

THE UNIVERSITY OF MANITOBA

TRAINING PROGRESSION OF ELDERLY WOMEN DURING A SIX MONTH
WALKING PROGRAM

By
Susan C. Oades

Submitted to
The Faculty of Graduate Studies

In Partial Fulfillment
of the Requirements for the Degree
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SUSAN C. OADES

A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

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Abstract

Training Progression of Elderly Women During a 24 Week Walking Program

Despite the well documented benefits of exercise in the elderly, guidelines for exercise prescription in this population appear to be almost nonexistent. Brisk walking programs have resulted in cardiovascular gains in elderly women, however the ACSM (1990) guidelines most currently used by health professionals apply mainly to fitness benefits (VO_2) which appear to be different then those required for health-related benefits (Decrease in total cholesterol [TC], decrease in low density lipoprotein cholesterol [LDL-C], increase in high density lipoprotein cholesterol [HDL-C], decrease in triglycerides, weight loss and body composition changes, and psychological benefits). As women are at greater risk for coronary heart disease after menopause, a reduction in risk factors through chronic exercise is relevant. The ability of elderly sedentary women to take part in continuous activity and the rate at which they can progress in regards to frequency, duration and intensity is unclear.

The purpose of this study was to determine the rate of training progression during a 24 week walking program involving sedentary postmenopausal women with slightly elevated cholesterol levels. Changes in frequency, duration, distance, intensity (speed and time at target heart rate) and energy expenditure were monitored on a weekly basis. These variables were examined in relation to age, initial fitness level (VO_2), adherence, and injury.

Sixteen healthy women with a mean age of 61.1 years were randomly assigned from a larger group of volunteers to the exercise group. Subjects demonstrated an overall 10% increase in VO_2 max ($p > 0.0001$). Participants walked an average distance of 4.9 km, 4.9 times per week, 53.4 minutes per session at approximately 54% heart rate reserve (HRR) for a 24 week period. Subjects expended an average of 5813.25 kJ (1388.9 kcals) per week, 22.2 kJ/minute (5.3

kcal/min) and 1184.36 kJ (283 kcal) per session. Change in energy expenditure (weeks [21-24] - [2-5]) was significant ($p = 0.0457$).

Results indicated a significant correlation between total frequency and duration ($p = 0.0329$), total duration and energy expenditure ($p = 0.017$), and total distance and energy expenditure ($p = 0.05$).

Regression analysis indicated that age was significantly and negatively related to total percent time spent at target heart rate ($r = -0.515$). Initial VO_2 was not significantly related to any of the variables and age and initial VO_2 were found not to be related in this study ($r = 0.14$).

Participants attended an average of 17.5 out of 24 supervised sessions. Adherence was not significantly related to training progression. Three minor injuries occurred throughout the study and did not effect the results.

The results indicate that healthy postmenopausal hyperlipidemic women are capable of taking part in a high frequency, long duration, moderate intensity walking program. An intensity of 54% was adequate to increase VO_2 max ($p > 0.0001$), decrease total cholesterol ($p = 0.0004$), and produce small but significant changes in weight loss ($p = 0.0086$). The results indicate that improvements in fitness (VO_2 max) may be related more to exercise intensity than to energy expenditure. Training progression was demonstrated by an increase in distance, duration and velocity over a 24 week period.

There is an apparent need for similar studies that focus on individual physiological goals and the amount of exercise and energy expenditure required to achieve each goal. Although more research is being done with elderly women, there is still a need for more. Studies that focus on psychological benefits and adherence of this population are also recommended.

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CHAPTER 1

INTRODUCTION

Regular physical activity has consistently been identified as a behavioral intervention likely to reduce morbidity and mortality (Paffenberger & Hyde, 1984). Increased physical activity has been associated with decreased risk of heart attack, back pain, obesity, as well as with increased longevity (Froelicher & Brown, 1981). Recent studies show that a variety of mental benefits, such as a reduction in anxiety and depression and an enhanced sense of well being are also associated with regular exercise (Rippe et al., 1988). Due to an increase in coronary heart disease (CHD) risk factors and other physiological changes associated with aging, these benefits are especially significant for the elderly.

Despite the well documented benefits of exercise in the elderly, guidelines for exercise prescription in this population appear to be almost nonexistent. Although most health care professionals currently use the recently revised ACSM guidelines as they pertain to cardiovascular fitness, debate continues concerning the optimal duration, frequency, and intensity of exercise required for health benefits (Rippe et al., 1988).

Aging and Activity

Aging is a term that often is used to describe the biologic, psychologic, and sociological changes that occur in persons over

time. Aging has been associated with a gradual decline in the body's functional capacities and a reduction in the system's resistance to stress and disease (Elia, 1991). The decreased ability of the elderly to perform aerobic exercise is attributed to decreased habitual physical activity and an age-related decline in physiological function (Seals et al., 1984). A decrease in the maximal capacity of the cardiovascular system occurs with age, as evidenced by a progressive decline in maximal oxygen uptake ($\text{VO}_2 \text{ max}$) after the age of 25 years (Seals et al., 1984). Age related decline in $\text{VO}_2 \text{ max}$ is about 5% per decade for physically active individuals, but almost twice that rate for sedentary individuals (Steinhaus et al., 1990). Regular endurance exercise increases $\text{VO}_2 \text{ max}$ in young, middle-aged and older populations.

A variety of gait characteristics have been attributed to the aging process. Martin et al., (1992) suggest that the decline of walking speed is perhaps the most consistently reported change in gait characteristics in the gerontology literature. These include visual observations of a slowed walking speed; flexion in the thoracic spinal area; a loss of the lordotic curve in the lumbar spine; a forward head position; short, shuffling steps; and a loss of normal arm action (Leiper & Craik, 1991).

Kaneko et al., (1991) state that maintaining stability during walking is important for the aged. An increased double support time with a lowered step length and step rate would render the individual more secure in maintaining balance. Toe height during the early part of the swing phase and the dorsiflexion angle of the ankle joint also decrease with age.

Himann et al., (1987) and Cunningham et al., (1982) found that elderly walkers had a significantly slower speed of walking and smaller step length than younger groups. Bassey and Terry (1986) reported that elderly females walked with a significantly reduced stride length compared to younger females. The difference in gait pattern between elderly and young females could be contributing to the higher oxygen cost of walking seen in elderly females. Winter et al., (1990) found that the natural cadence of fit and healthy elderly subjects was no different than that of young adults, but that their stride length was significantly shorter. They attributed this to the fact that their subjects were screened carefully to eliminate the unfit and those with any gait related pathological condition. Winter et al., (1990) also reported that significant differences between the young and the old were related to a less vigorous push-off and a more flat footed landing and were attributable to an adaptation related to a safer (less destabilizing) gait stride.

Martin et al., (1992) state that it is unclear why older adults may be less economical in terms of the energy cost of walking than their younger counterparts, but it has been suggested that decreasing levels of physical activity in the aged may be a contributing factor. This is based on the knowledge that a sedentary lifestyle contributes to diminished musculoskeletal functioning in the elderly, and also on the assumption that impaired musculoskeletal function underlies a further decrement in walking economy (Martin et al., 1992). Kaneko et al., (1991) also state that a decline in physical fitness likely affects speed of motion and movement patterns in the physical activity of an elderly individual.

Recent studies now show the relative change in VO_2 max of elderly participants in response to chronic physical activity to be similar to younger age groups (Seals et al., 1984; Pollock et al., 1976; Steinhaus et al., 1990). Therefore declines in VO_2 max due to decreased activity should be reversible with physical training (Seals et al., 1984; Taylor & Montoye, 1977). The need to understand how aging affects the physiological responses to submaximal exercise is apparent (LaPorte et al., 1983).

Benefits of Walking

Walking is an effective mode of activity which has been shown to improve both cardiovascular fitness (ACSM, 1990; Rippe et al., 1988; Jette et al., 1988; Pollock et al., 1971), and cardiovascular health (Duncan et al., 1991; LaPorte et al., 1983). Many health benefits have been associated with structured walking programs, including a reduced likelihood of developing CHD (Froelicher & Brown, 1981). Recent physiological studies demonstrate that regular brisk walking reduces anxiety and tension and aids in weight loss and changes in body mass and body fat (Seals et al., 1984; Porcari et al., 1989; Pollock et al., 1971). Regular walking may also help improve cholesterol profile and assist in controlling hypertension (Froelicher & Brown, 1981).

Walking is a safe activity and is preferred for sedentary or overweight individuals as it is a low impact exercise and offers little risk of injury (Rippe et al., 1988). The popularity of walking lies in the fact that it is simple, inexpensive, and can be performed

by individuals of all ages and abilities. Studies which have used walking as exercise intervention have typically reported fewer dropouts due to injury than other studies using high impact activities (Rippe et al., 1988). In addition these factors make it an attractive exercise which can easily be adapted for exercise testing (Porcari et al., 1989).

Benefits of Physical Activity in Women

Little research has been done with regards to older women and physical activity. Aging is associated with an increased risk of women dying from CHD as well as from all causes resulting in postmenopausal women being at greater risk for CHD than premenopausal women (Matthews et al., 1989). With age, the magnitude of the sex difference in CHD and all cause mortality decreases such that, at advanced age, the risk of dying is almost identical for men and women. In women, aging is associated with increased risk factors for CHD, including elevated blood pressure, increased weight, and alterations in lipids and lipoproteins. High levels of physical activity appear to protect men and women from cardiovascular morbidity and mortality, although few studies have included women (Owens et al., 1991).

Even though it may be reasonable to assume that the trainability of elderly women would be similar to that of older men there have been few studies to substantiate this (Adams et al., 1973; Kilbom et al., 1971). Adams et al., (1973) found that the trainability of the older female is similar to the older male as well as to the younger

individual if compared on a percentage basis. Kilbom et al., (1971) observed that training benefits were less pronounced in women once they reached the age of 50 years.

In a large cross sectional study, Owens et al., (1990) reported that the more active the women, the lower their blood pressure and heart rate. More active women had lower cholesterol and triglycerides, and higher high density lipoprotein cholesterol (HDL-C) than did sedentary women. Tricep and suprailiac skinfolds, fasting insulin, and insulin/glucose levels were also lower among more active women.

McAuley and Jacobson (1991) observed that middle-aged females have traditionally had limited opportunity to incorporate exercise habits into their everyday routines, a fact that may represent a cultural rather than biological bias. Recent studies also indicate that women demonstrate greater adherence to exercise programs than men suggesting that women may be better candidates to participate in a longitudinal exercise study (Steinhaus et al., 1990; Sallis et al., 1986).

Exercise Prescription for the Elderly

Despite the well documented benefits of exercise in the elderly, guidelines for exercise prescription for this population appear to be almost nonexistent. Guidelines most often followed for exercise prescription are those developed by the ACSM and updated in 1990. These guidelines recommend aerobic exercise for 20 to 60 minutes, 3 to 5 days per week, at an intensity of 60 - 90% of maximal heart

rate (HR max), or 50 to 85% of maximum oxygen uptake (VO_2 max) or heart rate reserve (HRR). These guidelines are applicable to the average healthy adult but it is unclear whether they apply specifically to elderly women. These guidelines are also designed for fitness-related benefits (VO_2) and may not be adequate to bring about health related changes such as weight loss, changes in body composition, lipid profile or bone density. In addition, these guidelines make only one specific point with regards to the elderly; that older adults need longer periods of time to adapt to the initial rigors of training, and therefore require a longer adaptation period to get the full benefit from a program. The differences in fitness and health-related benefits from exercise prescription guidelines for elderly women are not well documented.

Badenhop et al., (1983) stated that the ACSM guidelines may be too stringent for the elderly and reported that exercising at a low intensity (30 - 45% HRR) was an adequate training stimulus in older individuals and produced changes in VO_2 that were comparable to those elicited by high intensity (60 - 75% HRR) training. Posner et al., (1992) reported cardiovascular gains at a walking intensity of 45% HRR. However, Seals et al., (1984) and Sidney and Shephard (1978) found that high intensity training resulted in much larger gains than were evident with a low intensity program. Most of the current research concurs with Seals et al., (1984) and therefore the intensity listed in the ACSM (1990) guidelines for cardiovascular gains is most commonly used today.

Rate of Progression of Walking

The ACSM (1990) guidelines suggest that investigation is necessary to evaluate the rate of increase and decrease of fitness with varying training loads in relation to level of fitness, age, and length of time in training. The ability of elderly sedentary women to take part in continuous activity and the rate at which they can increase frequency, duration and intensity is unclear. Rate of progression itself has not been well defined. Many longitudinal studies document rate of progression by recording total distance and/or change in walking speed throughout the training program (Porcari et al., 1989; Sidney & Shephard, 1978; Pollock et al., 1971). Other studies have shown progression by recording the intensity of the exercise program (speed, prescribed target heart rate). Most studies show an improvement in fitness level (VO_2) over training time as opposed to an actual progression rate.

STATEMENT OF THE PROBLEM

The purpose of this study was to monitor the rate of training progression during a 24 week walking program involving elderly women with slightly elevated cholesterol levels. The rate of training progression was quantified by documenting walking frequency per week, distance walked per session, duration walked per session, walking intensity per session (speed, time at target heart rate), and energy expenditure per session. These variables were examined in relation to age, initial fitness level (VO_2), adherence, and injury. Exercise prescription variables related to fitness and health benefits were also examined.

RESEARCH HYPOTHESES

- 1) Postmenopausal sedentary women with elevated cholesterol levels will demonstrate training progression over time in a 24 week walking program as indicated by an increase in walking frequency per week, duration walked per session, distance walked per session, walking intensity per session (speed and time at target heart rate), and energy expenditure per session.
- 2) The rate of training progression will vary according to the individual's age, with age being an inverse predictor of training progression.

- 3) The initial level of fitness (VO_2) will be inversely related to rate of progression.
- 4) Adherence will serve as an indicator of rate of training progression.
- 5) Participants who sustain minimal or no injuries will progress at a faster rate.

DEFINITION OF TERMS

Rate of Progression: The rate of progression of the walking program was defined as change in frequency, duration, distance, intensity (speed and time at target heart rate) and energy expenditure over 24 weeks.

Energy Expenditure: Energy is the capacity to perform work while work is the application of force through a distance (Fox et al., 1988). Expenditure is the act or process of expending. At steady state, energy cost may be expressed as oxygen cost, providing the metabolism is purely aerobic (Astrand & Rodahl, 1977). Oxygen cost is the amount of oxygen consumed per kg body mass per unit distance.

Kilojoules (kJ)*: Unit of energy (Fox et al., 1988).

* 1 kJ = 0.23892 kilocalories.

Frequency: The total number of walking sessions each week.

Frequency was used as a secondary measure of adherence to the walking program.

Duration: The total and average duration (mins) walked each week as well as the total and average duration (mins) walked per supervised session.

Distance: Total and average distance (km) walked per week as well as total and average distance (km) walked per supervised session.

Intensity: The intensity was defined as:

A) Speed (km/hr) during five laps around the outside lane of the Max Bell track recorded at the weekly supervised sessions. Time for distance walked was calculated if speed was not available.

B) Time at target heart rate (min), percent time at target heart rate, and percent of target heart rate for each of 24 weeks.

Heart Rate Reserve (HRR): The difference between the resting heart rate and the maximal heart rate (Fox et al., 1988).

Predicted VO₂ Max: A prediction of the maximal rate at which O₂ can be consumed per minute (Fox et al., 1988).

IMPORTANCE AND RELEVANCE

This study has both theoretical and practical value. As previously stated, walking is a safe, practical and realistic form of exercise that can be done by people of all ages at any time or place. Little research has been conducted with sedentary postmenopausal women with elevated cholesterol taking part in continuous low intensity exercise over a long duration. This study has documented the rate of training progression in this population by monitoring exercise prescription variables over a 24 week period of regular walking.

Information regarding rate of progression (frequency, duration, intensity and energy expenditure) in relation to age, initial fitness level, adherence, or injury will be useful for exercise prescription purposes as well as in future research. Information relating to fitness and health benefits will also be useful for the development of exercise guidelines in this population.

ASSUMPTIONS AND LIMITATIONS

Self Recorded Data

This "community based" study examined a female population which consisted of volunteers recruited mainly via the media. The subjects involved in this study were participants in a long term walking study involving postmenopausal, hyperlipidemic sedentary women.

The importance of accurately recording the frequency, duration, distance, and time at target heart rate of each walking session in their individual log book was emphasized to each participant. All data was self recorded and therefore may be somewhat subjective. A fitness supervisor signed weekly log books to ensure accurate recording of data for that particular walking session. Walkers were shown how to take their own radial pulse.

To check for reliability the Sport Tester was used on two different occasions where fourteen participants compared heart rate by palpation to the Sport Tester reading. All values were found to be accurate.

The calculation of total time at or above target heart rate per week may be subjective. Four separate heart rate values were documented and although they were taken at equal time intervals during the supervised sessions, this may not have been the case for the nonsupervised sessions (It is assumed the HR's were taken at 15, 30, 45 and 60 minute intervals). Other limitations include the accurate documentation of distance as some participants chose to walk outside even though they were encouraged to walk indoors.

