INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

U·M·I

University Microfilms International
A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
313/761-4700 800/521-0600

Order Number 9402489

The effects of 16-week walking and 16-week weight-training programs on the performance of men and women ages 65–77 on the Ross Information Processing Assessment

Moul, Jamie Lynn, Ed.D.

The University of North Carolina at Greensboro, 1993

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

THE EFFECTS OF 16-WEEK WALKING AND 16-WEEK WEIGHT-TRAINING PROGRAMS ON THE PERFORMANCE OF MEN AND WOMEN AGES 65-77 ON THE ROSS INFORMATION PROCESSING ASSESSMENT

by

Jamie L. Moul

A Dissertation Submitted
to the Faculty of the Graduate School
at The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Greensboro
1993

Approved by

Dissertation Adviser

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at The University of North Carolina at Greensboro.

Dissertation Adviser: Bert A. Goldman

Committee Members: William B Karper

Dale L. Brubaker

C M Achilles

2/17/93
Date of Acceptance by Committee

2/17/93
Date of Final Oral Examination

MOUL, JAMIE L., Ed.D. The Effects of 16-week Walking and 16-week Weight-training Programs on Performance of Men and Women Ages 65-77 on the Ross Information Processing Assessment. (1993). Directed by Dr. Bert Goldman. 153pp.

The purpose of this investigation was to determine if performance on the Ross Information Processing Assessment (RIPA) by older adults is altered by 16-week walking and weight-training programs. Forty-four, nondiseased, inactive male and female subjects participated in the study (mean age = 69.1 ± 0.45 years). Pre- and posttraining data was obtained utilizing a maximal graded treadmill test, an isokinetic assessment of knee extensor strength and elbow flexor strength, and the RIPA. Participants were randomly assigned to one of three groups, a walking group, a weight-training group, or a placebo control group. The walking group met five days per week walking for thirty minutes at 60% of their heart rate reserve. Walking time was increased two minutes each week until 40 minutes was achieved. Additionally, at eight weeks training heart rate was increased to 65% of heart rate reserve. The weight-training group met five days per week and engaged in a progressive resistive weight program utilizing the DAPRE protocol. The placebo control group met five days per week and engaged in mild stretching exercises. Analysis of the maximal graded treadmill test data with a MANOVA revealed significant increases in both $\dot{V}$O2max and time on treadmill in the walking group. A MANOVA also revealed significant

improvements in elbow flexor and knee extensor strength in the weight-training group. Additionally, the walking group demonstrated significant increases in knee extension. An ANOVA was utilized to determine the effects of the training programs on blood pressure and RIPA. Results indicated a significant decrease in both systolic and diastolic blood pressures in the walking and weight-training groups. RIPA performance was significantly increased following the walking program compared to the weight-training or placebo control programs. A Pearson correlation coefficient revealed a significant relationship between RIPA performance and V̇O2max. In conclusion, data analysis indicates walking was more effective in improving RIPA performance compared to a weight-training or a placebo control program. Additionally, the data suggests a relationship between the functioning of the cardiovasular system and RIPA performance.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The primary focus of cognitive development research in the past has been upon the advancement of knowledge in areas such as learning, memory, and cognition throughout childhood and early adolescence. However, cognitive development does not end with adolescence; it continues over the life span. With the advent of an older population participating in educational experiences, a proliferation of research activity has occurred in the area of changes in cognitive functioning during late adulthood. This intensification of interest has generated contradictory literature extolling both the gains and declines in cognition with age. These contradictions are attributed to the investigators' lack of distinction between cognitive measures that are more dependent on effort than those categorized as automatic (Chodzko-Zajko, 1991).

The concepts of automatic versus effortful cognition have been elucidated through performance on both psychomotor tests and on tests of information processing. Decreased psychomotor performance is generally accepted as a consequence of aging (Panton, Graves, Pollack, Hagberg & Chen, 1990). Studies have shown that an age-related

Chen, 1990). Studies have shown that an age-related deterioration of the neuromuscular system causes a lengthening of both total reaction time and speed of reaction time (Baylor & Spirduso, 1988; Spirduso, 1980; Spirduso & Clifford, 1978). In addition, cognitive tasks with a large psychomotor component that must occur within a time limit have been shown consistently to be slower in the elderly (Kausler, 1985; Kirasic & Allen, 1985; Plude & Hoyer, 1985; Spilich, 1985). Information processing tasks have also been demonstrated to deteriorate with age (Salthouse, 1988). Administrators in higher education are currently dealing with an influx of older adults returning to school seeking degrees or for personal enrichment. The information generated from investigations elucidating the changes in cognitive abilities with age can provide the administrator with knowledge upon which to base programming and student advising decisions.

Numerous authors have proposed that information processing can be improved with aerobic exercise (Barry, Steinmetz, Page, & Rodahl, 1966; Baylor & Spirduso, 1988; Clarkson-Smith & Hartley, 1989; Emery & Getz, 1990; Stones & Kozma, 1989). A sound mind in a sound body may, in fact, be more plausible than was originally thought. However, the relationship among physical fitness, aging, and information processing has proven to be very abstruse.

A relationship between exercise and psychomotor speed has been suggested by several investigators (Barry et al., 1966; Baylor & Spirduso, 1988; Elsayed, Ismail, & Young, 1980; Powell & Pohndorf, 1971; Rikli & Busch, 1986; Spirduso, 1975; Spirduso & Clifford, 1978). Studies involving subjects who have been physically active for most of their lives have demonstrated significant differences in psychomotor speed when compared with sedentary, age-matched individuals (Baylor & Spirduso, 1988; Rikli & Busch, 1986; Spirduso, 1975; Spirduso & Clifford, 1978). Assessments of simple and choice reaction time utilizing a visual stimulus revealed that older men who were physically active in racquet sports responded with the same celerity as college men. These results led Spirduso (1975) to surmise that a life style of physical activity appeared to play a dominant role in determining simple reaction time, discrimination reaction time and movement time. Spirduso and Clifford (1978) replicated and expanded the findings of Spirduso's (1975) earlier work by investigating psychomotor performance of older men who chronically run or participate in racquet sports. Again, the chronically active men demonstrated significantly faster performances on the psychomotor tests than did the sedentary controls. Another finding was that the performances of the active older men were more similar to those of a young active group than to those of the sedentary older or sedentary younger group. Similar results were obtained for women by Rikli and Busch (1986). More recently, Baylor and Spirduso (1988) found that premotor time was significantly faster in an exercise group than in a non-exercise group regardless of age. The large differences in premotor time found in the older women of the Baylor and Spirduso study (1988) replicated a robust central processing activity-level relationship.

Barry et al. (1966) found that posttest scores on a visual discrimination test battery were significantly improved after a three-month intermittent, rhythmic conditioning program when compared to pretest and control group data. A study by Powell and Pondorf (1971) utilizing subjects ages 34 to 75 from an adult fitness program employed eight physiological measurements to determine their possible effects upon mental ability by comparing the results on these measures to performance on the Culture Fair Intelligence Test, an established measure of cognitive functioning. The authors found that in the physiological and cognitive parameters measured, better values were observed for the higher fit group. Elsayed et al. (1980)

concluded from their investigation that regardless of age, the high-fit group had significantly ($p < 0.05$) higher mean information processing scores than the low-fit group. Similar results have been demonstrated by several other studies (Clarkson-Smith & Hartley, 1989; Emery & Getz, 1990; Molloy, Beerschoten, Borrie, Crilly & Cape, 1988; Stones & Kozma, 1989).

Contradictions to the theory of exercising older adults performing superiorly on measures of pyschomotor performance and information processing also have been presented (Blumenthal & Madden, 1988; Blumenthal et al., 1989; Madden, Blumenthal, Allen, & Emery, 1989; Panton et al., 1990). Blumenthal and Madden (1988) attempted to determine whether memory-search peformance could be modified by improving subjects' (males, ages 30-58 years) levels of aerobic fitness. The investigators demonstrated an improvement in V̇O2max, a measure of aerobic capacity, in the exercise group, but failed to show a difference in pre-and posttest values in choice reaction time between the exercise and control groups. After a four-month training study, Blumenthal et al. (1989) concluded that even though VO2max increased significantly in the aerobic exercise group compared with the yoga or control group, measures of information processing improvement were not unique to a particular group. Two additional training studies failed to show improvements in information processing resulting from aerobic exercise (Madden et al., 1989; Panton et al., 1990).

Mechanisms by which chronic exercise might postpone the decline in information processing have not been thoroughly investigated. However, two areas have been proposed as links: 1) the effects of exercise on the oxidative capacity of the brain, and 2) the trophic effect that exercise may impose on central nervous system functioning.

Cardiovascular inefficiency and disease that frequently occur in senescent individuals result in a deficient cerebral circulation which in turn causes a decrease in brain oxidative capacity. Such a deficit results in less energy available to the brain for proper functioning and tissue maintenance. The relationship between cerebral blood flow and oxidative capacity has not been directly measured in humans; however, Patel (1977) documented a decrement in oxidative capacity of the cerebral cortex in older animals with decreased cerebral blood flow. Aerobic activity has been shown to increase circulation to areas of the brain specific to motor functioning as well as areas responsible for ideation and planning of movement (Dustman et al., 1984; Ingvar & Phillipson, 1977). Therefore, areas responsible for planning, initiating, and executing movement receive an increase in blood flow while total cerebral blood flow appears to remain unchanged. A regular aerobic exercise program may slow the aging decline in blood flow to and maintain levels of oxygen consumption in areas responsible for information processing. Thus, aerobic exercise may prevent or postpone the disuse cycle of decreased metabolic demands leading to decrease in regional blood flow, which in turn leads to neuronal destruction, which in turn leads to disuse, and so on.

In addition, aerobic exercise has been purported to decrease blood pressure, a measure of resistance to blood flow. Elias, Robbins, Schults and Pierce (1990) have demonstrated a negative correlation between neuropsychological performance and a wide range of blood pressures.

Less well documented is the effect of a weight training program on cardiovascular parameters. Frontera, Meredith, O'Rielly, & Evans (1990) demonstrated that in healthy older men a strength training program produced improvements in oxygen utilization in exercised muscles. From these results the authors have postulated that the local muscular changes may enhance aerobic capacity of the organism.

Little is known of the trophic influence of physical activity on the central nervous system. Muscles have been shown to have a trophic influence on innervating nerves and on receptors (Guyton, 1986). However, the influence of muscular activity on higher central nervous system functioning is not clear. To elucidate this influence, several studies investigating the effects of physical activity on neurotransmitter substances have been conducted (Brown et al., 1979; Forrester, 1978, McRae, Spirduso, Cartee, Farrar & Wilcox, 1987). Forrester (1978) found that adenosine triphosphate (ATP) is released from exercising muscles in sufficient quantities to alter cerebral blood flow and increase brain neurotransmitters. Both norepinephrine and serotonin brain concentrations have been shown to increase after an eight week endurance training program (Brown et al., 1979).

McRae et al. (1987) have proposed a link between chronic endurance training and the maintenance of the nigrostriatal dopamine system in senescent rats. The striatum and substania nigra function together to initiate intentional gross motor movement and responses to cognitive stimuli (Guyton, 1986) which have been shown to deteriorate with aging (McRae et al., 1987). This finding, however, has not been substantiated in humans. The contradictory and inconclusive results of investigations regarding the interaction between exercise and cognitive functioning have led Blumenthal and Madden (1988) to suggest that further research is needed to determine the outcome.

Purpose of the Study

The purpose of this study was to determine if information processing can be altered by 16-week walking and weight-training programs. To investigate the influences of an aerobic and a resistance training program on information processing in the older adult, the following research questions were addressed:

1. Is there a significant difference in the subjects' performance on the Ross Information Processing Assessment (RIPA) before and after a 16 week-walking program?

2. Is there a significant difference between the subjects' performance on the RIPA before and after a 16-week weight- training program?

3. Is there a significantdifference between the subjects' performances on the RIPA before and after a 16-week walking program as compared to before and after a 16-week weight-training program?

4. Is there a significantdifference between blood pressure measures of the subjects before and after a 16-week walking program?

5. Is there a significant difference between blood pressure measures of the subjects before and after a 16-week weight- training program?

6. Is there a significant difference between blood pressure of the subjects before and after a 16-week walking program compared to before and after a 16-week weight-training program?

Limitations of the Study

Several limitations on the scope of this study should be discussed. First, information processing is a multi-factoral event that involves memory, reasoning, and spatial relations (Salthouse, 1988) all three of which are difficult to assess directly in humans. Therefore, attempts to measure the effects of exercise on information processing have been indirect and the results remain equivocal (Blumenthal et al., 1989; Clarkson-Smith & Hartley, 1989; Emery & Getz, 1990; Panton et al., 1990).

Second, it is difficult to obtain a random sample of older adults from the population. Subjects are self-selected through a volunteer process. Such a sampling process makes it difficult to generalize the results to the population. However, attempts have been made to minimize this limitation through a randomized control group design.

Definition of Terms

Aerobic Capacity: Peak oxygen consumption; the point at which the oxygen consumption plateaus and shows no further increase with additional workload; $\dot{V}O_2max$ (McArdle, Katch & Katch, 1991)

Automatic Cognitive Processes: Those cognitive processes not requiring awareness or attention (Hasher & Zacks, 1979).

Cardiac Output: The quantity of blood pumped per minute by the heart.

Cognitive Functioning: Tasks involving the processes of perceiving relations, educing correlates, and maintaining span of immediate awareness in concept formation and attainment, reasoning, and abstracting (Horn & Catell, 1966).

Control Group: The group, designated as Group C, who will receive neither the walking nor weight training treatment following pretest data collection.

Effortful Cognition: Those cognitive processes requiring considerable attentional capacity or cognitive energy for their performance (Hasher & Zacks, 1979).

Heart Rate: The number of times the heart beats per minute.

Information Processing: The receiving, storage, and retrieval of messages relating to fluid cognitive abilities.

Isokinetic Dynamometer: An electromechanical instrument that allows the production of maximum force during all phases of a movement at a constant velocity (McArdle, Katch & Katch, 1991).

Maximal Oxygen Consumption: A measure of cardiovascular efficiency. The body's ability to transport and utilize oxygen; $\dot{V}$O2max (McArdle, Katch & Katch, 1988).

Older Adult: A person between the ages of 65 and 75.

Progressive Resistive Weight Training: A method of increasing strength of specific muscles by causing them to overcome a fixed resistance, usually in the form of a barbell, dumbell, or weight machine (McArdle et al., 1988).

Psychomotor Speed: Reaction time and other relatively simple tasks requiring information processing (Spirduso, 1980).

Stroke Volume: The quantity of blood pumped from the heart with each beat.

Trophic: Concerned with nutrition.

Walking Group: The group, designated as Group W, who will receive the walking treatment following pretest data collection.

Weight Training Group: The group, designated as T, who will receive the weight training treatment following pretest data collection.

Content of Remaining Chapters

The review of literature provides the reader with an overview of the literature relating to cognitive changes that occur with age, the effects of exercise on age-related morphological and physiological changes, and the effects that exercise has on cognitive performance. Following the review of literature a description of the methods used in conducting the study is presented. The results of data analysis are presented followed by a discussion of the results of this investigation as they relate to the present literature. Finally, culminating the discussion, conclusions derived from the study's results and recommendations for further investigation are included.

CHAPTER II

REVIEW OF LITERATURE

Aging or senescence can be defined as a group of deleterious processes that lead to a progressive loss of physiological adaptability of an organism that culminates in death (Sharkey, 1987; Spence, 1989). Hence, aging is a multi-factoral event occurring at variable rates in individuals (Spence, 1989). In recent years, increasing attention has been focused on the identification of environmental factors that may interact with underlying genetic propensities to alter the rate and extent of aging; among these factors are nutrition (ADA Report, 1987; Hodkinson, 1988; Tiidus, Shepard & Montelpare, 1989), lifestyles (Blair, Brill & Kohl, 1989), and physical fitness (Shepard, 1988; Spirduso, 1989). This thesis and its ramifications are central to the discussion of the relationship between physical fitness and cognitive performance in the older adult.

The review of literature is limited to the parameters isolated in the present investigation and includes the following: an overview of changes in cognitive performance with age; an overview of cardiovascular and neurological alterations that occur with age; proposed mechanisms for the alterations that occur with age; proposed mechanisms for the cognitive changes; and the effects of exercise on cognitive performance in the older population.

Overview of Cognitive Changes

Extensive efforts have been directed at increasing the understanding of the variability with which cognitive performance declines with age. Although a significant number of sensory, motor, and cognitive abilities can be shown to decline with age, there is wide variablity between individuals with respect to both the rate and extent of this decline. Elderly individuals often experience profound deficits in some areas of cognitive functioning while experiencing little or no loss of functioning in other areas of cognition. Botwinick (1984) has suggested that the understanding of age-related alterations in cognitive performance can be measured by an evaluation of the processing requirements of specific memory tasks. Memory is thought to have three processes: encoding, getting information in; storage; keeping information in; and retrieval or recalling the information when needed (Botwinick, 1984). Much recent research has focused on the encoding process, more specifically, the depth of processing. The concept is that the duration of memory depends mainly on the quality and extent of information processing (Botwinick, 1984). If information is deeply processed, it will be long remembered; conversely, if it is poorly learned or shallowly processed, it will soon be forgotten.

The depth of processing theory was initially proposed by Hasher and Zacks (1979). They conceived of effortful and automatic processing on opposite ends of a continua. In this model, effortfull cognitive processes are conceived of as those requiring considerable attentional capacity or cognitive energy for their performance (Hasher & Zacks, 1979, 1988). According to Hasher and Zacks (1979), automatic processes do not require awareness or attention.

Automatic Processing. Automatic processes operate continually to encode information that is the focus of attention (Hasher & Zacks, 1979). They do not require either awareness or intention; they require minimal energy from the attentional capacity to perform (Hasher & Zacks, 1979). According to Hasher and Zacks (1979), once a process is automitized, it can no longer be improved upon by practice or feedback about performance. Although automaticity can result from having practiced processes that once were effortful, some functions are inherently automatic (Hasher & Zacks, 1979). Inherent processes, as described in numerous studies include temporal processes and frequency-of-occurrence information (Attig & Hasher, 1980; Hasher &

Zacks, 1979; Kausler & Puckett, 1980; Sanders, Wise, Liddle, & Murphy, 1990). These inherent processes proposed by Hasher and Zacks (1979) should come as easily to the old as to the young because they are the processes for which humans are genetically prepared; these processes performed largely without conscious attention.

Results of several studies support the inherentness of frequency-of-occurrence (Attig & Hasher, 1980; Hasher & Zacks, 1979; Kausler & Puckett, 1980; Sanders et al., 1990). Hasher and Zacks (1979) presented lists of words to old (56-80 years) and young (18-24 years) subjects, each list varying in the frequency with which the words were repeated in the list. The task was to judge the frequency of occurrence of the words. The investigators found that the ability to estimate frequency was independent of age. In addition, Hasher and Zacks (1979) discovered that specific instructions that frequency estimations would be required were no more useful to either age-group than instructions that did not disclose this information.

Attig and Hasher (1980), using young (18-34 years), middle-aged (35-51 years), and older (60-77 years) groups of people, required subjects to compare two words at a time and indicate the word that they heard more frequently. The three age-groups were comparable in their frequency judgement, thus indicating that aging does not affect automatic processing.

Kausler and Puckett (1980) presented word information visually to three age-groups categorized similarly as those utilized by Attig and Hasher (1980). Their results were consistent with those of previous studies, supporting the concept of effortful and automatic processes. Sanders et al. (1990) asked subjects to search through each of five word lists and find the one word in each list that pertained to a geological formation. They were given five target words but were not informed which word appeared in which list. Data from this investigation supported the findings of previous studies; there were no age-group differences in frequency performance.

Hasher and Zacks (1979) have also proposed that temporal information is automatically processed. Therefore, they postulated that age-groups should not be different in these processes. McCormack's (1981) is the only study conducted to date to assess temporal information processing. McCormack (1981) presented elderly (60-75 years) and young (17-29 years) subjects a list of words auditorily. Half of the subjects in each age-group were instructed to study the words so that they could indicate later where the words belonged in the temporal order given. The remaining subjects were instructed to concentrate on each word with no mention of temporal order. The intention of this study was not to assess the subjects' abilities to remember the words, but rather the subjects' abilities to remember the locations of the words in the list. Data suggested age-group similarities in their recall of temporal order, thus supporting the theory proposed by Hasher and Zacks (1979).

Effortful Processing. Capacity theories of attention are a frequently invoked explanation for the discrepencies observed in age-related declines in cognitive performance. These theories propose that aging is associated with a reduction in the processing resources avaiable for the performance of cognitive tasks (Craik & Simon, 1980; Salthouse, 1988). The concept of effortful processing proposed by Hasher and Zacks (1979) supports the processing resources hypothesis. Hasher and Zacks (1979) defined effortful processes as those requiring effort and are associated with the availability of processing resources. Since effortful processing tasks such as free recall are dependent upon the availability of sufficient attentional resources for successful completion, these tasks are disproportionately compromised by age-related declines in attentional capacity (Chodzko-Zajko, 1991).

