise regression analyses were used in order to further explore interrelations among the variables using a data set which included an additional 19 older adults for whom a complete set of baseline psychological and fitness tests were available.

Baseline Cognitive Performance in Relation to Baseline Physical Fitness

In order to assess the relationship between cognitive performance and physical fitness, the baseline cognitive performance of the Athletic group was compared with that of the two more sedentary groups: the Exercise and Control groups. Before these comparisons were made, the fitness scores of the three groups were compared to confirm that the Athletic group was in fact significantly more physically fit than the other two groups. The fitness measures which were administered to all three groups were paper and pencil measures of 1) cardiovascular fitness (LTA heavy), 2) perceived fitness, and 3) perceived health. A one-way multivariate analysis of covariance (MANCOVA) established that there were group differences in physical fitness $\underline{F}(6, 76) = 5.1$, $\underline{p} < .001$. One-way analyses of covariance (ANCOVAS) established that there were group differences in baseline LTA heavy scores $\underline{F}(2, 40) = 15.7$, $\underline{p} < .001$. Scheffe post hocs showed that the Athletic group had a significantly higher mean adjusted score than both the Exercise group $\underline{F}(2, 40) = 26.0$, $\underline{p} < = .01$, and the Control group $\underline{F}(2, 40) = 17.6$, $\underline{p} < .01$. These results are illustrated in Figure 1. The groups also differed significantly in perceived fitness $\underline{F}(2, 40) = 6.7$, $\underline{p} < .01$. Scheffe comparisons showed that the Athletic group had a significantly higher adjusted mean perceived fitness score than the Exercise group $\underline{F}(2, 40) = 13.3$, $\underline{p} < .05$. The group differences in perceived health were in the same direction as on the other two measures, but were not statistically reliable. The adjusted means, standard deviations (SD), and F values of the three groups on the perceived fitness, and perceived health measures are summarized in Table 7. A summary table for the one-way MANCOVA and the one-way ANCOVAS comparing the experimental groups on baseline fitness measures is presented in Appendix 1. Fitness assessments on a bicycle ergometer yielding

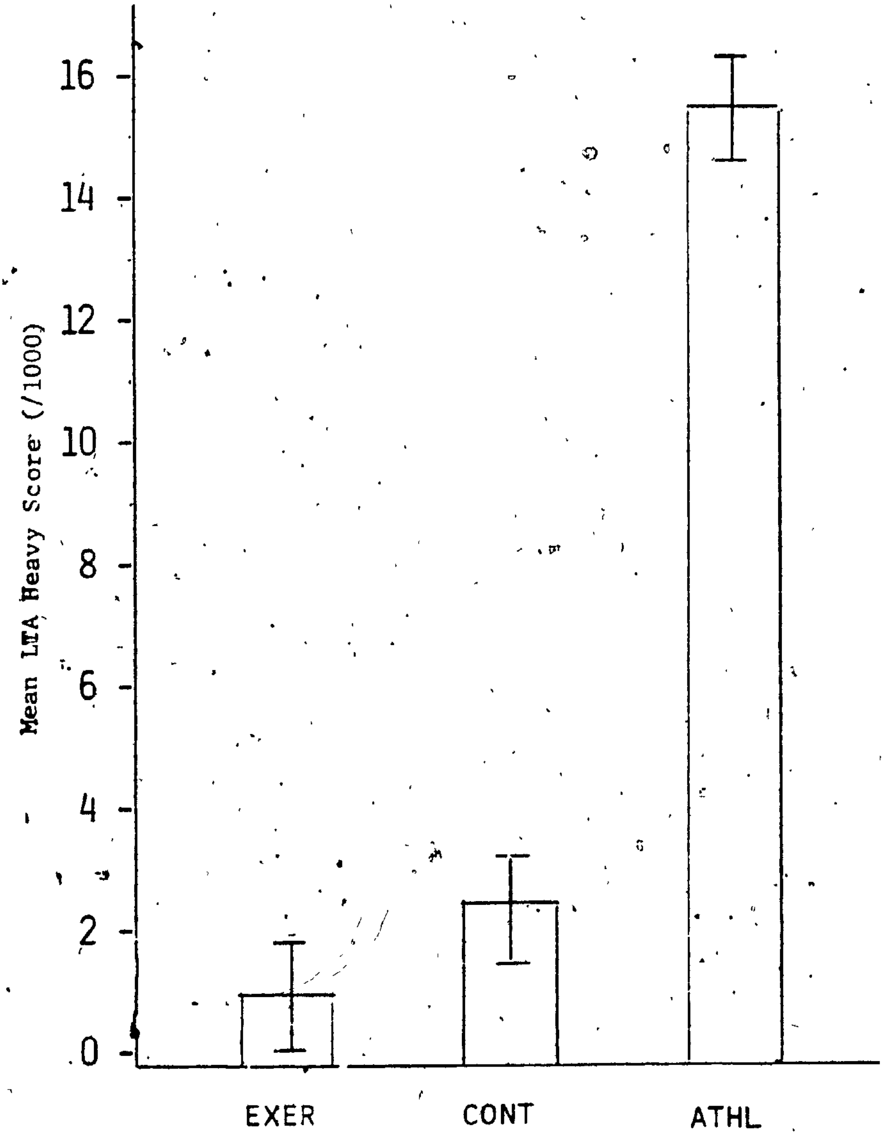

Figure 1. Adjusted mean LTA heavy scores at baseline.

Table 7

A Baseline Comparison of Groups on Perceived Fitness, and Perceived Health Based on One-Way ANCOVAS

Experimental Group	Perceived Fitness Adjusted M	Perceived Fitness (SD)	Perceived Health Adjusted M	Perceived Health (SD)
Exercise (n = 17)	5.5	(1.8)	7.3	(1.5)
Control (n = 14)	6.5	(1.3)	7.3	(1.2)
Athlete (n = 14)	7.6	(1.5)	7.8	(1.0)
F(2, 40)	6.7*		.80	

Fitness Variable

* $p < .01$.

measures of maximum workload and heart rate at 375 KPM (HR375), were only conducted for the Exercise group, and for nine of the 14 Athletic older adults. The Athletic group was shown to have a significantly higher mean maximum workload score than the Exercise group $F(1, 22) = 9.0$ $p < .01$. Although the adjusted mean HR375 score for the Athletic group was lower than that of the Exercise group, indicating better physical fitness, this difference did not reach statistical significance. The adjusted means, standard deviations, and F values of the Exercise and Control groups, for maximum workload and HR375 are presented in Table 8. Differences in physical fitness were therefore established among the groups. The Athletic group had significantly higher LTA heavy scores than both the Exercise and Control groups. The Athletic group also had significantly higher perceived fitness and maximum workload scores than the Exercise group.