Attendance, Illness, and Injury

Due to the longevity of the study some participants were not able to attend all of the supervised sessions as some went on trips over the 24 week period. To help control for noncompliance, participants were advised of the serious commitment they were making at the onset of the program. All participants who went away were encouraged to continue to record their walking sessions in their log

books during that time. The log book results indicated that walkers recorded all data while out of town.

Illness was a relevant factor in this study as three of the initial 24 women dropped out because of this reason. No participants dropped out due to injury.

Supervision

Participants were required to walk under supervision once per week. According to the results, many of the training variables were greater (distance, duration, intensity) during the supervised sessions as opposed to the nonsupervised sessions. Although it would have been quite unrealistic to supervise the entire 24 week program, it appears that supervision may have had an effect on some of the results. It is, however, important to note that it would be more difficult to generalize our results if all sessions were supervised as in reality people do not usually walk under supervised conditions.

Prediction of Energy Expenditure

The submaximal steady state treadmill test used to measure the energy expenditure of the walkers is a recent test. The validity and reliability of this test have been demonstrated by a recent study which showed VO_2 during the treadmill test to be an accurate reflection of VO_2 when walking (Brennan et al., 1990).

Homogeneous Population

Another limitation may include the subject population of 16 women. It appears that the subjects were a fairly homogeneous group as there was no relationship between age and initial fitness level (VO_2), an unusual finding as an inverse relationship between age and VO_2 is common (Seals et al., 1984). Numerous statistical analyses showed that this was not the case for this particular study. This should not be a reflection of sampling error as all subjects were part of a larger study and were randomly selected.

The participants ranged in age from 56.0-69.0 years with an average age of 61.1 ± 4.4 years. Initial VO_2 values ranged from 23.9-37.2 ml/kg-min with a mean value of $30.2 \text{ ml/kg-min} \pm 4.0$, slightly above average for this population (Stephens & Craig, 1990). Both the age and fitness ranges appear to be relatively small in nature, suggesting that this subject population is fairly homogeneous.

The subjects in this study were the ones that successfully completed the 24 week walking program as well as the submaximal steady state treadmill test. This is a limitation to this study as only the data of the 16 successful participants was analyzed and may represent a biased subject population. The above average VO_2 indicates that although these subjects were initially sedentary, they appear to be fairly fit for their age group compared to the general population.

Control of Extraneous Variables

Other variables may have influenced the results of this study. One of these variables is lack of control over diet. Participants were instructed at the onset of the study to maintain their normal eating patterns and completed three day food frequency records to monitor energy intake, and proportion of calories as carbohydrate, fat and protein. A nutritionist met with each subject at the beginning of the study, and counselled them to maintain their normal diet throughout the 24 weeks.

There was also little control over the activity level of the participants aside from their structured walking. Although subjects were instructed to stay mainly with the structured walking, some became involved with other activities such as square dancing and badminton. These subjects may have expended more energy overall than those taking part solely in the walking program.

CHAPTER TWO

REVIEW OF LITERATURE

It is well documented that increased physical activity is associated with reduced premature mortality. Habitual physical activity reduces the incidence of hypertension, hyperlipidemia, obesity, diabetes type II, impaired glucose tolerance, osteoporosis, psychologic impairment, colon cancer, stroke, and back injury. The effect on some of these factors may be small however, the sum of these effects may have an important positive impact, influencing health and disease, life and death (Astrand, 1991).

Despite the well known benefits of exercise in the elderly, guidelines for exercise prescription in this population are not well documented. The ACSM (1990) guidelines make only one specific point with regards to the elderly and that is that older adults may require a longer adaptation period to get the full benefit of a program. In addition, these guidelines do not differentiate between fitness and health-related benefits. Although most health care professionals routinely prescribe exercise in accordance with the ACSM (1990) guidelines, debate continues concerning the optimal duration, frequency, and the intensity of exercise (Rippe et al., 1988).

This comprehensive literature review will include research regarding physiological changes that occur with aging, the

trainability of older adults, benefits of walking, adherence, benefits of exercise for women, exercise prescription and training progression in the elderly.

Factors Affecting Activity Levels During Aging

Over the years we have seen a dramatic increase in the proportion of the population aged 65 and over. With aging there is an impairment in bodily functions and structures, diseases develop, and the endpoint is death (Astrand, 1991). The changes that occur with aging are well documented. Physical decline in the aging include cardiovascular fitness, respiratory fitness, the nervous system, metabolism, and the musculoskeletal system (Elia, 1991).

Research in aging has emphasized average age-related losses and neglected the substantial heterogeneity of older persons. The effect of the aging process itself has been exaggerated, and the modifying effects of diet, exercise, personal habits, and psychosocial factors, underestimated. Within the category of normal aging, a distinction can be made between usual aging, in which extrinsic factors heighten the effects of aging alone, and successful aging, in which extrinsic factors play a neutral or positive role. Research on the risks associated with usual aging and strategies to modify them should help elucidate how a transition from usual to successful aging can be facilitated (Rowe & Kahn, 1987).

The key question, therefore, is to what extent impairment, morbidity, and mortality are inevitable consequences of the individual's innate genetic composition, and to what extent

environment and the individual's lifestyle can modify these processes (Astrand, 1991).

Decreased habitual physical activity and age-related alterations in physiological function of the elderly may explain the decreased ability of the elderly to perform aerobic exercise. Endurance training can partially reverse this age related decline in aerobic power as older adults are able to undergo adaptive increases in VO_2 max (Seals et al., 1984; Sidney & Shephard, 1977). In older adults, increased activity may be important for prevention of morbidity, successful rehabilitation, and decreased risk of heart attack, back pain, and obesity (Taylor & Montoye, 1977; Froelicher & Brown, 1981).

Cardiovascular Fitness

Numerous cross-sectional studies have concluded that there is a decline in maximal oxygen uptake amounting to 0.5-1.0% per year. However, as has been reported the degree of habitual activity and heredity can markedly affect this rate of decline (Astrand, 1991).

Aging may result in changes in both myocardial function and the peripheral vascular system (Shephard, 1987). After age 25 the resting stroke volume falls approximately 30% and the myocardium undergoes hypertrophy. Although stroke volume is similar between the elderly and the young during light workloads, an increase in workload can result in lower increases in stroke volume in the elderly (Shephard, 1987). The resting heart rate is not significantly altered with age, although a decline is seen in the maximal

obtainable heart rate with exertion, approximately one beat per year. The drop in maximal heart rate with age results in a 58% reduction in resting cardiac output between ages 25 and 85 (Shephard, 1987). Maximum cardiac output in a 65 year old is 20 to 30% less than in a young adult.

The post-exercise rate of return to baseline of heart rate, blood pressure, oxygen consumption, and carbon dioxide elimination is slower for elderly subjects. Changes between resting and exercise blood pressure are also different for the elderly. With age, elasticity of the major blood vessels declines. Systolic blood pressure is higher at rest and during exercise by 10 to 40 mmHg respectively (Shephard, 1987).

Sidney and Shephard (1978) reported that cardiovascular training responses were at least as large in elderly subjects as in younger adults. Yerg et al (1985) stated that the increase of ventilatory response/oxygen uptake (VE/VO_2) during submaximal exercise observed with aging can be reversed by endurance training, and that after training previously sedentary older individuals breathe at the same percentage of maximum voluntary ventilation (MVV) during maximal exercise as highly trained athletes of similar age.

Elia (1991) suggests that the relative benefits of conditioning on the cardiovascular system in older subjects are similar to those observed in younger subjects. At a given workload, heart rate and blood pressure are reduced after training. Myocardial performance during exercise remains unchanged. Elia (1991) also suggests that respiratory fitness does not limit exercise capacity in normal individuals at any age. The ventilation changes that occur with

aging do not preclude significant improvement in aerobic capacity after training.

The decline of exercise heart rate with age, and a corresponding lower heart rate at a given percentage of maximum oxygen intake than in younger subjects has been documented (Shephard, 1978). Because of this relationship, it can be speculated that the influences of the sympathetic nervous system during exercise also decline with age (Badenhop et al., 1982). It has also been suggested that peripheral factors, such as a widened arteriovenous oxygen difference, and a redistribution of blood flow and an increase in oxygen debt, predominate in meeting oxygen demands during submaximal exercise in the elderly (Shephard, 1978). Because the extent of adaptability to training is reduced so much in the elderly, even minimal training will produce favorable changes in their aerobic capacities. Higher intensity exercise may contribute significantly to increased exercise tolerance in individuals who are capable of improved central circulatory parameters. (Badenhop et al., 1982).

Cardiovascular benefits with training in the elderly have been reported by numerous studies (Astrand, 1991; Jette et al., 1988; Duncan et al., 1991).

Metabolism

Resting metabolic rate exhibits a 5% per decade reduction in active women. Glucose tolerance diminishes with age and relative body fat increases as lean body mass decreases. Total cholesterol

and low density lipoprotein cholesterol levels increase with age, however the concentration of high density lipoprotein remains the same (Shephard, 1987). Astrand (1991) reports that elderly individuals may develop a reduced glucose tolerance. Elevated blood glucose concentration may therefore trigger a glucose-protein reaction, resulting in hyperinsulinemia, a risk factor for CHD. A training program can normalize the glucose tolerance in elderly people and enhance the muscle's sensitivity to insulin. Muscle contractions will promote the muscle's uptake even with no insulin present (Astrand, 1991).

The daily energy expenditure of exercised individuals is ordinarily greater than that of those who are sedentary. The energy cost of the exercise itself clearly accounts for some portion of this difference in daily expenditure. It is still uncertain whether an elevated rate of resting metabolism also contributes to the exercised individual's increase in daily expenditure (Wilderdink et al., 1991).

Poehlman et al., (1991) suggested that a sedentary lifestyle in older men may be associated with a lower resting metabolic rate (RMR), independent of fat free weight (FFW) and percent body fat (%BF), relative to younger and older men who exercised regularly. Poehlman et al., (1991) also reported elevated rates of resting metabolism in persons who trained regularly and proposed that exercise-induced increases in resting metabolic rate may be related to the increase in maximum oxygen uptake known to occur with strenuous training.

At increased age there is gradual reduction in the basal metabolic rate, but no proportional reduction of the demand for essential nutrients. For this reason it is recommended that old people try to stay physically active (Astrand, 1991).

Respiratory Fitness

With age there is a decrease in lung elasticity (deVries & Adams, 1972). Residual lung volume increases 30 to 50% as vital capacity decreases 40 to 50% by age 70. During exertion the elderly person increases respiratory frequency while maintaining constant tidal volume. This accounts for an increase in work (breathing) of about 20% to overcome the added resistance (deVries & Adams, 1972).

Nervous and Musculoskeletal Systems

With aging changes occur in the central and peripheral nervous systems that involve reaction times and neuron conduction velocities. Reaction times lengthen and nerve conduction velocity slows 10 to 15% which will affect the ability to exercise. The increasing amount of falls by persons over 60 are attributed to these changes (Elia, 1991).

Aging causes a decrease in muscle mass, both fibre and number due to a decrease in motor neurons. Functionally, muscular strength decreases from 20% to 40% by age 65. As a result, older adults must use a higher proportion of available muscle mass for a given workload and may fatigue earlier. Degeneration of the joints,

especially the spine, is often found in older people (Elia, 1991). Posner et al., (1992) state that glycolytic fast twitch muscle fibres atrophy with age and that changes in peripheral muscle can have an effect on VO_2 max in older subjects. Shephard (1987) found significant strength increases with elderly subjects who followed a structured strength training program.

Walking speed and gait are also affected by age. Himann et al., (1988) suggest that the "slowing down" of walking speed shows a critical age of accelerated decline with elderly walkers (63 years and older) having a significantly slower speed and smaller step length than younger walkers. This may be an attempt to obtain maximum stability and security in the walking motion. In this study, age was the only significant independent variable for walking speed at any of three paces (Himann et al., 1988).

Winter et al., (1990) found that the natural walking velocity of elderly subjects is reduced due to a reduction in stride length as opposed to a decrease in cadence. Waters et al., (1988) stated that normal speed for senior adults was significantly lower than for young adults. They also found a significant sex difference in senior adults at normal and fast speeds, with males walking at a greater velocity (m/min) than females. During a self paced walking study involving elderly and young men, Bassey et al., (1976) reported that the younger group walked significantly faster than the older group in a "fast" walk, and had a significantly greater stride length at any given speed.

When walking the elderly demonstrate lower cadence, shorter and more variable step length, increased head and torso flexion, and

increased knee and elbow flexion. The suggested reasons imply a degeneration of balance control combined with a general loss of muscle strength (Winter et al., 1990).

Trainability of the Elderly

Little is known about the responses of elderly subjects to training programs (Sidney & Shephard, 1977). Research has shown that the elderly can adapt to prolonged endurance training with a large increase in aerobic power (Seals et al., 1984). This is in agreement with almost all recent literature which documents numerous health benefits achieved by elderly adults participating in regular physical activity (Kohrt et al., 1991; Elia, 1991; Astrand, 1991).

The magnitude of the training response in young adults is related to their initial level of cardiovascular fitness, their level of physical activity before entering the study, the training stimulus applied (intensity, frequency, and duration of training sessions), and the duration of the training program. The role of these factors in determining the training response of the elderly has received little study (Thomas et al., 1985; Kohrt et al., 1991).

Although earlier studies showed a lower training effect with middle-aged or elderly subjects compared to the young, recent studies demonstrate similar changes for each group in parameters such as VO_2 max and strength. The adaptation time, however, appears to be longer for elderly participants (Shephard, 1987). In

addition the initial baseline fitness levels in older subjects is lower than in younger subjects (Ninimaa & Shephard, 1978).

The mechanisms of training adaptation may differ in the elderly from mechanisms in the young. Much of the early strength gain during training of the elderly may reflect an increase in neuronal activation rather than muscle hypertrophy (Smith et al., 1981).

Research indicates that exercise can benefit carbohydrate and lipid metabolism in younger adults, but the effects in sedentary elders are less definitive (Saltin et al., 1979). Training in the elderly shows improvement in joint flexibility as well as subjective perception of improved mobility and well being in many subjects (Smith et al., 1981).

Numerous studies report that although there is a decline in physiological function such as aerobic capacity with age, it can be partially counteracted with sufficient increased physical activity (Elia, 1991; Steinhaus et al., 1990; Winter et al., 1990).

Benefits of Walking

Recent studies have reported that regular walking is linked with a reduced likelihood of developing CHD (Rippe et al., 1988). Walking has also been recommended as an effective mode of activity to improve cardiovascular fitness (ACSM, 1990; Rippe et al., 1988; LaPorte et al., 1985) and increase aerobic power (Jette et al., 1988; Pollock et al., 1971). Many health benefits have been associated with structured walking programs including improvements in cholesterol profile and hypertension (Duncan et al., 1991). Porcari

et al., (1989) suggest that walking may reduce anxiety and tension and bring about positive changes in body mass and body fat.

Walking has recently emerged as one of the most popular activities for fitness. In Canada, over half of the population aged ten and over report that walking is their most frequent physical activity (Stephens & Craig, 1990). Walking is simple, inexpensive, and can be performed by individual's of all ages and abilities. A recent survey of 541 women using the Paffenbarger Activity Questionnaire reported walking as the most prevalent activity (Owens et al., 1990).

Enjoyment and injury prevention are crucial factors in the maintenance of motivation and adherence. Walking is preferred for sedentary or moderately overweight individuals since it is a low impact activity and is associated with very little risk of injury (Rippe et al., 1988). When compared to running, the ground reaction forces are 3.6 times less for walking, resulting in less joint stress on the lower extremities (Voloshin, 1988). Studies which have used walking as exercise intervention have typically reported fewer dropouts due to injury (Rippe et al., 1988).

Walking can be easily adapted for exercise testing using the treadmill (Porcari et al., 1989). For reliability and validity purposes it is important to be consistent with the mode of exercise intervention and the type of tests conducted.

Energy cost provides a basis for prescribing duration and intensity of walking programs, and walking speed is an important determinant of energy cost. Walking is different than running where total distance/volume is used to measure energy cost. The walking

speed required to achieve cardiovascular benefits is related to initial level of fitness and may be related to age and body composition. Individuals with high aerobic capacities must walk faster than those with low capacities to reach a training threshold (Porcari et al., 1989). Speed has been shown to be related to gait or stride length which in turn appear to decrease with age (Bassey et al., 1976).

Caldwell (1988) states that walking is very efficient when done slowly, and is therefore not very effective for weight loss. At a pace under 20 mins per mile the calorie cost is about half that of running or about 55 kcals per mile. As walking speed increases so does the energy cost until a 13 minute mile pace is reached. Rothstein et al., (1991) report that regardless of speed, older adults expend more energy than younger adults to walk a given distance as walking efficiency decreases with age (Grimby & Soderholm, 1962). Waters et al., (1988) state that efficiency of walking can be determined by energy cost. Their study reported no significant differences in energy cost that depended on sex, however age was a significant factor. The velocity and rate of oxygen consumption were lower for senior adults than for the group of younger adult subjects during "fast" walking.