Several recent investigations have corroborated the age-related deficits found by Craik and Simon (1980) and Hasher and Zacks (1979) in tasks requiring effortful processes (Albert, Wolfe, & Lafleche, 1990; Arenberg, 1990; Craik & McDowd, 1987; Guttentag & Madden, 1987; Madden, 1985; Wright, 1981). Albert et al. (1990) investigated differences in abstraction ability with age. The investigators assessed abstraction ability in subjects 30-39 years, 40-49 years, 50-59 years, 60-69 years, and 70-79 years utilizing the Proverb Interpretation Test and Visual-Verbal Test. The results demonstrated significant differences with age on abstraction tasks. Data from a longitudinal study by Arenberg (1990) suggested that age-related declines are present in tests of memory for geometric designs.

Craik and McDowd (1987) assessed age differences in recall and recognition utilizing a dual task methodology. Their subjects performed a continuous reaction time (RT) task either alone or simultaneously with word retrieval to test recognition or cued recall. The RT task was a four-choice task in which one of four classes of alphanumeric characters was displayed visually; the subject pressed the corresponding response key as quickly as possible. A correct response caused the next visual character to be displayed. The primary task in this investigation consisted of either cued-recall or recognition. Lists of 12 words were first presented to the subjects visually to be learned without the RT task permitting full attention on the primary task. In addition, descriptive phrases were presented in conjunction with each word. The RT task was performed concurrently during the word retrieval segment of the investigation. Craik and McDowd (1987) attempted to equate performance levels in the cued-recall and recognition tasks; this was accomplished by presenting the cued-recall test immediately following each list and delaying the recognition test until all word lists have been presented and the recall was performed. The results suggested that the older subjects ($\bar{X}$ age = 72.8 years) performed significantly poorer than the younger subjects ($\bar{X}$ age = 20.7 years) on dual tasks involving recall; recognition performance was not significantly different between the two groups. Craik and McDowd (1987) postulated that due to a smaller pool of processing resources at the older subjects' disposal, the more difficult task (recall) was more severly impaired. Similar results utilizing information processing tasks of retrieval were found by Madden (1985) and Guttentag and Madden (1987).

Madden (1985) investigated the difference in time required to retrieve a letter identity and semantic information between young (18-20 years) and older, community dwelling individuals (58-72 years). Each trial began with a two-second warning signal on the screen of an Apple II computer. Following the signal, a word-pair was presented on the viewing screen. The subjects were asked if the two words had approximately the same meaning; they responded yes or no by pressing the appropriate key. The keypress response removed the word-pair and brought the warning signal back to the screen. Data were analyzed for RT and error rate. Results suggested that the older subjects' performance was consistently slower than the younger subjects'. In addition, the error rate of the older individuals was significantly greater than that of the younger group.

Guttentag and Madden (1987) examined the speed and attentional requirements of physical identity (PI) and name identity (NI). Utilizing a dual-task condition and three groups of subjects (19-25 years, 53-65 years, and 67-74 years) changes in attentional capacity across age were determined. The attentional demands were assessed by a secondary tone-detection task presented simultaneously with a primary task, visual-letter display. The visual-letter display task utilized was a simultaneous-presentation letter-matching task involving the presentation of a single standard letter located above the target letters. In the PI task the target letters and standard letter were presented in upper case style; the target letters in the NI task were lower case while the standard was upper case. Each subject was asked to match the target letter with the standard letter. Subjects responded to the tone when it was presented by pressing the appropriate response key. Subjects, under dual-task conditions, are asked to devote as much attention to the primary task as is necessary to maintain a high level of primary task performance. The greater the attentional demands of the primary task, the less attention remains to be allocated to the secondary task, thus, the greater should be the reduction in the secondary task performance. Guttentag and Madden (1987) compared the performance of the subjects on the baseline (single-task) and dual-task trials. Results indicated that the magnitude of the RT difference between PI and NI increased with age, suggesting that older adults are slower than younger adults at retrieving information. In addition, data revealed a significantly slower RT for NI than for PI tasks under dual-task conditions, indicating greater attentional demands for NI than PI.

In summary, numerous investigators have documented a decline in cognitive abilities with age. However, the decline appears to be selective with more consistent deficits demonstrated in those processes requiring effortful cognition than those dependent upon automatic processes.

Proposed Mechanisms of Cognitive Decline With Age

Mechanisms by which cognitive functioning declines with age have not been thoroughly investigated. However, two areas have been proposed as links: 1) the effects of exercise on the oxidative capacity of the brain and 2) the trophic effect that exercise may impose on the functioning of the central nervous system.

Oxidative Capacity. Cardiovascular inefficiency and disease that frequently occur in older individuals result in a deficient cerebral circulation which, in turn, causes a decrease in brain oxidative capacity. Such a deficit results in less energy available to the brain for proper functioning and tissue maintenance. The relationship between cerebral blood flow and oxidative capacity has not been directly measured in humans. However, Patel (1977) documented a decrement in oxidative capacity of the cerebral cortex in animals. Fitzpartrick, Gilboe, Drewes, and Betz (1976) demonstrated a decrease in the dominant frequency of the electroencephalogram (EEG) with a decline in cerebral oxygen uptake. Support has been established for some relationship between the EEG and oxidative metabolism of brain tissue, as well as to cerebral blood flow, which is controlled by the metabolism (Ingvar & Phillipson, 1977). Ingvar and Phillipson (1977) reported that the cerebral blood flow increases following sensory stimulation, brain stem activity, or arousal reactions in general.

Two additional investigators (Fitzpatrick et al., 1976; Ingvar & Phillipson, 1977)have also demonstrated alterations in cerebral blood flow. Conversely, inactivity of the motor centers decreases the metabolic demands. As a result, the blood flow to those regions is lessened. This eventually initiates a cyclic effect that when occurring concomitantly with aging becomes pathological. Thus, Spirduso (1980) suggested that perhaps it is not cerebral blood flow that increases in active individuals, but rather that the continual activation of motor centers maintains cerebral circulation to these centers postponing the age-related deterioration of neurons in the motor regions. The outcome is improvement of cognitive function.

The fact that total cerebral blood flow remains constant regardless of the level of activity being performed does not eliminate chronic exercise as a potential modifier of cerebral circulation. Regional blood flow shifts according to metabolic demands of the different regions. A study conducted by Leenders et al. (1990) investigated regional blood flow using a positron emission tomography. The results indicated a significant decrease in blood flow with age in the frontal and insular regions of the brain.

An additional cardiovascular mechanism proposed by several investigators is blood pressure (Elias, Robbins, Schulz & Pierce, 1990; Powell & Pondorf, 1971). Powell and Pondorf (1971) educed a relationship between exercise, blood pressure, and cognitive performance. They found that as blood pressure increased the ability to perform cognitive tasks decreased. Conversely, as blood pressure decresed cognitive performance improved. Powell and Pondorf (1971) hypothesized that the decrease in blood pressure demonstrated a decrease in peripheral resistance hence improving blood flow to the brain. Elias et al. (1990) have also demonstrated a negative correlation between blood pressure and cognitive performance. Blood pressure and cognitive abilities were assessed on 301 subjects. The results indicated significant differences in cognitive performance based on blood pressures in the normotensive range with those higher normal blood pressures correlating with poorer cognitive performance.

Trophic Influences. Investigations of trophic influences on cognitive performance have concentrated on levels of neurotransmitters and neurotransmitter receptor site availablity (Bartus, Dean, Beer, & Lippa, 1982; Bartus, Dean, Pontecorro, & Flicker, 1985; Nilsson, Strecker, Daszuta, & Bjorklund, 1988; Richter-Levin & Segal, 1988; Rinne, Lonnberg, & Marjamaki, 1990; Weihmuller & Bruno, 1989). The neurotransmitters and receptors implicated in processing abilities are acetylcholine, dopamine, seratonin, and norepinephrine, all classified as having excitatory effects at the neural synapse thus allowing the transmission of impulses (Guyton, 1986).

A link between depletion of acetylcholine and the ability to process information has been suggested by Bartus et al. (1985). In a study investigating the neurochemical changes in brains of Alzheimer's patients, Bartus et al. (1985) reported consistently lower levels of acetylcholine and a reduction in the number of receptor sites. Thus, the researchers reasoned that acetylcholine may also play a role in the age-related decline in cognitive abilities evident in the normal elderly. Additional support for the cholinergic receptor link to cognitive performance has been documented by Bartus et al. (1982). Cadaveric dissection has shown a selective reduction in the number of available cholinergic receptor sites in the frontalcerebral cortex and hippocampal regions of normal brains of older individuals (Bartus et al., 1982). Both the frontal portion of the cerebral cortex and the hippocampus function in codification, storage, and retrieval of information (Guyton, 1986). Therefore, selective depletion of cholinergic receptor sites in these regions could possibly alter an individual's processing capabilities. Two additional investigations have shown cholinergic deficits to be congruent with cognitive impairments (Nilsson et al., 1988; Richter-Levin & Segal, 1988). Both studies indicated a relationship between cholinergic and seratonergic levels and receptor activity and performance on spatial learning tasks.

A correlation also exists between the neurotransmitter dopamine and its receptors and cognitive performance (Rinne et al., 1990; Weihmuller & Bruno, 1989). Like the cholinergic neurotransmitters, dopamine also has an excitatory funtion in impulse transmission (Guyton, 1986). Utilizing rats, Weihmuller and Bruno (1989) assessed dopaminergic control of sensorimotor function. Data from this investgation suggested that deficits in dopamine negatively affected performance of sensorimotor tasks. In addition, Rinne et al. (1990) educed a correlation between reduced dopamine receptor site binding and declines in processing capabilities. They hypothesized that since both cognitive skills and dopamine receptor binding decline with age a relationship exists between the two phenomenon.

In summary, age-related declines in cognitive performance have been linked to alterations in cardiovascular and neurological functioning. The major postulated explanations concentrate on changes in blood flow and neurotransmitter levels as well as neurotransmitter receptor site availability.

Effects of Exercise on Age-related Morphological and Physiological Changes

As humans age, the anatomical structure of many organs change; the physiologic functioning is also altered in many organ systems. This review will concentrate on the age-related morphologic and physiologic changes relavent to the discussion of the effects that exercise may have on cognitive performance in the older individual. These systems include: the cardiovascular system; the neuroendocrine system; and the muscular system. In addition, the effects that exercise has on these systems will be discussed.

Cardiovascular System. Various investigators have reported alterations in cardiovascular system morphology and physiology with age in the general population (Harris, 1987; Lakatta, 1990; Rivera et al., 1989; Safar, 1990; Shepard, 1981; Skinner, Tipton, & Vailas, 1982; Van Camp & Boyer, 1989; Waller & Morgan, 1988; Waller, 1988; Weisfeldt & Gerstenblith, 1986). Maximum work capacity, heart rate, stroke volume, and cardiac output decreases while resting and exercise blood pressure increase.

The heart and blood vessels undergo a number of changes in composition detrimental to contractility and elasticity (Harris, 1987; Skinner et al., 1982; Waller & Morgan, 1988). As elastin in the myocardium decreases, fat, connective tissue, and collagen increases (Harris, 1987; Skinner et al., 1982). The functional capacity of the heart is weakened due to a decrease in muscle mass, capillary blood flow, and capillary density (Harris, 1987; Skinner et al., 1982; Shepard, 1981). Blood vessels lessen in compliance and in internal diameter (Harris, 1987; Waller, 1988). Atheromatous change, calcification, and ulceration occur producing rigidity and narrowing of the vessel (Skinner et al., 1982; Waller, 1988).

In a non-diseased state, age-related decreases in the size of the left ventricle and right atrium have been reported (Harris, 1987). In addition, left ventricular work at rest declines as ventricular power ouput declines due to changes in size and muscularity (Harris, 1987; Skinner et al., 1982). The wall of the left ventricle thickens, is less compliant, relaxation is slowed, and filling of the ventricle is decreased (Lakkata, 1990; Skinner et al., 1982; Weisfeldt & Gerstenblith, 1986). Preloading of the left ventricle may be further reduced by poor venous tone (Shepard, 1981). Decreases in the preload directly affect stroke volume. In the face of inadequate pumping and decreased pre-loading and increased after-loading, stroke volume is lower at rest in older individuals when compared to younger individuals (Shepard, 1981). Concomitant with reductions in stroke volume is an age-related lowering of cardiac output (Shepard, 1981).

Maximum cardiac output declines 0.9% tp 1% per year., or 20-30% by age 65 (Harris, 1987; Shepard, 1981). In addition to stroke volume, cardiac output is altered by changes in the structure and function of the heart valves, conduction system, heart rate, and perhipheral resistance to blood flow (Safar, 1990; Shepard, 1981; Waller & Morgan, 1988; VanCamp & Boyer, 1989). Changes in the heart valves contribute to decreased cardiac functional efficiency with age. Increases in valve thickness and rigidity due to sclerosis and fibrosis of the margins have been reported (Safar, 1990; Shepard, 1981; Waller & Morgan, 1988). Annular calcification may also involve the aortic valve leaflets, producing aortic regurgitation and stenosing (Van Camp & Boyer, 1989). According to Van Camp and Boyer (1989), heart block may occur if the calcification extends into the interventricular septum. The aorta widens and often shifts to the left resulting in increased stiffness and alterations in its valvular mechanical properties (Harris, 1987).

Examination of the conduction system of the older heart reveals a decrease in the number of sinoatrial node cells (Harris, 1987, Shepard, 1981). In addition, an increased fibrosis of the atrioventricular node, bundle of

His, and main bundle branches have been demonstrated (Harris, 1987). Electrocardiogram assessment of the conduction system demonstrates physiologic effects of these morphologic changes. The pre-ejection period lengthens from 80 in the young to 95-100 in the aged (Shepard, 1981), and QRS-axis changes are evident. (Evans, Prior, & Tunbridge, 1982). Shepard (1981) posited that slower tension development and loss of coordination in the contractile process due to alterations in conductivity may explain these changes.

Age-related declines in maximum heart rate have been demonstrated by Shepard (1981). This decline may be due to a decreased sensitivity of the sinoatrial node to beta-adrenergic stimulation and a decreased inotropic response to catecholamines and sympathetic stimulation (Shepard, 1981; Weisfeldt & Gerstenblith, 1986). Weisfeldt & Gerstenblith (1986) have reported a decreased inotropic response to digitalis but not to calcium. This indicates that myofibrillar contractile function is well maintained in the older individual. However, Safar (1990) and Shepard (1981) have demonstrated decreased myocardial contractility. Alterations in myocardial contractility are probably influenced more by less efficient left ventricular filling rather than inotropic responses (Safar, 1990; Shepard, 1981). Left ventricular filling reduction has been reported by several investigators and is thought to be due to the increased peripheral resistance to blood flow (Safar, 1990; Shepard, 1981; Van Camp & Boyer, 1989).

At rest, peripheral resistance has been reported to increase approximately 1% per year (Shepard, 1981). Increases in intimal thickness, elastic fragmentation, and collagen deposition and calcification result in progressive dilitation, gradual arterial wall stiffness, and reduction in arterial compliance which result in greater resistance (Safar, 1990; Shepard, 1981; Waller, 1988). Shepard (1981) has shoen that greater resistance to blood flow is a factor in the increased blood pressure evidenced in older individuals.

Numerous investigations have been conducted to assess the effects that age-related changes have on cardiovascular functioning (Benestad, Halvorsrud, & Andersen, 1978; Bruce, 1984; Drinkwater, Horvath, & Wells, 1975; Rivera et al., 1989; Rogers, Hagberg, Martin, Ehsani, & Holloszy, 1990). Benestad et al. (1968) evaluated the work capacity of 20 men and 10 women over the age of 70 recruited from older adult clubs in Norway. When maximal oxygen uptake ($\dot{V}$O2max) values for the older group were compared to those of a younger group a 50% reduction was discovered. In addition, maximal heart rate as well as maximal oxygen pulse were decreased, indicating a reduced cardiac output. These data led the investigators to conclude that the old heart has an impaired functional performance. These findings have been corroborated by Bruce (1984) and Drinkwater et al. (1975). Further investigations of the ability of the older individual to deter or reverse the age-related decline in cardiac functioning have been conducted (Cunningham, Rechnitzer, Howard, & Donner, 1987; deVries, 1970; Drinkwater et al., 1975; Ehsani, 1987; Fleg & Lakatta, 1988; Gerstenblith, Renland, & Lakatta, 1987; Heath, Hagberg, Ehsani, & Holloszy, 1981; Kasch, Boyer, VanCamp, Verity, & Wallace, 1990; Makrides, Hesgenhauser, & Jones, 1990; Rivera et al., 1990; Rogers et al., 1990; Sidney, 1981). Three studies (Heath et al., 1981; Rivera et al., 1989; Rogers et al., 1990) comparing masters athletes with age-matched could sedentary and active younger subjects found that exercise attenuate the age-related decline in $\dot{V}$O2max but not prevent it. Data from the Heathe et al. (1981) investigation of older athletes ($\bar{X}$ age = 59 years) suggested a mean difference of 15% between old and young athletes' $\dot{V}$O2max. However, the data also revealed a 60% higher VO2max in the trained versus untrained older men. Rivera et al. (1989) evaluated the $\dot{V}$O2max of 11 male masters runners ($\bar{X}$ age = 66 ± 8 (SD) years) and 11 male young runners ($\bar{X}$ age = 32 ± 5 years). Data revealed a 36% higher $\dot{V}$O2max value in the younger runners compared to the older runners. A longitudinal study, by Rogers et al. (1990), was conducted to investigate the change in $\dot{V}$O2max over an eight year. period in 15 well-trained master endurance athletes [$\bar{X}$ age (±SE) = 62.3 ± 2.3 years] and 14 sedentary controls [$\bar{X}$ age (±SE) = 61.4 ± 1.4 years]. The results suggested a 12% decline over the eight-year period for the sedentary controls; a 5.5% decline was found for the endurance-trained group. These data support the findings of earlier studies that although exercise can slow the age-related decline it cannot completely eradicate it. Drinkwater et al. (1975) conducted a similar investigation using females, ages 10 to 68 years. They concluded that identical variations in $\dot{V}$O2max occur in females that have been reported for males.

Several training studies have been conducted to investigate the direct effects of training on $\dot{V}$O2max (Barry et al., 1966; Cononie et al., 1991; Cunningham et al., 1987; deVries, 1970; Kasch et al., 1990; Makrides et al., 1990; Sidney, 1981). One of the earliest training studies was conducted by Barry et al. (1966). Five men and three women ($\bar{X}$ age = 70 years) engaged in an exercise program three days per week in 40 minute sessions; two men and three women served as controls. The results indicated an improvement in work capacity of the training group compared to the sedentary controls. Cunningham et al. (1987) investigated the effects of one year of exercise training on fitness.

Two hundred men at retirement (ages 55-65) were randomly assigned to exercise and control groups. $\dot{V}$O2max was evaluated on a maximal graded treadmill test. The subjects trained three days per week at 60-70% of their $\dot{V}$O2max values. Data analysis revealed a 10.9% increase in $\dot{V}$O2max in the exercise group which was significant;y better than the control group. Ten 20-30-year-old males and 12 60-70-year-old males engaged in a high-intensity endurance training program (Makrides et al., 1990). Makrides et al. (1990) found improvements in $\dot{V}$O2max in both the young and old groups, 29% and 38% respectively, utilizing this training protocol. They concluded that older individuals could benefit from high-intensity training at least as much as their younger counterparts. Additional short-term training studies to support the hypothesis that the cardiovascular systems of older individuals respond similarly to training as do those of younger subjects have been conducted by deVries (1970) and Sidney (1981).

Cononie et al. (1991). assessed the effect of six months of resistance or endurance exercise training on blood pressure. Men and women 70-79 years of age were randomly assigned to a resistance-training or an endurance-training group. The resistance group trained using Nautilus machines three times per week while the endurance group trained at 75-85% $\dot{V}$O2max for 35-45 minutes three times per week.

Posttest data indicated a slight improvement in the blood pressures of the endurance-trained group but no change in the resistance-trained group. In addition, Cononie et al. (1991) reported a 20% increase in $\dot{V}$O2max in the endurance group but no change in the $\dot{V}$O2max of the subjects in the resistance-trained group.

Kasch et al. (1990) investigated the effects of physical activity on work capacity in older men. To asses the decline in $\dot{V}$O2max with age, two groups of men were studied. One group consisted of 15 exercisers who were followed from age 48 to 68 years.; the other group, 15 controls whose $\dot{V}$O2max was measured while training at age 52 years and again at age 70 after being detrained for 18 years. The results indicated a 13% decline in the exercisers over the 23-year span. However, a 41% decline was noted in the control group. The data suggest that regular aerobic exercise retards the usual loss in work capacity with age.