Despite baseline differences in physical fitness among the groups, a one-way MANCOVA did not establish group differences on the baseline cognitive measures. The adjusted means, and standard deviations of the three groups on psychomotor speed, digits forward, digits backward, and associate learning are presented in Table 9.

The apparent absence of a relation between baseline cognitive performance and physical fitness was explored using stepwise regression techniques on a second body of data which overlapped only partially with the data set used in the ANCOVAS. In these analyses the four cognitive measures constituted the dependent variables, while the independent variables included fitness, background and self-concept baseline measures of maximum workload, LTA heavy, perceived fitness, perceived health, age, intelligence, SES, education, and the five TSCS

Table 8

A Baseline Comparison of the Exercise and Athletic Groups on Maximum Workload and HR375 Based on One-Way ANCOVAS

Experimental Group	Fitness Variable			
	Maximum Workload		HR375	
	Adjusted *M*	(*SD*)	Adjusted *M*	(*SD*)
Exercise (*n* = 17)	455	(131)	129	(23)
Athlete (*n* = 09)[a]	697	(250)	121	(27)
	F(1, 22)	9.0*	*F*(1, 21)[b]	0.59

* $p < .01$.

[a] Only 9 of the 14 athletic older adults underwent stress testing.

[b] Only 8 of these 9 athletic adults had their heart rate monitored at 375 KPM.

Table 9

Adjusted Mean Cognitive Scores of Groups at Baseline

	Cognitive Variable			
Experimental Group	Psychomotor Speed Adjusted M (SD)	Digits Forward Adjusted M (SD)	Digits Backward Adjusted M (SD)	Asssociate Learning Adjusted M (SD)
Exercise	118	7.0	5.4	15
(n = 17)	(30)	(1.4)	(1.9)	(3.2)
Control	125	6.8	5.0	16
(n = 13)	(23)	(1.5)	(1.5)	(3.6)
Athlete	116	6.5	4.9	15
(n = 14)	(24)	(1.3)	(1.4)	(3.0)

Multivariate F(8, 72) = .50

subscales. The data set for these stepwise regressions excluded the Control group and five of the 14 athletes because maximum workload scores were not available for them. However, the data set included an additional 19 older adults for whom a complete set of psychological and fitness tests were available. Ten of the 19 additional individuals were either ´dropouts´ from the exercise programme, or pilot subjects, and the other nine were adults who had been screened from the exercise programme because of the presence of coronary illness. With the addition of these 19 subjects, the data set analysed included the 17 members of the Exercise group, 9 members of the Athletic group, 10 people who could have qualified for the Exercise group and 9 people who were excluded from the Exercise group because of cardiovascular problems. The table of intercorrelations among the whole set of dependent and predictor variables for this sample of 45 older adults is given in Appendix 2. Despite the increased range of fitness that was associated with the inclusion of nine individuals with coronary illness, actual physical fitness did not emerge as a significant predictor on any of the four cognitive measures. The only fitness measure to emerge at all was perceived health as a predictor of forward digit span. Perceived health was positively associated with forward digit span. Perceived health however was only modestly correlated with the actual fitness measure of maximum workload, $r = .09$. Age was found to be a predictor of both psychomotor speed, and backward digit span, and intelligence was a significant predictor on all four cognitive measures. Both age and intelligence were positively associated with the cognitive measures. The results of these regression analyses are summarized in Table 10.

Table 10

Variables Which Predict Cognitive Performance Based on Stepwise Regressions with 45 Older Adults

Dependent Variable	Independent Variable[a]	R^2	R^2 Increase
Psychomotor Speed	Intelligence	.29	.29
	Age	.50	.21
	Family-Self-Concept	.55	.05
Backward Digit-Span	Intelligence	.27	.27
	Age	.34	.07
Forward Digit-Span	Intelligence	.25	.25
	Perceived Health	.32	.07
Associate Learning	Intelligence	.16	.16

[a] Variables that contributed to R given F to enter and F to remove set at 4.0. For the full set of potential predictors, see text.

In summary, the Athletic group had a significantly higher mean LTA heavy score than both the Exercise and Control groups. The Athletic group also had higher scores on maximum workload and perceived fitness, than the Exercise group. Despite these baseline differences in physical fitness, there were no baseline differences in cognitive performance among the groups. Also, with one exception, measures of physical fitness did not emerge as significant predictors of any aspect of cognitive performance. The above results do not support a relationship between cognitive performance and physical fitness in older adults.

Baseline Self-Concept in relation to Baseline Physical Fitness

A one-way MANCOVA was conducted to assess baseline group differences on the five TSCS subscales. The one-way MANCOVA showed a trend towards statistical significance $F(10, 70) = 1.8$, $p < .10$. The trend reflects a general tendency for the Athletic and Control groups to have higher adjusted mean self-concept scores than the Exercise group. The adjusted means, and standard deviations of the three groups on the physical, personal, social, family, and moral subscales are presented in Table 11. Because the overall multivariate F did not reach an acceptable level of statistical reliability, no univariate analyses were performed on the separate measures.