Pearce et al., (1983) reported that elderly subjects had higher energy cost values for level walking than did younger subjects, except at normal walking velocity on the floor. Gardner et al., (1988) stated that energy expenditure during steady state exercise decreased in middle-aged and older men over a 16 year time period. Bassey et al., (1988) reported that elderly females had a higher

oxygen cost of walking than young females which may be due to a significantly reduced stride length of the older woman.

Mattsson (1989) states that oxygen consumption is not reported to vary with age and sex. Thus, the oxygen cost is not changed if measurements are performed at the same walking speed (Blessey et al., 1976). Mattsson (1988) also reports that measurements of walking speed and oxygen cost of level walking are useful objective parameters for assessing walking.

Adherence

Adherence to a walking program is an important factor in a longitudinal training study. McAuley and Jacobson (1991) state that high levels of motivation are required to sustain an exercise program since exercise behaviors may be somewhat resistant to change.

The initial desire which encourages individuals to begin exercising may not be strong enough to ensure maintenance over time. As initial motivation decreases, many real and perceived barriers including inconvenience, inaccessible program locations, work conflicts, lack of time and energy, and medical problems can hinder long term exercise participation. Dishman et al., (1980) suggest that the perceived barriers may reflect a lack of motivation rather than reasons for inactivity.

Thomas et al., (1985) examined determinants of the training response in elderly men via a one year walk/jog program. Although a slight decrease in the frequency of attending after the first quarter

was evident, it was not significant. Overall, good adherence to the training program was reflected in the high percent of prescribed heart rates achieved and mean frequency of attendance.

Steinhaus et al., (1990) reported that while men attended more sessions during a structured program, more women than men were likely to continue exercising four years later (80% vs 44%). This is in agreement with Sallis et al., (1986) who stated that men were more likely to adopt vigorous activity for a short time while women were more likely to maintain moderate activity over a longer time period.

Benefits of Exercise in Women

Although exercise has been found to be a key factor in reducing risk factors associated with CHD, few studies have included women (Owens et al., 1990; Hardman et al., 1989). With age, the magnitude of the sex difference in CHD and all cause mortality decreases to when, at advanced age, the risk of dying is almost identical for men and women. Aging is associated with increased levels of many biological risk factors for CHD, including levels of blood pressure, weight, and lipids and lipoproteins. Postmenopausal women may have higher plasma levels of cholesterol, triglycerides, very-low-density lipoprotein (VLDL) cholesterol, and low-density lipoprotein cholesterol (LDL) than premenopausal women and are therefore at greater risk for CHD (Matthews et al., 1989). High levels of physical activity appear to help in prevention of cardiovascular morbidity and mortality (Owens et al., 1991).

Owens et al., (1990) found that active women exhibited lower blood pressure and heart rates, cholesterol, triglycerides, and higher high density lipoprotein (HDL) cholesterol. Tricep and suprailiac skinfolds, fasting insulin, and insulin/glucose levels were also lower. Studies show an unchanging HDL-C coupled with an increase in LDL-C with age support the hypothesis of increased atherogenic risk for women after menopause. Thus exercise may have a greater effect on lipids in older as opposed to younger women.

There have been few studies to substantiate that the trainability of elderly women is similar to that of older men (Kilbom et al., 1971). Adams et al., (1973) report that when compared on a percentage basis the trainability of the older female is similar to the older male as well as the younger individual. Kilbom et al., (1971) suggested that training benefits were less pronounced in women over 50 years.

The ACSM (1990) guidelines report that available evidence indicates that women tend to adapt positively to endurance training. Shephard (1965) suggests that not only is the older woman trainable but that the magnitude of the capacity for training is not greatly different from that of the younger individual.

McAuley and Jacobson (1991) state that in general, women have traditionally had limited opportunity to incorporate exercise habits into their everyday routines. This may represent a cultural bias and help explain why a majority of the older female population remain sedentary. Recent studies also indicate that women demonstrate greater adherence to exercise programs than men (Steinhaus et al.,

1990; Sallis et al., 1986) and may therefore be better candidates to participate in a longitudinal exercise program.

Exercise Prescription for the Elderly

Although research clearly depicts the improvement of cardiovascular fitness in the elderly with regular exercise, exercise prescription guidelines for older adults needs to be documented with regards to fitness and health-related benefits. The guidelines most often used are those originally written and updated in 1990 by ACSM. These are as follows:

- 1) Frequency of training: 3-5 days/week.
- 2) Intensity of training: 60-90% of maximum heart rate (HR max) or 50-85% of maximum oxygen uptake (VO_2 max) or HR max reserve.
- 3) Duration: 20-60 minutes of continuous aerobic activity
- 4) Mode of activity: Any activity that uses large muscle groups, can be maintained continuously, and is rhythmical and aerobic in nature. Examples include walking, running, cycling, and swimming.

These guidelines are recommended for the "healthy adult" and are based more on fitness benefits (improvement in VO_2) than health-related benefits (weight loss, changes in body composition, lipid profile, bone density, mental health). In regards to body composition the guidelines suggest that a program of three days per week, of at least 20 minute duration and of sufficient intensity to expend approximately 300 kcals per exercise session is recommended as a

threshold level for total body mass and fat weight loss. If weight loss is the primary focus then regimens of greater frequency and duration of training and low to moderate intensity are recommended.

The ACSM (1990) guidelines state that adaptation to conditioning may take longer in older individuals. Although these guidelines are currently used for exercise prescription purposes, the amount and intensity of exercise required for achieving optimal health benefits is not well documented.

Exercise prescription is based upon the frequency, intensity, and duration of training, the mode of activity, and the initial level of fitness (ACSM, 1990). Intensity and duration of training are interrelated, with total amount of work accomplished being an important factor in improvement in fitness. The guidelines recommend programs emphasizing low to moderate intensity training with longer duration for most adults. In regards to frequency, the amount of improvement in VO_2 max tends to plateau when frequency is increased above three days per week. Training more than 5 days per week shows small to no improvement in VO_2 max (Pollock et al., 1971). The guidelines also state that if frequency, intensity, and duration are similar (total kcal expenditure), the training adaptations appear to be independent of the mode of aerobic activity.

Badenhop et al., (1983) reported that high or low intensity training produced the same gain in VO_2 max. Posner et al., (1992) conducted a four month low intensity (45% HRR) and reported an 8%

increase in VO_2 max along with a slight increase in lean body mass and decrease in blood pressure.

Numerous studies have prescribed a high intensity for their exercise intervention programs. Pollock et al., (1971) found a 28% increase in VO_2 max in a group of middle-aged men who walked 40 minutes, 4 times per week for 20 weeks at an average of 63% to 76% of MHRR. Sidney and Shephard (1977) conducted a study involving four different exercise groups; high frequency high intensity (HF HI), low frequency high intensity (LF HI), high frequency low intensity (HF LI), and low frequency low intensity (LF LI). High frequency was defined as more than two one hour sessions per week while low frequency was less than two one hour sessions per week. Low intensity was defined as a heart rate of 120-130 beats per minute maximum and high intensity was a heart rate of 140-150 beats per minute maximum.

The largest (29%) and most rapid gains were registered by the HF HI group. The LF HI group made more modest gains in the first 7 weeks, with little subsequent improvement. The HF LI group made small but significant gains in both the first and second 7 week periods, while the LF LI group showed no change of predicted VO_2 max. The HI group commenced training at about 60% of VO_2 max, and as the program continued advanced to pulse rates equivalent to 80% or more of VO_2 max. Low intensity participants commenced at approximately the same effort, but failed to progress to higher intensities.

It is interesting to note that the LF LI group were initially less fit than the other three categories. It therefore appears that

intensity of effort was relatively more important than the frequency of training for VO_2 max improvements over the first 7 weeks of training. Sidney and Shephard (1977) state that although the HF HI program was optimal for a quick cardio-respiratory response to endurance training, they felt that a moderate intensity of effort (HR 120-130 bpm, equivalent to 60% VO_2 max at the age of 65) eventually produces some training response.

The choice between the HF HI and the HF LI programs would be influenced by the participant's ability to withstand a vigorous program, their willingness to devote a sustained period to exercise, and the degree of supervision available. An over-vigorous start can endanger the heart and the locomotor system. Therefore although greater fitness benefits were reported in the HF HI group, the HF LI group also reported significant gains in VO_2 max over a longer duration. The HF LI program may appear safer as the fitness results are similar with those of the HF HI program, however injury was not a problem with these participants as only occasional muscle strains resulted from this walking program.

Other high intensity studies include research by Kohrt et al., (1991) who trained elderly female walkers for 9-12 months, 4 times per week, 45 min/day at about 80% max HR. The women experienced a $23 \pm 12\%$ increase in VO_2 max and a 4% weight loss. No significant relationships were found between improvement in VO_2 max and exercise frequency, duration, or intensity. However the authors also state that in general, the exercise programs, including their study, that have generated the greatest improvements in VO_2 max (18-28%) in older people have lasted more than 26 weeks and

consisted of endurance exercise performed three or more days per week, 40 minutes per day, progressing to intensities of about 80-90% of maximal HR. With this type of vigorous exercise training, people in the 60 to 70 year old age range are able to improve VO_2 max to the same relative degree as young people.

Steinhaus et al., (1990) studied the effects of a 4 month higher intensity walk/jog program with elderly subjects. Subjects in the aerobic group worked at 65% of maximal heart rate for the first two months and then progressed to 75-80% of their maximal heart rates during the third and fourth month. Results showed improved cardiovascular efficiency (27% increase in VO_2 max), reduced resting heart rate and blood pressure, reduced number of premature ventricular depolarizations (PVDs), and enhanced work performance.

These results are in agreement with Duncan et al., (1991) who found a linear dose-response gradient across all three walking groups of women in regards to VO_2 max, with the aerobic walkers experiencing the greatest increase of VO_2 max, the brisk walkers experiencing a moderate rise of VO_2 max, and the strollers achieving a minimal increase in VO_2 max. These results demonstrate a clear distinction between fitness and health benefits. However Duncan et al., (1991) also state that to obtain meaningful improvements in lipoprotein profile vigorous exercise is not necessary. Women who walked 4.8 km, 5 days per week, at a low intensity for a long duration (4.8 km/hr) achieved a minimal increase in fitness, but experienced the same significant increase in HDL-C as women who followed a similar program but walked vigorously enough to achieve an aerobically trained state.

Hardman et al., (1989) found that walking for 12 months at a pace that elicited 60% of predicted maximal uptake enhanced exercise tolerance and modified favorably the metabolic and cardiovascular responses to standard submaximal exercise. Their sedentary female subjects exhibited a considerable progressive increase in HDL-C after the one year program of brisk walking. A similar walking study by Probart et al., (1991) included 16 women over age 70 who trained for 6 months, walking three times each week for 20 minutes, at 70% of measured maximum heart rate. Both cardiorespiratory fitness and functional status improved significantly.

Other research has looked at a low intensity program immediately followed by a high intensity program in order to compare results. Seals et al., (1984) conducted a study with elderly subjects involved in 6 months of low intensity (LI = HR less than 120 bpm) exercise followed by 6 months of high intensity (HI = 75-85% HRR or about 156 bpm) exercise. The 6 months of LI training elicited an average increase in VO_2 max of 12%, while the additional 6 months of HI training produced a further, more-marked increase of 18%. Ventilation during maximal exercise was increased 7 and 29% following LI and HI training, respectively. Heart rates at the same absolute work rates as before training were 5-10 beats/min lower after LI training and were reduced 4-6 beats/min further after HI training. Body weight and sum of skinfolds were unchanged in response to LI training but were reduced after HI training. This may be partially due to the fact that duration increased from 20-30 minutes for the LI group to 30-45 minutes

for the HI group. This increase in duration would lead to an increase in energy expenditure. The changes in body weight and composition may therefore be related more to the increase in energy expenditure than the increase in intensity.

Seals et al., (1984) concluded that a moderate increase in daily physical activity can result in small but significant increases in VO_2 max and favorable adaptations in the response to submaximal exercise in healthy men and women over 60 years of age. Higher intensity training can result in an additional increase in VO_2 max similar in magnitude to that observed in younger populations.

Rate of Progression of Walking

The rate at which elderly sedentary females can progress during a walking program has not been well documented. Several studies have measured rate of progression by reporting the intensity (target heart rate and speed) and changes in the intensity of the program. (Rippe et al., 1988; Jette et al., 1988; Porcari et al., 1987). Frequency, duration, and distance have been measured and have been reported mainly as total values as opposed to weekly changes. Few studies have documented descriptive information and weekly changes over time that would be valuable information in regards to exercise prescription for the elderly.

ACSM (1990) guidelines state that the recommended rate of progression in the exercise conditioning program depends on the individual's functional capacity, health status, age, preferences and needs or goals. The endurance phase of the exercise prescription has

three stages of progression: initial, improvement, and maintenance. The initial stage consists of the first 5 weeks, the improvement stage includes weeks 6-27 and the last stage is the maintenance stage which is from week 28 on. These guidelines are universal and not specific to any one population. These guidelines suggest that although age in itself is not a limiting factor to exercise training, a more gradual approach in applying the prescription at older ages seems prudent. Elia (1991) reports that more than for other age groups, activity programs for elders must be tailored to the individual participant's age, fitness level, and health status.

In a study by Pollock et al., (1971), middle-aged men walked three times per week for 20 weeks. Walking progressed from 4.0 to 5.6 km per day and walking pace increased from 6.8 to 7.6 km/h from week one to week 20. VO_2 max increased by 28% and was partially attributed to the low initial fitness level of the subjects. Sidney and Shephard (1978) taught subjects to take their pulse rates and measure heart rate during a 7 week walking program. As training continued, the distance covered during the "fast" phase was progressively increased. Criteria for progression included subjective reactions to the required exercise, and heart rate readings below the required level during activity.

Hardman et al., (1989) followed 28 formerly sedentary females over a one year walking program and reported average walking time per week over the year and average estimated weekly energy expenditure. An increase in walking speed was reported but only speeds at the beginning and end of the study were reported. No rate of training progression was documented.

Jette et al., (1988) reported a mean increase in the work output of women by 20% in a 12 week treadmill walking program. The actual average walking speed at 60% of VO_2 max as determined by direct measurement on the treadmill was 3.9 mph. Thomas et al., (1985) suggested that an increased ability to perform aerobic activity was indicated by a progressive increase in average speed of walking.

Initial level of fitness appears to be a factor influencing the rate of progression of the walking program. The amount of improvement may be dependent upon initial fitness levels; the less fit, the greater overall improvement (Steinhaus et al., 1990). Thomas et al., (1985) specify that the best predictor of what an elderly subject's VO_2 max will be after one year of training is the initial VO_2 max. ACSM (1990) guidelines state that interpretation and comparison of training results are dependent on the initial level of fitness. For example, data from training studies using subjects with varied levels of VO_2 max found the lower the initial VO_2 max, the larger the percentage of improvement. The person with a low fitness level can achieve a significant training effect with a sustained training heart rate as low as 40-50% HR max reserve, while persons with higher fitness levels require a higher training stimulus.

The relationship between initial level of fitness and rate of progression (frequency, intensity, duration) has not been well documented in the literature. Data evaluating trainability with age, comparison of the different magnitudes and quantities of effort,

and comparison of the trainability of men and women may be influenced by initial fitness levels.

CHAPTER 3

METHODS

Subject Recruitment and Screening

The subjects involved in this study were participants in a long term walking study involving postmenopausal, hyperlipidemic sedentary women. Forty female volunteers with mildly elevated serum cholesterol (5.9-8.0 mmol/L) were randomly assigned to either a Walking (24) or Control (16) group. The 24 women who took part in the exercise group were the initial subjects in this study. Sixteen of the original 24 women completed the 24 week program and the submaximal steady state treadmill test required to be included in this study.

Participants were healthy (no cardiovascular, pulmonary or metabolic diseases that would preclude safe participation in an exercise program), non-smokers, at least one year post menopause, who consumed less than one ounce of alcohol per day, and were not on medications that would affect lipids (bile binding resins, statins, fibric acid derivatives, niacin, probucol). Only sedentary or minimally active individuals who had not made recent changes in their activity level were included in the study. Women with triglyceride levels greater than 4.2 mmol/L and women receiving estrogen replacement therapy were also excluded. Participants

completed an informed consent form, and a medical questionnaire prior to taking part, and initial lipid measurements, a 12 lead ECG and symptom limited treadmill test were evaluated by a cardiologist to determine whether exercise was safe for each volunteer.