Neuroendocrine System. Perhaps the most worrisome age-related change occurs in the neuroendocrine system. In nervous tissue, many cells die in the course of aging. This presents a problem because nerve cells do not undergo mitosis, therefore, any neurons lost are not replaced. Since neurons do not regenerate, there is a gradual loss of nervous tissue with aging. The loss of neurons in the central nervous system is thought to be largely responsible for the reduction in brain mass commonly associated with age (Jernigan, Press & Hesselink, 1990). Jernigan et al. (1990) have shown age-related decreases in brain weight and volume in nondemented subjects. Brain weight increases up to about age 30, declines slightly over the next two decades, and declines more dramatically with increasing age; at the age of 90 years, a brain may lose as much as 10% of its maximum weight (Jernigan et al., 1990). As the volume of nervous tissue becomes less, the ventricles enlarge, the gyri forming the surface of the cerebrum decrease in size, and the sulci between them widen (Yamaura, Ito, Kubota, & Matsuzawz, 1980). In addition, when the brains of older individuals were examined utilizing magnetic resonance imaging (MRI), both the gray and white matter are reduced (Hunt et al., 1989; Kobari, Meyer & Ichijo, 1990).

The most noticable changes that accompany the reduction of brain mass are those associated with processing information (Tyler & Tyler, 1984)). Horn and Catell (1966) have suggested that a greater age-related decline exists in speed of respose and the ability to integrate what is observed than there is in intellectual abilities. Although the brain has an abundance of neurons and synapses, the age-related loss that occurs has been demonstrated to cause up to a 25% reduction in processing abilities in the normal elderly when compared with a person 30 years old (Horn & Catell, 1966).

Other changes noted in older individuals are a decrease in the rate of conduction of impulses and an increase in impulse transmission time (Severson, 1984; Tyler & Tyler, 1984). Tyler and Tyler (1984) proposed that the decrease in conduction velocity is the result of a loss of myelin from the sheaths surrounding neurons. Numerous authors have posited that the increased transmission time is due to decreases in the levels of neurotransmitters (Jost, Weiss, & Weicker, 1990; Marshall & Rosenstein, 1990; Weihmuller & Bruno, 1989) and a reduction in the number of receptors available for impulse reception and a decreased sensitivity of receptors (Gross-Isseroff, Salama, Israeli & Biegon, 1990; Popova & Petkov, 1989; Severson, 1984; Rinne, Lonnberg & Marjamaki, 1990).

Impulse transmission from one neuron to an effector requires a neurotransmitter. Specific neurotransmitters appropriate to this discussion are acetlycholine, dopamine, seratonin, and norepinephrine. Acetylcholine is secreted from cholinergic neurons in the sympathetic division of the autonomic nervous system; the effects of the sympathetic system are excitatory. Age-related decrements in acetlycholine have been suggested by Bartus, Dean, Beer, &

Lippa (1982) suggesting a decline in transmission of impulses from one neuron to its effector.

Dopamine and seratonin are also characterized as excitatory neurotransmitters. Age-related declines in levels of these hormones have been demonstrated. Using male F344 rats 4-8 and 25-27 months old, Marshall and Rosenstein (1990) electrochemically determined the levels of dopamine in the brain tissue. They found a significant decrease in the older rats than in the younger rats, suggesting that as brain tissue ages its ability to produce the neurotransmitter, dopmine, declines. An earlier study by Weihmuller and Bruno (1989) revealed similar findings. Regional brain seratonin levels were investigated using human cadavers (Gross-Isserhoff et al., 1990). Selective decline in levels of seratonin were reported in the frontalcerebral cortex and the hippocampus of 12 normal subjects.

Jost et al. (1990) investigated the changes in norepinephrine, a sympathetic neurotransmitter, with age. They reported an age-related increase in blood levels of norepinephrine indicating enhanced sympathetic activity. One of the consequences of increases in sympathetic activity is an increase in blood pressure (Guyton, 1986).

A neurotransmitter receptor implies a recognition site for a neurotransmitter. Alterations in the receptor sites for the above neurotransmitters have been reported to decline with age. Gross-Isserhoff et al. (1990) have reported region-selective changes in receptor site density for seratonin in 12 normal cadaver brain tissue assays.

Rinne et al. (1990) performed assays on 65 autopsy patients of varying ages to determine the effects of age on dopamine receptor site density and binding capacity. The investigators found a decline in both dopamine receptor site and binding capacity in the older patients suggesting an age-related decline.

The receptors that recognize acetylcholine and norepinephrine are called muscarinic receptors and beta-adrenoreceptors. Popova and Petkov (1989), using 2, 10, and 22 month-old Wistar rats, investigated the effects of age on muscarinic receptors and beta-adrenoreceptors. At sacrifice, binding assays for acetylcholine and norepinephrine were performed on each group. Results of the assays revealed an increase in receptor density and binding capacity from 2 to 10 months. but a decline from 10 to 22 months. suggesting an age-related effect on muscarinic receptors and beta-adrenoreceptors.

Whereas investigations suggesting a positive effect of exercise on the aging cardiovascular system are prevalent, such studies are few for the neuroendocrine system. McRae et al. (1987) investigated the effects of endurance training on striatal dopamine receptor binding using 21 month old Sprague-Dawley rats. Prior to sacrifice the rats were trained on a treadmill for six months; VO2max measures confirmed a training effect. Assays of brain tissue revealed significantly lower metabolite levels in the trained rats when compared with the controls. These data indicate an enhanced binding capacity in the trained versus untrained old rats.

Jost et al. (1990) measured blood levels of norepinephrine in trained and untrained young males. Blood-born norepinephrine was found to be lower in the trained versus untrained subjects. Jost et al. (1990) hypothesized that decreases in blood norepinephrine might indicate better binding capacity of the receptors. Although, this study was conducted on young males, an extrapolation to the older population might be possible because other responses to training across age are similar.

Muscular System. One of the most obvious age-related change in skeletal muscle is a general reduction in the total mass of the muscle. Spence (1989) has postulated that the loss of muscle mass is due to atrophy of muscle fibers, resulting in both a decrease in the number of fibers and the diameter of the remaining fibers. Muscle fibers are postmitotic, and therefore new fibers cannot be formed to replace those lost (Spence, 1989). Consequently, many of the lost fibers are replaced by adipose tissue. According to Spence (1989) the amount of muscle cells lost and their replacement by adipose depend on a number of factors, including the amount of exercise the muscle undergoes and the nutrition of the individual. Studies have shown that strength values reach their peak levels in approximately the third decade of life and plateau until about age 50 (Larsson, 1978; Stamford, 1988). Shepard (1986) reports that strength remains at the young-adult level until approximately 40 to 45 years of age, then rapidly deteriorates with increasing age. In addition, the amount of muscle mass present at age 20 is reduced 20% by the age of 65 and progrssively decreases, especially in the lower extremity muscles, which decline at a faster rate than upper extremity muscles (Brown, 1989).

Recently research has detailed the changes that occur in skeletal muscle with weight training (Brown, McCartney, & Sale, 1990; Brown, 1989; Fiatarone et al., 1990; Frontera et al., 1990; Frontera, Meridith, O'Reilly, Knuttgen, & Evans, 1988; Klitgaard et al., 1989; Panton et al., 1990). Brown et al. (1990) assessed 14 elderly males ($\bar{X}$ (±SD) age = 63 ± 2.7 years) before and after 12 weeks of weight training. Dynamic elbow flexion training of one arm resulted in a significant (48%) mean increase in the maximal load that could be lifted; bilateral leg press training reflected an increase of 23% in dynamic lifting capacity. In addition, Brown et al. (1990) documented a mean 17.4% increase in cross-sectional area of the trained arm but no change in the untrained. Researchers concluded that older individuals retain the potential for significant increases in strength performance and upper limb muscle hypertrophy in response to overload training.

Fiatarone et al. (1990) sought to characterize the muscle weakness of the very old and its reversibility through strength training. Ten frail, institutionalized volunteers ($\overline{X}$ (±SEM) age = 90 ± 1 years) undertook eight weeks of high-intensity resistance training. In this nonagenarian population, mean (± SEM) strength gains of 174% ± 31% were evident in the 9 subjects who completed the training. Midthigh circumference increased by a mean (± SEM) diameter of 9.0% ± 4.5%. Fiatarone et al. (1990) concluded that high-reisitance weight training leads to significant gains in muscle strength and size among the frail elderly. In addition, the subjects' times on a walking test had decreased suggesting an improvement in neuromuscular coordination, a measure of cerebral cortex functioning.

Frontera et al. (1988) demonstrated even greater improvement in strength than did Fiatarone et al. (1990). Frontera trained males, ages 60-72 years, three days per week for 12 weeks at 80% of their one repetition maximum. Each subject was evaluated before, at 6 weeks, and at the end of the 12 week training session for gains in strength. After 12 weeks, the strength of the knee extensors and flexors had increased 107.4% and 226.7%, respectively, over pretraining values. Frontera et al. (1988) also found an 11.4% increase in total muscle area. They concluded that strength gains in older men were associated with significant muscle hypertrophy. In a follow-up investigation, Frontera et al. (1990) assessed the effects of strength training on V̇O2max. The strength training protocol utilized was identical to that described in the 1988 study. V̇O2max was assessed using a leg cycle ergometer test. A small (1.9 ml) but significant (p = 0.034) increase in leg cylce V̇O2max was evidenced. Biopsies of the vastus lateralis showed a 28% increase in fiber area, a 15% increase in capillary density per fiber, and a 38% increase in citrate synthase activity. An increase in citrate synthase activity is a marker of oxidative production of energy (Guyton, 1986). Frontera et al. (1990) concluded that the small increase in leg cycle V̇O2max in older men may be due to adaptations in oxidative capacity and increased mass of the strength-trained muscles.

In a similar study, Panton et al. (1990) compared the results of a resistance training program to V̇O2max. Panton et al. used a comparable resistance training protocol as described by Frontera et al. (1988) with one change. The training period was 26 weeks instead of 12 weeks as described by Frontera et al. (1988). $\dot{V}$O2max was assessed using a modified Naughton treadmill protocol which gradually increases the speed and incline of the treadmill. Small increases in $\dot{V}$O2max values were evidenced in the posttesting data, however, no biopsies were performed to determine the possible reason for this increase.

Animal model studies investigating the morphologic and biochemical changes in old muscle have been conducted (Brown, 1989; Klitgaard et al., 1989). Klitgaard et al. (1989) trained a group of old male Wistar rats to determine the influence of resistance training on histochemical and metabolic characteristics of skeletal muscle. They concluded that strength-training counteracted the age-related atrophy of the muscle fibers, but reduced the aerobic capacity of the muscles. In addition, Klitgaard et al. reported higher concentrations of adenosine triphosphate, a high energy compound, in the trained versus untrained rats. Brown trained Sprague-Dawley rats age 21, 24, 27, and 30 months for three months. Similar findings were reported for prevention of atrophy. Brown (1989) was also interested in the safety of resistance training on old rat muscle. The results suggest that resistance exercise can be engaed in successfully at any age without causing harm to the muscle tissue.

In summary, many morphologic and physiologic alterations occur in the body with age. The changes discussed in this segment are those related to the scope of this investigation. In addition, numerous studies have been conducted that show exercise to be an effective moderator of the age-related declines that occur in the cardiovascular, neuroendocrine, and muscular systems.

Effects of Exercise on Cognitive Functioning

Several investigators have suggested a relationship between exercise and cognitive functioning has been suggested by several investigators (Barry et al., 1966; Baylor & Spirduso, 1988; Dustman et al., 1984; Elsayed et al., 1980; Powell & Pohndorf, 1971; Rikli & Busch, 1986; Spirduso, 1975; Spirduso & Clifford, 1978). Studies involving subjects who have been physically active for most of their lives have demonstrated significant differences in cognitive functioning when compared with sedentary, age-matched individuals (Baylor & Spirduso, 1988; Rikli & Busch, 1986; Spirduso, 1975; Spirduso & Clifford, 1978). Sixty volunteers from the University of Texas at Austin and the surrounding community were categorized according to age and activity level for the purpose of investigating the effects of exercise on psychomotor performance (Spirduso, 1975).

Assessments of simple and choice reaction time utilizing a visual stimulus revealed that older men who were physically active in racquet sports responded with the same celerity as college men. From the results Spirduso (1975) surmised that a life stlye of physical activity appeared to play a dominant role in determining simple RT, discrimination RT, and movement time. Barry et al. (1966) found that posttest scores on a visual discrimination test were significantly improved after a three-month, intermittent rhythmic type of conditioning when compared to pretest and control group data. Powell and Pohndorf (1971) utilizing subjects age 34 to 75 years from an adult fitness program employed eight physiological measurements chosen on the basis of their possible effects upon mental ability. They compared the results to performance on the Culture Fair Intelligence Test, an established measure of cognitive functioning. Data suggested that in all parameters, better values were observed for the higher fit group, including the performance on the Culture Fair test.

Spirduso and Clifford (1978) replicated and expanded the findings of Spirduso's (1975) earlier work by investigating psychomotor performance of older men who regularly run or participate in racquet sports. Again, the chronically active men demonstrated significantly faster performances on the psychomotor tests than the age-matched sedentary controls. Interestingly, Spirduso and Clifford (1978) demonstrated that the performances of the active older men were more similar to those of a younger active group than to those of the sedentary older or sedentary younger group. Similar results were obtained for women by Rikli and Busch (1986). Psychomotor test performance time for two groups of women, active and inactive, ($\bar{X}$ age = 68.7 years) were compared using the protocol described by Spirduso and Clifford (1978). The subjects' times were then compared with two groups of young ($\bar{X}$ age = 22.2 years), active and inactive women. The relationship found by Rikli and Bush (1986) for older women replicated that found by Spirduso and Clifford (1978) for older men. That is, women demonstrate a similar age-related decline in psychomotor speed to that of men.

One of the few earlier studies in which investigators researched the effects of exercise specifically on cognitive functioning was conducted by Elsayed et al. (1980). Elsayed et al. (1980) selected subjects, age 24 to 68 years., to participate in a four-month physical fitness program. Researchers divided subjects into four discrete groups established using physical fitness and age as criteria. These groups were designated high-fit young; high-fit old;

low-fit young; and low-fit old. Pre-and posttest data were collected from physiological assessments; pre- and posttest cognitive functioning data were collected utilizing the Culture Fair Intelligence Test. They concluded that, regardless of age, the high-fit groups had significantly ($p \leq 0.05$) higher mean cognitive functioning scores than the low-fit groups. More recently, Baylor and Spirduso (1988) recruited women ranging in age from 48 to 63 years who had participated in a previous study and who had maintained a self-reported commitment to an exercise program for at least the past five years. The purpose was to investigate the effects of exercise on RT fractionated by electromyography into premotor time, a central processing component, and contractile time, a muscle contractile component. Baylor and Spirduso (1988) found that premotor time was significantly faster in the exercise group than in the non-exercise group suggesting a link between central processing and activity level. Studies utilizing protocols similar to the ones discussed previously produced comparable results: the more active, older groups performed better on the psychomotor or congnitive functioning measures than did their age-matched sedentary counterparts (Clarkson-Smith & Hartley, 1989; Emery & Getz, 1990; Molloy et al., 1988; Stones & Kozma, 1989).

Dustman et al. (1984) correlated improvements in cognitive performance with improvements in $\dot{V}$O2max and hypothesized that this increase in cardiac functioning would avail the brain of improved blood flow. Several other investigators have demonstrated improvements in cognitive functioning concomitantly with increases in $\dot{V}$O2max (Barry et al., 1966; Elsayed et al., 1980; Powell & Pondorf, 1971). Regular exercise may also reduce acquired hypertension (deVries, 1970; McArdle, Katch & Katch, 1988; Shepard, 1988). Hypertension increases peripheral resistance and the possibility of cerebral hemorrhage resulting in a change in cerebral circulation.

McRae et al.(1987) proposed a link between chronic endurance training and the maintenance of the nigrostriatal dopamine system in senescent rats. Following 12 weeks of treadmill conditioning, McRae et al. (1987) analyzed the nigrostriatal dopamine metabolite levels in the brains of Sprague-Rawley rats (age 22 months). The conditioning program appeared to protect the nigrostriatal dopamine metabolite levels suggesting that endurance training may stabilize metabolite levels and alter the relationship between levels of metabolized nigrostriatal dopamine and receptor numbers in a reciprocal fashion.

Contradictions to the notion that exercising older adults perform at a superior level on measures of psychomotor performance and cognitive function have been presented (Blumenthal & Madden, 1988; Blumenthal et al., 1989; Madden et al., 1989; Panton et al., 1990). Blumenthal and Madden (1988) attempted to determine if memory-search performance could be modified by improving subjects' (males, ages 30-58 years) levels of aerobic fitness. The investigators demonstrated an improvement in $\dot{V}$O2max in the exercising group, but failed to show a difference in pre- and posttest values on the memory-search activity between the exercise and control groups. After a four-month study, Blumenthal et al. (1989) concluded even though $\dot{V}$O2max increased significantly in the aerobic exercise group compared with the yoga or control group that the improved performance on the measures of cognitive functioning were not unique to a particular group. Two additional training studies failed to show improvements in cognitive functioning resulting from aerobic exercise (Madden et al., 1989; Panton et al., 1990). The above studies utilized similar measures of RT. However, these investigations measured choice RT rather than simple RT as was assessed in the studies demonstrating an improvement in cognitive functioning as a result of exercise. Birren, Woods, and Williams (1979) stated that choice and simpel RT are indicators of different components of nervous system functioning. Choice RT is a marker of peripheral functioning, whereas simple RT is an indicator of central processing, a documented measure of cognitive functioning (Birre et al., 1979). Future researchers should investigate the possibility that there may be a specific subset of cognitive skills that are influenced by aerobic exercise (Blumenthal & Madden, 1988).

To date, only one research group has addressed the effects of variable resistance training on cognitive performance (Panton et al., 1990). Pretraining $\dot{V}$O2max, strength, and psychomotor performance were assessed on 23 male and 26 female volunteers between the ages of 70 and 79 years. $\dot{V}$O2max was determined utilizing a modified Naughton protocol; a one repetition maximum was used to assess strength; and Total RT, fractionated RT, and speed of movement measurements were obtained using electronic instrumentation to receive, transmit, and convert electrical signals. Subjects were randomly assigned to a walk/jog group, a control group, or a variable resistance strength training group. Following a 26-week training program, posttraining assessments were conducted. Analysis of pre- and posttest data revealed improvements in VO2max and strength values independently of psychomotor performance.

In summary, studies relating cardiovascular fitness to cognitive functioning in older adults have presented mixed results as to the efficacy of exercise as a treatment for the decline in cognition found in aging individuals. However, correlational evidence does suggest that a positive relationship exists between cardiovascular fitness and performance on measures of cognition. When highly cardiovascularly fit groups are compared to sedentary, low fit groups, the performances of the highly fit groups on psychomotor and cognitive tests are significantly better than the performance of the low-fit groups on the psychomotor and cognitive test. In addition, when low cardiovascularly fit groups undergo endurance-training an improvement in cognitive skills is evidenced. Several physiological mechanisms have been proposed to link physical activity to cognitive functioning. They include an increase in the functioning of the cardiovascular system effecting a change in cerebral blood flow and changes within the neurotransmitter systems in the brain itself.

Muscular strength and endurance, in addition to cardiovascular endurance, are considered vital components of maintaining independence later in life. Therefore, many fitness programs are emphasizing resistance training to improve this aspect of physical fitness. However, research linking resistance-training to cognitive performance is lacking. Also absent is documentation of the efficacy of cardiovascular-training compared to resistance-training in cognitive improvement. Although scientific evidence of a linkage of resistance-training and improvement in cognitive functioning is lacking, the idea is a plausible one and deserves further research.

CHAPTER III

METHODS

Six questions served as the framework for the investigation of the effects of walking and weight-training on information processing in older adults. They included:

1) Is there a significant difference between subjects' performance on the Ross Information Processing Assessment (RIPA) before and after a 16-week walking program?

2) Is there a significant difference between subjects' performance on the RIPA before and after a 16-week weight-training program?

3) Is there a significant difference between subjects' performance on the RIPA before and after a 16-week walking program compared to before and after a 16-week weight-training program?

4) Is there a significant difference between blood pressure measures of the subjects before and after a 16-week walking program?

5) Is there a significant difference between blood pressure measures of the subjects before and after a 16-week weight-training prgoram?

6) Is there a significant difference between blood pressure measures of the subjects before and after a 16-week walking program compared to a 16 week weight-training program?

In an attempt to address these questions, a 16-week performance responses of older adults who engage in a training program was utilized to study the cognitive walking program, a weight-training program, or a flexibility program. Following is an outline of the methodology employed to answer the questions involved in the analysis of the training experiences.