The relationship between self-concept and physical fitness was also assessed with stepwise regression techniques using the same group of 45 adults (see last section). The five TSCS subscales were the dependent variables, and the independent variables included fitness, background, and cognitive baseline measures of maximum workload, LTA heavy, perceived fitness perceived health, age, intelligence, SES,

Table 11

Adjusted Mean Self-Concept Scores of Groups at Baseline

	Self-Concept Variable				
Experimental Group	Physical Adjusted M (SD)	Personal Adjusted M (SD)	Social Adjusted M (SD)	Family Adjusted M (SD)	Moral Adjusted M (SD)
Exercise	64	65	64	73	74
(n = 17)	(9)	(10)	(9)	(10)	(6)
Control	72	70	76	77	77
(n = 14)	(9)	(6)	(7)	(5)	(5)
Athlete	69	69	72	76	76
(n = 13)	(8)	(7)	(6)	(6)	(6)

Multivariate $F(10, 70) = 1.8^*$

* $p < .10$

education, psychomotor speed, forward digit span, backward digit span, and associate learning. (The intercorrelations among the variables in this sample were presented in Appendix 2.) Physical fitness as assessed by maximum workload emerged as a significant predictor of physical, personal, and social self-concept. Perceived health was shown to be a predictor of physical, personal, and family self-concept. Both maximum workload and perceived health were positively associated with self-concept. The results of these regression analyses are summarized in Table 12.

In summary, physical fitness as measured by maximum workload emerged as a significant predictor of physical, personal, and social self-concept. Perceived health emerged as a significant predictor of physical, personal, and family self-concept. These results support a relationship between self-concept and physical fitness and between self-concept and perceived health in older adults.

Relationships between Improvement in Physical Fitness and Improvement in Cognitive Performance in Older Adults

In order to assess the relationship between improvement in physical fitness, and improvement in cognitive performance, it was necessary to determine whether the Exercise group did in fact improve in their physical fitness. LTA heavy, perceived fitness, and perceived health scores were available for all three groups both at Time 1 and Time 2. A two-way MANCOVA established that there was a significant group by time interaction for physical fitness $F(6, 62) = 3.6$, $p < .01$. A two-way ANCOVA comparing the groups on LTA heavy scores established that there was a significant group by time interaction $F(2, 35) = 15.6$, $p < .001$. Scheffe tests showed that the Exercise group significantly

Table 12

Variables which Predict Self Concept Based on Stepwise Regressions with 45 Older Adults

Dependent Variable	Independent Variable[a]	R^2	R^2 Increase
Physical	Maximum Workload	.31	.31
	Perceived Health	.52	.21
Personal	Maximum Workload	.12	.13
	Perceived Health	.21	.09
Social	Psychomotor Speed	.15	.15
	Maximum Workload	.22	.07
Family	Perceived Health	.17	.17

[a] Variables that contributed to R, given F to enter and F to remove set at 4. For the full set of potential predictors, see text.

improved their LTA heavy scores $F(2, 35) = 9.9$, $p < .05$, whereas the scores of the other two groups did not change at Time 2, as illustrated in Figure 2. Although there was an overall increase in perceived fitness at Time 2, $F(2, 40) = 10.0$, $p < .01$, the group by time interaction was not significant. Therefore, the Exercise group did not improve more than the Control and Athletic groups in perceived fitness. The groups showed no change in perceived health. The adjusted means, and standard deviations of the groups on perceived fitness, and perceived health measures are listed in Table 13. A summary table of the two-way MANCOVA and the two-way ANCOVAS comparing the experimental groups on physical fitness at pre and posttest is presented in Table A, Appendix 3.

Only the Exercise group was fitness tested on the bicycle ergometer at Time 2. The Exercise group showed a significantly improved mean maximum workload score $t(13) = 2.8$, $p < .05$, as illustrated in Figure 3. Mean HR375 score was lower at Time 2 indicating an improvement in physical fitness, although this difference did not attain statistical significance (see Figure 4). The results of these analyses suggest that the Exercise group did improve in physical fitness, after following the 14-week programme.

Examination of individual data from the Exercise group showed that only 10 of the 14 individuals actually improved on the maximum workload and HR375 scores. In order to make the strongest possible test of the hypothesis that improvement in physical fitness is related to improvement in cognitive performance, comparisons were made of these 10 individuals, designated the Exercise Change group, with the Athletic and Control groups on the cognitive measures. A two-way MANCOVA showed