Experimental Design

Participants were asked to walk 5 days a week, 60 minutes each session for 24 weeks at an intensity of 60% HRR. Subjects were encouraged to first increase frequency, followed by duration, then intensity. Walkers were supervised twice per week for the first two weeks. Participants were then asked to walk a minimum of once per week at a supervised session held at an indoor track where a fitness leader would monitor heart rates, log books, and speed of the walkers. Participants began the program at staggered start times throughout a six month period.

Participants were given a log book in order to accurately record walking frequency, duration, distance, and average 15 minute heart rates after each walking session. All log books were kept in order and were found to be well documented and organized after the 24 week program. Walkers were also encouraged to record comments related to environmental, physiological, and psychological conditions.

Subjects were assigned a target heart rate based on their initial max heart rate value from the submaximal Balke protocol treadmill test administered at the onset of the study. Heart rate was

monitored by palpation of the radial pulse and tested against the Sport Tester for accuracy on two separate occasions with 14 of the participants.

Energy cost of walking was measured approximately 6-8 months after the initial start of the program by a submaximal steady state treadmill test with gas analysis. Total energy expenditure (kJ) was calculated for each individual for the entire 24 week program as well as on a weekly basis.

Participants were encouraged to adhere to the program by receiving verbal feedback, prizes, social events and special t-shirts.

Procedures

Log book:

Each participant was given an individual log book where they recorded their daily walking. The log book had a title page listing the target HR zone for a 15 second count for that particular individual as well as daily activity record sheets which included frequency, duration, distance, average exercise HR, and space for comments. Each page covered a one week time period.

Subjects were required to accurately record details of both their structured walking as well as any other activities they participated in. The log book sheets were numbered for all 24 weeks and were handed in on a regular basis to the exercise leader and filed in the participant's file.

Log books may have had a secondary purpose as a motivational tool as participants knew they were being monitored closely. Sample log book pages can be found in Appendix two and three.

Heart rate monitoring:

Subjects were taught how to measure their radial pulse in order to determine heart rate. Heart rates were taken over a 15 second time period at four separate time periods (every 15 minutes) during each walking session. All four heart rates were recorded in the log book. Target heart rates for each individual were listed on the front page of each log book. A validity check using a Solar Sport Tester was done to compare the heart rates from palpation and Sport Tester reading. Heart rates taken by palpation coincided with the Sport Tester and were found to be accurate.

Symptom limited treadmill test:

A Balke protocol treadmill test (Quinton motor driven treadmill) was used to predict VO_2 max and to determine whether each participant could safely take part in the exercise program. Maximal oxygen uptake was predicted from time to exhaustion during this test (Pollock et al., 1991). Sixty percent HRR was calculated from maximal oxygen uptake values ($60\% \text{ HRR} = \text{resting HR} + [0.6(\text{Max HR} - \text{Resting HR})]$).

Subjects walked on the treadmill at a constant speed of 5.4 km/h (3.3 mph). Elevation began at 0% grade and was increased by 1% each minute. Blood pressure and a 12 lead electrocardiogram (Cambridge EKG) was administered before each test by a

cardiologist. Heart rate was continually recorded throughout the test using the EKG and heart rate ruler.

Submaximal steady state test:

The submaximal steady state protocol was administered in order to predict energy expenditure of the subjects throughout four different time periods in the 24 week program. Participants walked on the level treadmill (0% grade) for four ten minute stages achieving steady state at each stage. Four different velocities were used, with each stage consisting of a velocity attained at a specific time in the walking program. The initial ten minute stage was a warm-up using the velocity corresponding with that at the end of week #2 of the actual walking program (V1). The velocity used in stage three was the one that corresponded to the time the target heart rate was reached (V3) while stage two used the velocity corresponding to the middle point between the end of week #2 and the time the target heart rate was attained (V2). Stage four used the velocity that corresponded to the end of the 24 week program (V4). Velocities were calculated using distance/time (m/min) recorded in the participants' log books or by using a time of speed for 5 laps recorded on a weekly basis by a fitness monitor.

Expired gases were collected during the final minutes of each test (Sensormedics metabolic measurement cart) so that the steady state oxygen uptake (VO_2) and the respiratory exchange ratio (R) could be determined. Energy expenditure was calculated using the caloric equivalent for a liter of oxygen at the measured R value (Gardner et al., 1988).

This steady state treadmill protocol has been shown to be an accurate method of predicting energy cost in this population (Brennan et al., 1990). This test was administered approximately six to eight months after the initial start of each individual's walking program. Energy expenditure for each week was interpolated from the values obtained with this test. The weekly energy cost values served as an indicator of rate of progression of the training program.

Statistical Analysis

Descriptive statistics (total, mean, standard deviation) were used to document rate of training progression (frequency, duration, distance and intensity [time at THR, % time at THR, actual time at THR, speed, and energy expenditure]). Percent change over time was also calculated to document weekly changes. These descriptive statistics were used to illustrate changes in each individual variable over the 24 week time period.

Regression analysis was used to look at the effect of age, fitness level, and adherence on the above mentioned training progression variables as well as on change in VO_2 .

Regression analysis was also used to determine the relationship between age and initial fitness level (VO_2).

CHAPTER 4

RESULTS

Introduction

The results of the investigation of the effects of a 24 week walking program on the training progression of elderly women are as follows.

1. Physical Characteristics of the Subjects.

Mean values, standard deviations, and ranges (including minimum and maximum values) for descriptive characteristics of 16 subjects are presented in Table 4-1.

2. Walking Program Characteristics.

Mean values, standard deviations, ranges (including minimum and maximum values), and percent changes are described under the following categories.

i) Average Walking Characteristic over 24 weeks.

Data includes total distance (km), duration (min), time at target heart rate (min), energy expenditure (kJ), energy expenditure per

minute (kJ), and supervised sessions attended. (i.e. mean values for 16 subjects) (Table 4-2).

Total frequency was significantly related to total duration (min) ($R^2 = 0.286$, $p = 0.0329$). This indicates that total frequency is a good predictor of total walking duration.

Table 4-1 Descriptive characteristics of subjects

Subject	Age (yr)	Height (cm)	Weight (kg)	Initial VO ₂ max (ml/kg-min)	Final VO ₂ max (ml/kg-min)
1	57.0	172.3	75.3	29.4	32.3
2	56.0	159.0	95.2	36.3	36.4
3	55.7	163.7	85.1	23.9	25.7
4	64.5	158.1	63.6	29.7	30.9
5	64.3	165.6	77.3	31.0	36.8
6	60.2	168.5	92.1	30.2	35.0
7	57.8	155.8	65.5	27.4	32.7
8	55.8	165.8	68.7	33.0	41.1
9	67.0	167.0	75.2	26.5	31.4
10	59.2	168.2	73.3	28.0	30.2
11	57.7	158.3	75.4	37.2	38.1
12	68.8	158.6	51.5	29.8	31.2
13	60.7	164.3	74.3	27.8	26.6
14	67.8	166.4	92.3	24.8	27.6
15	61.3	151.9	65.2	30.7	35.3
16	60.8	158.7	68.1	36.7	42.4
Mean	61.1	162.6	74.9	30.2	33.3*
SD	4.4	5.5	11.7	4.0	4.9
Range	13.0	20.4	43.7	13.2	16.7
Min	56.0	151.9	51.5	23.9	25.7
Max	69.0	172.3	95.2	37.2	42.4

* $p < 0.05$ pre to post VO₂ max.

Table 4-2 Average walking characteristics over 24 weeks (n=16)

	Distance (km)	Duration (min)	Time at Target HR (min)	Energy Expenditure (kJ)	Supervised Sessions Attended (#)
Mean	569.5	6254.7	1638.3	139518.1*	17.5
SD	201.5	1252.7	1596.0	40471.6	4.2
Range	751.3	5204.0	5100.0	134966.2	15.0
Min	247.5	4099.0	0.0	57827.5	8.0
Max	998.8	9303.0	5100.0	192793.7	23.0

*Note: 1 kJ = 0.23892 kcals

ii) Average Walking Characteristics per Session over 24 Weeks.

Average distance (km), average duration (min), and average time at target heart rate (min) are reported in Table 4-3.

iii) Average Walking Characteristics for each of 24 Weeks.

Data includes average frequency, distance (km), duration (min), and total time at target heart rate (min) (Table 4-4).

iv) Averages per Session for Each of 24 Weeks.

Data includes average frequency, distance (km), duration (min), time at target heart rate (min), percent time at target heart rate, velocity (km/hr), energy expenditure (kJ), and energy expenditure/minute (kJ) (Tables 4-5 & 4-6).

Total distance ($R^2 = 0.235$, $p = 0.05$) and total duration ($R^2 = 0.516$, $p = 0.0017$) were significantly related to total energy expenditure (kJ). These results indicate that both total distance and duration are good predictors of total energy expenditure.

v) Supervised Sessions: Average Walking Program Characteristics for each of 24 Weeks.

Data includes average distance (km), average duration (min), average time at target heart rate (min), average percent time at

target heart rate, actual percent of target heart rate, and percent change over time (Table 4-7).

vi) Change in Progression Variables over 24 weeks.

Data includes total weekly energy expenditure (kJ), total weekly distance (km), total weekly duration (min), and total percent time at target heart rate per week. Total energy expenditure per week was the only significant change to occur with all of the progression variables over time.

**Table 4-3 Average walking characteristics per session
over 24 weeks (n=16)**

	Average Distance (km)	Average Duration (min)	Average Time at Target HR (min)
Mean	4.9	53.4	21.3
SD	1.7	8.5	15.1
Range	6.4	30.6	44.7
Min	2.6	36.4	0.0
Max	9.0	67.0	44.7

Table 4-4 Average walking characteristics for each of 24 weeks
(n=16)

Week	Distance (km)	% Change (Dist)	Duration (min)	% Change (Dur)	Total Time at Target HR (min)	% Change (Time at THR)	Frequency
1	17.4 ± 11.3	0.0	203.8 ± 97.9	0.0	72.6 ± 83.0	0.0	4.5
2	23.3 ± 10.2	34.0	262.4 ± 79.6	29.0	78.2 ± 90.0	8.0	5.1
3	21.4 ± 9.5	-8.0	252.7 ± 83.0	-4.0	160.0 ± 107.2	36.0	4.9
4	22.5 ± 10.4	5.0	260.9 ± 78.7	3.0	99.1 ± 71.7	-7.0	4.9
5	23.6 ± 10.0	5.0	257.1 ± 69.3	-1.0	121.1 ± 89.1	22.0	4.8
6	22.5 ± 8.6	-5.0	253.6 ± 74.5	-1.0	87.7 ± 73.3	-28.0	4.9
7	22.2 ± 11.4	-1.0	244.6 ± 82.8	-4.0	80.5 ± 53.3	-8.0	4.6
8	24.9 ± 12.2	12.0	274.7 ± 105.9	12.0	78.2 ± 78.2	-3.0	4.9
9	23.1 ± 9.0	-7.0	265.9 ± 66.0	-3.0	67.7 ± 85.0	-13.0	4.8
10	23.1 ± 10.3	0.0	253.9 ± 93.8	-5.0	88.2 ± 83.8	30.0	4.6
11	22.9 ± 11.0	-1.0	248.4 ± 85.3	-2.0	106.1 ± 80.3	20.0	4.5
12	24.6 ± 10.4	7.0	269.1 ± 79.0	8.0	121.5 ± 83.6	15.0	5.3
13	25.5 ± 11.0	4.0	257.8 ± 66.9	-4.0	84.1 ± 67.2	-31.0	4.9
14	26.9 ± 10.7	6.0	290.0 ± 79.6	13.0	114.1 ± 135.7	36.0	5.3
15	26.3 ± 12.0	-2.0	280.6 ± 79.6	-3.0	105.0 ± 143.0	-8.0	5.1
16	26.7 ± 11.7	2.0	289.2 ± 79.1	3.0	70.8 ± 52.9	-33.0	4.9
17	28.2 ± 10.3	6.0	299.0 ± 82.9	3.0	98.6 ± 106.2	39.0	5.1
18	23.9 ± 11.4	-15.0	258.1 ± 92.9	-14.0	108.2 ± 103.8	10.0	4.4
19	23.0 ± 11.4	-4.0	238.1 ± 79.1	-8.0	113.0 ± 104.4	4.0	4.4
20	30.2 ± 16.2	31.0	286.9 ± 82.3	21.0	95.9 ± 87.0	-15.0	4.9
21	27.7 ± 13.0	-8.0	285.2 ± 109.5	-1.0	102.5 ± 82.1	7.0	5.0
22	25.0 ± 11.5	-10.0	266.9 ± 112.2	-6.0	103.1 ± 92.2	1.0	4.6
23	26.0 ± 9.4	4.0	271.2 ± 76.6	2.0	101.3 ± 86.2	-2.0	4.8
24	27.4 ± 8.0	5.0	284.1 ± 48.4	5.0	94.5 ± 80.3	-7.0	5.3

Table 4-5 Average walking program characteristics per session for each of 24 weeks (n=16)

Week	Frequency	Distance (km)	% Change (Dist)	Duration (min)	% Change (Dur)	Time at Target HR (min)	% Change (Time at THR)	% Time at Target HR	% Change (% Time at THR)
1	4.5	3.8 ± 1.9	0.0	45.4 ± 16.0	0.0	20.2 ± 15.9	0.0	34.0 ± 32.2	0.0
2	5.1	4.5 ± 1.6	18.0	51.4 ± 12.9	13.0	28.5 ± 19.9	41.0	28.9 ± 27.8	-15.0
3	4.9	4.5 ± 1.7	0.0	52.1 ± 12.1	1.0	29.6 ± 22.4	5.0	39.8 ± 32.7	38.0
4	4.9	4.6 ± 1.8	2.0	53.8 ± 10.5	3.0	33.8 ± 18.6	13.0	39.7 ± 22.0	0.0
5	4.8	5.0 ± 1.7	9.0	54.6 ± 8.3	1.0	33.1 ± 21.4	-2.0	51.6 ± 32.9	29.0
6	4.9	4.7 ± 1.9	-6.0	52.2 ± 11.0	-4.0	28.4 ± 20.7	-14.0	35.1 ± 27.1	-32.0
7	4.6	4.6 ± 2.0	-2.0	51.0 ± 12.4	-2.0	29.5 ± 20.7	4.0	29.2 ± 17.3	-17.0
8	4.9	5.0 ± 1.8	9.0	56.1 ± 14.8	10.0	24.3 ± 15.9	-18.0	30.1 ± 27.2	3.0
9	4.8	5.0 ± 2.0	0.0	55.8 ± 9.1	-1.0	25.6 ± 18.2	5.0	25.0 ± 28.6	-17.0
10	4.6	5.1 ± 1.7	2.0	55.2 ± 8.8	-1.0	31.3 ± 18.1	22.0	39.3 ± 32.2	57.0
11	4.5	4.8 ± 1.8	-4.0	52.8 ± 11.7	-4.0	32.0 ± 17.5	2.0	42.6 ± 31.0	8.0
12	5.3	4.8 ± 2.3	-2.0	50.7 ± 14.2	-4.0	31.8 ± 16.3	-1.0	43.4 ± 30.0	2.0
13	4.9	5.2 ± 2.1	8.0	52.0 ± 12.1	3.0	25.2 ± 14.7	-21.0	36.0 ± 30.1	-17.0
14	5.3	5.0 ± 2.0	-4.0	54.1 ± 11.9	4.0	34.4 ± 22.0	37.0	33.5 ± 31.2	-7.0
15	5.1	5.1 ± 2.1	2.0	55.1 ± 10.6	2.0	30.0 ± 22.5	-13.0	30.2 ± 32.8	-10.0
16	4.9	5.9 ± 2.9	16.0	59.1 ± 7.9	7.0	28.7 ± 17.7	-4.0	27.4 ± 23.1	-9.0
17	5.1	6.0 ± 2.8	2.0	57.3 ± 9.2	-3.0	29.4 ± 17.0	2.0	30.6 ± 27.2	12.0
18	4.4	5.7 ± 2.0	-5.0	58.7 ± 11.5	2.0	37.8 ± 22.2	29.0	38.3 ± 32.1	25.0
19	4.4	5.3 ± 1.9	-7.0	54.7 ± 11.9	-7.0	37.1 ± 20.3	-2.0	42.3 ± 30.4	10.0
20	4.9	6.3 ± 4.2	21.0	57.2 ± 11.5	5.0	30.6 ± 19.7	-18.0	37.9 ± 34.3	-10.0
21	5.0	5.5 ± 2.2	-14.0	57.3 ± 14.2	0.0	30.2 ± 16.6	-1.0	37.7 ± 27.7	-1.0
22	4.6	5.2 ± 2.0	-6.0	55.2 ± 14.7	-4.0	29.9 ± 21.7	-1.0	40.0 ± 38.5	6.0
23	4.8	5.4 ± 1.8	4.0	56.3 ± 11.5	2.0	28.4 ± 16.0	-5.0	36.9 ± 30.7	-8.0
24	5.3	5.4 ± 1.8	0.0	54.9 ± 5.8	-2.0	23.9 ± 15.4	-15.0	37.8 ± 36.5	2.0