Subjects

Forty-five sedentary subjects, recruited from the surrounding community through newspaper advertisements and by direct contact with local retirement centers and community senior citizens groups began this study with 44 subjects completing it. Inclusion criteria required that the subjects be between the ages of 65 and 85, non-diseased (no current symptoms or signs suggestive of heart disease), and inactive (< 2 moderate-to-vigorous aerobic or resistance training sessions of > 20 min/wk). Physical charateristics of the 44 subjects are represented in Appendix B. According to Craik and Simon (1980) information processing begins to decline in the mid 50's with a noticeable decline by the age of 65 yrs. Therefore, this age range should exhibit some decline in the ability to process information allowing improvements to be observed. In addition, subjects were required to pass a complete physical examination within the past year and receive written permission from their personal physician in order to participate in this study.

Procedures

Testing Protocol. An initial organizational meeting was held prior to the beginning of the study to apprise subjects of the design of the study, to obtain informed consent (Appendix A), and to ensure confidentiality of all information. In addition, practice sessions were permitted on the equipment utilized in the testing protocol.

All subjects participated in two testing sessions at Appalachian State University's Human Performance Laboratory (HPL) and Athletic Training Laboratory (ATL). One week prior to the scheduled research (baseline) and following 16 weeks of exercise training, subjects reported to the HPL and ATL for cardiorespiratory and muscular strength assessments. Information processing ability was evaluated in a quiet classroom setting.

Maximal graded treadmill testing using automated cardiorespiratory monitoring techniques (MMC Horizon System

Exercise Evaluation Cart, SensorMedics, Yorba Linda, CA) was administered to all subjects using a protocol developed in previous research with a sedentary elderly population (Nieman et al., 1990). The initial stage was 40.2 m/min, 0% grade followed by stage 2, 53.6 m/min, 0% grade; stage 3, 67 m/min, 0% grade; stage 4, 80.4 m/min, 0% grade; stage 5, 80.4 m/min, 3% grade; stage 6, 80.4 m/min, 6% grade; stage 7, 80.4 m/min, 9% grade; and stage 8, 80.4 m/min, 12% grade.

Resting heart rate (RHR) and blood pressures (BP) were obtained after the subjects had been sitting quietly in a separate room for at least five minutes prior to the cardiorespiratory evaluation. A 12 lead electrocardiogram (EKG) utilizing a Quinton Q4000 Stress Test System (Seattle, WA) was monitored through the graded exercise test with a 12 lead EKG recorded at the end of each stage and during minute 2 and minute 4 of recovery. Heart rates were recorded every 3 minutes. Blood pressure was monitored by cuff syphnomanometry at 3-minute intervals. Continuous measurements of VO2, expired ventilation (VE), and respiratory exchange ratio (RER) were made and recorded at the end of each stage and at the point of test termination. During the test, the subjects were praised and encouraged to continue as long as possible. Guidelines established by the American College of Sports Medicine (ASCM) for conducting a maximal exercise stress test were followed (ACSM, 1991). Maximal exercise performance is defined as an RER above 1.0, a maximal heart rate within one standard deviation (±12 bpm) of predicted values, and an inability of the subject to continue despite urging by the laboratory staff. During recovery, the subjects walked at stage 1 velocity and grade for a 4 minute period and then sat for an additional 4 minutes. Recovery blood pressures were monitored and a 12 lead EKG was recorded every 2 minutes for subjects' safety.

Maximal strength testing was performed utilizing a Kinetic Communicator (Kin-Com), an isokinetic dynamometer (Chattex Corportation, Hixson, TN). Subjects performed three maximal contractions of right leg extension and right elbow flexion at 60°/sec. Positioning was consistent with that recommended by Chattex. Leg extension was performed in the seated position with the right thigh and hips secured to the seat and the chest secured to the back of the seat; the shin pad was secured to the anterior lower leg in a position to prevent rolling upon extension. The elbow flexion test position was as follows: standing, with the right arm resting on the extension pad; the shin pad was strapped to the palmar side of the forearm proximal to the wrist. During the test the subjects were encouraged to produce maximal force by the lab staff. Three maximal contractions were used to assure consistency which in turn ensured a valid maximal effort test. Results of the tests were stored in an IBM AT compatible computer interfaced with the Kin-Com.

The Ross Information Processing Assessment (RIPA)(Pro-Ed, Inc. Austin, TX) was utilized to evaluate changes in information processing abilities. RIPA is a valid and reliable measure of information processing, normed on adults ages 16-77 (Ross, 1986). RIPA was validated against the Wechsler Adult Intelligence Scale; reliability was determined using a test-retest comparison (Ross, 1986). The test consisted of 10 subsets of exercises related to processing skills. The subtests assess the following: 1) immediate memory; 2) recent memory; 3) temporal orientation (recent memory; 4) temporal orientation (remote memory); 5) spatial orientation; 6) orientation to environment; 7) recall of general information; 8) problem-solving and abstract reasoning; 9) organization; and 10) auditory processing and retention. RIPA was administered in an interview setting. Administration took approximately 40 minutes. The interviews were conducted in a quiet classroom at Appalachian State University conducted on alternate days from the exercise testing sessions.

Training Protocol

Randomized grouping. Following testing, the subjects were randomly assigned to either a walking group (n=15), a weight-training group (n=14), or to a control group (n=15).

Exercise training. The walking group met at the univeristy track and exercised five days per week, for 30-40 minutes per session. Walking sessions were conducted on a 400 m outdoor track or on an indoor track during inclement weather. The walking group (W) started training by walking for 30 minutes at 60% of their heart rate reserve (HRR) as determined by baseline treadmill testing. Heart rates were monitored every 10 minutes through the use of Polar Pacer heart rate monitors (Polar USA, Inc). Values were recorded by the supervisor and subjects were instructed to maintain a proper walking rate. Walking duration was increased 2 minutes each week until the subjects were walking 40 minutes per session by the sixth week. Training heart rates were readjusted to 65% of the subject's HRR after 8 weeks of training to reflect an improvement in cardiorespiratory fitness. ACSM Guidelines were followed regarding the conduct of the exercise programs (ACSM, 1991).

Subjects in the weight-training group (T) met at the university weight room and exercised five days per week. Each Monday, Wednesday, and Friday T performed the following exercises: bench press; arm curls; triceps extensions;

lateral shoulder raises; abdominal crunches; and back extensions. Each Tuesday and Thurday T performed leg extensions, leg curls, squats, step ups, abdominal crunches, and back extensions. T exercised without weights for the first week to ensure proper technique and safety. Beginning with the second week of training and continuing to the final week, T exercised utilizing a daily adjusted progressive resistive exercise (DAPRE) program. An initial light working weight was arbitrarily determined by the participant. The first workout consisted of four sets performed as follows: 10 repetitions in the first and second set and maximum repetitions in the third set. The weight and number of repetitions for the fourth set were determined by the number performed in set three (Table 1). Subsequent working weights were adjusted based on the subject's performance in the fourth set (Table 1).

Table 1

Adjusted Weight for the 4th Set and Next Day

Reps 3rd Set	4th Set	Next Day
0-2	decrease 5-10 lbs	decrease 5-10 lbs
3-4	decrease 0-5 lbs	keep same
5-6	keep same	increase 5-10 lbs
7-10	increase 5-10 lbs	increase 5-10 lbs
11-	increase 10-15 lbs	increase 10-20 lbs

Daily working weights were recorded on individualized cards and adjusted for the following workout. Periodically, heart rate was monitored using a Polar Pacer to determine the intensity of the work. Blood pressure measures were also taken during the weight-training sessions to ensure participant safety. In addition, ACSM quidelines relevant to this type of exercise were followed (ACSM, 1991).

The control group (C) met five days per week at the university and engaged in mild stretching exercise under the direction of an experienced exercise leader. Emphasis was placed on range-of-motion and flexibility involving minimal challenge to the cardiorespiratory system or to the strength component of the musculoskeletal system. Polar Pacer heart rate monitors were used to ascertain the intensity of the work.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS/PC+) software program (Norusis, 1988). The independent variable was the type of exercise, i.e. walking, weight-training, or control. The dependent variables were the performance on the RIPA, the strength measures, and maximal treadmill testing. To determine the effects of the training programs on the subjects' RIPA performance a 2 x 3 repeated measures ANOVA with two within-subjects factors (pre- and posttest values) and three between-subjects factors (W vs T vs C) was utilized. To determine the effects of the training programs on subjects' performance on the multiple variables ($\dot{V}$O2max, time-on-treadmill, VO2, VE, and RER) related to maximal treadmill test results, a 2 x 3 repeated measures MANOVA with two within-subjects factors (pre- and posttest values) and three between-subjects factors (W vs T vs C) was utilized. To determine the effects of the training programs on the subjects' performance on the two variables (arm strength and leg strength) related to the strength test, a 2 X 3 repeated measures MANOVA with two within-subjects factors (pre- and posttest values) and three between-subjects factors (W vs T vs C) was utilitzed. A posteriori analysis (Tukey's) was used where necessary to clarify results. To enrich the findings, a 2 x 3 repeated ANOVA with two within-subjects factors (pre- and posttest values) and three between-subjects factors (W vs T vs C) was utilized to examine resting pre- and posttest blood pressure differences between groups. A .05 level of significance was established for all analyses. Additionally, a Pearson correlation coefficient was utilized to analyze the relationship between performance on the RIPA and maximal treadmill testing measures, elbow flexion strength, knee extension strength, and blood pressure.

CHAPTER IV

RESULTS

The purpose of this study was to investigate the influences of a walking and a weight-training program on information processing in the older adult. To further elucidate this purpose, six questions were formulated which served as the framework for the study. They included:

1) Is there a significant difference between subjects' performance on the Ross Information Processing Assessment (RIPA) before and after a 16-week walking program?

2) Is there a significant difference between subjects' performance on the RIPA before and after a 16-week weight-training program?

3) Is there a significant difference between subjects' performance on the RIPA before and after a 16-week walking program compared to before and after a 16-week weight-training program?

4) Is there a significant difference between blood pressure of the subjects before and after a 16-week walking program?

5) Is there a significant difference between blood pressure of the subjects before and after a 16-week weight-training program?

6) Is there a significant difference between blood pressure of the subjects before and after a 16-week walking program compared to a 16-week weight-training program?

To determine pre- and posttest RIPA group mean differences statistically, a 2x3 repeated measures analysis of variance (ANOVA) was employed. A 2x3 repeated measures multivariate analysis of variance (MANOVA) was employed to determine if pre- and posttest group means were different in the following areas: four maximal treadmill test variables (VO2max, time on treadmill, VE, and RER) and two strength test variables (arm and leg strength). Additionally, a 2x3 repeated measures ANOVA was employed to determine pre- and posttest blood pressure group mean differences. A posteriori (Tukey's) test was employed to determine significanct differences between any two mean values. A .05 level of significance was established for all analyses.

RIPA

Mean and individual scores from the pre/posttest performance on the RIPA are presented in Appendix C. The mean ±SE pretest score on the RIPA for the walking group (W) was 126.00 ±2.27 while the mean ±SE pretest scores for the

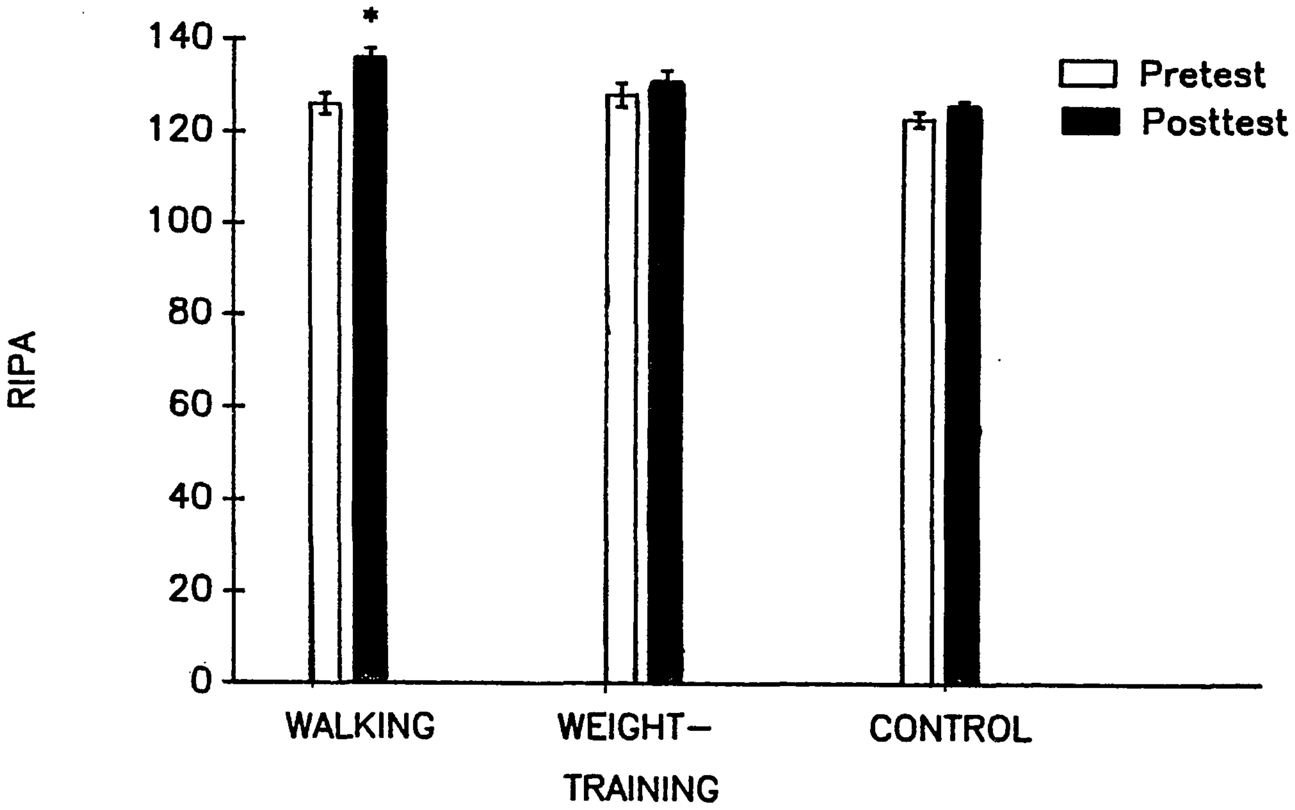

Figure 1. Group Means ±SE for RIPA at Pre and Posttest Measurements. Asterick Denotes a Significant Treatment Interaction. (*p* < .05)

weight-training (T) and control (C) groups were 128.21 ±2.59 and 123.31 ±1.62, respectively. The mean ±SE posttest scores for W, T, and C were 136.21 ±2.06, 131.07 ±2.36, and 126.75 ±0.83, respectively. The group means ±SE for the pre- and posttest scores are graphically represented in figure 1. The MANOVA revealed statistcally significant differences over time [$\underline{F}$ (1,41) = 26.61, $\underline{p}$ = 0.0001]. Additionaly, a significant interaction [$\underline{F}$ (2,41) = 3.77, $\underline{p}$ = 0.03] was found between RIPA and treatment. A posteriori analysis revealed a statistically significant increase in the walking group's postest RIPA mean score when compared to each of the posttest scores of T and C.

Blood Pressure

Mean and individual data from the pre/posttest systolic and diastolic blood pressure measures are presented in Appendix D and Appendix E, respectively.

Systolic Blood Pressure

The mean ±SE pretest systolic blood pressure measure for W was 129 ±1.91 mmHg while the mean ±SE pretest systolic blood pressures for T and C were 136 ±3.26 mmHg and 133 ±3.34 mmHg, respectively. The mean ±SE posttest systolic blood pressure measures for W, T, and C were 126 ±1.85 mmHg, 131 ±3.35 mmHg, and 132 ±3.39 mmHg, respectively. The group

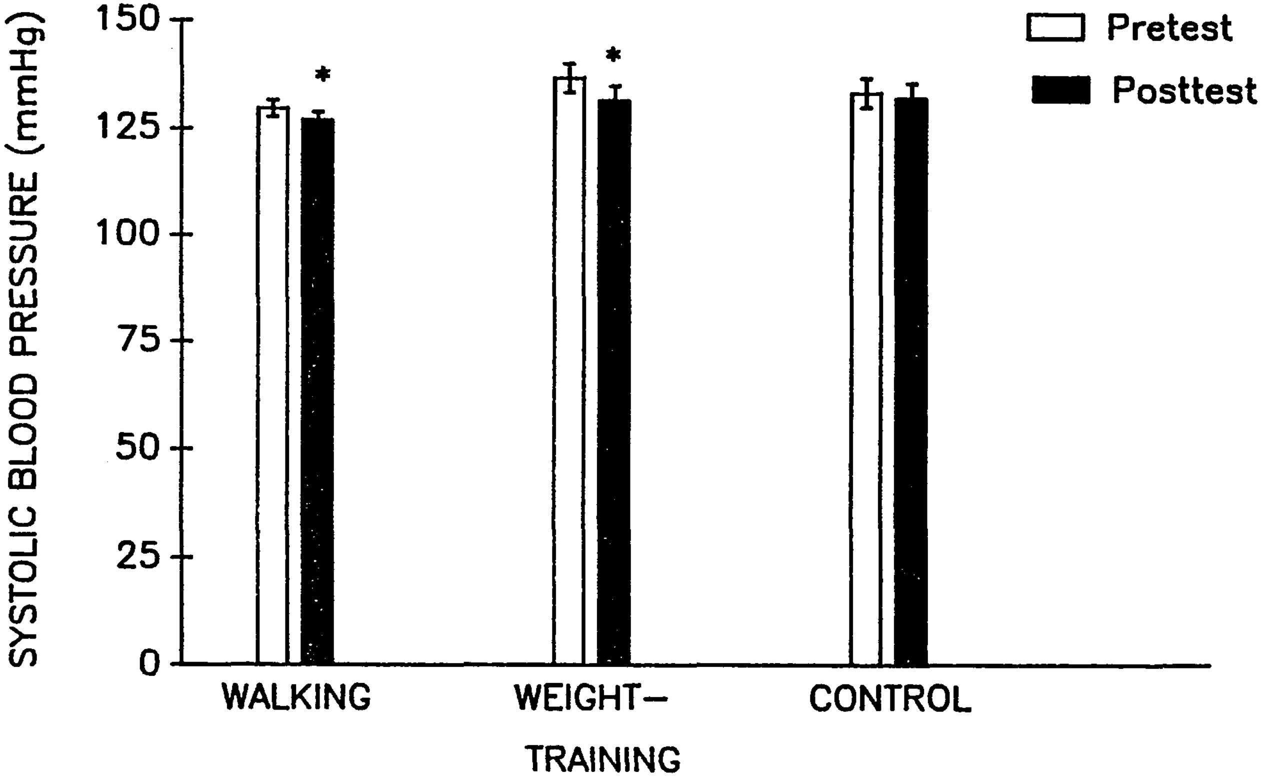

Figure 2. Group Means ±SE for Systolic Blood Pressure at Pre and Posttest Measurements. Astericks Denote Significant Treatment Interactions. (p < .05)

means ±SE for pre- and posttest systolic blood pressure measures are graphically represented in figures 2. The MANOVA revealed statistically significant differences for W and T over time [*F* (1,41) = 13.67, *p* = 0.0006], but not for C. No significant differences were noted between systolic blood pressure measures and the treatment.

Diastolic Blood Pressure

The mean ±SE pretest diastolic blood pressure measure for W was 79 ±2.47 mmHg while the mean ±SE pretest diastolic blood pressure measures for T and C were 81 ±2.52 mmHg and 77 ±2.79 mmHg, respectively. The mean ±SE posttest diastolic blood pressure measures for W, T, and C were 74 ±2.05 mmHg, 77 ±2.67 mmHg, and 77 ±2.58 mmHg, respectively. The group means ±SE for pre- and posttest diastolic blood pressure measures are graphically presented in figure 3. The MANOVA revealed statistically significant differences for W and T over time [*F* (1,41) = 7.05, *p* = 0.01]. No significant differences were noted between diastolic blood pressure and treatment.

Maximal Treadmill Test

Mean and individual data from the pre/posttest performance on the maximal treadmill test are presented in Appendices F-I.