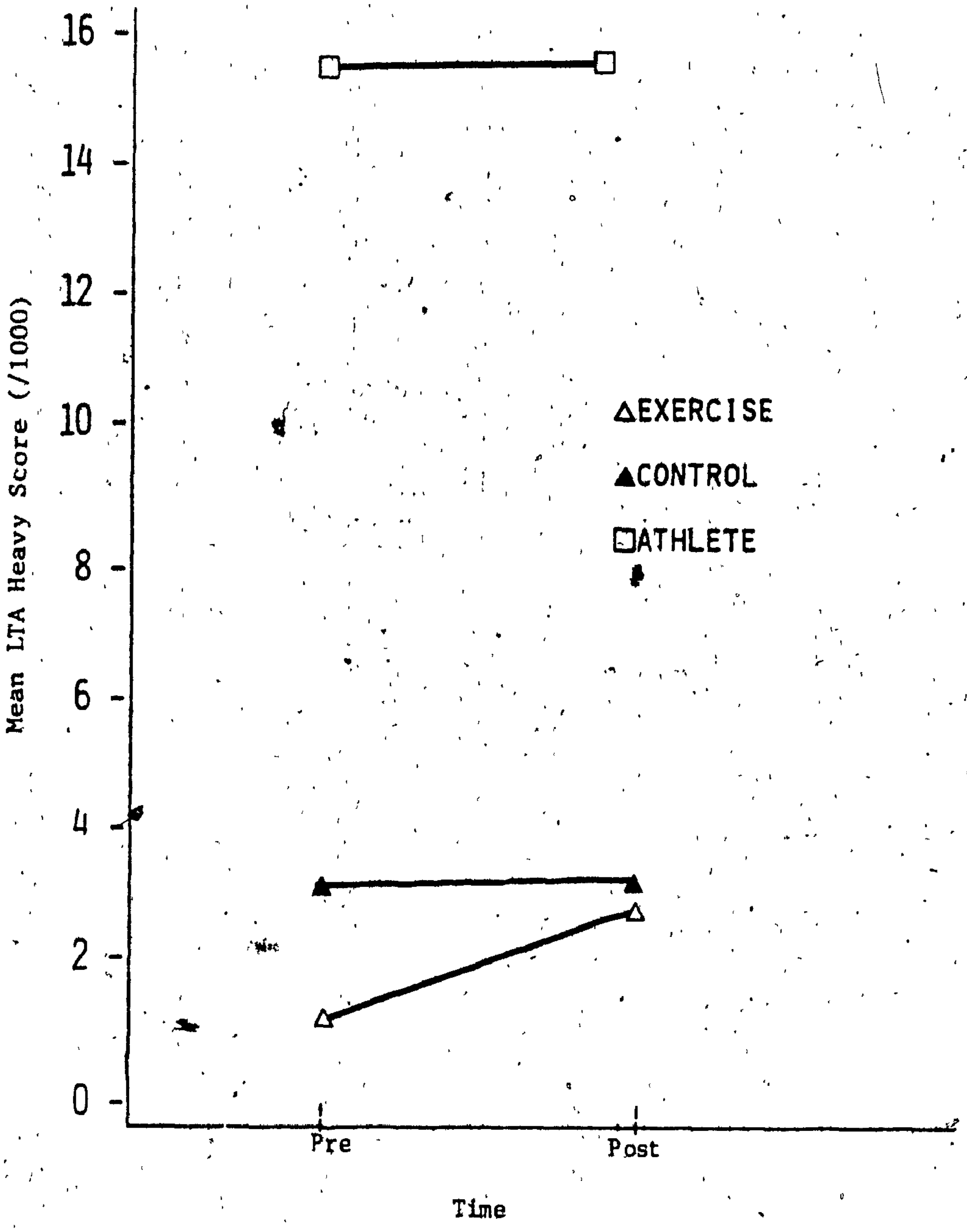

Figure 2. Pre and post adjusted mean LTA heavy score

Table 13

Adjusted Mean Pre and Post Physical Fitness Scores

Experimental Group	Fitness Variable			
	Perceived Fitness		Perceived Health	
	Pre	Post	Pre	Post
	M (SD)	M (SD)	M (SD)	M (SD)
Exercise (n = 17)	5.5 (1.8)	6.6 (1.8)	7.3 (1.5)	7.1 (1.6)
Control (n = 14)	6.5 (1.3)	7.0 (1.4)	7.3 (1.2)	7.1 (1.2)
Athlete (n = 12)	7.5 (1.6)	8.0 (0.7)	7.8 (1.0)	7.9 (0.7)

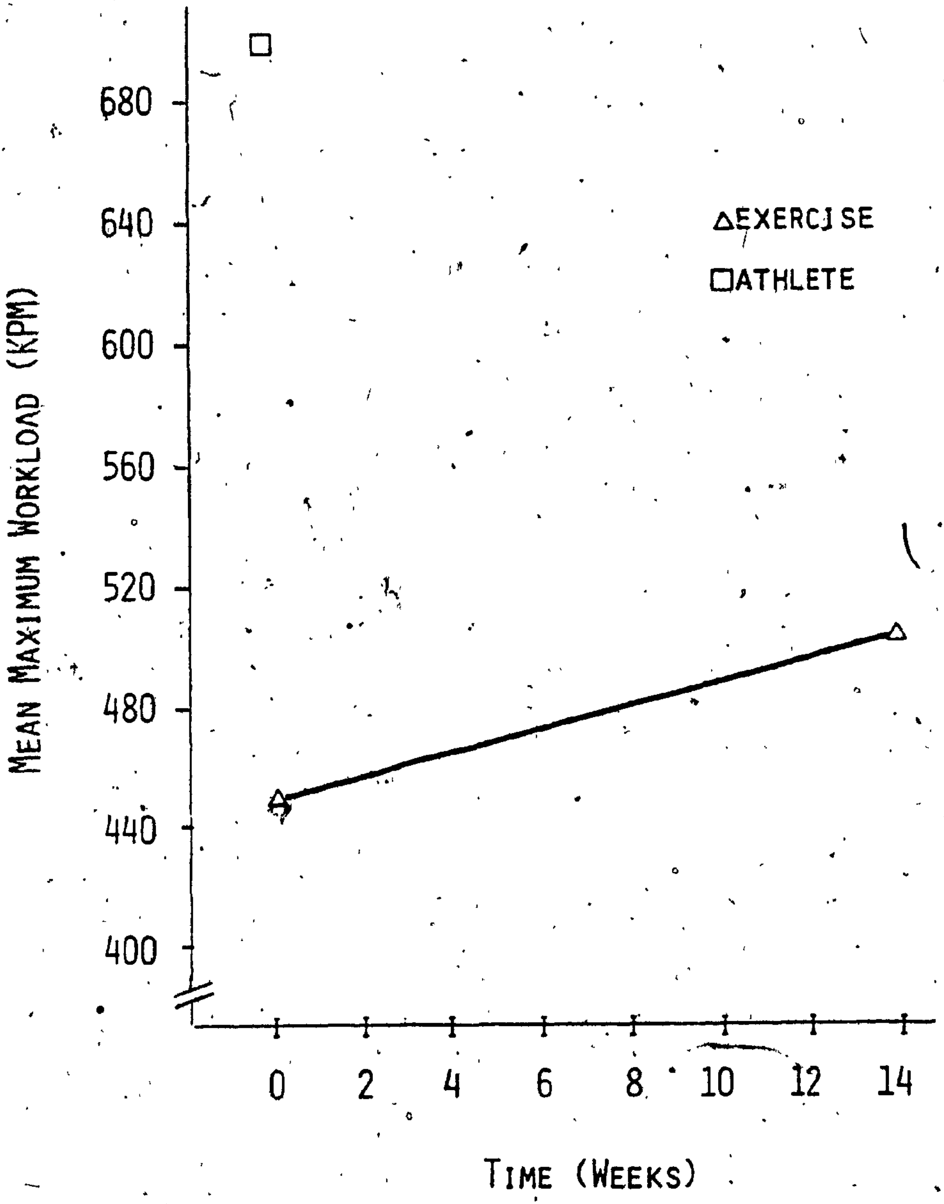

Figure 3. Pre and post adjusted mean maximum workload.