Table 4-6 Average velocity and energy expenditure for each of 24 weeks (n=16)

Week	Velocity (km/hr)	% Change (Vel)	EE (kJ)	EE/min (kJ)	% Change EE/min (kJ)
1	5.5	0	4179.9	20.8	0
2	5.5	0	5357.0	20.8	0
3	5.5	0	5276.5	21.0	0
4	5.5	0	5438.2	20.8	0
5	5.5	0	5415.7	21.1	1
6	5.5	0	5483.9	21.2	1
7	5.5	0	5324.9	21.4	1
8	5.6	2	6062.9	21.9	2
9	5.6	0	5949.0	22.0	1
10	5.7	2	5365.8	22.1	1
11	5.7	0	5211.0	22.2	1
12	5.7	0	6097.0	22.3	1
13	5.7	0	5765.5	22.4	0
14	5.8	2	6463.2	22.4	0
15	5.8	1	6337.6	22.5	0
16	5.8	0	6112.9	22.6	0
17	5.8	0	5980.5	22.8	1
18	5.8	0	5767.2	22.9	0
19	5.9	1	5334.4	23.0	0
20	5.9	1	6645.6	23.1	0
21	5.9	0	6506.2	23.2	0
22	6.0	2	6378.7	23.3	0
23	6.0	0	6354.1	23.4	0
24	6.0	0	6707.0	23.5	0

Table 4-7 Walking program characteristics for 24 supervised sessions (n = 16)

Supervised Sessions	Distance (km)	% Change (Dist)	Duration (min)	% Change (Dur)	Time at Target HR (min)	% Change (Time at THR)	% Time at Target HR	Actual % of Target HR
1	3.4 ± 2.0	0.0	39.2 ± 21.0	0.0	10.4 ± 14.2	0.0	30.1	85.8
2	5.1 ± 1.1	50.0	55.5 ± 8.2	42.0	25.0 ± 24.2	140.0	43.3	87.6
3	4.7 ± 1.6	-8.0	50.3 ± 14.6	-9.0	16.4 ± 24.0	-34.0	34.6	88.2
4	5.2 ± 1.2	11.0	53.7 ± 11.1	7.0	27.9 ± 26.4	70.0	51.9	90.3
5	5.6 ± 1.4	8.0	57.9 ± 10.0	9.0	30.2 ± 24.8	8.0	54.2	90.7
6	5.5 ± 1.0	-2.0	57.5 ± 4.0	-1.0	25.9 ± 24.2	-14.0	44.3	90.8
7	5.3 ± 1.5	-4.0	56.6 ± 10.0	-2.0	27.0 ± 26.4	4.0	43.0	89.6
8	5.6 ± 0.9	6.0	58.3 ± 4.4	2.0	21.4 ± 14.8	-21.0	37.8	90.6
9	5.3 ± 1.0	-4.0	56.9 ± 56.9	-2.0	21.8 ± 20.5	2.0	37.9	88.3
10	5.7 ± 0.7	6.0	58.4 ± 3.7	3.0	27.8 ± 17.0	28.0	48.0	90.5
11	5.8 ± 0.7	2.0	60.5 ± 1.6	4.0	30.6 ± 25.0	10.0	50.2	90.6
12	5.7 ± 1.0	0.0	57.4 ± 6.3	-5.0	23.5 ± 23.9	-23.0	41.7	91.1
13	5.5 ± 1.5	-4.0	56.7 ± 13.0	-1.0	29.0 ± 22.7	23.0	54.4	88.6
14	5.6 ± 5.6	2.0	55.7 ± 8.3	-2.0	23.3 ± 23.9	-20.0	41.0	88.9
15	5.6 ± 0.9	0.0	58.0 ± 6.3	4.0	12.5 ± 17.0	-46.0	21.9	90.3
16	5.7 ± 0.9	2.0	60.4 ± 2.0	4.0	28.1 ± 21.9	125.0	47.2	89.9
17	5.3 ± 1.4	-7.0	56.0 ± 15.0	-7.0	18.0 ± 20.3	-36.0	29.4	90.6
18	5.5 ± 0.6	4.0	60.0 ± 0.0	7.0	27.1 ± 28.0	51.0	42.9	90.0
19	5.7 ± 1.0	4.0	59.5 ± 3.0	-1.0	19.3 ± 21.5	-29.0	32.4	89.6
20	5.7 ± 0.7	0.0	59.1 ± 4.9	-1.0	29.0 ± 25.7	50.0	53.4	87.8
21	6.1 ± 0.3	7.0	60.3 ± 0.8	2.0	39.0 ± 17.1	35.0	64.5	91.3
22	5.8 ± 0.8	-5.0	58.5 ± 4.7	-3.0	32.1 ± 22.0	-18.0	53.6	91.2
23	5.9 ± 0.9	2.0	62.6 ± 8.8	7.0	31.4 ± 22.8	-2.0	52.2	91.2
24	6.0 ± 0.6	2.0	59.1 ± 3.0	-6.0	22.0 ± 21.8	-30.0	36.7	91.0

Actual % of Target Heart rate (60% HRR): Total = 2158/24 weeks = 90%
Therefore average intensity was 54% HRR.

Table 4-8 Change in progression variables
(n = 16)

Variable	Mean data: Initial weeks 2-5	Mean data: Final weeks 21-24	Difference: Final - Initial weeks	p value
Total energy expenditure per week (kJ)*	5372.1	6486.5	1114.4	0.0457
Total duration per week (min)	258.3	276.8	18.5	0.3587
Total distance per week (km)	22.7	26.9	4.2	0.0967
Total % time at target HR per week	20.13	18.4	-1.73	.5279

* Note: 1 kJ = 0.23892 kcals

3. Influence of Age on Training Progression

Age was entered into a simple regression analysis to determine the extent of its effect on the relative change on each of the dependent variables (frequency, distance, duration, time at target heart rate, velocity, and energy expenditure). The only significant relationship was a negative correlation with percent time at target heart rate ($R^2 = 0.265$, $p = 0.0497$) (Figure 4-1).

Age was not significantly related to distance (km), duration (min), time at target heart rate (min), percent time at target heart rate, velocity (m/s), energy expenditure (kJ), energy expenditure/minute (kJ) or change in VO_2 .

4. Influence of Initial Fitness Level on Training Progression

Initial fitness level ($VO_{2\text{ max}}$) was entered into a simple regression analysis to determine the extent of its effect on the relative change in each of the dependent variables (frequency, distance, duration, time at target heart rate, velocity, energy expenditure). Initial fitness level was not significantly correlated with change in VO_2 .

Initial fitness level was not significantly related to distance (km), duration (min), time at target heart rate (min), percent time at target heart rate, velocity (km/hr), energy expenditure (kJ), or energy expenditure/minute (kJ).

Subjects demonstrated an overall 10% increase in VO_2 max over the 24 weeks ($p > 0.0001$). This statistical analysis used only the data from the subjects involved in this particular study ($n = 16$) and not from the larger ongoing walking program which utilized a control group.

Relationship Between Age and Initial Fitness Level

Age and initial fitness level (VO_2 max) were entered into a simple regression analysis and were found not to be related in this particular study ($r^2 = 0.022$). (Figure 4-2).

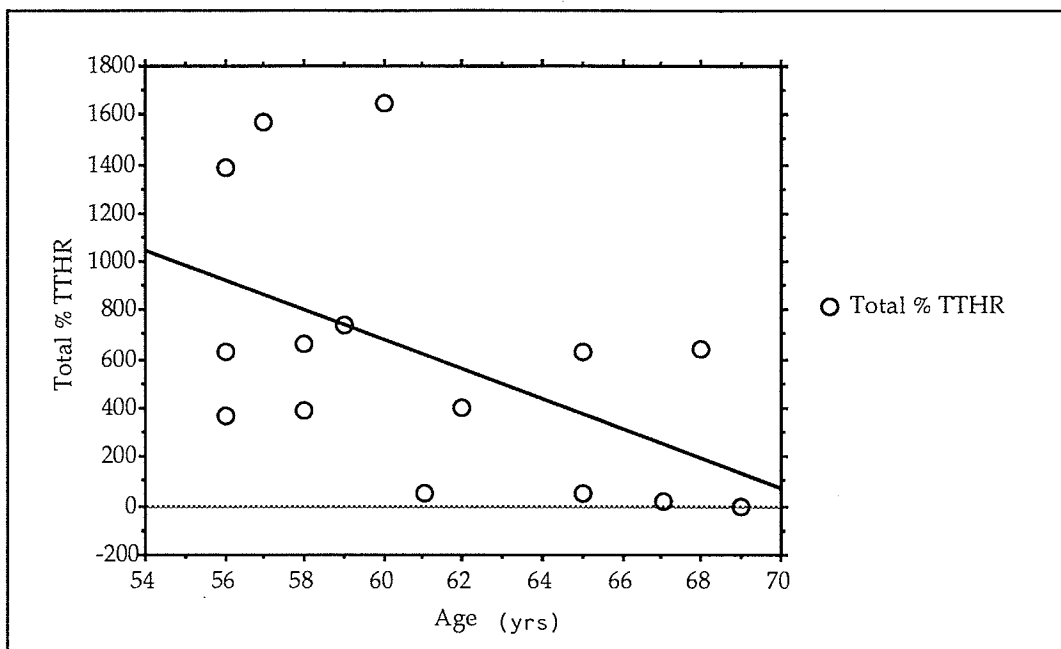


Figure 4-1. Age and total percent time at target heart rate.
(n = 16).

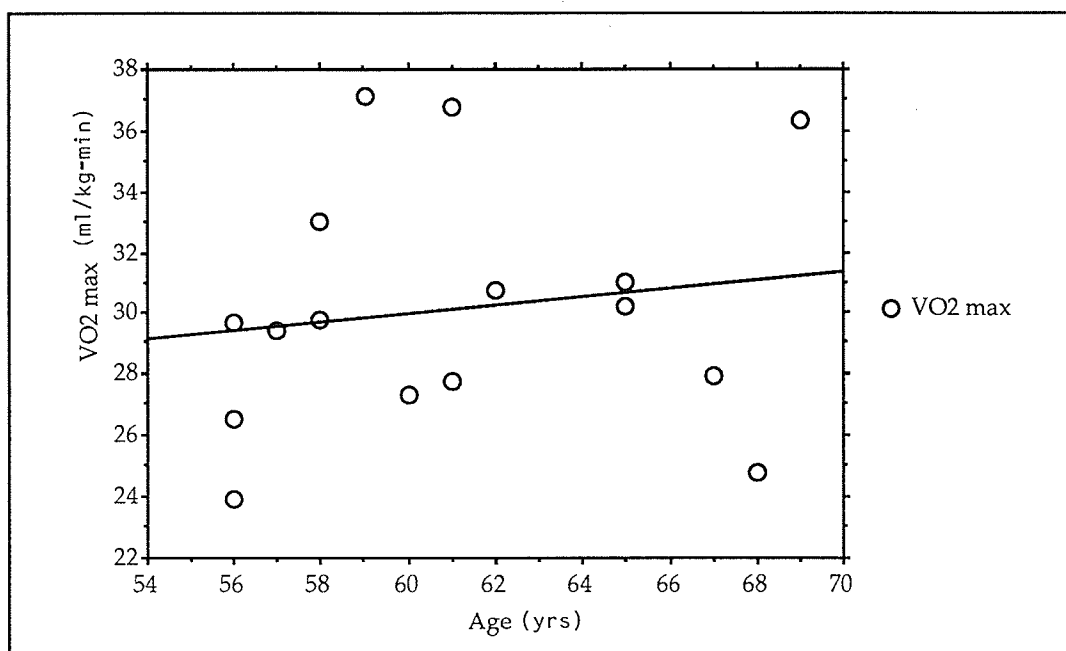


Figure 4-2. Age and VO₂ max relationship (n = 16).

5. Influence of Adherence on Training Progression

Adherence (total number of supervised sessions attended out of 24) was entered into a simple regression analysis to determine the extent of its effect on the relative change of each of the dependent variables (frequency, distance, duration, time at target heart rate, velocity, and energy expenditure).

Adherence was not significantly related to distance (km), duration (min), time at target heart rate (min), percent time at target heart rate, velocity (km/hr), energy expenditure (kJ), energy expenditure/minute (kJ) or change in VO_2 .

6. Influence of Injury on Training Progression

Injury questionnaires were completed by all 16 subjects. All subjects were individually interviewed and the questionnaires were discussed.

Three out of 16 subjects reported injuries related to walking during the 24 week program. One of these subjects reported that she had a build up of scar tissue in their ankle which came to light during her walking but was in fact not caused by the actual walking program. This subject also reported she was managing her ankle fairly well and that it did not significantly interfere with her walking program. The second subject who reported an injury related to walking stated that she had strained her ankle by slipping on the ice and as a result had modified her walking program for 2 weeks. The third reported injury involved tendonitis in the knee joint which

was fairly minor in nature. No injuries were sustained during testing and no subjects were lost due to injury.

7. Changes in Lipid Profile, Percent Body Fat and Weight Loss

Total serum cholesterol significantly decreased over the 24 week period ($p = 0.0004$) with a pre-program mean value of $6.66 \pm .57$ mmol/L and a post-program mean value of $6.32 \pm .53$ mmol/L. High density lipoprotein cholesterol (HDL-C) did not significantly change ($p = 0.5633$) nor did cholesterol: HDL ratio ($p = 0.2874$).

Percent body fat ranged from a pre-program mean of $35.86\% \pm 5.85$ to a post-program mean of $34.66\% \pm 7.07$ but was not statistically significant ($p = 0.0599$). Weight loss was significant ($p = 0.0086$) with a pre-program mean of $74.88 \text{ kg} \pm 11.74$ and a post-program mean of $73.12 \text{ kg} \pm 12.2$.

These values were obtained using only the subject values involved in this particular study ($n = 16$).

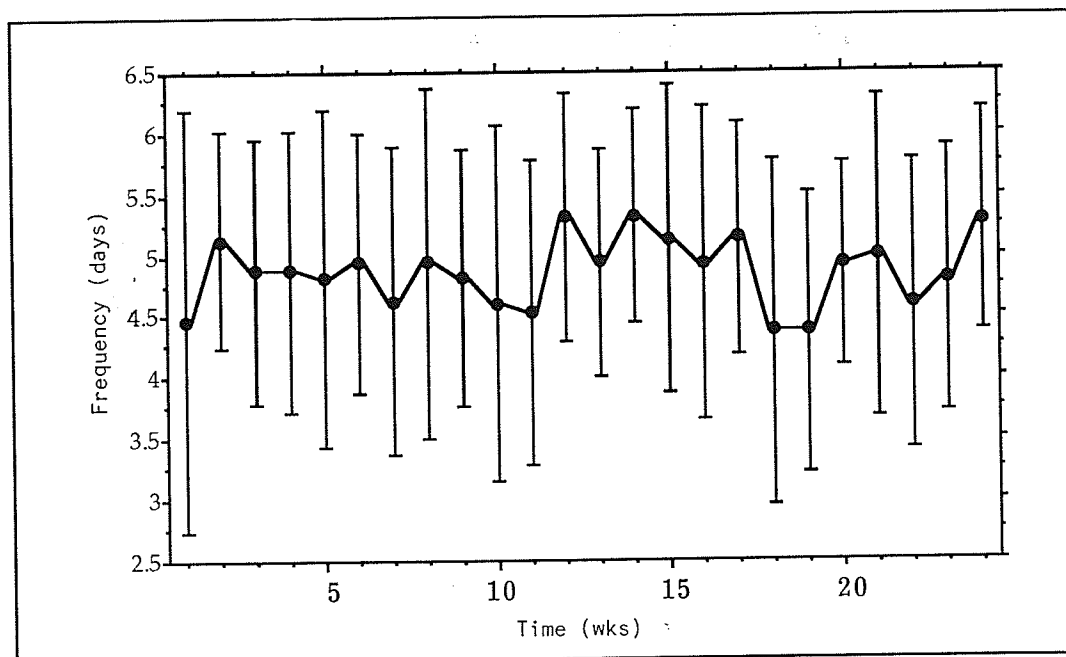


Figure 4-3. Average frequency over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