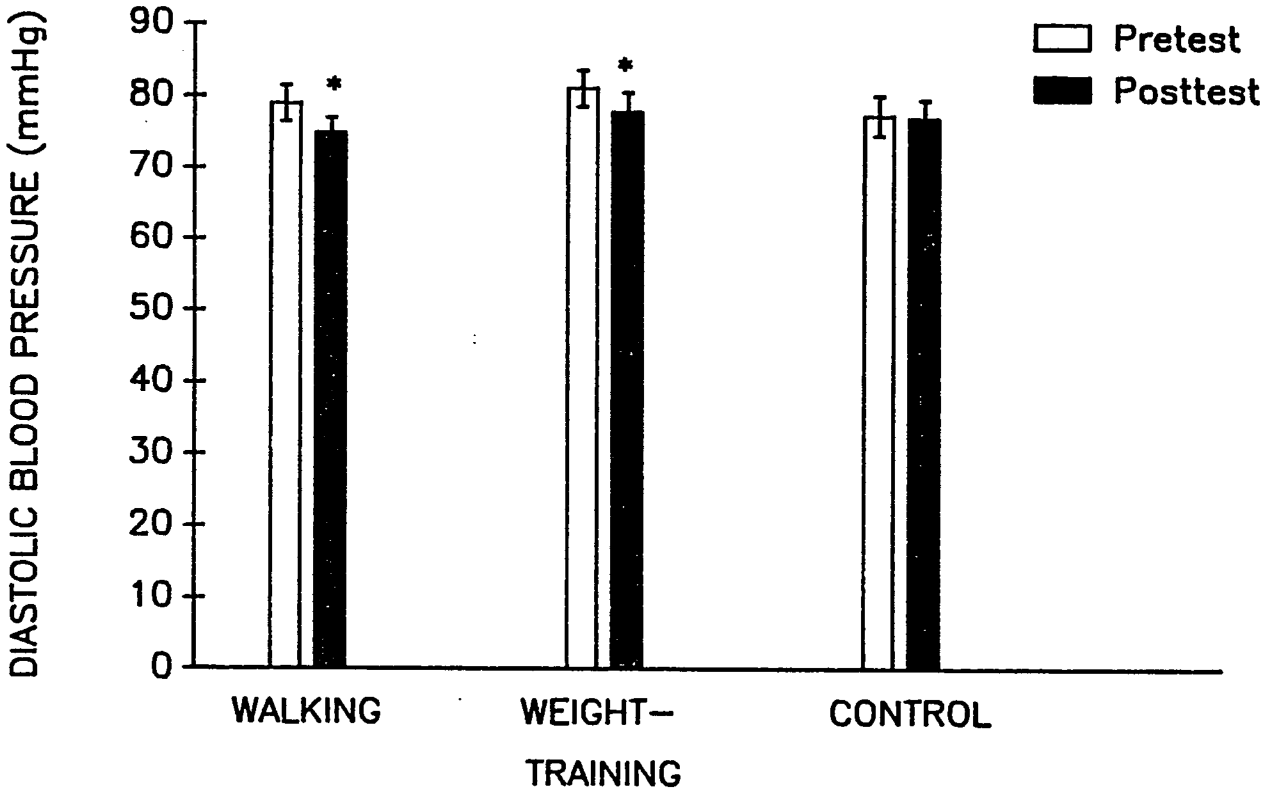

Figure 3. Group Means ±SE for Diastolic Blood Pressure at Pre and Posttest Measurements. Astericks Denote Significant Treatment Interactions. ($p < .05$)

Maximal Oxygen Consumption

The mean ±SE pretest $\dot{V}$O2max value for W was 22.37 ±1.06 ml/kg/min while the mean ±SE pretest $\dot{V}$O2max values for T and C were 21.35 ±0.84 ml/kg/min and 20.90 ±1.05 ml/kg/min, respectively. The mean ±SE posttest values for W, T, and C are 26.55 ±1.12 ml/kg/min, 20.41 ±0.99 ml/kg/min, and 19.36 ±0.59 ml/kg/min, respectively. The group means ±SE are graphically represented in figure 4. The MANOVA did not reveal a statistically significant difference over time. However, a statistically significant interaction was noted between $\dot{V}$O2max and the treatment [*F* (2,41) = 22.83, *p* = 0.0001]. A posteriori analysis revealed a statistically significant increase in the pretest to posttest value for W when compared to T and C pretest to posttest $\dot{V}$O2max values.

Time on Treadmill

The mean ±SE pretest time on treadmill value for W was 20.62 ±1.07 minutes while the mean ±SE pretest values for T and C were 19.67 ±0.61 minutes and 21.26 ±0.76 minutes, respectively. The mean ±SE posttest time on treadmill values for W, T, and C were 22.76 ±1.17 minutes, 19.99 ±0.61 minutes, and 20.35 ±0.64 minutes, respectively. The group means ±SE for pre- and posttest time on treadmill values are graphically represented in figure 5. Statistically

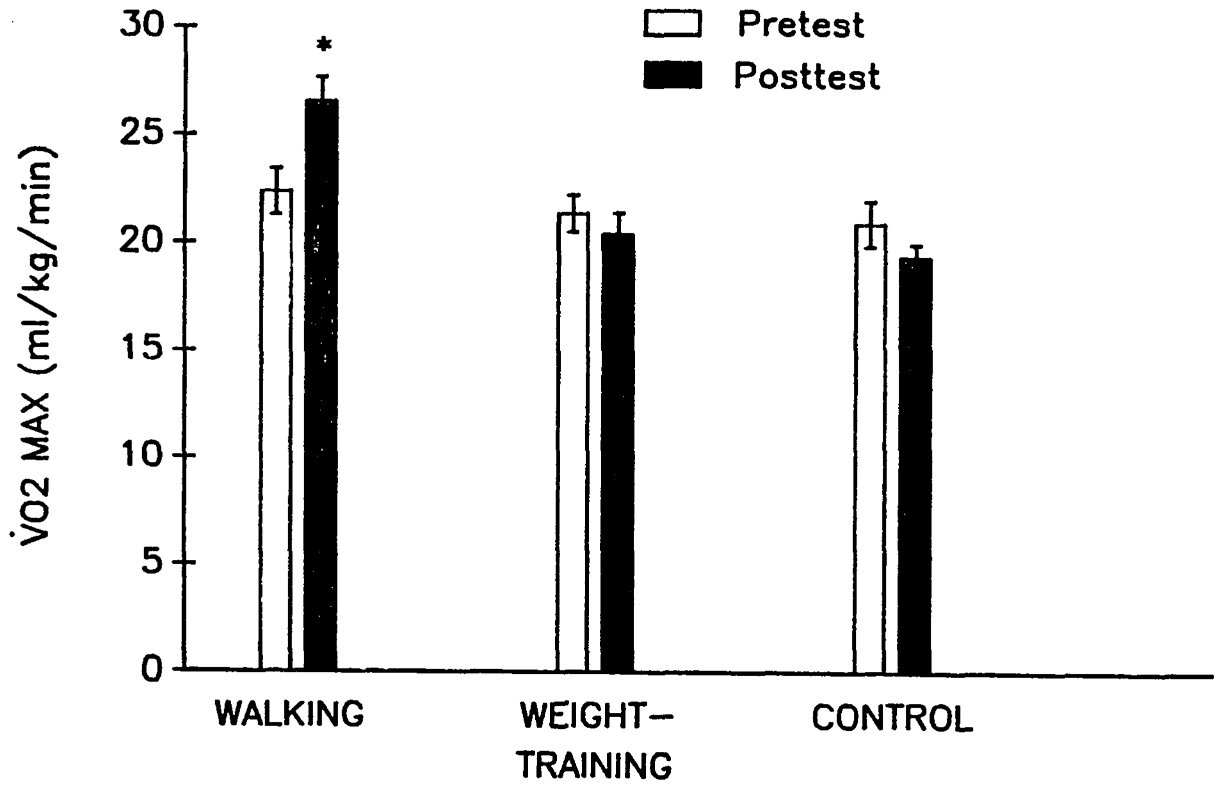

Figure 4. Group Means ±SE for V̇O2max at Pre and Posttest Measurements. Asterick Denotes a Significant Treatment Interaction. ($p < .05$)

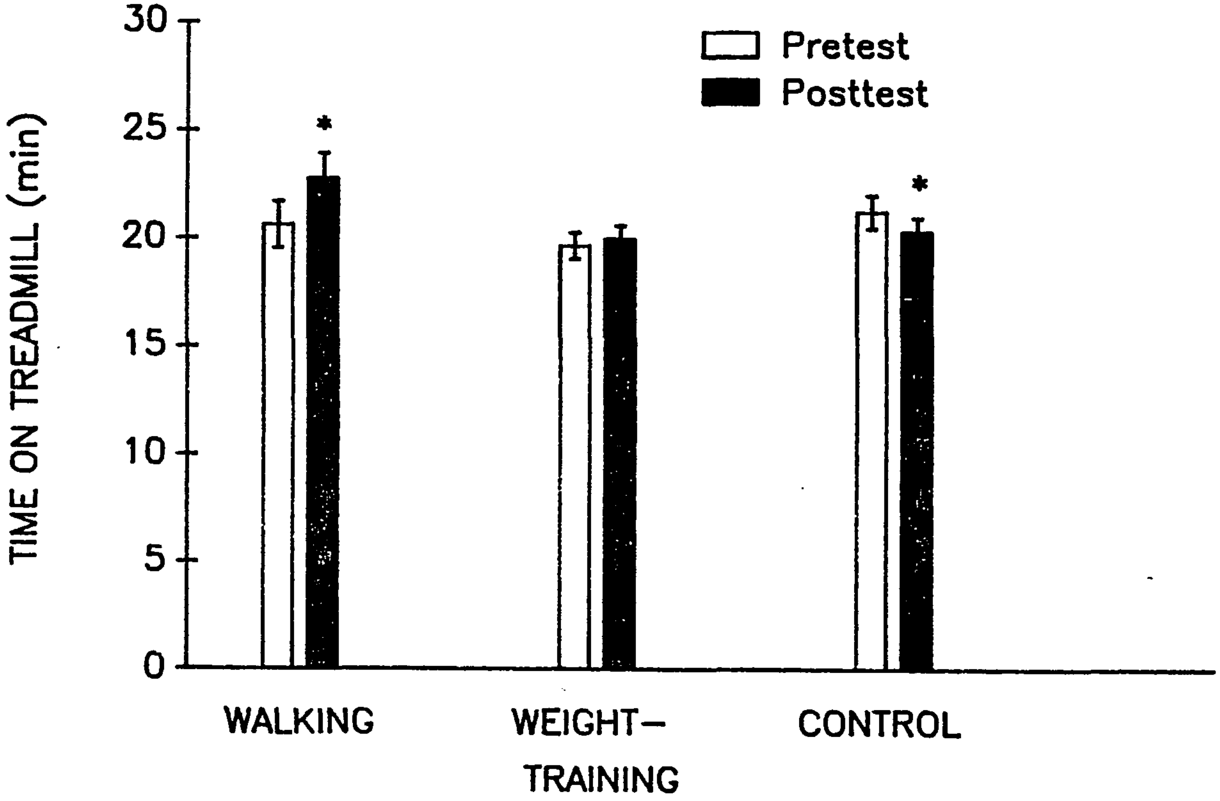

Figure 5. Group Means ±SE for Time on Treadmill at Pre and Posttest Measurements. Astericks Denote Significant Treatment Interactions. (p <.05)

significant differences were revealed by the MANOVA for W [F (1,41) = 4.58, p = .03] and C [F (1,41) = 4.58, p = .03], but not for T. Additionally, a statistically significant interaction between time on treadmill and the treatment was noted [F (2,41) = 13.57, p = .0001]. A posteriori analysis revealed a statistically significant increase in pretest to posttest values for W when compared to T and C.

Ventilation

The mean ±SE ventilation (VE) pretest value for W was 73.08 ±2.78 L min-1 while the mean ±SE pretest values for T and C were 77.19 ±5.65 L/min and 68.93 ±2.78 L/min, respectively. The mean ±SE posttest values for W, T, and C were 76.23 ±3.08 L/min, 77.94 ±6.53 L/min, and 67.45 ±3.72 L/min, respectively. The group means ±SE for pre- and posttest VE values are graphically represented in figure 6. Statistical analysis of the data with a MANOVA did not reveal significant differences over time or between treatment groups.

Respiratory Exchange Ratio

The mean ±SE respiratory exchange ratio (RER) pretest value for W was 1.08 ±0.01 while the mean ±SE pretest values for T and C were 1.11 ±0.01 and 1.09 ±0.00, respectively. The mean ±SE posttest values for W, T, and C were 1.11

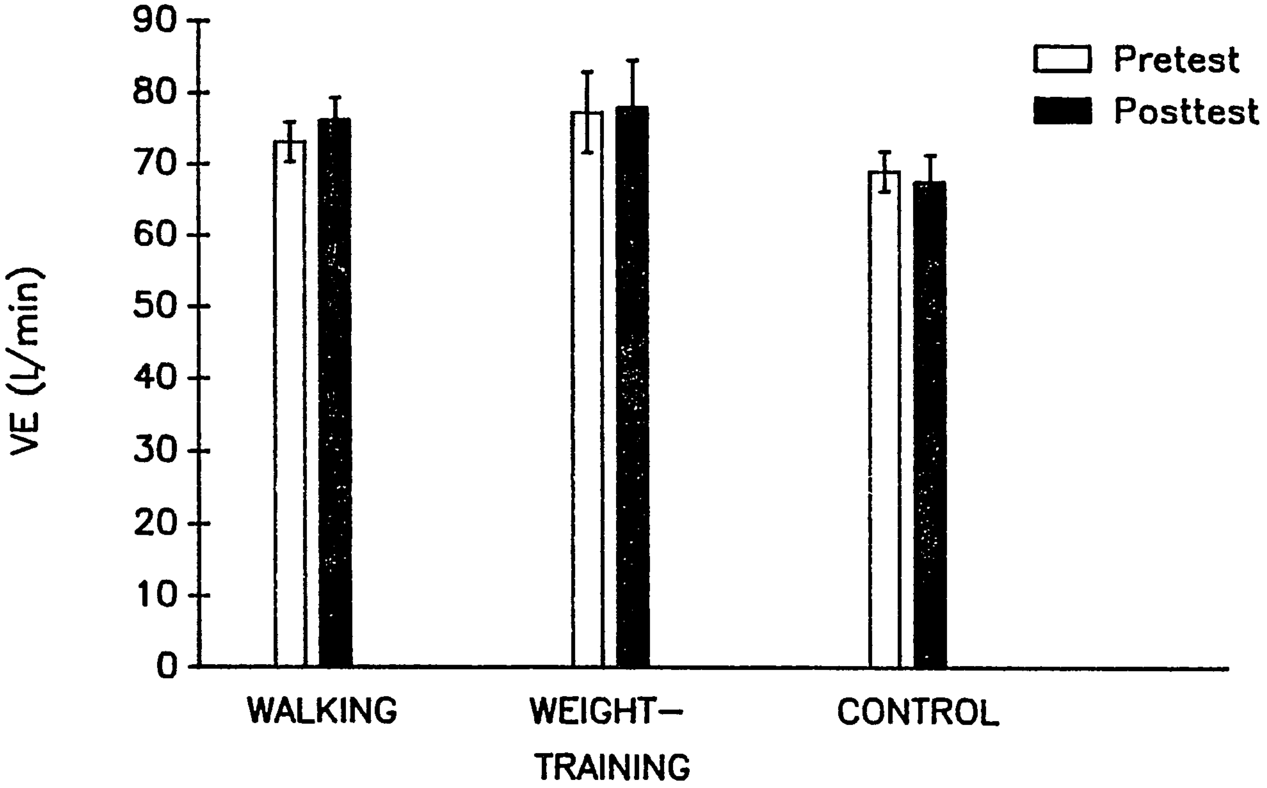

Figure 6. Group Means ±SE for VE at Pre and Posttest Measurements.

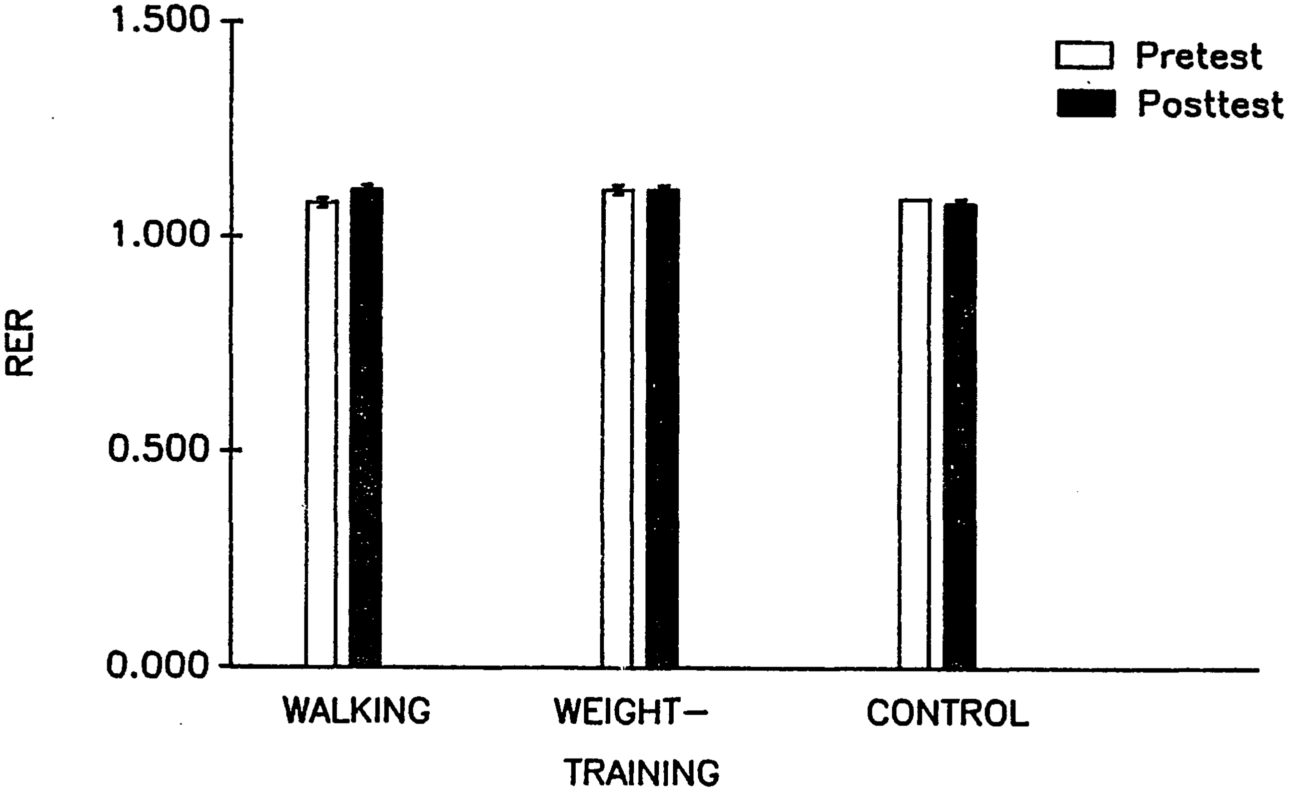

Figure 7. Group Means ±SE for RER at Pre and Posttest Measurements.

±0.01, 1.11 ±0.01, and 1.08 ±0.01, respectively. The group means (±SEM) for the pre- and posttest RER values are of the graphically represented in figure 7. Statistical analysis data with a MANOVA did not reveal significant differences over time or between treatment groups.

Maximal Isokinetic Strength

Mean and individual data for performance on the maximal isokinetic strength assessment are presented in Appendices J and K.