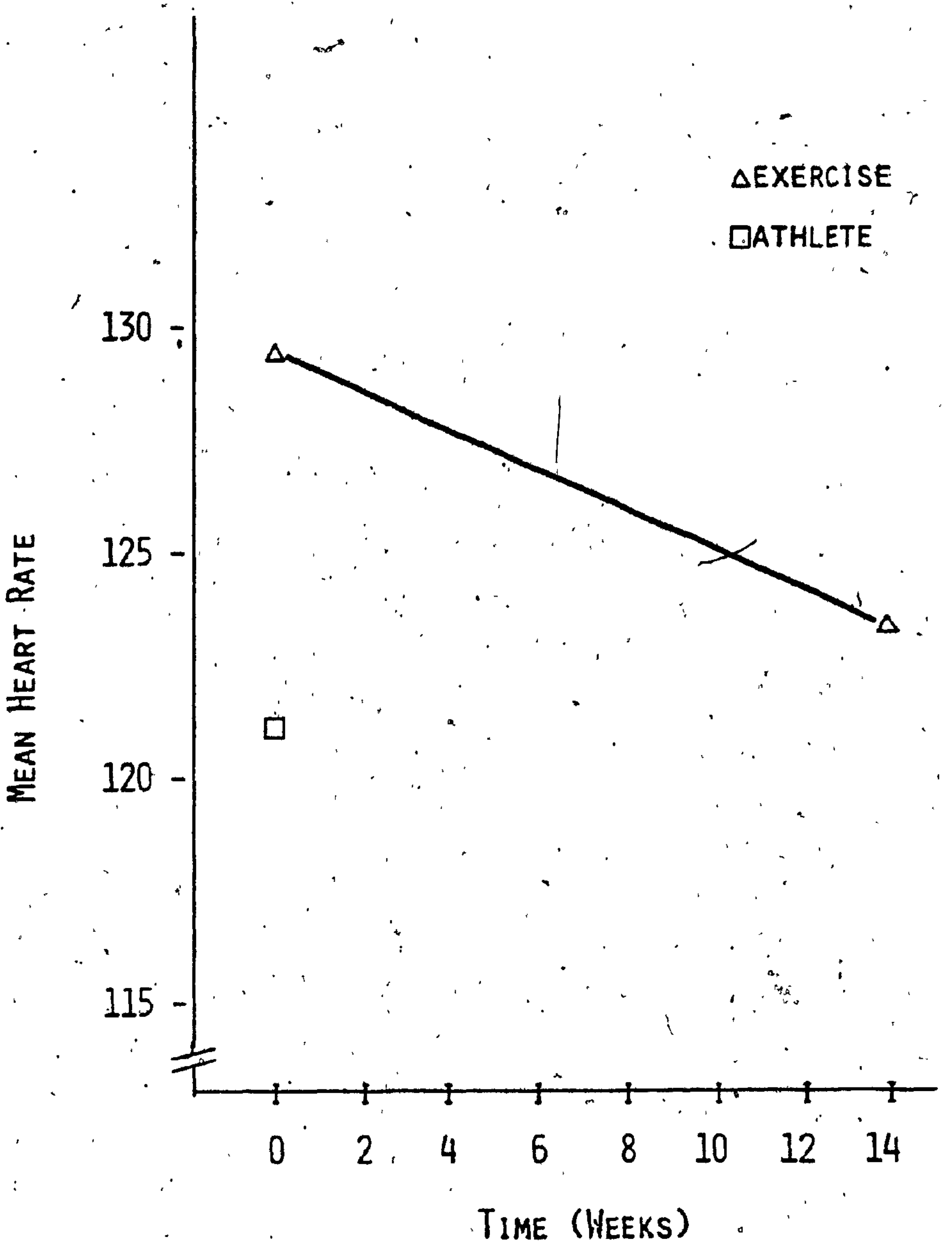

Figure 4. Pre and post adjusted mean heart rate at a workload of 375 KPM

that there was no significant group by time interaction for cognitive performance. Pre and Post adjusted mean scores, and standard deviations of the groups on psychomotor speed, forward digit span, backward digit span, and associate learning are presented in Table 14. A summary table of the two-way MANCOVA comparing the experimental groups on cognitive performance at pre and posttest is presented in Table B, Appendix 3.

Relationships between Improvement in Physical Fitness and Improvement in Self-Concept in Older Adults

A MANCOVA comparing the groups on the five TSCS subscales did not show any significant Group by Time interactions. Therefore the Exercise Change group did not show significant improvement in self-concept despite the group's improvement in physical fitness. The pre and post adjusted means, and standard deviations of the groups on the five TSCS subscales are presented in Table 15. A summary table of the two-way MANCOVA comparing the experimental groups on self-concept at pre and posttest is presented in Table C, Appendix 3.

Semi-Structured Interview with the Exercise Group upon Programme Completion

Interviews with the members of the Exercise group upon completion of their programme revealed that 94 percent of them perceived that they had benefitted physically, socially, and educationally from the programme, rank ordering fitness benefits first, social benefits second, and educational benefits third. Fifty percent of the participants felt that they had more available energy, and 24 percent felt that they were more flexible. At six-month follow up, 71 percent of the participants were still active in various exercise 'seniors'

Table 14

<u>Adjusted Mean Pre and Post Cognitive Scores</u>

	Cognitive Variable							
	Psychomotor Speed		Digits Forward		Digits Backward		Associate Learning	
Experimental	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Group	M	M	M	M	M	M	M	M
	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)
Exercise	120	122	7.0	7.2	4.9	5.8	14.9	16.1
(n = 10)	(26)	(39)	(1.4)	(1.5)	(1.9)	(1.8)	(2.7)	(2.2)
Control	129	134	6.9	6.7	5.2	5.4	16.2	16.0
(n = 13)	(23)	(26)	(1.5)	(0.9)	(1.5)	(1.6)	(3.6)	(2.8)
Athlete	121	125	6.7	6.3	5.1	5.1	15.6	15.6
(n = 12)	(18)	(19)	(1.3)	(1.1)	(1.3)	(1.4)	(2.8)	(3.1)

Table 15

Adjusted Mean Pre and Post Self-Concept Scores

	TSCS Subscale									
	Physical		Personal		Social		Family		Moral	
Experimental	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Group	M	M	M	M	M	M	M	M	M	M
	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)	(SD)
Exercise	61	63	65	66	63	65	70	70	71	71
(n = 10)	(9)	(9)	(11)	(9)	(5)	(6)	(11)	(8)	(7)	(7)
Control	73	70	70	69	76	74	78	74	78	74
(n = 14)	(9)	(6)	(6)	(6)	(7)	(8)	(5)	(10)	(5)	(7)
Athlete	71	71	71	69	71	71	76	74	76	74
(n = 12)	(7)	(8)	(7)	(7)	(7)	(5)	(7)	(7)	(6)	(7)

programmes offered in the community.