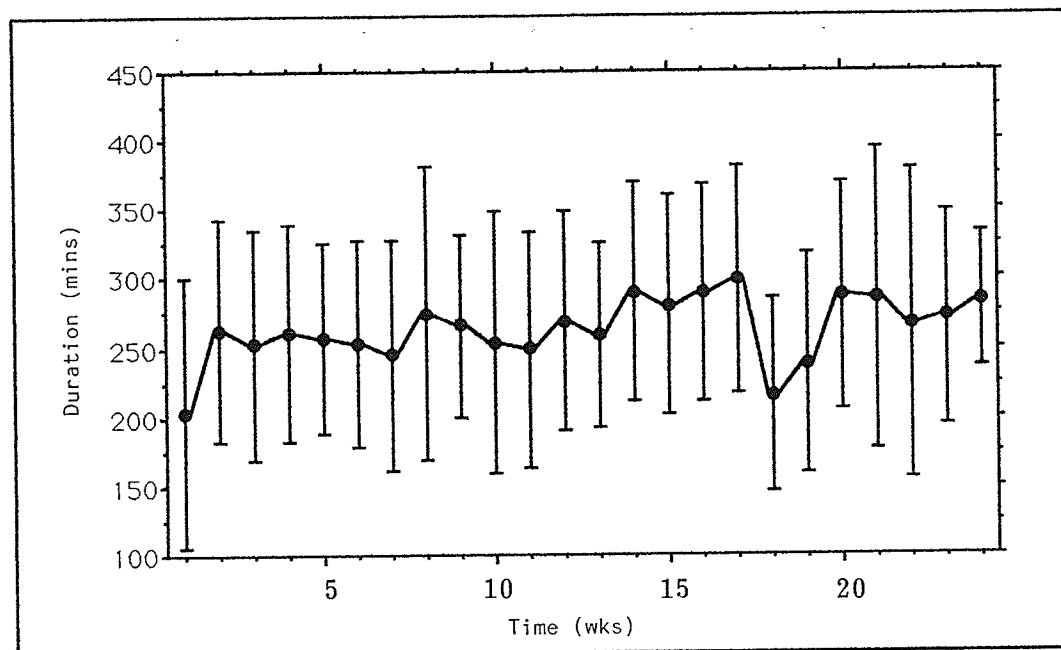


Figure 4-4. Average duration per week over 24 weeks ($n = 16$, $\bar{x} \pm SD$)

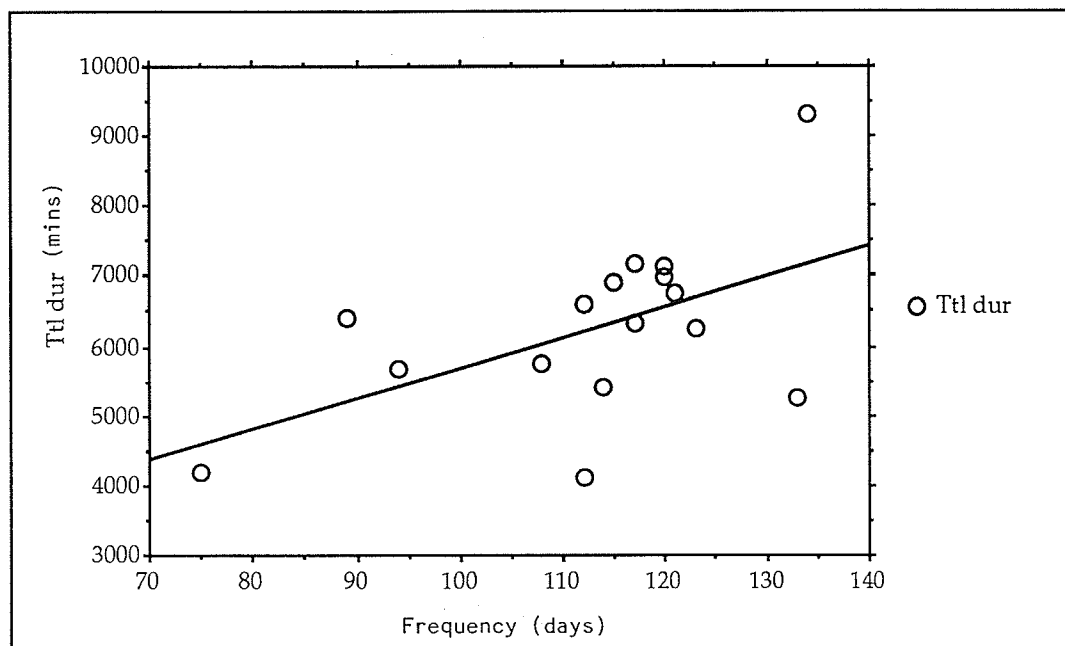


Figure 4-5. Relationship between total frequency and total duration (n = 16).

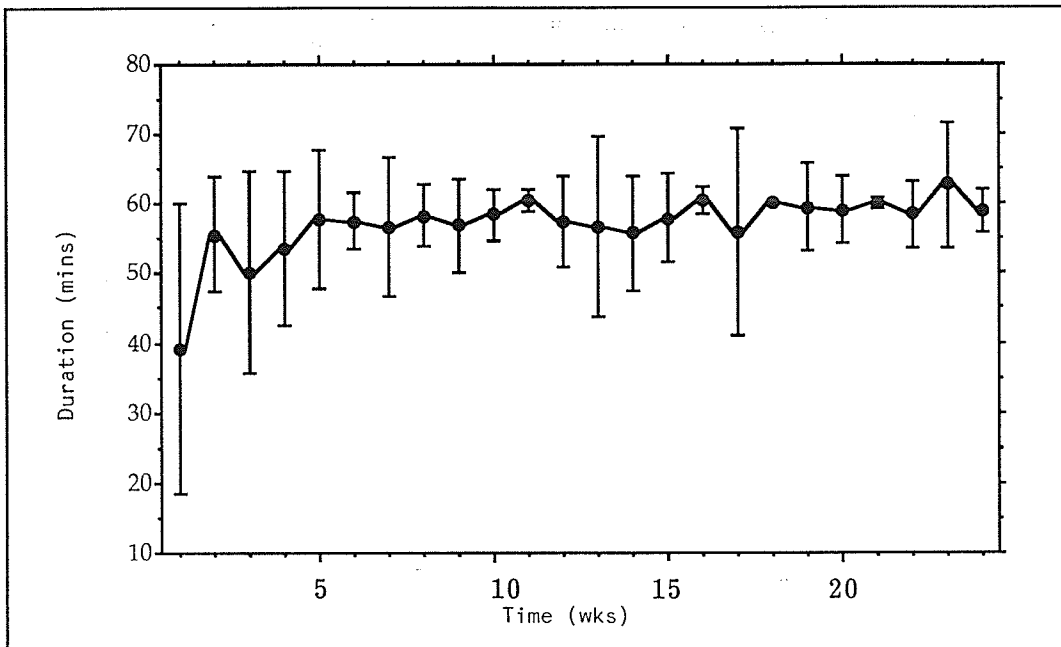


Figure 4-6. Average duration over 24 supervised sessions ($n = 16$, $\bar{x} \pm SD$).

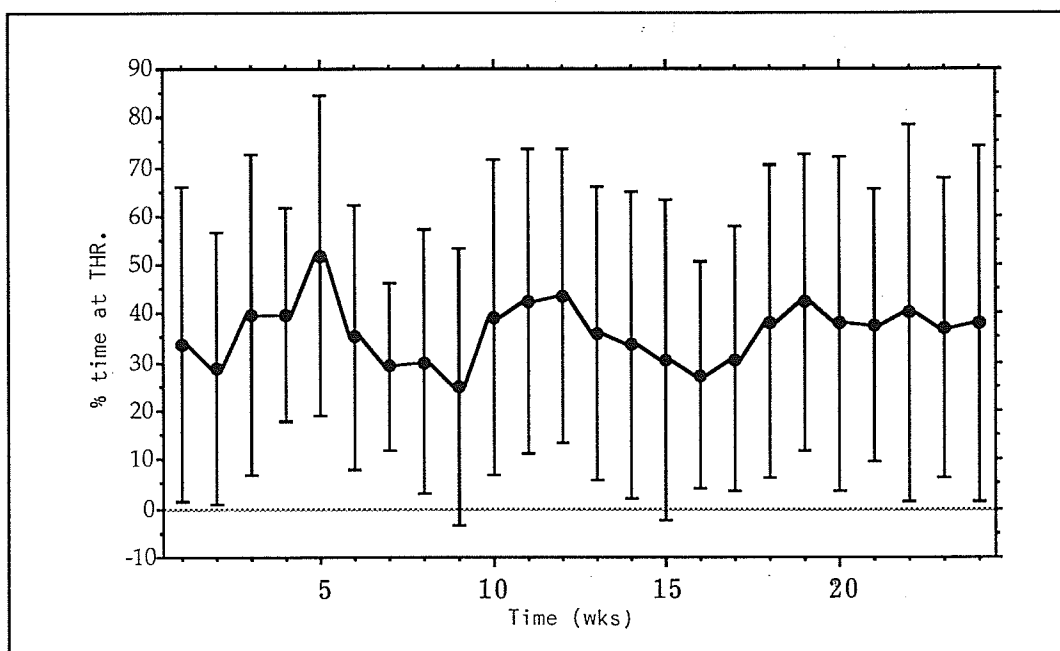


Figure 4-7. Percent time at target heart rate over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

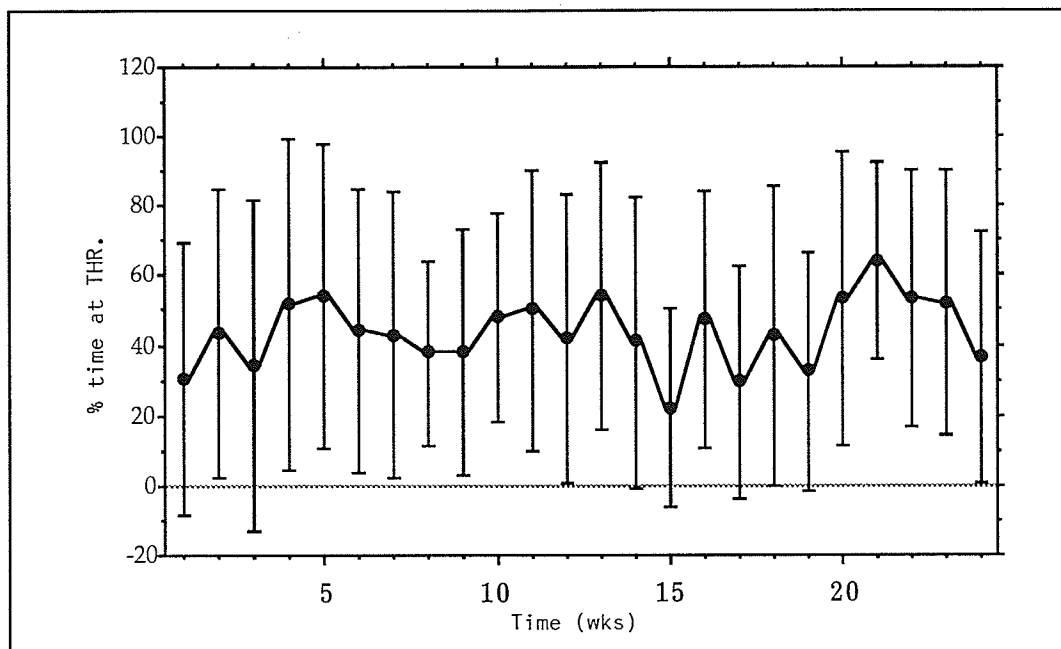


Figure 4-8. Percent time at target heart rate over 24 supervised sessions ($n = 16$, $\bar{x} \pm SD$).

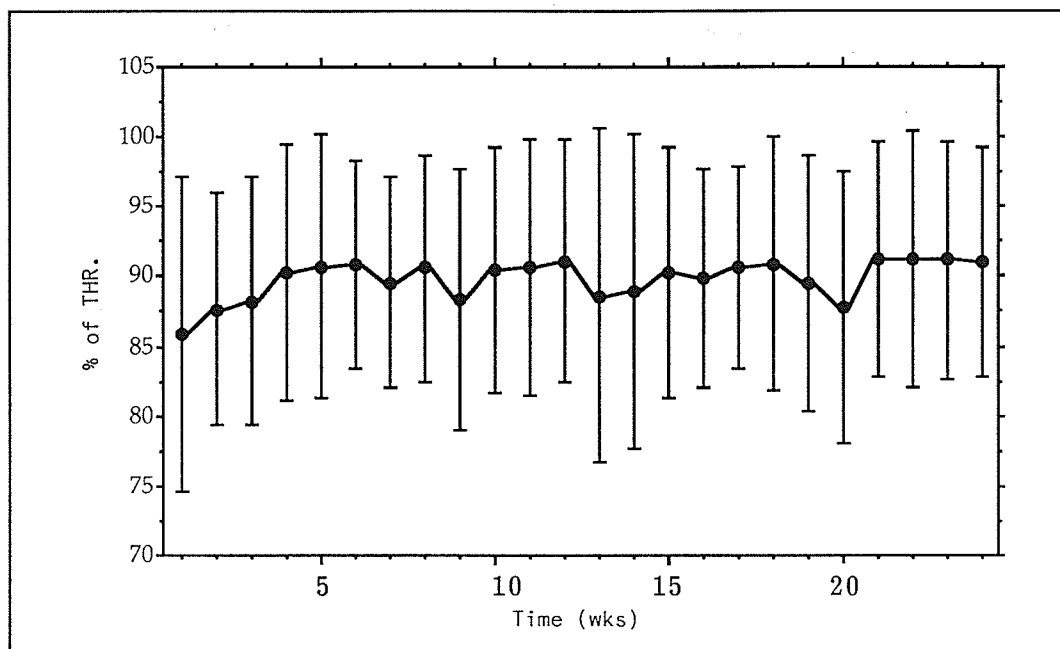


Figure 4-9. Percent of target heart rate over 24 supervised sessions ($n = 16$, $\bar{x} \pm SD$).

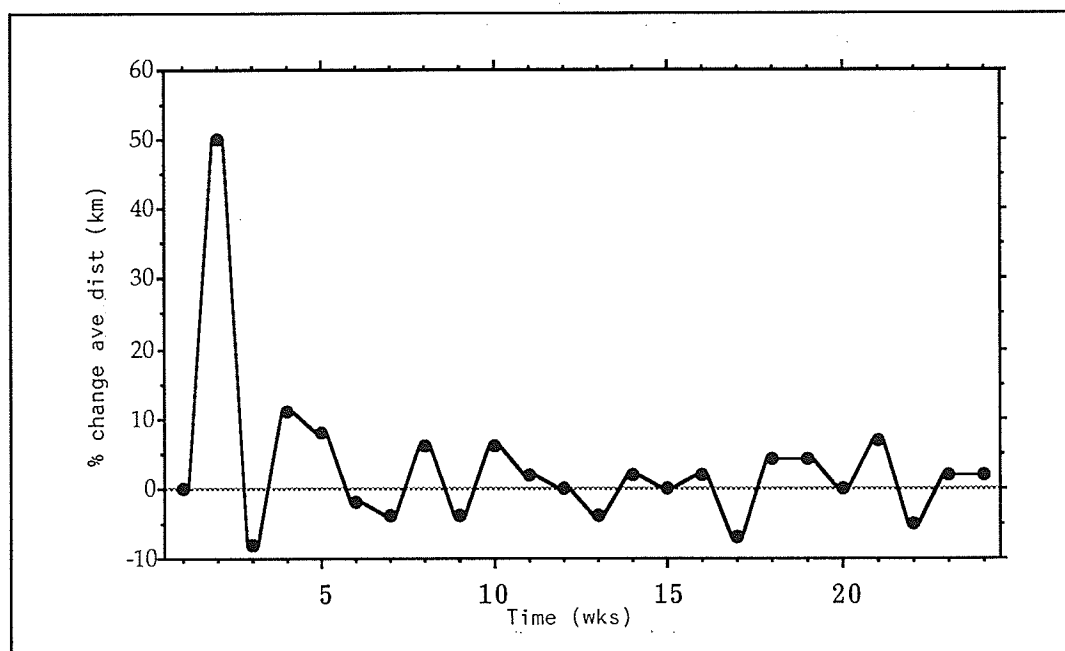


Figure 4-10. Percent change in average distance over 24 supervised sessions ($n = 16$, $\bar{x} \pm SD$).

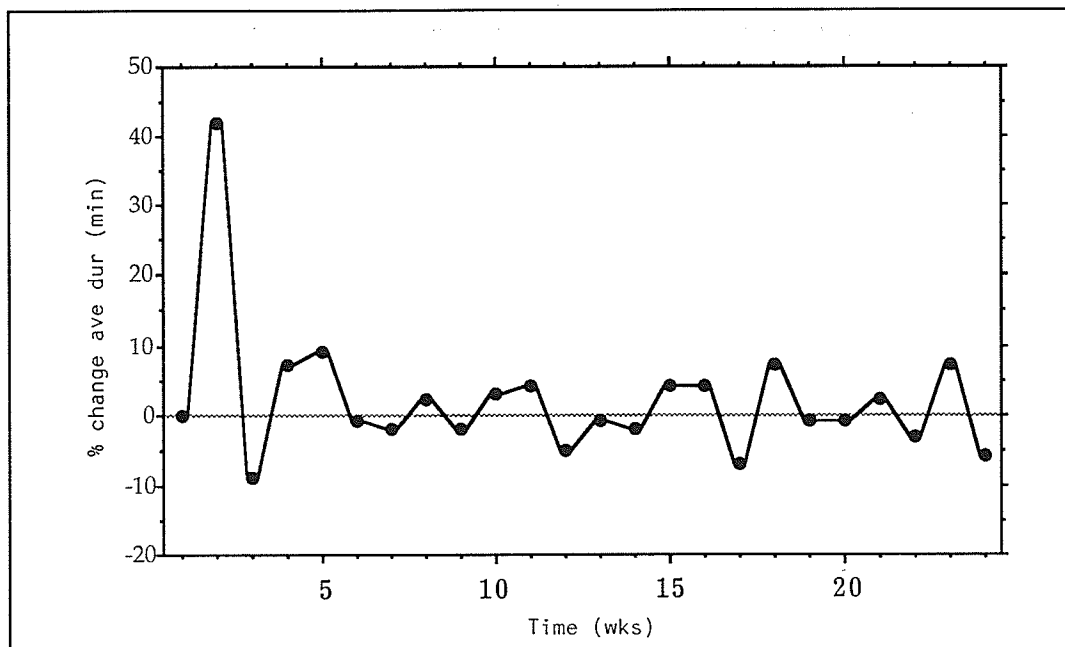


Figure 4-11. Percent change in average duration over 24 supervised sessions ($n = 16$, $\bar{x} \pm SD$).