Maximal Isokinetic Elbow Flexion Strength

The mean ±SE pretest elbow flexion strength value for W was 21.60 ±2.79 lbs while the mean ±SE pretest values for T and C were 24.57 ±2.61 lbs and 23.06 ±2.31 lbs, respectively. The mean ±SE posttest values for W, T, and C were 24.42 ±2.61 lbs, 33.35 ±2.40 lbs, and 23.06 ±1.65 lbs, respectively. The group means ±SE for the pre- and posttest elbow flexion values are graphically represented in figure 8. Statistically significant differences were revealed by a MANOVA for all three groups over time [F (1,41) = 18.63, p = 0.0001]. Additionally, a significant interaction was noted between strength and the treatment [F (2,41) = 28.21, p = 0.0001]. A posteriori analysis revealed a statistically

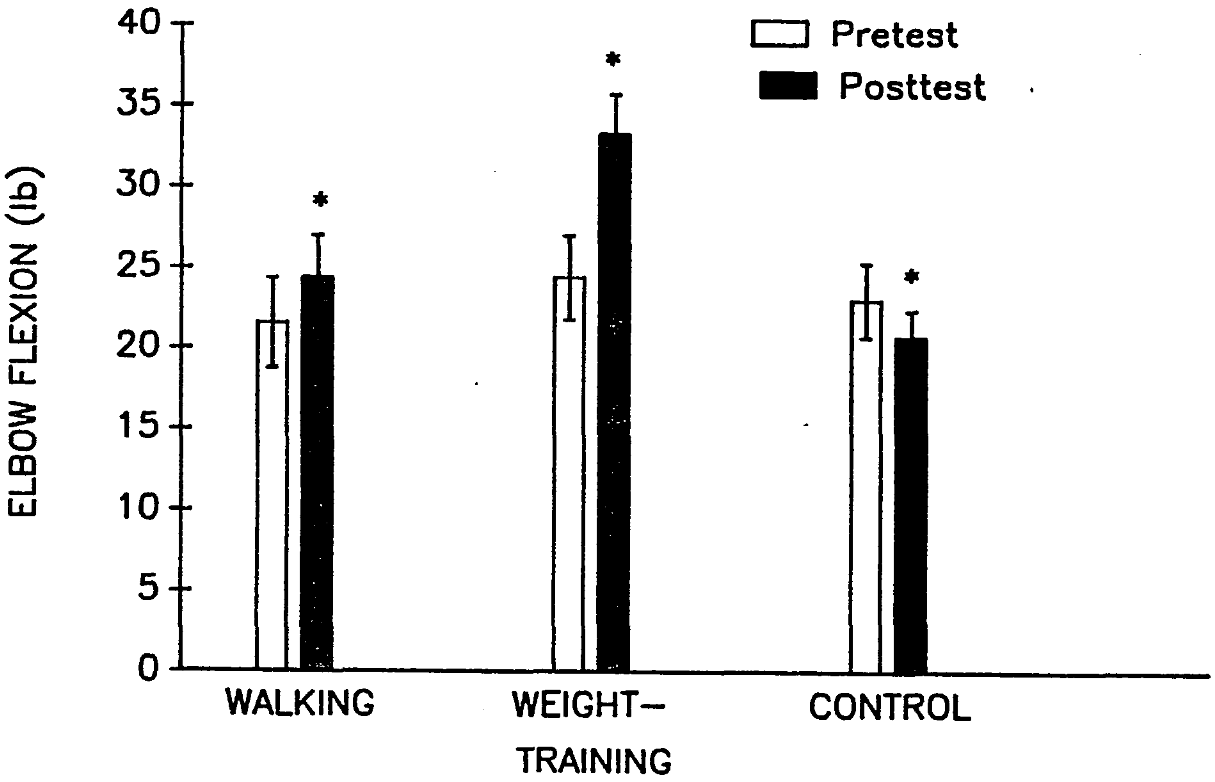

Figure 8. Group Means ±SE for Elbow Flexion at Pre and Posttest Measurements. Astericks Denote Significant Treatment Interactions. ($p < .05$)

significant greater increase in the elbow flexion values of T when compared to W and C.

Maximal Isokinetic Knee Extension

The mean ±SE pretest knee flexion strength value for W was 64.53 ±3.81 lbs while the mean ±SE pretest values for T and C were 57.64 ±5.20 lbs and 54.25 ±5.16 lbs, respectively. The mean ±SE posttest values for W, T, and C were 74.64 ±5.42 lbs, 76.64 ±7.11 lbs, and 53. 93 ±5.35 lbs, respectively. The group means ±SE for pre- and posttest knee extension values are graphically represented in figure 9. Statistically significant differences were revealed by a MANOVA for W and T over time [$\underline{F}$ (1,41) = 37.08, $\underline{p}$ = 0.0001]. A significant interaction was noted between strength and treatment [$\underline{F}$ (2,41) = 12.74, $\underline{p}$ = 0.0001]. A posteriori analysis revealed a significantly greater increase in strength in T when compared to W or C. Additionally, the strength of W was revealed to be significantly greater than C.

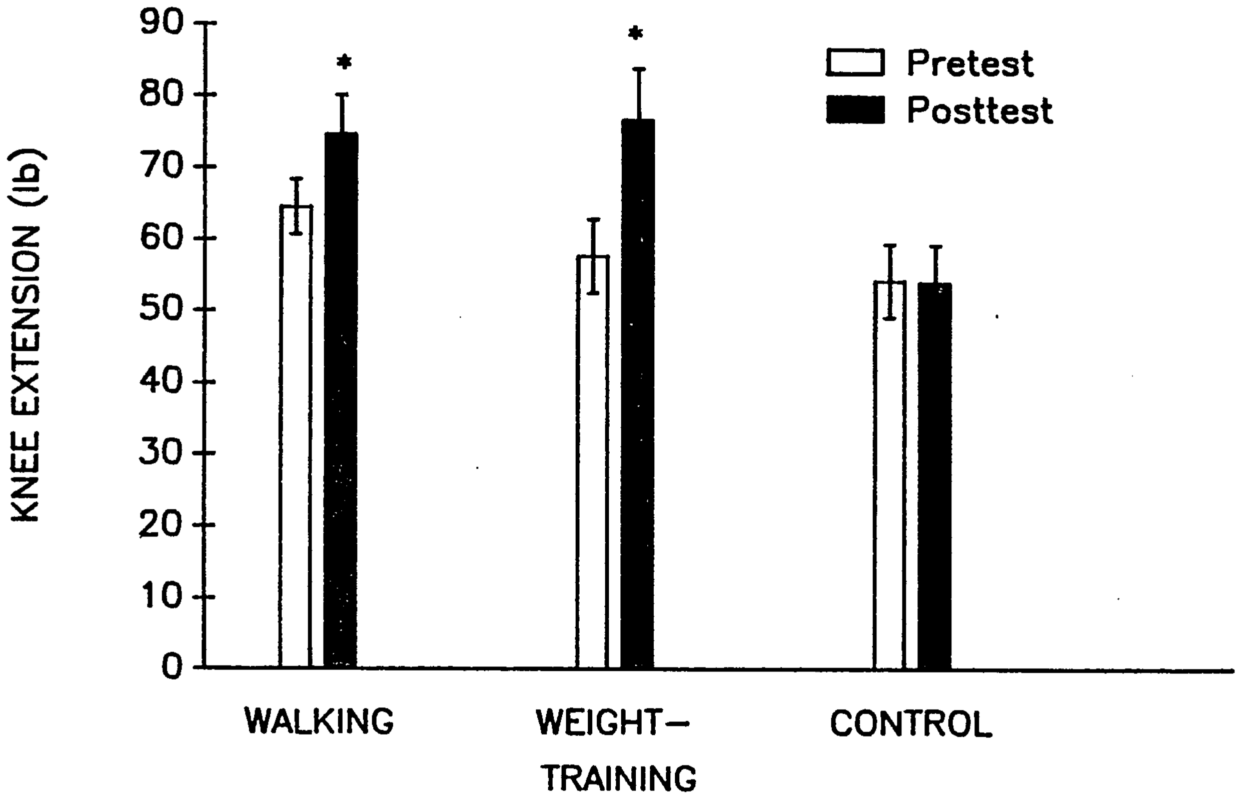

Figure 9. Group Means ±SE for Knee Extension at Pre and Posttest Measurements. Astericks Denote Significant Treatment Interactions. (*p* < .05)

CHAPTER V

DISCUSSION

The purpose of this study was to investigate the effects of a 16-week walking program and a 16-week weight-training program on Ross Information Processing Assessment (RIPA) performance. To further elucidate the investigation's intent, six research questions were formualted. They included:

1. Is there a significant difference in the subjects' performance on the RIPA before and after a 16-week walking program?

2. Is there a significant difference between the subjects' performance on the RIPA before and after a 16-week weight-training program?

3. Is there a significant difference between the subjects' performance on the RIPA before and after a 16-week walking program compared to before and after a 16-week weight-training program?

4. Is there a significant difference between blood pressure of the subjects' before and after a 16-week walking program?

5. Is there a significant difference between blood pressure of the subjects' before and after a 16-week weight-training program?

6. Is there a significant difference between blood pressure of the subjects' before and after a 16-week walking program compared to before and after a weight-training program?

The results indicate that performance on the RIPA was significantly improved after 16 weeks of brisk walking [beginning at 60% of heart rate reserve (HRR) and progressing to 65% by week six]. Significant differences were not found for either the weight-training group or the control group. Additionally, significant strength gains were noted in elbow flexion for the weight-training group, but not the walking group or the control group; however, significant strength gains in knee extension were revealed for both the walking and weight-training groups. Maximal oxygen uptake ($\dot{V}O2max$) was significantly improved after the 16-week walking program; significant changes were not revealed in the control group or weight-training group. Significant decreases in both systolic and diastolic blood pressure were noted for the walking and weight-training groups, but not for the control group.

The discussion will be limited to the parameters isolated in the present investigation which demonstrated significance. It will include a discussion of the following: the effects of exercise on $\dot{V}$O2max; the effects of exercise on muscular strength; the effects of exercise on blood pressure; and the effects of exercise on cognitive performance.

The Effects of Exercise on $\dot{V}$O2max

The significant differences between groups in $\dot{V}$O2max values can be attributed to the mode of exercise. The subjects who engaged in 16 weeks of walking demonstrated a 14% increase in $\dot{V}$O2max whereas the subjects in the weight-training group demonstrated no increase and a 6% decrease was noted for those in the control group. The results of this investigation, enhanced $\dot{V}$O2max following aerobic exercise, support the findings of many researchers (Barry et al., 1966; Blumenthal et al., 1989; Dustman et al., 1984; Hagberg et al., 1989). However, the percent increases found in this and other investigations vary widely. For example, Barry et al. (1966), in an uncontrolled study , reported that 70-year-old subjects increased their $\dot{V}$O2max by 38% through three months of bicycle ergometer training for 120 minutes per week; however, wide variations in pre- and postmaximal exercise testing were reported for RER, heart rate, and blood lactate concentrations. Such discrepancies may indicate that subjects did not achieve a valid $\dot{V}$O2max test initially, thus skewing the improvement percentage to a higher value. Dustman et al. (1984) reported a 27% increase in $\dot{V}$O2max in 13 subjects over 4 months of exercise training. However, an adequate control group was lacking.

In two recent randomized controlled design studies, similar improvements in $\dot{V}$O2max to those of this investigation were reported (Blumenthal et al., 1989; Hagberg et al., 1989). Blumenthal et al. (1989) reported an 11.6% improvement in $\dot{V}$O2max in 33 subjects (mean age = 67 years) randomly assigned to 16 weeks of aerobic training while no improvements were noted in a Yoga control group or a waiting list control group. Similarly, Hagberg et al. (1989), in a randomized controlled study of 70-79-year-old men and women, found that six months of exercise training increased $\dot{V}$O2max by 22%. Subjects in this study engaged in treadmill walking/jogging at 40-70% HRR for the first 13 weeks and increased the intensity to 75-85% HRR during the last 13 weeks. When the intensity of training was similar to the present investigation (i.e. first 13 weeks), a 14.6% improvement was noted in $\dot{V}$O2max. Thus, it appears when a randomized control design with precise maximal VO2 measurements is utilized, improvements in $\dot{V}$O2max for individuals over 65 years of age range from 11.6-14.6% through participation in 12-16 weeks of aerobic activity.

This investigation supports findings reported by Cononie et al. (1991). Cononie et al. (1991) conducted a study to assess the effect of six months of resistance or endurance exercise on cardiovascular measures. Men and women 70-79 years of age were randomly assigned to a resistance-training group or an endurance-training group. The resistance group trained utilizing Nautilus machines three times per week while the endurance group jogged at an intensity 75-85% of $\dot{V}$O2max for 35-45 minutes three times per week. A 20% increase in $\dot{V}$O2max was reported for the endurance group, however, no improvement was reported for the resistance group.

The results of this investigation are contradictory to reported claims by two research groups of enhanced $\dot{V}$O2max following weight-training (Frontera et al., 1988; Panton et al., 1990). Frontera et al. (1988) assessed the effects of strength on $\dot{V}$O2max before and after a 12-week weight-training program. They reported a 1.9 ml increase in $\dot{V}$O2max per unit fat-free mass utilizing leg cycle ergometry, however, arm cycle $\dot{V}$O2max remained unchanged. The subjects in the investigation by Frontera et al. (1988) selectively trained the extensor and flexors of the knee. Therefore, they concluded that the small increase in leg cycle $\dot{V}$O2max may have been due to adaptations in the oxidative capacity and increased mass of the strength-trained muscles. Panton et al. (1990) reported a 3.6% increase in $\dot{V}$O2max following a 26-week upper and lower body strength-training regimen. A modified Naughton treadmill protocol was used by Panton et al. (1990) to assess each subject's $\dot{V}$O2max. This protocol closely matched the protocol used in the present investigation for assessing $\dot{V}$O2max. Although Panton et al. (1990) demonstrated a slight increase in $\dot{V}$O2max following weight-training, the improvement was not statistically significant.

Effects of Exercise on Muscular Strength

Significant increases in knee extension strength were noted for both the weight-training group and the walking group. Although both groups demonstrated improvement, the weight-training group improved an average of 71.6% and the walking group 27.8%. No significant changes were noted in elbow flexion strength for the walking group whereas the weight-training group demonstrated significant increases (38%).

These results support the findings of several researchers who found that exercise had a positive effect on muscular strength in the older population (Brown et al., 1990; Fiaterone et al., 1990; Frontera et al., 1988; Whitw et al., 1984). Slightly lower mean gains (71.6%) in knee extension strength were noted from this investigation than those reported by Fiaterone et al. (1990) and Frontera et al. (1988) can be explained by the variations in subject population and methodology. Fiaterone et al (1990) utilized frail, institutionalized elderly who were dependent upon assistance to walk, whereas, this investigation involved mobile, independently living individuals. Additionally, the mean age of the subjects in the study by Fiaterone et al. (1990) was 90 ±1 years. The present study's mean age was 69.1 ± .45 years. Brown (1989) has reported strength decrements of 20% by the age of 65 and continued decline, especially in the lower extremities as age increases. Therefore, perhaps the population utilized by Fiaterone et al. (1990) demonstrated lower pretraining strength values than did the subjects in the present investigation. Frontera et al. (1988) isolated the knee flexors and extensors and trained them utilizing three sessions per week. The weight-training protocol utilized in the present investigation involved upper and lower body exercises performed on alternate days, three days per week for upper body and two days per week for lower body. The additional day utilized by Frontera et al. (1988) may account for the greater percentage gain in knee extension strength.

The significant gains in knee extension strength following the walking program support the findings reported by White et al. (1984). Although the mean gains (27.8%) noted in this investigation were higher than those reported by White et al. (1984), 11.7%, differences in training and testing protocols exist. The subjects in the present study walked, under supervision, five days per week beginning at 60% of HRR and progressed to 65%. In the investigation by White et al. (1984) the subjects walked two miles, four days per week with one supervised and three unsupervised sessions. Additionally, White et al. (1984) tested knee extension isometrically at 115° of flexion, whereas, strength in this study was tested isokinetically through a full range of motion.

Brown et al. (1990) documented an increase of 23% in dynamic elbow flexion. The results of the present study, a 38% increase noted in the weight-training group, closely parallel those reported by Brown et al. (1990). The nonsignificant differences between pre- and posttraining assessment of elbow flexion strength in the walking group support the findings of White et al. (1984). Therefore, these data suggest that a weight-training program utilizing the DAPRE protocol, involving upper and lower body exercises, will improve knee extension and elbow flexion strength more than a brisk walking program.

Effects of Exercise on Systolic and Diastolic Blood Pressure

Significant decreases in systolic and diastolic blood pressure were noted for the walking and weight-training groups but not for the control group. This supports the findings by deVries (1970) who reported significantly decreased blood pressures following 12 weeks of walking. However, the nonsignificant correlation between blood pressure and performance on the RIPA refutes the findings reported by previous investigators (Elias et al., 1990; Powell & Pondorf, 1971). Powell and Pondorf (1971) reported a significant negative correlation between blood pressure and performance on cognitvie measures. This was supported by Elias et al. (1990). Although the present investigation evidenced a small negative correlation between blood pressure and RIPA scores ($r = -.2$), the relationship was nonsignificant. The findings of the previous studies (Elias et al., 1990; Powell & Pondorf, 1971) compared cognitive performance of hypertensive individuals to normotensive subjects. Both the pre- and postsystolic and diastolic blood pressure values of the present subjects were within the normal ranges. Thus, blood flow may not have been enhanced sufficiently by the small decrements in systolic and diastolic blood pressures to alter cognitive functioning significantly.

Effects of Exercise on Cognitive Functioning

The significant increase in performance on the RIPA by the walking group support the findings reported by numerous researchers (Barry et al., 1966; Baylor & Spirduso, 1988; Dustman et al, 1984; Elsayed et al., 1980; Emery & Getz, 1990). In addition, the significant correlation between RIPA scores and $\dot{V}$O2max ($p = .002$) supports the relationship between cognitive performance and $\dot{V}$O2max suggested by Dustman et al. (1984). $\dot{V}$O2max is a function of the body's ability to transport, distribute, and utilize oxygen (McArdle et al., 1988). This relationship is explained by the Ficke equation (the product of cardiac output and arteriovenous difference) (McArdle et al., 1988). Research (Hickson, 1981; Rogers et al., 1988) has demonstrated that short-term training, six months or less, produces central rather than peripheral changes in cardiovascular functioning. Central changes are evidenced by increases in stroke volume and a decrease in resting heart rate (RHR) resulting in improved blood flow (Dustman et al., 1984). The present investigation demonstrated a 3% decrease in RHR in the walking group compared to a 5% increase in RHR in the weight-training group and no change in the control group. These data suggest that walking improves central cardiovascular functioning which may result in enhanced blood flow to the brain, thus increasing performance on cognitive measures. Further support for this hypothesis is evidenced by the nonsignificant differences between pre- and posttraining RIPA performance and $\dot{V}$O2max values for the weight-training and control groups. The nonsignificant differences in cognitive performance in the weight-training group support the findings of an investigation by Panton et al. (1990).

Methodological differences may explain the differences between findings of the present investigation and those by previous researchers who reported no significant improvements in cognitive performance concomittant with significant increases in $\dot{V}$O2max (Blumenthal & Madden, 1988; Blumenthal et al., 1989; Madden et al., 1989). The mean age in this investigation was 69.1 ± 0.45 years whereas the mean age of the subjects in previous investigations (Blumenthal & Madden, 1988; Blumenthal et al., 1989; Madden et al., 1989) was 43.32 ± 8.84 years. According to Craik and Simon (1980) information processing begins to decline in the mid 50's with a noticeable decline by the age of 65 years. The training protocol utilized by previous researchers (Blumenthal & Madden, 1988; Blumenthal et al., 1989; Madden et al., 1989) consisted of continuous walking or jogging for 30-45 minutes, three days per week for 12 weeks contrasted with a five day per week, 16-week walking program in the present study. Madden at al. (1989) reported $\dot{V}$O2max increases of 15% as a result of their training protocol; the present investigation reported a 14% increase resulting from the walking. Therefore, perhaps the training protocol was not as instrumental in producing the contradictory findings as the discrepency in age between the subjects in the previous investigations and the present one.

Summary

The purpose of this investigation was to determine the effects of a 16-week walking program and a 16-week weight-training program on performance by older adults on the RIPA. An ANOVA was employed to analyze the differences between pre- and posttraining performance on the RIPA by group. Statistically significant improvements were noted for the walking group, but not for the weight-training or control groups.

MANOVA's were utilized to ascertain the effects of the exercise modalities on parameters assessed during maximal treadmill testing and the isokinetic strength assessment. Data analysis revealed a significant increase in $\dot{V}$O2max following 16 weeks of walking. Nonsignificant differences between pre- and posttraining values were noted for the weight-training and control groups. Further analysis utilizing a Pearson correlation coefficient demonstrated a significant positive relationship between improvements in

VO2max and performance on the RIPA. These findings support the group differences in RIPA scores noted between the walking, weight-training, and control groups.

Significant improvements in both elbow flexion and knee extension strength were evidenced by the weight-training group. Although the walking group demonstrated a significant increase in leg strength, it did not improve significantly in elbow flexion strength. The results of a Pearson correlation coefficient revealed a nonsignificant relationship between elbow flexion and knee extension strength and performance on the RIPA.

To enhance the findings of this study, an ANOVA was employed to analyze the differences between pre- and posttraining blood pressure by group. Results of the data analysis revealed significant decreases in both systolic and diastolic blood pressure for the walking and weight-training groups, but not for the control group. These results, occurring concomittantly with improved $\dot{V}$O2max following walking, lend credence to the hypothesis that improvements in measures of central cardiovascular functioning may enhance blood flow to the brain, thus increasing cognitive abilities.

In conclusion, the results of this study support the hypothesis that a 16-week walking program has a positive effect on performance on the RIPA in older adults. Additionally, the 16-week walking program was more effective in improving RIPA scores than were a 16-week weight-training program or a placebo control program.

Implications for administrators in higher education include advising older students to participate in physical activity classes and programming activity courses that meet the needs of the older student. Additionally, providing recreational opportunities and special classes for older students on campus may encourage these students to become involved thus enhancing their educational experiences.

Although a positive correlation was revealed between RIPA performance and VO2max suggesting increased blood flow to the brain as a possible mechanism for the improvement in RIPA score following the walking treatment, further elucidation is needed. Such research would require assessing enzymatic and metabolic measures, quantifying blood flow to the brain, and evaluating computed tomographies of the brain before and after an exercise training program.