A comparison of the Exercise and Coronary Groups

A complete set of baseline psychological and fitness data was available for nine of the individuals who were screened from the exercise programme because they exhibited symptoms of coronary illness. Although a comparison of this group with the Exercise group was not originally part of the research design, the availability of this sample presented an important opportunity to assess the relationship between cardiovascular health and psychological well-being, particularly in light of existing empirical support for an association between cardiovascular health and cognitive performance (e.g. Herzog, Schaie, & Gribbin, 1978). Although random assignment to groups was impossible, the Exercise group is a meaningful comparison group, because before being tested by the cardiologist the Coronary group members perceived themselves to be in sufficiently good health to join the exercise programme, and were similarly motivated to join. Also, psychological testing of all nine coronary individuals was conducted before their cardiologists' appointments. T-tests comparing the Exercise and Coronary groups on background variables of age, intelligence, education, and SES, show that they differed on age only $\underline{t}(24) = 3.7$, $\underline{p} < .01$ (see Table 16). The groups were also compared on fitness, cognitive and self-concept measures based on ANCOVAS covarying out effects of age and intelligence. The groups did not differ on any of the fitness, cognitive or self-concept variables. The adjusted means, standard deviations, t, and F scores for the groups on fitness, cognitive, and self-concept measures are listed in Tables 17, 18, and 19 respectively.

Table 16

Age, Intelligence, SES, and Education Comparisons for the Coronary and Exercise Groups

	Experimental Group				
	Coronary (_n_ = 9)		Exercise (_n_ = 17)		
Background Variable	_M_	(_SD_)	_M_	(_SD_)	_t_
Age					
Years	72.6	(4.1)	66.0	(4.7)	3.7*
Intelligence					
Vocabulary Subscale - Stanford - Binet	27	(8)	31	(5)	1.6
SES					
Blishen	3.1	(1.5)	3.1	(1.6)	.01
Education					
Years	11	(3)	12	(3)	.65

* $p < .01$.

Table 17

A Baseline Comparison of the Coronary and Exercise Groups on Fitness Variables Based on One-Way ANCOVAS

Fitness Variable	Experimental Group				
	Coronary (n = 9)		Exercise (n = 17)		F(1, 22)
	M[a]	(SD)	M[a]	(SD)	
Maximum Workload	444	(124)	443	(131)	.0008
LTA Heavy (/1000)	1.0	(1.7)	1.1	(1.0)	.0004
Perceived Health	6.4	(1.7)	7.6	(1.5)	1.6
Perceived Fitness	4.7	(0.9)	5.5	(1.8)	.72

[a] M = Adjusted mean.

Table 18

A Baseline Comparison of the Coronary and Exercise Groups on Cognitive Variables Based on One-Way ANCOVAS

	Experimental Group				
Cognitive Variable	Coronary (n = 9) M[a]	 (SD)	Exercise (n = 17) M[a]	 (SD)	F(1, 22)
Forward Digit-Span	6.4	(1.7)	6.5	(1.4)	.03
Backward Digit-Span	5.6	(1.6)	4.6	(1.9)	1.6
Associate Learning	14.4	(3.4)	14.2	(3.3)	.03
Psychomotor Speed	89	(30)	105	(30)	2.4

[a] M = Adjusted mean.

Table 19

A Baseline Comparison of the Coronary and Exercise Groups on Self-Concept Based on One-Way ANCOVAS

	Experimental Group				
Self-Concept Variable	Coronary (n = 9) M^a	(SD)	Exercise (n = 17) M^a	(SD)	F(1, 22)
Physical Self	59	(7)	65	(9)	2.1
Moral Self	70	(7)	74	(6)	1.8
Personal Self	61	(10)	67	(10)	1.3
Family Self	66	(8)	74	(10)	2.7
Social Self	65	(10)	64	(9)	.02

[a] M = Adjusted mean.

Discussion

The discussion is organized in terms of the four hypotheses which were presented in the Introduction section.

1) There is a Positive Association between Cognitive Performance and Physical Fitness in Older Adults

Despite baseline differences in physical fitness among the Exercise, Control, and Athletic groups, the groups did not differ in their baseline performance the four cognitive measures of psychomotor speed, forward digit span, backward digit span, and associate learning. These results do not support Ohlsson's (1983) findings. He found that Athletic older adults had better short-term memory skills and faster psychomotor speed than Sedentary older adults. One explanation for this discrepancy is that the Athletes in his study were all actively competitive, whereas the Athletic adults in this study were 'athletic' by virtue of the quantity rather than the quality of their athletic pursuits. Very few of these individuals were competitive. Perhaps the Athletes in Ohlsson's study became competitive because they possessed superior skills such as unusually fast psychomotor speed. The outcome of the group comparisons on cognitive performance in the present study is also different from that of Spirduso and Clifford's (1978) research in which Athletic older adults were found to possess faster reaction times than their more sedentary peers. Perhaps this discrepancy in results is a reflection of the use of different measures of psychomotor speed. The Clerical Speed and Accuracy Test is language based to the extent that it requires the recognition of letters and numbers, and it mimics tasks which are inherent in certain work situations such as proof reading which might be required of a teacher or an accountant. The relative advantage of certain individuals whose work requires these skills may have confounded the results.

Physical fitness did not emerge as a significant predictor of cognitive performance based on stepwise regression analyses even with the inclusion of additional sedentary and 'coronary' older adults. These findings are in contrast to those of Crooks (1976) in which physical fitness was shown to be a significant predictor of backward digit span among older adults between the ages of 55 and 89 years. Perhaps Crooks' inclusion of a wider age range explains the different outcomes. The majority of participants in the present study were in their 60s. Only a handful were in their 70s, and none were in their 80s or 90s. The theoretical rationale for anticipating a baseline association between cognitive performance and physical fitness was that physical fitness might help to offset the age - related decline typically seen in older adults in the selected cognitive measures. This decline is more dramatic in older adults in their 70s and 80s as opposed to older adults in their 60s. Perhaps the lack of a significant association between baseline cognitive performance and physical fitness reflects the 'young old' status of the participants in this study. The fact that age emerged as a significant predictor of psychomotor speed and backward digit span performance confirms that these were appropriately selected measures of cognitive skills in that they are negatively associated with age (even within the limited age range of the sample). However any effects of physical fitness in offsetting age - related declines in cognitive abilities may become apparent only at a later age, when cognitive deficits are more exaggerated.