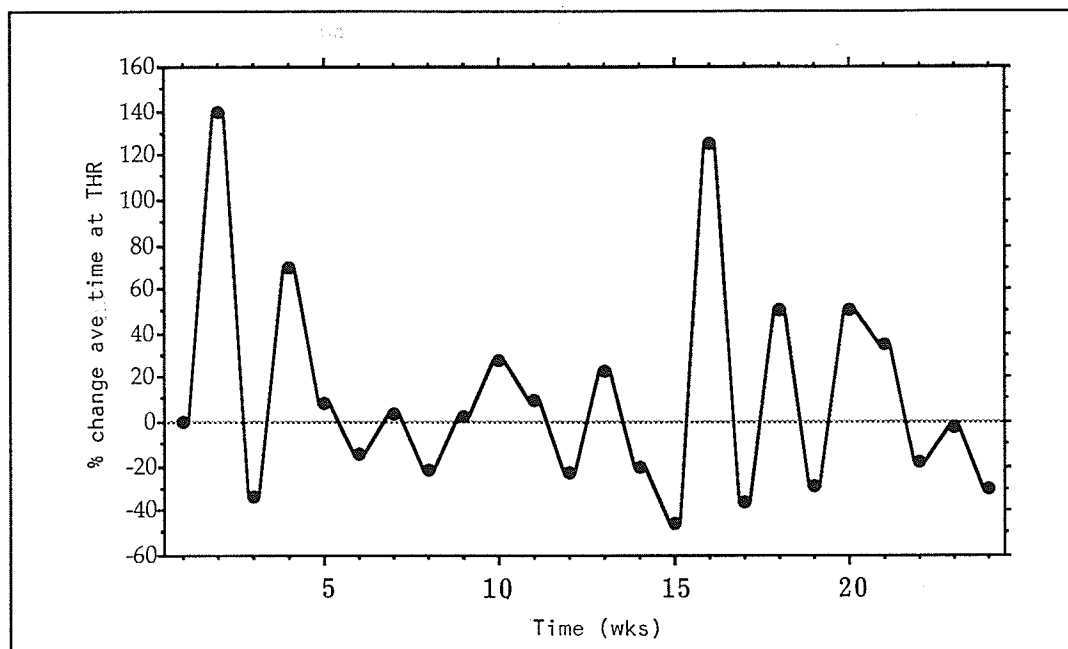


Figure 4-12. Percent change in average time at target heart rate over 24 supervised sessions ($n = 16$, $\bar{x} \pm SD$).

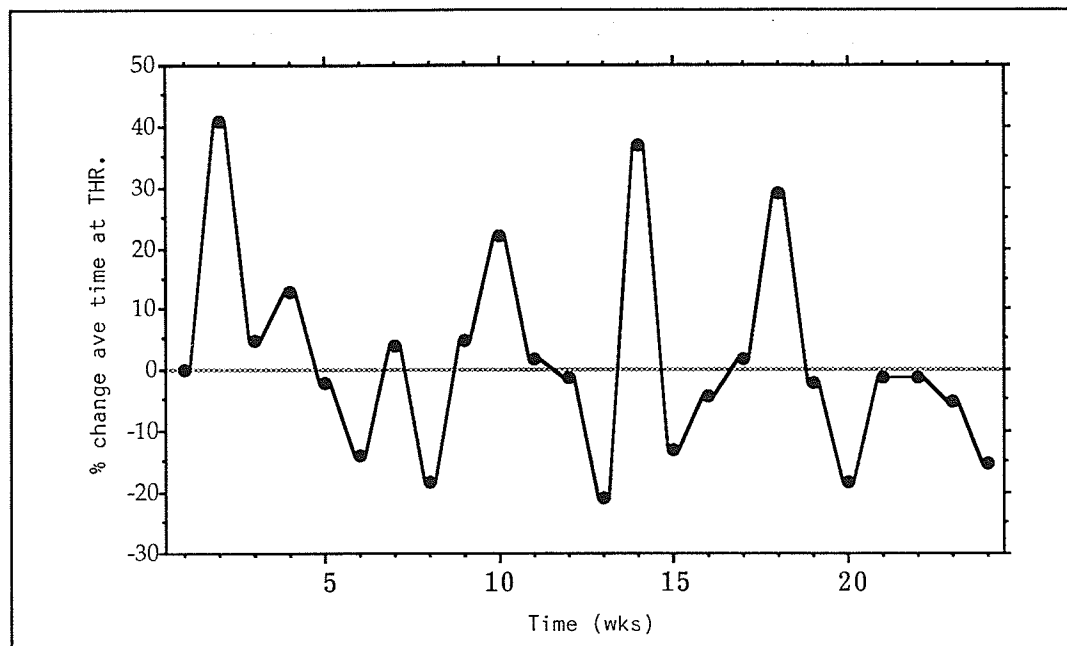


Figure 4-13. Percent change in average time at target heart rate over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

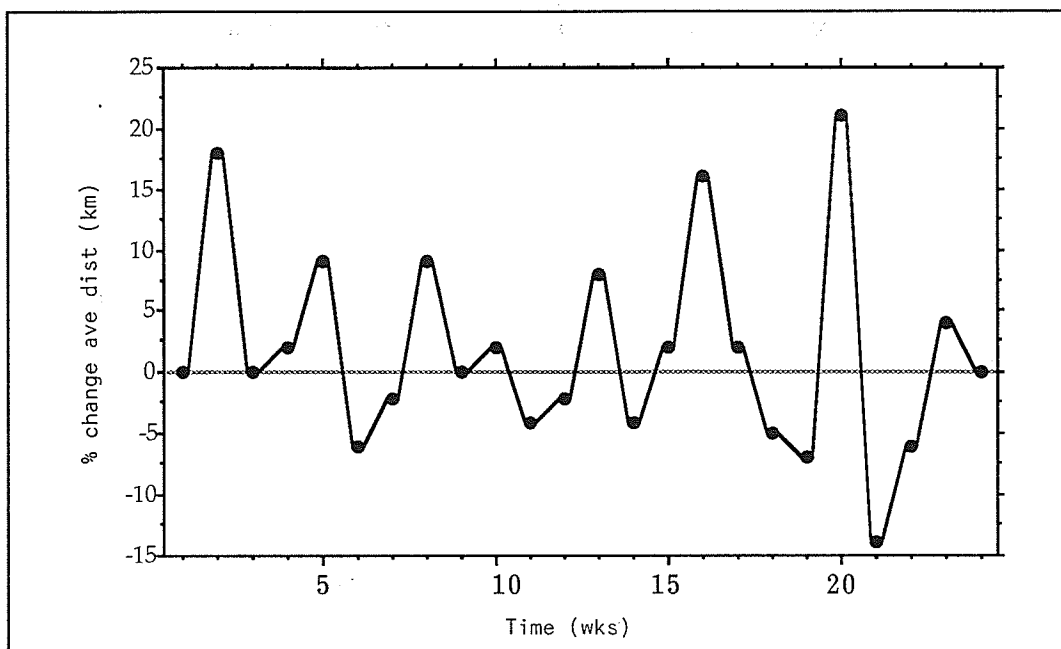


Figure 4-14. Percent change in average distance over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

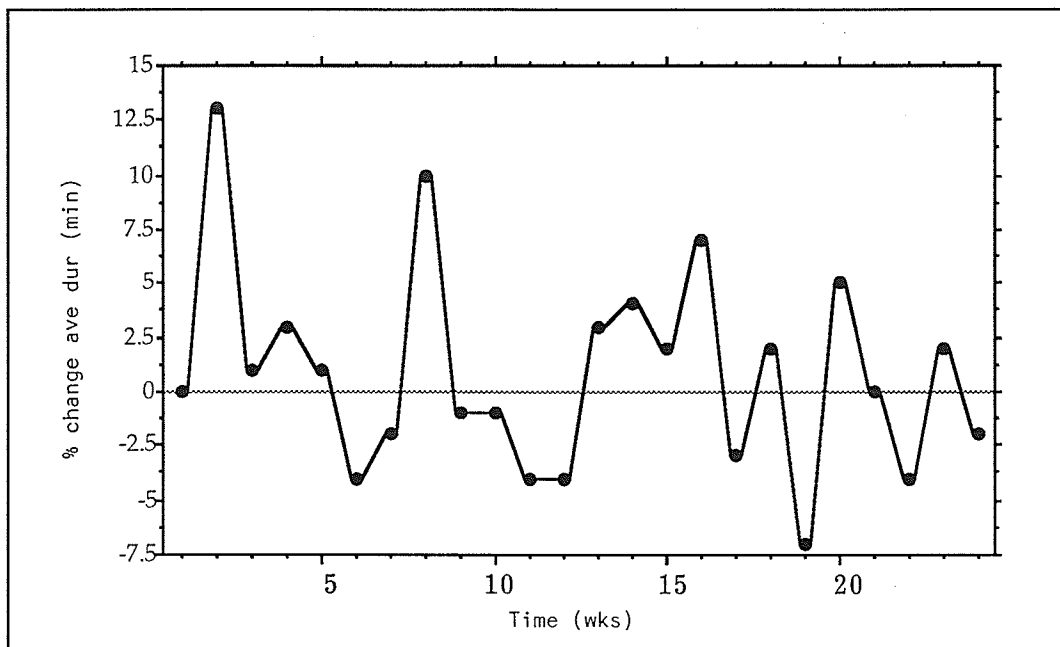


Figure 4-15. Percent change in average duration over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

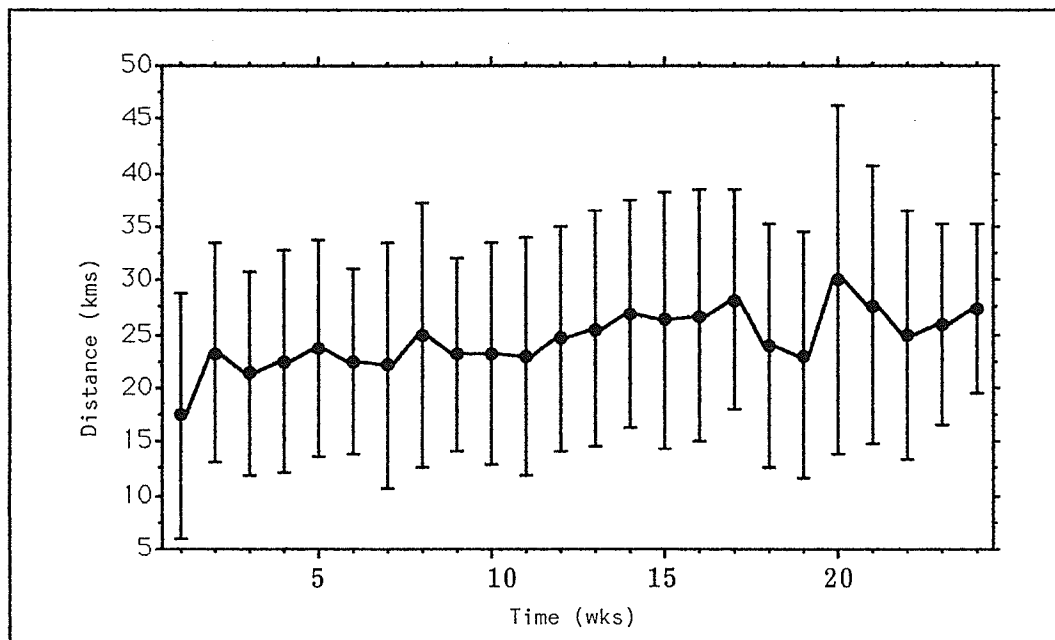


Figure 4-16. Average distance per week over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

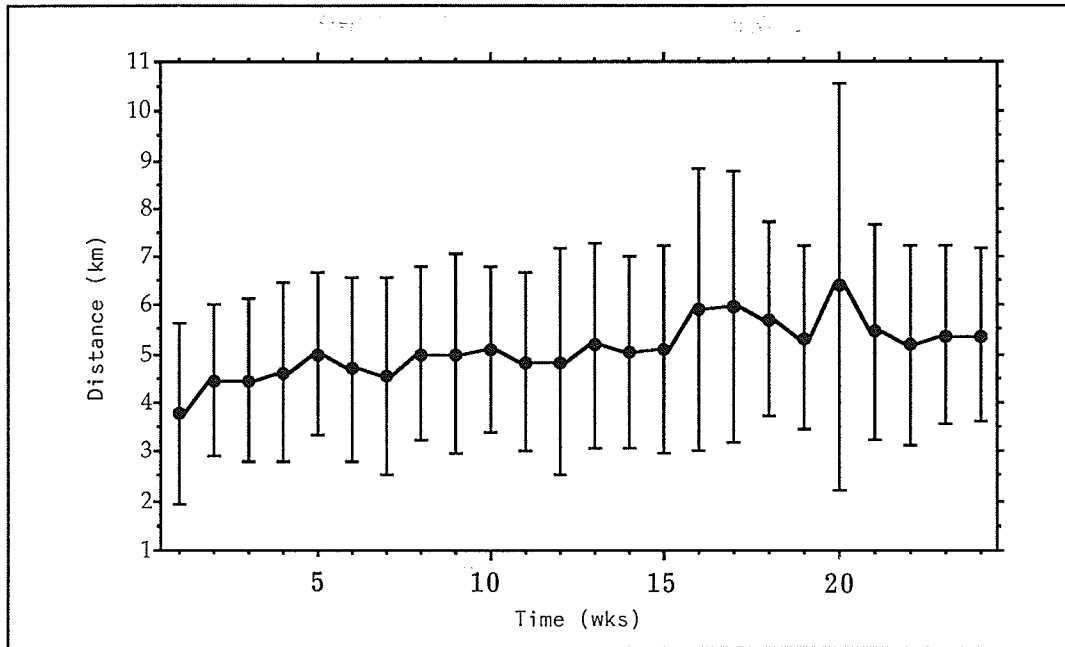


Figure 4-17: Average distance per session over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

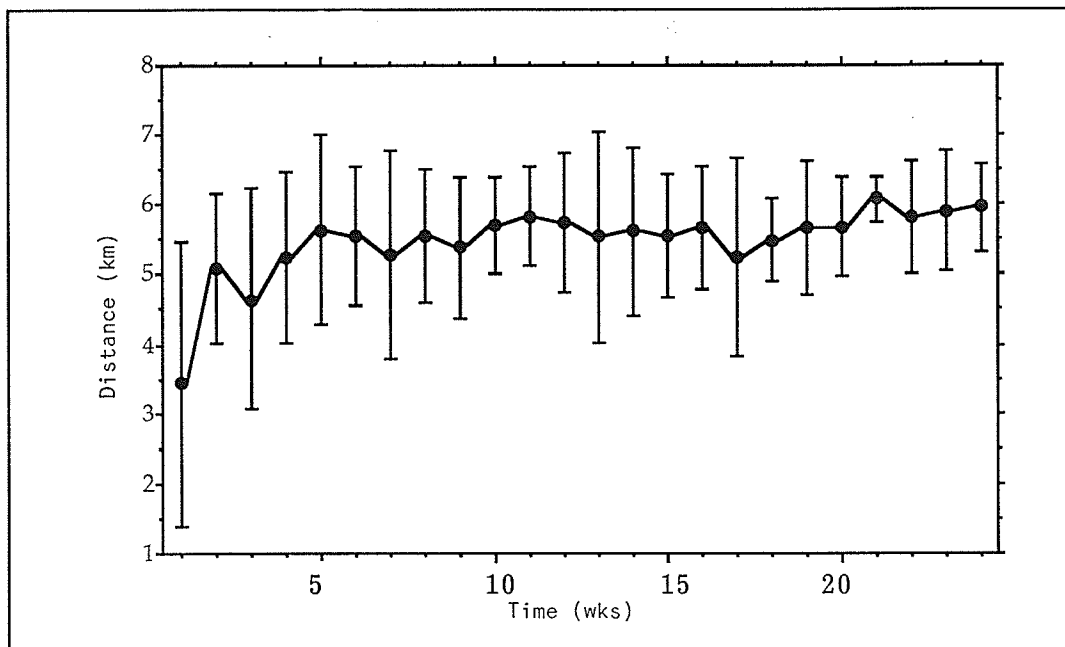


Figure 4-18. Average distance over 24 supervised sessions ($n = 16$, $\bar{x} \pm SD$).