BIBLIOGRAPHY

ADA Reports. (1987). Nutrition, aging, and the continum of health care: Technical support paper. Journal of American Dietetic Association, 87(3), 345-347.

Albert, M.S., Wolfe, J., & Lafleche, G. (1990). Differences in abstraction ability with age. Psychology and Aging, 5(1), 94-100.

American College of Sports Medicine. (1991). Guidelines for exercise testing and prescription. Philadelphia: Lea and Febiger.

Arenberg, D. (1990). Longitudinal changes in congnitive performance. Advances in Neurology, 51, 207-209.

Attig, M. & Hasher, L. (1980). The processing frequency of occurrence information by adults. Journal of Gerontology, 35, 66-69.

Barry, A.J., Steinmetz, J.R., Page, H.F., & Rodahl, K. (1966). The effects of physical conditioning on older individuals. II. Motor performance and cognitive functioning. Journal of Gerontology, 21, 192-199.

Bartus, R.T., Dean, R.L., & Beer, B., & Lippa, A.S. (1982). The cholinergic hypothesis of geriatric memory dysfunction. Science, 217, 408-417.

Bartus, R.T., Dean, R.L., Pontecorro, M.J., & Flicker, C. (1985). The cholinergic hypothesis: A historical overview, current perspective, and future dierections. In D.S. Olton, E. Gamzu, & S. Corkin (Eds.) Memory dysfunction: An integration of animal and human research from preclinical and clinical perspectives (pp. 332-358). New York: The New York Academy of Sciences.

Baylor, A.M. & Spirduso, W.W. (1988). Systematic aerobic Exercise and Components of reaction time in older women. Journals of Gerontology: Psychological Sciences, 43(5), 121-126.

Benestad, A.M., Halvorsrud, J., & Andersen, K.L. (1968). The physical fitness of old Norwegian men and women. Acta Medica Scandinavia, 183, 73-78.

Birren, J.E., Woods, A.M., & Williams, M.V. (1979). Speed of behavior as an indicator of age changes and the integrity of the nervous system. In F. Hoffmeister, C, Muller, and H.P. Krause (Eds.), *Brain function in old age* (pp. 10-44). New York: Springer-Verlag.

Blair, S.N., Brill, P.A., & Kohl, H.W. (1989). Physical activity patterns in older individuals. In W.W. Spirduso and H.M. Eckert (Eds.) *Physical activity and aging: American academy of physical education papers no.22.* (pp. 120-139). Champaign: Human Kinetics Books.

Blumenthal, J.A., Emery, C.F., Madden, D.J., George, L.K., Coleman, R.E., Riddle, M.W., McKee, D.C., Reasoner, J., & Williams, R.S. (1989). Cardiovascular and behavioral effects of aerobic exercise training in healthy older men and women. *Jounrals of Gerontology: Medical Science*, 44(5), 147-157.

Blumenthal, J.A., & Madden, D.J. (1988). Effects of aerobic exercise training, age, and physical fitness on memory-search performance. *Psychology and Aging*, *3*, 280-285.

Botwinick, J. (1984). Newer perspectives in learning-memory. In J. Botwinick (Ed.) *Aging and behavior: A comprehensive integration of research findings* (pp. 336-358). New York: Springer Publishing Company.

Brown, A.B., McCartney, N., & Sale, D.G. (1990). Positive adaptations to weight-lifting training in the elderly. *Journal of Applied Physiology*, *68*, 1725-1732.

Brown, B.S., Payne, T., Kim, C., Moore, G., Krebs, P. & Martin, W. (1979). Chronic response of rat brain norepinephrine and serotonin levels to endurance. *Journal of Applied Physiology*, *46*, 19-23.

Brown, M. (1989). Resistance exercise effects on aging skeletal muscle in rats. *Physical Therapy*, *69*(1), 46-53.

Bruce, R.A. (1984). Exercise, functional aerobic capacity, and aging: Another viewpoint. *Medicine and Science in Sports and Exercise*, *16*(1), 8-13.

Chodzko-Zajko, W.J. (1991). Physical fitness, cognitive performance, and aging. *Medicne and Science in Sports and Exercise*, *23*(7), 868-872.

Clarkson-Smith, L. & Hartley, A. (1989). Relationships between physical exercise and cognitive abilities in older adults. Psychology and Aging, 4(2), 183-189.

Cononie, C.C., Graves, J.E., Pollock, M.L., Phillips, M.I., Sumners, C., & Hagberg, J.M. (1991). Effects of exercis training on blood pressure in 70- to 79- year-old men and women. Medicine and Science in Sports and Exercise, 23(4), 505-511.

Craik, F.I. & McDowd, J.M. (1987). Age differences in recall and recognition. Journal of Experimental Psychology: Learning, Memory, and Cognition, 13(3), 474-479.

Craik, F.I. & Simon, E. (1980). Age differences in memory: The roles of attention and depth of processing. In L.W. Poon, J.L. Fozard, L.S. Cermak, D. Arenberg, & L.W. Thompson (Eds.) New directions in memory and aging (pp.95-112). Hillsdale: Lawrence Erlbaum Associates, Inc.

Cunningham, W.R., Clayton, V., & Overton, W. (1975). Journal of Gerontology, 30(1), 53-55.

de Vries, H.A. (1970). Physiological effects of an exercise training regimen upon men aged 52 to 88. Journal of Gerontology, 25(4), 325-336.

Drinkwater, B.L., Horvath, S.M., & Wells, C.L. (1975). Aerobic power of females, ages 10-68. Journal of Gerontology, 30(4), 385-394.

Dustman, R.E., Ruhling, R.O., Russell, E.M., Shearer, D.E., Bonekat, H.W., Shigeoka, J.W., Wood, J.S., &Bradford, D.C. (1984). Aerobic exercise training and improved neuropsychological function of older individuals. Neurobiology of Aging, 5, 35-42.

Ehsani, A.A. (1987). Cardiovascular adaptations to exercise training in the elderly. Federation Proceedings, 46, 1840-1843.

Elias, M.F., Robbins, M.A., Schultz, N.R., & Pierce, T.W. (1990). Is blood pressure an important variable in research on aging and neuropsychological test performance? Journals of Gerontology: Psychological Sciences, 45(4), 128-135.

Elayed, M., Ismail, A.H., & Young, R.J. (1980). Intellectual differences of adult men related to age and physical fitness before and after an exercise program. Journal of Gerontology, 35(3), 383-387.

Emery, C.F. & Getz, M. (1990). Psychological and cognitive effects of an exercise program for community-residing older adults. The Gerontologist, 30(2), 184-188.

Evans, J.G., Prior, I.A.M., & Tunbridge, W.M.G. (1982). Age-associated change in QRS axis: Intrinsic or extrinsic ageing? Gerontology, 28, 132-137.

Fiatarone, M.A., Marks, E.C., Ryan, N.D., Meredith, C.N., Lipsitz, L.A., & Evans, W.J. (1990). High-intensity strength training in nonagenarians. Journal of American Medical Association, 263(22), 3029-3034.

Fitzpatrick, J.H., Gilboe, D.D., Drewes, L.R., & Betz, A.L. (1976). Relationship of cerebral blood oxygen uptake to EEG frequency in isolated canine brain. American Journal of Physiology, 231, 1840-1846.

Fleg, J.L. & Lakatta, E.G. (1988). Role of muscle loss in the age-associated reduction in VO2max. Journal of Applied Physiology, 65(3), 1147-1151.

Forrester, T. (1978). Extracellular nucleotides in exercise: Possible effect on brain metabolism. Journal of Applied Physiology, 74, 477-483.

Frontera, W.R., Meredith, C.N., O'Reilly, K.P., & Evans, W.J. (1990). Strength training determinants of VO2max in older men. Journal of Applied Physiology, 68, 329-333.

Frontera, W.R., Meredith, C.N., O'Reilly, K.P. Knuttgen, H.G., & Evans, W.J. (1988). Strength conditioning in older men: Skeletal muscle hypertrophy and improved function. Journal of Applied Physiology, 64, 1038-1044.

Gerstenblith, G., Renland, D.G., & Lakatta, E.G. (1987). Cardiovascular response to exercise in younger and older men. Federation Proceedings, 46, 1834-1839.

Gross-Iseroff, R., Salama, D., Israeli, M., & Biegon, A. (1990). Autoradiographic analysis of age-dependent changes in serotonin 5-HT2 receptors of the human brain postmortem. Brain Research, 519, 223-227.

Guttentag, R.E. & Madden, D.J. (1987). Adult age differences in the attentional demands of letter matching. Experimental Brain Research, 13(2), 93-99.

Guyton, A.C. (1986). Textbook of medical physiology (7th edition). Philadelphia: W.B. Saunders.

Harris, R. (1987). Cardiovascular features unique to the elderly. Baylor Cardiology Series, 10, 1-26.

Hasher, L. & Zacks, R. (1979). Automatic and effortful processes in memory. Journal of Experimental Psychology: General, 108(3), 356-388.

Hasher, L. & Zacks, R. (1988). Working memory, comprehension, and aging: A review and a new view. The Psychology of Learning and Motivation, 22, 193-225.

Heath, G.W., Hagberg, J.M., Ehsani, A.A., & Holloszy, J.O. (1981). A physiological comparison of young and older endurance athletes. Journal of Applied Physiology, 59, 634-640.

Hickson, R.C. (1981). Time course of the adaptive responses of aerobic power and heart rate to training. Medicine and Science in Sport and Exercise, 13(1), 17-20.

Hodkinson, H.M. (1988). Diet and maintenance of mental health in the elderly. Nutrition Reviews, 46(2), 79-87.

Horn, J.L. & Cattell, R.B. (1966). Refinement and test of the theory of fluid and crystallized general intelligences. Journal of Educational Psychology, 57, 253-270.

Hunt, A.L., Orrison, W.W., Yeo, R.A., Haaland, K.Y., Rhyne, R.L., Garry, P.J., & Rosenberg, G.A. (1989). Neurology, 39, 1470-1474.

Ingvar, D.H. & Phillipson, L. (1977). Distribution of cerebral blood flow in the dominant hemisphere during motor ideation and motor performance. Annals of Neurology, 2, 253-270.

Jernigan, T.L., Press, G.A., & Hesselink, J.R. (1990). Methods for measuring brain morphologic features on magnetic images. Archives of Neurology, 47, 27-32.

Jost, J., Weiss, M., & Weicker, H. (1990). Sympathoadrenergic regulation anf the adrenoreceptor system. Journal of Applied Physiology, 68, 897-904.

Kasch, F.W., Boyer, J.L., Van Camp, S.P., Verity, L.S., Wallace, J.P. (1990). The effect of physical activity and inactivity on aerobic power in older men: A longitudinal study. The Physican and Sportsmedicine, 18(4), 73-83.

Kausler, D.H. (1985). Episodic memory: Memorizing performance. In N. Charness (Ed.) Aging and human performance. (pp.101-141). New York: John Wiley & Sons.

Kausler, D.H. & Puckett, J.M. (1980). Frequency judgements and correlated cognitive abilities in young and elderly adults. Journal of Gerontology, 35, 376-382.

Kirasic, K.C. & Allen, G.L. (1985). Aging, spatial performance and spatial competence. In N. Charness (Ed.) Aging and human performance. (pp.225-259). New York: John Woley & Sons.

Klitgaard, H., Brunet, A., MAton, B., Lamaziere, C., Lesty, & Monod, H. (1989). Morphological and biochemical changes in old rat muscles: Effect of increased use. Journal of Applied Physiology, 67, 1409-1417.

Kobari, M., Meyer, J.S., & Ichijo, M. (1990). Leuko-araiosis, cerbral atrophy, and cerebral perfusion in normal aging. Archives of Neurology, 47(2), 161-165.

Lakatta, E.G. (1990). Changes in cardiovascular function with aging. European Heart Journal, 11(Suppl. C), 22-29.

Larsson, L., Grimby, G., & Karlsosn, J. (1979). Muscle strength and speed of movement in relation to age and muscle morphology. Journal of Applied Physiology, 46, 451-456.

Leenders, K.L., Perani,D., Lammertsma, A.A., Heather, J.D., Buckingham, P., Healy, M.J.R., Gibbs, J.M., Wise, R.J.S., Hatazawa, J., Herold, S., Beany, R.P., Brooks, D.J., Spinks, T., Rhodes, C., Frackowiak, R.S.J., & Jone, T. (1990). Cerebral blood flow, blood volume and oxygen utilization. *Brain*, *113*, 27-47.

Madden, D.J. (1985). Age related slowing in the retrieval of information from long-term memory. *Journal of Gerontology*, *40*(2), 208-210.

Madden, D.J., Blumenthal, J.A., Allen, P.A., & Emery, C.F. (1989). Improving aerobic capacity in healthy older adults does not necessarily lead to improved cognitive performance. *Psychology and Aging*, *4*(3), 307-320.

Makrides, L. Heigenhauser, G.J.F., & Jones, N.L. (1990). High intensity endurance training in 20-to 30-and 60- to 70 -years-old healthy men. *Journal of Applied Physiology*, *68*, 1792-1797.

Marshall, J.F. & Rosenstein, A.J. (1990). Age-related decline in rat striatal dopamine metabolism is regionally homogeneous. *Neurobiology of Aging*, *11*, 131-137.

McArdle, W.D., Katch, F.L., &Katch, V.L. (1988). *Exercise physiology: Energy, nutrtion, and human performance* (2nd ed.). Philadelphia, Pa: Lea & Febiger.

McCormack, P.D. (1981). Temporal coding by young and elderly adults. *Developmental Psychology*, *17*, 509-515.

McRae, P.G., Spirduso, W.W., Cartee, G.D., Farrar, R.P., & Wilcox, R.E. (1987). Endurance training on striatal D2 dopamine receptor binding and striatal dopamine metabolite levels. *Neuroscience Letters*, *79*, 138-144.

Molloy, D., Beerschoten, D.A., Borrie, M.J., Crilly, R.G, & Cape, R.D.T. (1988). Acute effects of exercise on neuropsychological function in elderly subjects. *Journal of American Geriatrics Society*, *36*(1), 29-33.

Nieman, D.C., Pover, N.C., Segebartt, K.S., Arabatzia, K., Johnson, M., & Dietrich, S.J. (1990). Hematological, anthropometric, and metabolic comparisons between active and inactive healthy elderly women. *Annals of Sports Medicine*, *5*, 2-8.

Nilsson, O.G., Strecker, R.E., Daszuta, A., & Bjorklund, A. (1988). Combined cholinergic and serotonergic denervation of forebrain produces severe deficits in a spatial learning task in the rat. Brain Research, 453, 235-246.

Norusis, M.J. (1988). SPSS/PC+ V2.0 base manual; SPSS/PC+ advanced statistics V2.0. Chicago: SPSS, Inc. Panton,

L.B, Graves, J.E., Pollock, M.L., Hagberg, J.M., & Chen, W. (1990). Effects of aerobic and resistance training on fractionated reaction time and speed of movement. Journals of Gerontology: Medical Sciences, 45(1), 26-31.

Patel, S. (1977). Age-dependent changes in the oxidative metabolism in the rat brain. Journal of Gerontology, 32(4), 643-646.

Plude, D.J. & Hoyer, W.J. (1985). Attention and performance: Identifying and localizing age. In N. Charness (Ed.) Aging and human performance. (pp. 47-99). New York: John Wiley & Sons.

Popova, J.S. & Petkov, V.D. (1989). Age-related changes in rat brain muscarinic receptors and beta-adrenoreceptors. General Pharmacy, 20(5), 581-584.

Powell, R.R. & Pohndorf, R.H. (1971). Comparison of adult exercisers and nonexercisers on fluid intelligence and selected physiological variables. The Research Quarterly, 42(1), 70-77.

Richter-Levin, G. & Segal, M. (1988). Spatial performace is severly impaired in rats with combined reduction of serotonergic and cholinergic transmission. Brain Research, 477, 404-407.

Rikli, R. & Busch, S. (1986). Motor performance of women as a function of age and physical activity level. Journal of Gerontology, 41(5), 645-649.

Rinne, J.O., Lonnberg, P, & Marjamaki, P. (1990). Age-dependent decline in human brain dopamine D1 and D2 receptors. Brain Research, 508, 349-352.

Rivera, A.M., Pels, A.E., Sady, S.P., Sady, M.A., Cullinane, E.M., & Thompson, P.D. (1989). Physiological factors associated with the lower maximal oxygen consumption of master runners. Journal of Applied Physiology, 67, 949-954.

Rogers, M.A., Hagberg, J.M., Matin, W.H., Ehsani, A.A., & Holloszy, J.O. (1990). Decline in VO2max with aging in master athletes and sedentary men. Journal of Applied Physiology, 68, 2195-2199.

Rogers, M.A., Yamamoto, C., Hagberg, J.M., Martin, W.A. III, Eshani, A.A. & Holloszy, J.O. (1988). Effect of six days of exercise training on responses to maximal and sub-maximal exercise in middle-aged men. Medicine and Science in Sport and Exercise, 20(3), 260-264.

Ross, D.G. (1986). Ross information processing assessment. Austin: PRO-ED, Inc.

Safar, M. (1990). Ageing and its effects on the cardiovascular system. Drugs, 39(Suppl. 1), 1-8.

Salthouse, T.A. (1988). The role of processing resources in cognitive aging. In M.L. Howe and O.J. Brainerd (Eds) Cognitive development in adulthood: Progress in cognitive development research (pp.185-239). New York: Springer-Verlag, Inc.

Sanders, R.E., Wise, J.L., Liddle, C.L., & Murphy, M.D. (1990). Adult age comparisons in the processing of event frequency information. Psychology of Aging, 5(2), 172-177.

Severson, J.A. (1984). Neurotransmitter receptors and aging. Journal of American Geriatrics Society, 34(1), 24-27.

Sharkey, B.J. (1987). Functional vs chronological aging. Medicine and Science in Sports and Exercise, 19(2), 174-177.

Shepard, R.J. (1981). Cardiovascular limitations in the aged. In E.L. Smith & R.C. Serfass (Eds.) Exercise and aging: The scientific basis (pp.19-28). Hillside: Enslow Publishers.

Shepard, R.J. (1986). Physical training for the elderly. Clinics in Sports Medicine, 5, 515-533.

Shepard, R.J. (1988). Physiologic changes over the years. In ACSM Resource mannual for guidelines for exercise testing and prescription (Sec. VII pp. 297-304). Philadelphia: Lea & Febiger.

Sidney, K.H. (1984). Cardiovascular benefits of physical activity in the exercising aged. In E.L. Smith & R.C. Serfass (Eds.) Exercise and aging: The scientific basis (pp. 131-147). Hillside: Enslow Publishers.

Skinner, J.S., Tipton, C.M., & Vailas, A.C. (1982). Exercise, physical training and the ageing process. In A. Vidik (Ed.) Lectures on gerontology, volume I: On biology of ageing (pp. 407-439). London: Academic Press.

Spence, A. (1989). Biology of human aging. Englewood Cliffs: Prentice Hall.

Spilich, G.J. (1985). Discourse comprehension across the span of life. In N. Charness (Ed.) Aging and human performance. (pp. 143-190). New York: John Wiley & Sons.

Spirduso, W.W. (1975). Reaction time and movement time as a function of age and physical activity level. Journal of Gerontology, 30(4), 435-440.

Spirduso, W.W. (1980). Physical fitness, aging, and psychomotor speed: A review. Journal of Gerontology, 35(6), 850-865.

Spirduso, W.W. (1989). Physical activity and aging: Introduction. In W.W. Spirduso and H.M. Eckert (Eds.) Physical activity and aging: American academy of physical education papers no.22. (pp. 1-5). Champaign: Human Kinetics Books.

Spirduso, W.W. & Clifford, P. (1978). Replication of age and phsyical activity on reaction time and movement time. Journal of Gerontology, 33(1), 26-30.

Stamford, B.A. (1988). Exercise and the elderly. Exercise and Sport Science Review, 16, 341-379.

Stones, M.J. & Kozma, A. (1989). Age, exercise, and coding performance. Psychology and Aging, 4(2), 190-194.

Tiidus, P., Shepard, R.L., & Montelpare, W. (1989). Overall intake of energy and key nutrients: Data for middle-aged and older middle-class adults. Canadian Journal of Sport Science, 14(3), 173-177.

Tyler, K.L. & Tyler, H.R. (1984). Differentiating organic dementia. Geriatrics, 39, 38-40.

Van Camp, S.P. & Boyer, J.L. (1989). Cardiovascular aspects of aging: Part 1 of 2. The Physician and Sportsmedicine,17(4), 121-130.

Waller, B.F. (1988). The old-age heart: Normal aging changes which can produce or mimic cardiac disease. Clinics in Cardiology, 11, 513-517.