In conclusion, support for an association between baseline cognitive performance and physical fitness in ´young old´ older adults was not found, leaving open the possibility that such a relationship may be established in a more elderly population who are exhibiting more acute cognitive decline.

2) Improvement in Physical Fitness is Associated with Improvement in Cognitive Performance in Older Adults

The Exercise Change group participants did not improve to a statistically significant extent in their performance on the four cognitive measures of psychomotor speed, forward digit span, backward digit span, and associate learning despite their improvement in physical fitness on completion of the exercise programme. These results do not support the work of Dustman et al. (1983), who established associations between participation in a fitness programme, and improvement in cognitive performance. The difference in results may be a function of the relatively older age of the sample in Dustman et al.´s study. Their sample included individuals in their early to late 70s whereas the majority of participants in the present study were in their early to late 60s. A relationship between improvement in physical fitness and improvement in cognitive performance may exist for a more elderly population in which decline in both cognitive performance and physical fitness is more evident.

In conclusion, the hypothesis that there is an association between improvement in physical fitness and improvement in cognitive performance in older adults was not supported.

3) There is a Positive Association between Self-Concept and Physical Fitness in Older Adults

Support for a positive association between self-concept and physical fitness was evident in the results of the stepwise regression analyses. Physical fitness as measured by maximum workload emerged as a significant predictor of physical, personal, and social self-concept. The stepwise regressions included a wider range of unfit older adults including nine individuals who were diagnosed as having coronary illness. Perhaps the support for a self-concept - fitness relationship in this second data base is an inditation that older adults who are very unfit have a poor self-concept as opposed to older adults in excellent physical condition having an elevated self-concept.

Perceived fitness did not emerge as a significant predictor of self-concept. Thus, actual as opposed to perceived fitness was positively associated with self-concept. Perceived health emerged as a significant predictor of physical, personal, and family self-concept. This relationship supports Jarvik's (1983) contention that one's perceived health may be the single most important factor in predicting successful adjustment to old age.

In conclusion, the hypothesis that there is an association between self-concept and physical fitness in older adults was supported. The pattern of results suggest that there may be a threshold level of fitness which must be maintained in order to preserve a positive self-concept, but exceeding that threshold level may not enhance one's self-concept in old age.

4) Improvement in Physical Fitness is Associated with Improvement in Self-Concept in Older Adults

The Exercise Change group did not improve to a statistically significant extent in self-concept as measured by the TSCS. Hanson and Nedde (1978) found that although the group of young women they studied improved their physical fitness after participating in an exercise programme for four months, they did not improve in their self-concept to a statistically significant extent until they had been participating for eight months. Perhaps if the Exercise programme had been extended for a longer period of time, an improvement in self-concept would have accompanied the improvement in physical fitness.

In conclusion, support for the hypothesis that improvement in physical fitness is associated with improvement in self-concept in older adults was not supported.

Semi-Structured Interview upon Programme Completion

The strong enthusiasm which the participants expressed towards their experience in the exercise programme during private interviews at posttest demonstrates that they perceived that they had benefitted both physically and socially. The exercise programme effected a significant behavioural change in the Exercise group in that 71 percent of the participants remained active in exercise programmes at six-month follow-up. This is an impressive lifestyle change for a group of formerly sedentary older adults. The fact that psychological change was not reflected in the test scores suggests that the selected measures were not sufficiently sensitive to the type of psychological change which was effected as evidenced by the participants' subjective experience of benefit and by their behaviour change.

Coronary Group

Although a relationship between cardiovascular health and cognitive performance has been established in other studies (e.g. Herzog, Schaie, & Gribbin, 1978), it was not in evidence here. There were no statistically significant differences in cognitive performance or self-concept between the Coronary and Exercise groups. However there was a trend towards poorer performance on the cognitive measure of psychomotor speed on the part of the Coronary group.

Conclusions and Suggestions for Future Research

Conclusions

1) This study confirmed that sedentary older adults have the capacity to train, and to improve their aerobic fitness.

2) A positive association between self-concept and physical fitness in older adults was establishd. This association was much more in evidence when the data base included a wider range of unfit older adults. The pattern of results lends itself to the interpretation that a threshold level of physical fitness must be maintained in old age in order that self-concept not be diminished, as opposed to the interpretation that a superior level of physical fitness enhances self-concept. Possibly, very athletic older adults are comparing themselves with equally athletic and younger adults with whom they are exercising, and therefore they do not experience themselves in a superior way.

3) Although a baseline association between self-concept and fitness was established, improvement in fitness was not accompanied by improvement in self-concept. Perhaps a longer period of time was necessary to consolidate changes such as improved body image which may

mediate the fitness - self-concept relationship.

4) An association between baseline cognitive performance and physical fitness was not established. Athletic older adults were not shown to possess superior cognitive functioning in the domains of psychomotor speed and short-term memory.

5) Exercise participants who had improved in their physical fitness did not show improvement in cognitive performance.

Suggestions for future research

1) In future research, it would be advantageous to work with a more elderly population for whom both diminished psychological functioning in the domains of self-concept and cognition, as well as diminished fitness would be more salient. Thus, ceiling effects which may have confounded the establishment of associations among these variables would be avoided. It would also be interesting to consider the benefits of exercise programmes for special populations such as depressed elderly, and demented elderly for whom deficits in self-concept and cognition are of particular relevance. Encouraging work with the demented elderly in this regard has already begun (Diesfeldt et al., 1977).

2) The selection of the Clerical Speed and Accuracy Test may have masked the existence of a positive association between psychomotor speed and fitness in the elderly. Selection of a test which would not be in any way more familiar to some of the subjects would be recommended.

3) Given the benefits of the exercise programme for the participants as evidenced by their continued participation in fitness programmes at six-month follow-up, and by their subjective expression

of having benefitted, selection of additional psychological measures which can more sensitively tap these benefits would be important. Measures of life-satisfaction and happiness are two possibilities.

4) Two of the women in the study reported dramatic personal benefits as a result of their participation in the exercise programme. One woman felt that the programme showed her that she was still ´strong and capable´, and that she was ´a person of worth´ whereas before she felt that she had ´nothing to look forward to´. The other woman felt that for the first time in her life she was going to reorganize her priorities and place her health and personal well-being before her work-related commitments. A more in depth case study of these women would have permitted an understanding of why they were so deeply affected by their involvement, and thus, what type of older individual could benefit most from participation in an exercise programme.

5) Because an exercise programme geared for older adults must provide close supervision and personal attention in order to be safe and effective, the nature of the control intervention must offer similar ´side´ benefits. It is challenging to create such a control. In an elderly sedentary population, creating a ´pseudo-fitness programme´ in which strength and flexibility but not aerobic fitness is promoted, aerobic benefits might nonetheless occur because of their very poor initial conditioning. Developing meaningful control interventions warrants attention.

6) The present study confirmed that sedentary older adults have the capacity to improve their aerobic fitness, and that doing so effects positive psychological change. Given the typical prediction of decline in all areas of physical and psychological functioning which is

usually made for older adults, these findings are particularly optimistic. Because physical fitness has been shown to remain labile in old age, it may prove to be an important adjunct to programmes designed to improve the quality of life of the healthy elderly, as well as programmes geared towards the depressed and demented elderly for whom diminished self-concept and diminished cognitive functioning are of more acute concern.

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Appendix 1

Summary Tables for One-Way Multivariate and Univariate Analyses of Covariance: Comparisons of Experimental Groups on Physical Fitness Measures

Table A

A Baseline Comparison of Experimental Groups on Fitness Measures

Fitness Variable	MS	$F(2, 40)$
Multivariate $F(6, 76) = 5.1^{**}$		
LTA Heavy	8.8×10^{10}	15.7^{**}
Error	5.6×10^{10}	
Perceived Fitness	16.1	6.7^{*}
Error	2.4	
Perceived Health	1.3	.80
Error	1.6	

** $p < .001$.

* $p < .01$.

Appendix 2

Table of Intercorrelations among Background, Fitness, Cognitive, and Self-Concept Baseline Measures for the Sample of 45 Older Adults used in the Stepwise Regression Analyses

Table A

Intercorrelations among Background, Fitness, Cognitive and Self-Concept Baseline Measures for the Sample of 45 Older Adults used in the Stepwise Regression Analysis

	1	2	3	4	5	6	7	8	9	10
1. Age	1.00									
2. Intelligence	-.11	1.00								
3. Education	-.10	-.48	1.00							
4. SES	-.23	.45	-.49	1.00						
5. Max. Work.	-.01	.21	-.33	.30	1.00					
6. LTA Heavy	.17	.33	-.28	.12	.58	1.00				
7. Perc. Fit.	.15	.34	-.23	.31	.43	.53	1.00			
8. Perc. Health	.15	.04	.03	-.02	.09	.27	.47	1.00		
9. Psych. Speed	-.52	.54	-.20	.18	.14	.09	.12	.12	1.00	
10. Digits Forward	-.09	.50	-.34	.17	.22	.10	.34	.29	.29	1.00
11. Digits Backward	-.32	.52	-.17	.29	.06	.03	.28	.12	.52	.42
12. Assoc. Learning	-.10	.39	-.08	.12	-.07	.11	.26	.15	.37	.30
13. Physical S. C.	.15	-.02	-.04	.12	.48	.35	.38	.55	.04	.24
14. Moral S. C.	-.19	.08	.20	.22	-.07	-.05	-.03	.14	.28	-.13
15. Personal S. C.	-.06	.03	.10	.15	.30	.19	.27	.34	.14	.10
16. Family S. C.	-.00	.17	.08	-.15	-.04	.01	.14	.41	.29	.31
17. Social S. C.	-.14	.29	-.02	.15	.32	.17	.24	.22	.38	.24

	11	12	13	14	15	16	17
11. Digits Backward	1.00						
12. Assoc. Learning	.48	1.00					
13. Physical S. C.	.04	-.07	1.00				
14. Moral S. C.	.06	.02	.24	1.00			
15. Personal S. C.	.03	.00	.76	.39	1.00		
16. Family S. C.	.28	.23	.49	.47	.52	1.00	
17. Social S. C.	.03	.00	.51	.33	.52	.62	1.00

Appendix 3

Summary Tables for Repeated Measures Multivariate and Univariate Analyses of Covariance: Comparisons of Experimental Groups on Fitness, Cognitive, and Personality Measures

Table A

A Comparison of Experimental Groups on Fitness Measures at Pre and Posttest

Source	*MS*	*DF*	*F*
Experimental Group Multivariate *F*(6, 58) = 5.2**			
LTA Heavy	1.3 x 10^{11}	2	10.5**
Error	1.3 x 10^{10}	31	
Perceived Fitness	28.5	2	10.0**
Error	2.9	31	
Perceived Health	6.2	2	2.2
Error	2.8	31	
Time Multivariate *F*(3, 31) = 4.5*			
LTA Heavy	1.0 x 10^{8}	1	3.1
Error	3.2 x 10^{7}	33	
Perceived Fitness	9.7	1	10.0*
Error	1.0	33	
Perceived Health	0.1	1	.02
Error	.58	33	
Experimental Group by Time Multivariate *F*(6, 62) = 3.6*			
LTA Heavy	3.3 x 10^{8}	2	10.1**
Error	3.2 x 10^{7}	33	
Perceived Fitness	1.3	2	1.3
Error	1.0	33	
Perceived Health	.17	2	.30
Error	.58	33	

** $p < .001$.
 * $p < .01$.

Table B

A Comparison of Experimental Groups on Cognitive Measures at Pre and Posttest

Source	DF	Multivariate F
Experimental Group	8, 54	.43
Time	4, 29	2.2
Experimental Group by Time	8, 58	1.1

Table C

A Comparison of Experimental Groups on Self-Concept Measures at Pre and Posttest

Source	DF	Multivariate F
Experimental Group	10, 52	2.2*
Time	5, 28	1.7
Experimental Group by Time	10, 56	.52

*$p < .05$