Waller, B.F. & Morgan, R. (1988). The very elderly heart. In B.F. Waller (Ed.) Contemporary issues in cardiovascular pathology (pp. 321-425). Philadelphia: F.A. Davis Company.

Weihmuller, F.B. & Bruno, J.P. (1989). Age-dependent plasticity in the dopaminergic control of sensorimotor development. Behavioural Brain Research, 35, 95-109.

Weisfeldt, M.L. & Gerstenblith, G. (1986). Cardiovascualr aging and adaptation to disease. In J.W. Hurst (Ed.) The Heart (pp. 1403-1411). New York: McGraw-Hill Book Company.

White, M.K. et al. (1984). Effects of aerobic dancing and walking on cardiovascular function and muscular strength in postmenopausal women. Journal of Sports Medicine and Physical Fitness, 24(2), 159-166.

Wright, R.E. (1981). Aging, divided attention, and processing capacity. Journal of Gerontology, 36(5), 605-614.

Yamaura, H., Ito, M., Kubota, K., & Matsuzawa, T. (1980). Brain atrophy during aging: A quantitative study with computed tomography. Journal of Gerontology, 35, 492-498.

APPENDICES

APPENDIX A

CONSENT TO ACT AS A HUMAN SUBJECT

UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

APPALACHIAN STATE UNIVERSITY

Consent to Act as a Human Subject

SUBJECT NAME ____

DATE OF CONSENT ______________________________

PROJECT TITLE:
The Effects of a 16-week Walking Program and a 16-week Weight-training Program on the Performance of Men and Women Ages 65-85 on the Ross Information Processing Assessment

DESCRIPTION OF PROCEDURES:
I have been told that this project is designed to determine whether any important changes in memory variables occur in people who walk briskly for 30-40 minutes, five days per week, for 16 weeks, or who engage in a weight-training program, five days per week for 16 weeks. Before the study begins and after 16 weeks of training, memory, cardiovascular fitness and muscular strength will be measured using the Ross Information Processing Assessment, and standard treadmill and strength training protocols. All subjects will report to Appalachian State University's Human Performance Laboratory, Athletic Training Laboratory, and an assigned classroom at designated times for testing.

At the testing dates, weight and skinfold measurements will be taken to determine percent body fat, a maximal graded exercise test with a metabolic cart and a 12-lead EKG will be conducted to determine the fitness of the heart and lung system, and a maximal strength test will be performed to determine the strength of the muscular system. I will not be charged for these tests, and all information will be explained to me free of charge. As a project participant, I have had these tests explained to me and understand the relative importance of the test results for purposes of this study.

RISKS AND DISCOMFORTS:
I have been told that the risks associated with maximal treadmill-EKG testing include the signs and symptoms of heavy exercise. These are: dizziness, nausea, fatigue, shortness of breath, and temporary pain. There is a very rare possibility of death. One researcher has reported, however, no deaths in 20,000 treadmill tests and less than 0.01% injury. In the event of an emergency, the established medical procedures of the Human Performance Laboratory will

be followed. A medical doctor will be present during testing in addition to appropriate emergency equipment and the necessary medications. The test will be stopped if signs and/or symptoms of intolerance to heavy exercise occur. As a result of the strength testing, muscle soreness will result and last approximately one to two days. There is a very small risk of musculoskeletal injury and of having a heart attack during the moderate exercise training sessions. A medical doctor will be on call if a subject experiences difficulty during the walking, weight-training, or flexibility sessions.

POTENTIAL BENEFITS:
I have been told that the benefits I am to receive include results from several sophisticated tests that will include information on overall health, body composition, fitness, and memory variables. This information will help researchers gain a greater understanding of the effects that a 30-40 minute walking program and a weight-training program have on memory variables.

COMPENSATION/TREATMENT FOR INJURY:
A medical doctor will be present for all maximal treadmill testing sessions and on-call for all exercise sessions. In addition, following examination by a medical doctor and a written prescription for treatment, subjects will be permitted treatment for musculoskeletal injuries incurred during the study at the Appalachian State University athletic training room.

CONSENT:
I have been satisfactorily informed about the procedures described above and the possible risks and benefits of the project, and I agree to participate in this project. Any questions that I have about the procedures have been answered. I understand that this project and this consent form have been approved by the University Institutional Review Board which ensures that research projects involving human subjects follow federal regulation. If I have any questions about this, I will call the Office of Research Services at (919)334-5878.

I understand that I am free to withdraw my consent to participate in the project at any time without penalty or prejudice. In addition, I will not be identified by name as a participant in this project.

Any new information that might develop during the project will be provided to me if that information might affect my willingness to participate in the project.

Subject Signature

Witness to Signature

APPENDIX B

PHYSICAL CHARACTERISTICS

Table 2

Individual and Mean ± SE Physical Characteristics for the Walking Group

SUBJECT	AGE (y)	HEIGHT (cm)	PRE TRAINING BODY MASS (kg)	POST TRAINING BODY MASS (kg)	PRE TRAINING SUM OF SKINFOLDS (mm)	POST TRAINING SUM OF SKINFOLDS (mm)
1	65	152.9	53.3	50.9	55	49
2	72	173.9	67.7	65.0	46	37
3	65	160.5	72.7	58.2	70	54
4	65	162.4	93.3	92.3	103	100
5	65	163.7	78.6	74.7	43	38
6	70	161.2	72.9	74.8	52	63
7	65	170.7	73.6	69.1	41	43
8	67	177.7	78.6	78.6	72	68
9	68	172.6	79.5	79.5	70	70
10	72	180.2	92.3	92.3	68	64
11	76	175.1	78.2	78.2	65	73
12	73	159.9	65.5	65.5	65	62
13	70	164.9	68.6	68.6	69	64
14	69	154.8	56.4	56.4	42	38
15	68	152.3	54.5	54.5	56	56
$\bar{X}$	68.7	165.5	72.4	71.4	61.1	58.9
SE	±0.89	±2.33	±3.10	±3.38	±4.16	±4.62

Table 3

Individual and Mean ± SE Physical Characteristics for the Weight-Training Group

SUBJECT	AGE (y)	HEIGHT (cm)	PRE TRAINING BODY MASS (kg)	POST TRAINING BODY MASS (kg)	PRE TRAINING SUM OF SKINFOLDS (mm)	POST TRAINING SUM OF SKINFOLDS (mm)
1	66	180.2	98.6	98.4	78	68
2	71	183.4	95.2	95.2	72	61
3	69	173.2	78.4	78.6	73	51
4	66	185.9	97.2	98.6	76	61
5	73	158.0	65.6	58.2	74	54
6	68	152.3	54.1	54.1	43	50
7	67	159.9	60.9	60.9	78	70
8	71	159.9	61.8	61.8	72	62
9	73	157.4	58.2	58.2	71	65
10	76	154.8	56.8	56.8	68	66
11	70	177.7	85.9	85.9	68	66
12	68	182.7	97.3	97.3	66	56
13	67	172.6	84.5	84.5	71	68
14	69	175.1	87.7	87.7	73	70
$\overline{X}$	69.6	169.5	77.3	77.4	70.2	62.3
SE	±0,78	±3.18	±4.55	±4.59	±2.30	±1.75

Table 4

Individual and Mean ± SE Physical Characteristics for the Control Group

SUBJECT	AGE (y)	HEIGHT (cm)	PRE TRAINING BODY MASS (kg)	POST TRAINING BODY MASS (kg)	PRE TRAINING SUM OF SKINFOLDS (mm)	POST TRAINING SUM OF SKINFOLDS (mm)
1	65	157.4	63.7	62.2	75	75
2	69	156.1	58.2	58.2	46	54
3	66	185.3	99.0	99.1	60	60
4	68	182.7	99.9	99.9	105	102
5	68	172.6	88.6	88.2	60	60
6	69	170.0	90.0	90.9	63	63
7	70	175.1	91.4	91.4	59	59
8	73	175.1	84.5	84.5	45	45
9	77	177.7	90.9	90.1	73	73
10	71	159.9	60.9	61.8	72	72
11	70	157.4	60.0	60.0	73	73
12	68	157.4	55.0	55.0	76	76
13	67	164.9	61.8	64.5	80	80
14	70	167.5	64.5	64.5	77	77
15	66	162.4	62.7	63.6	69	69
$\overline{X}$	69.1	167.4	74.3	75.4	67.0	70.3
SE	±0.72	±2.46	±4.15	±3.98	±3.81	±3.41

APPENDIX C

ROSS INFORMATION PROCESSING
ASSESSMENT SCORES

Table 5

Individual and Mean ±SE Scores on the Ross Information Processing Assessment for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	137	137
2	128	137
3	108	136
4	116	119
5	148	146
6	126	149
7	119	144
8	126	121
9	126	132
10	126	138
11	126	130
12	126	142
13	126	138
14	126	126
15	126	142
$\bar{X}$	126.00	136.21
SE	±2.26	±2.06

Table 6

Individual and Mean ±SE Scores on the Ross Information Processing Assessment for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	140	139
2	104	116
3	131	147
4	141	138
5	145	142
6	126	128
7	126	126
8	126	123
9	126	128
10	126	134
11	126	126
12	126	130
13	126	124
14	126	129
$\bar{X}$	128.21	131.07
SE	±2.59	±2.35

Table 7

Individual and Mean ±SE Scores on the Ross Information Processing Assessment for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	121	121
2	107	128
3	107	119
4	126	126
5	126	131
6	126	128
7	126	126
8	126	127
9	126	125
10	126	129
11	126	128
12	126	130
13	126	123
14	126	130
15	126	128
$\overline{X}$	123.31	126.75
SE	±1.62	±0.83

APPENDIX D

SYSTOLIC BLOOD PRESSURE VAULES (mmHg)

Table 8

Individual and Mean ±SE Systolic Blood Pressure Values (mmHg) for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	130	130
2	132	116
3	120	112
4	132	132
5	123	128
6	124	118
7	122	120
8	140	130
9	130	130
10	120	120
11	130	128
12	144	138
13	126	126
14	130	126
15	140	140
$\bar{X}$	129.53	126.85
SE	±1.91	±1.84

Table 9

Individual and Mean ±SE Systolic Blood Pressure Values (mmHg) for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	140	122
2	130	130
3	144	130
4	120	110
5	150	126
6	166	166
7	140	140
8	132	132
9	142	130
10	130	130
11	140	140
12	120	120
13	128	128
14	130	130
$\overline{X}$	136.57	131.42
SE	±3.26	±3.35

Table 10

Individual and Mean ±SE Systolic Blood Pressure Values (mmHg) for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	132	118
2	114	120
3	130	130
4	142	142
5	150	150
6	162	162
7	120	120
8	130	130
9	138	130
10	140	140
11	150	150
12	130	130
13	130	130
14	120	120
15	130	130
$\overline{X}$	133.25	132.12
SE	±3.34	±3.39

APPENDIX E

DIASTOLIC BLOOD PRESSURE VAULES (mmHg)

Table 11

Individual and Mean ±SE Diastolic Blood Pressure Values (mmHg) for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	72	72
2	78	69
3	60	78
4	80	70
5	87	68
6	60	60
7	80	70
8	90	90
9	70	68
10	78	74
11	90	80
12	88	80
13	82	80
14	90	82
15	80	80
$\overline{X}$	79.00	74.92
SE	±2.55	±2.06

Table 12

Individual and Mean ±SE Diastolic Blood Pressure Values (mmHg) for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	90	80
2	82	82
3	98	72
4	80	66
5	82	76
6	70	80
7	80	80
8	74	70
9	82	90
10	90	90
11	80	90
12	60	60
13	78	70
14	90	90
$\bar{X}$	81.14	77.85
SE	±2.52	±2.67

Table 13

Individual and Mean ±SE Diastolic Blood Pressure Values (mmHg) for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	84	68
2	60	60
3	82	82
4	78	78
5	90	90
6	78	74
7	70	70
8	70	68
9	92	90
10	70	70
11	90	90
12	80	80
13	90	90
14	60	60
15	84	84
$\bar{X}$	77.38	77.00
SE	±2.79	±2.58

APPENDIX F

MAXIMAL OXYGEN CONSUMPTION VAULES (ml/kg/min)

Table 14

Individual and Mean ±SE Maximal Oxygen Consumption Values (ml/kg/min) for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	24.7	26.6
2	30.9	34.9
3	18.8	25.2
4	20.7	26.2
5	30.8	32.5
6	18.4	23.2
7	22.0	31.2
8	18.8	22.5
9	20.2	23.9
10	21.0	24.7
11	19.3	26.5
12	20.5	24.2
13	24.0	27.7
14	26.0	29.7
15	19.5	19.8
$\bar{X}$	22.4	26.6
SE	±1.06	±1.12

Table 15

Individual and Mean ±SE Maximal Oxygen Consumption Values (ml/kg/min) for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	27.0	24.1
2	16.1	17.1
3	21.5	21.6
4	21.6	21.5
5	25.2	24.4
6	18.8	18.8
7	19.0	12.5
8	20.3	19.6
9	21.3	17.8
10	18.6	18.1
11	18.9	19.0
12	23.2	23.1
13	20.9	20.4
14	26.5	26.0
$\bar{X}$	21.4	20.4
SE	±0.84	±0.99

Table 16

Individual and Mean ±SE Maximal Oxygen Consumption Values (ml/kg/min) for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	21.1	18.1
2	30.2	19.6
3	19.7	18.7
4	18.3	18.0
5	18.1	18.2
6	17.8	17.2
7	17.6	17.6
8	20.3	19.4
9	19.2	19.0
10	17.4	17.0
11	21.6	21.3
12	23.8	23.4
13	24.0	21.8
14	18.1	18.4
15	17.0	17.0
$\overline{X}$	20.9	19.3
SE	±1.05	±0.59

APPENDIX G

TIME ON TREADMILL (minutes)

Table 17

Individual and Mean ±SE Time on Treadmill (minutes) for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	22.1	21.5
2	25.1	29.3
3	21.1	25.1
4	17.0	22.2
5	28.0	30.1
6	14.0	17.2
7	18.0	23.0
8	20.0	21.1
9	21.0	22.0
10	18.0	20.5
11	16.0	20.25
12	19.0	19.9
13	24.0	24.8
14	28.0	31.0
15	18.0	19.0
$\bar{X}$	20.6	22.8
SE	±1.07	±1.17

Table 18

Individual and Mean ±SE Time on Treadmill (minutes) for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	20.5	22.0
2	14.0	14.3
3	18.9	19.8
4	22.1	22.5
5	21.0	19.0
6	19.0	19.0
7	20.0	20.5
8	21.0	20.9
9	23.0	23.0
10	18.0	18.1
11	17.0	18.0
12	19.0	18.9
13	21.0	19.8
14	21.0	21.0
$\overline{X}$	19.6	19.9
SE	±0.61	±0.61

Table 19

Individual and Mean ±SE Time on Treadmill (minutes) for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	20.1	16.7
2	26.1	19.1
3	18.0	17.5
4	16.0	16.1
5	19.0	19.0
6	20.0	19.8
7	20.0	20.0
8	23.0	22.8
9	20.0	22.0
10	20.0	19.6
11	23.0	23.0
12	24.0	24.0
13	26.0	22.0
14	20.0	20.1
15	19.0	19.0
$\bar{X}$	21.2	20.3
SE	±0.76	±0.64

APPENDIX H

MAXIMAL VENTILATION (L/min)

Table 20

Individual and Mean ±SE Maximal Ventilation (L/min) for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	54.5	57.6
2	82.1	85.2
3	65.5	58.3
4	80.3	70.3
5	92.3	99.8
6	48.8	50.2
7	67.6	76.2
8	70.3	72.2
9	76.1	78.0
10	78.2	81.0
11	73.0	77.0
12	76.1	76.1
13	76.1	78.0
14	76.1	76.1
15	79.2	79.5
$\bar{X}$	73.0	76.2
SE	±2.79	±3.08

Table 21

Individual and Mean ±SE Maximal Ventilation (L/min) for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	127.0	144.0
2	74.1	74.1
3	83.1	75.8
4	113.0	113.0
5	72.6	80.3
6	80.3	80.3
7	70.1	70.5
8	43.6	43.1
9	52.1	52.1
10	67.0	68.3
11	70.1	72.0
12	72.3	72.1
13	76.1	76.1
14	79.3	79.5
$\bar{X}$	77.2	77.9
SE	±5.66	±6.53

Table 22

Individual and Mean ±SE Maximal Ventilation (L/min) for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	44.9	23.1
2	61.4	67.1
3	80.6	80.4
4	80.7	80.4
5	76.9	76.9
6	79.8	77.0
7	74.3	74.3
8	72.1	70.9
9	86.8	86.8
10	52.1	50.9
11	63.8	63.8
12	64.0	64.0
13	65.1	65.1
14	67.0	68.2
15	72.1	72.0
$\overline{X}$	67.9	67.4
SE	±3.72	±2.78

APPENDIX I

RESPIRATORY EXCHANGE RATIO

Table 23

Individual and Mean ±SE Respiratory Exchange Ratio for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	1.03	1.04
2	1.21	1.23
3	1.13	1.19
4	1.05	1.18
5	0.97	1.11
6	1.03	1.09
7	1.10	1.13
8	1.10	1.11
9	1.10	1.09
10	1.10	1.13
11	1.10	1.10
12	1.10	1.10
13	1.10	1.13
14	1.10	1.10
15	1.10	1.10
$\bar{X}$	1.08	1.11
SE	±0.01	±0.01

Table 24

Individual and Mean ±SE Respiratory Exchange Ratio for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	1.14	1.18
2	1.03	1.03
3	1.12	1.13
4	1.19	1.18
5	1.19	1.10
6	1.10	1.10
7	1.10	1.13
8	1.10	1.08
9	1.11	1.10
10	1.09	1.13
11	1.13	1.12
12	1.07	1.10
13	1.08	1.07
14	1.12	1.10
$\bar{X}$	1.11	1.12
SE	±0.01	±0.01

Table 25

Individual and Mean ±SE Respiratory Exchange Ratio for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	1.11	1.02
2	1.07	1.07
3	1.06	1.04
4	1.11	1.06
5	1.14	1.10
6	1.09	1.04
7	1.02	1.10
8	1.18	1.10
9	1.16	1.10
10	1.04	1.06
11	1.10	1.10
12	1.01	1.10
13	1.10	1.10
14	1.10	1.00
15	1.19	1.10
$\bar{X}$	1.09	1.08
SE	±0.00	±0.01

APPENDIX J

ELBOW FLEXION (pounds)

Table 26

Individual and Mean ±SE Elbow Flexion Values (pounds) for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	18	17
2	28	31
3	3	26
4	12	20
5	36	35
6	8	10
7	31	36
8	32	32
9	24	24
10	31	31
11	38	40
12	20	20
13	18	20
14	15	15
15	10	10
$\bar{X}$	21.6	24.4
SE	±2.79	±2.61

Table 27

Individual and Mean ±SE Elbow Flexion Values (pounds) for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	27	39
2	40	49
3	23	32
4	34	47
5	14	21
6	12	52
7	11	62
8	26	57
9	15	24
10	14	25
11	32	37
12	32	41
13	36	38
14	28	34
$\bar{X}$	24.6	33.4
SE	±2.62	±2.47

Table 28

Individual and Mean ±SE Elbow Flexion Values (pounds) for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	31	21
2	35	21
3	25	25
4	24	24
5	24	25
6	32	29
7	36	32
8	24	23
9	26	25
10	18	19
11	15	14
12	12	12
13	11	12
14	11	14
15	10	10
$\bar{X}$	23.1	20.8
SE	±2.31	±1.65

APPENDIX K

KNEE EXTENSION (pounds)

Table 29

Individual and Mean ±SE Knee Extension Values (pounds) for the Walking Group

SUBJECT	PRE TRAINING	POST TRAINING
1	63	78
2	86	102
3	67	60
4	77	79
5	63	93
6	74	99
7	64	98
8	68	72
9	72	72
10	74	78
11	76	84
12	63	72
13	52	54
14	41	47
15	28	34
$\overline{X}$	64.5	74.6
SE	±3.81	±5.42

Table 30

Individual and Mean ±SE Knee Extension Values (pounds) for the Weight-Training Group

SUBJECT	PRE TRAINING	POST TRAINING
1	73	98
2	83	113
3	29	63
4	86	137
5	52	62
6	35	52
7	56	62
8	46	57
9	52	67
10	21	30
11	68	76
12	68	79
13	72	86
14	66	74
$\bar{X}$	57.6	76.6
SE	±5.26	±7.10

Table 31

Individual and Mean ±SE Knee Extension Values (pounds) for the Control Group

SUBJECT	PRE TRAINING	POST TRAINING
1	79	86
2	64	61
3	64	63
4	59	60
5	72	70
6	74	73
7	68	68
8	78	79
9	65	67
10	42	40
11	35	38
12	34	24
13	32	33
14	20	23
15	18	18
$\bar{X}$	54.3	53.9
SE	±5.16	±5.35