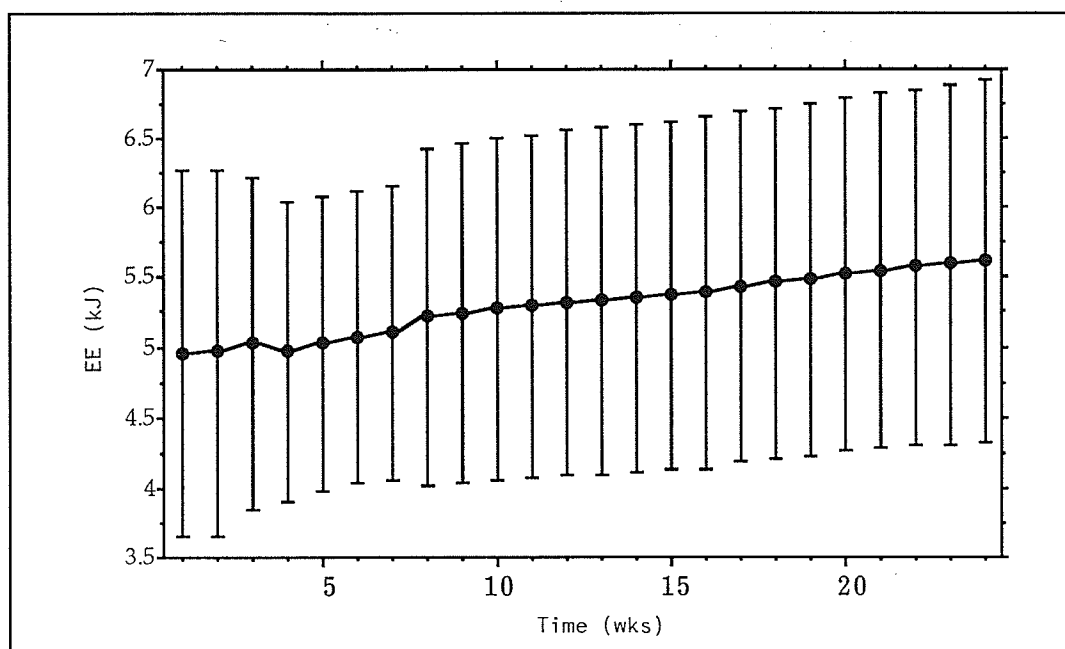


Figure 4-19. Average energy expenditure per minute over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

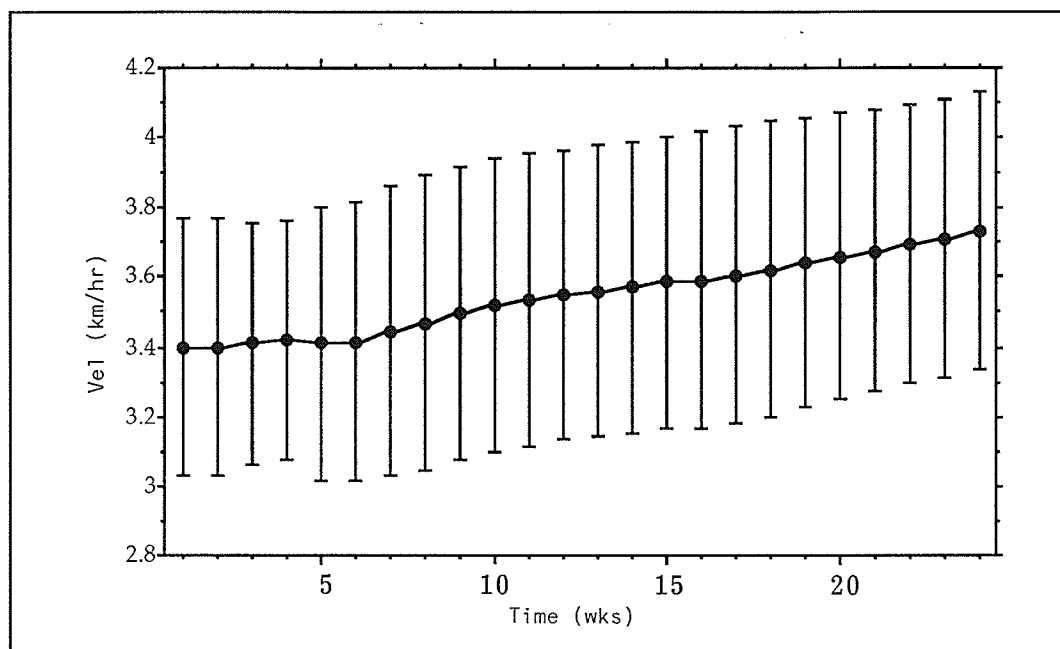


Figure 4-20. Average velocity over 24 weeks (n = 16, $\bar{x} \pm SD$).

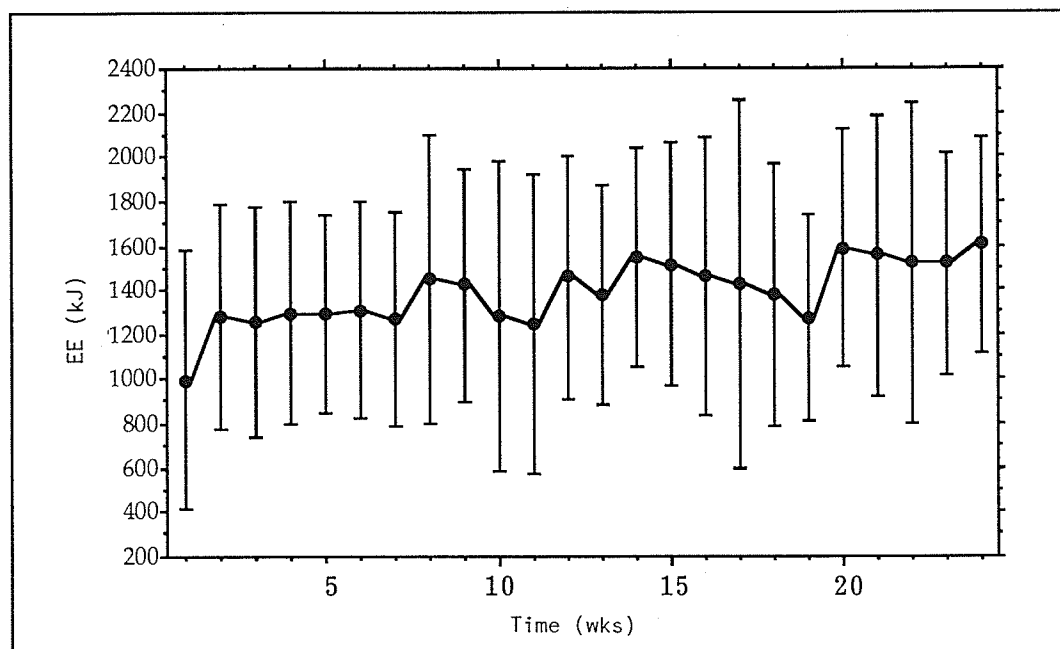


Figure 4-21. Average energy expenditure over 24 weeks
($n = 16$, $\bar{x} \pm SD$).

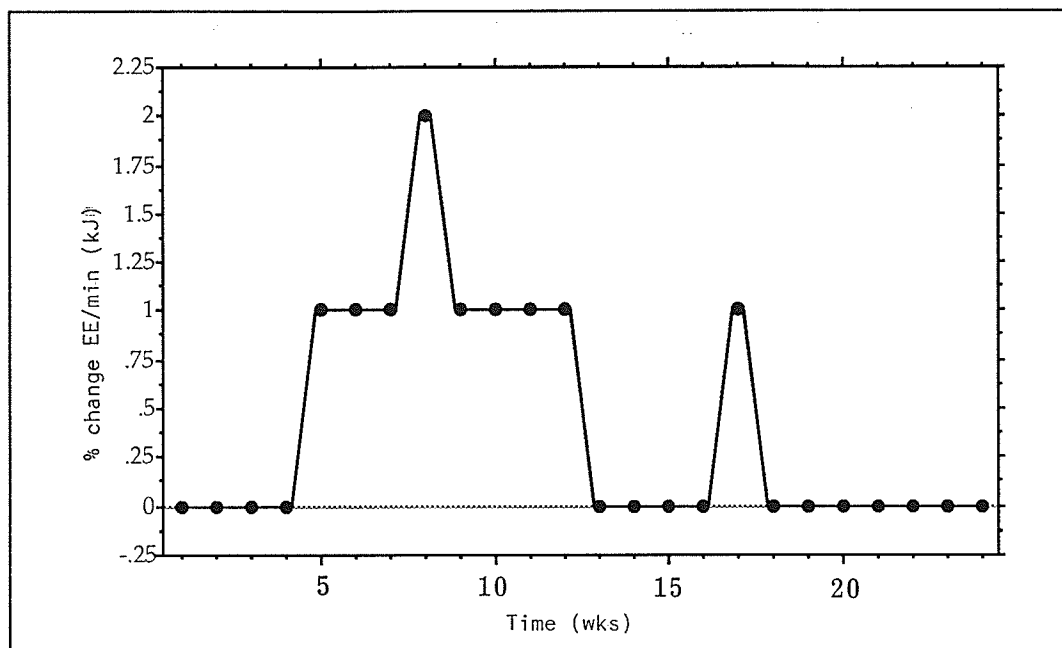


Figure 4-22. Percent change in energy expenditure per minute over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

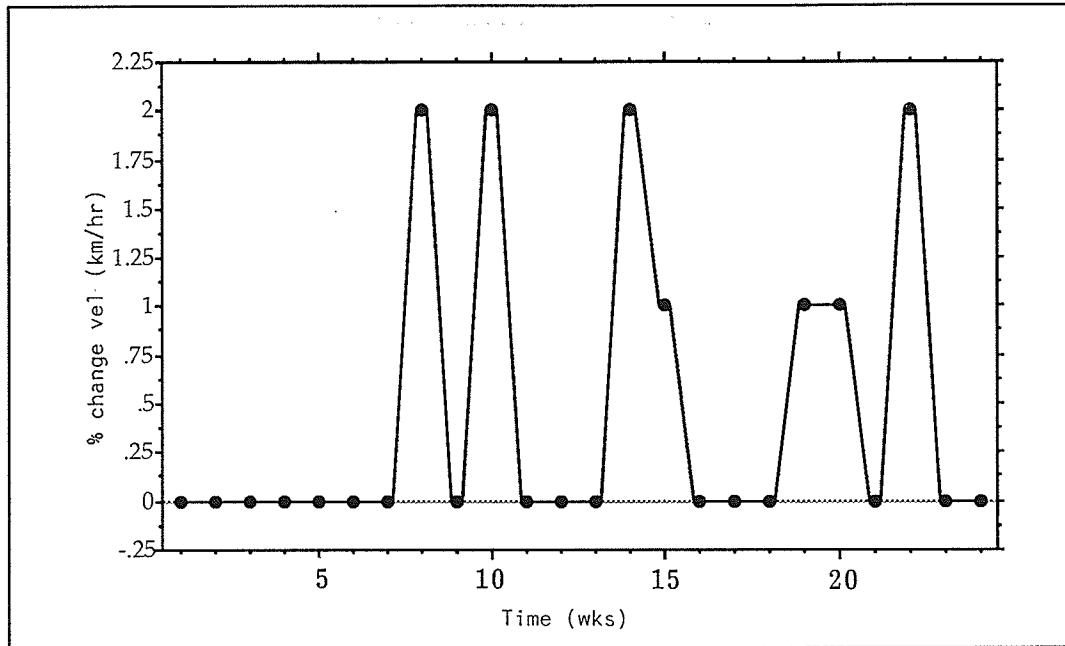


Figure 4-23. Percent change in velocity over 24 weeks ($n = 16$, $\bar{x} \pm SD$).

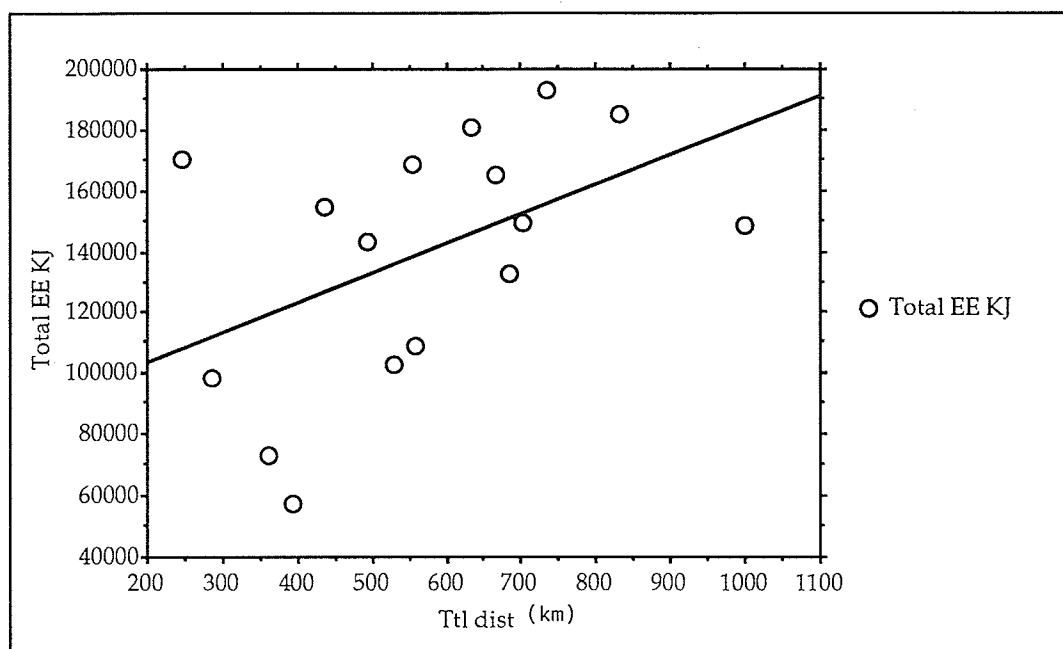


Figure 4-24. Relationship between total distance and total energy expenditure (n = 16).

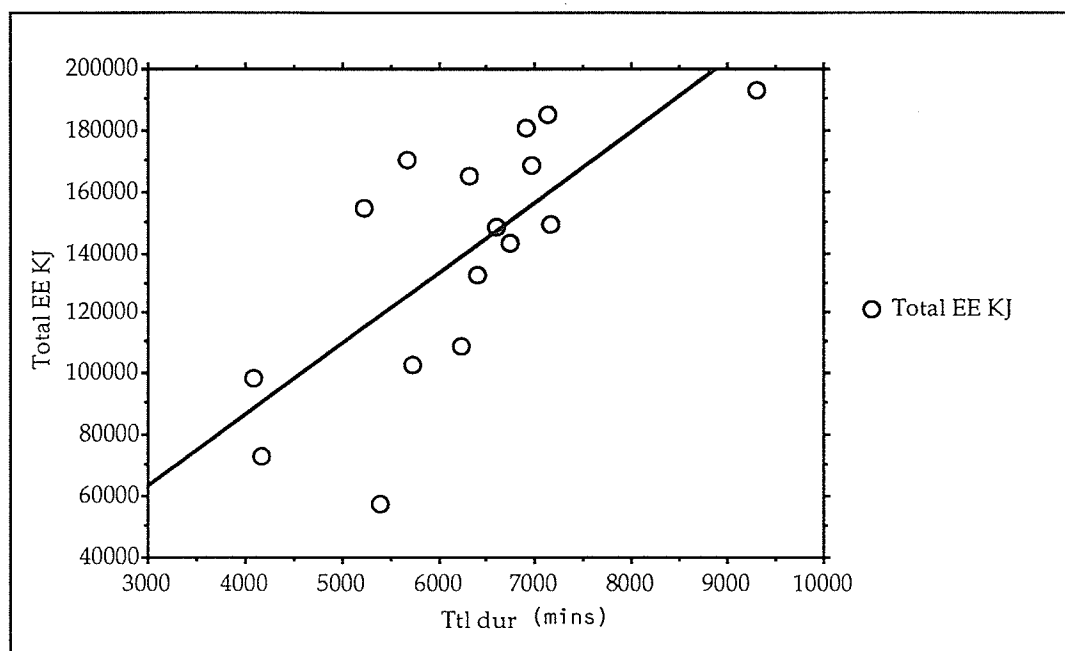


Figure 4-25. Relationship between total duration and total energy expenditure (n = 16).

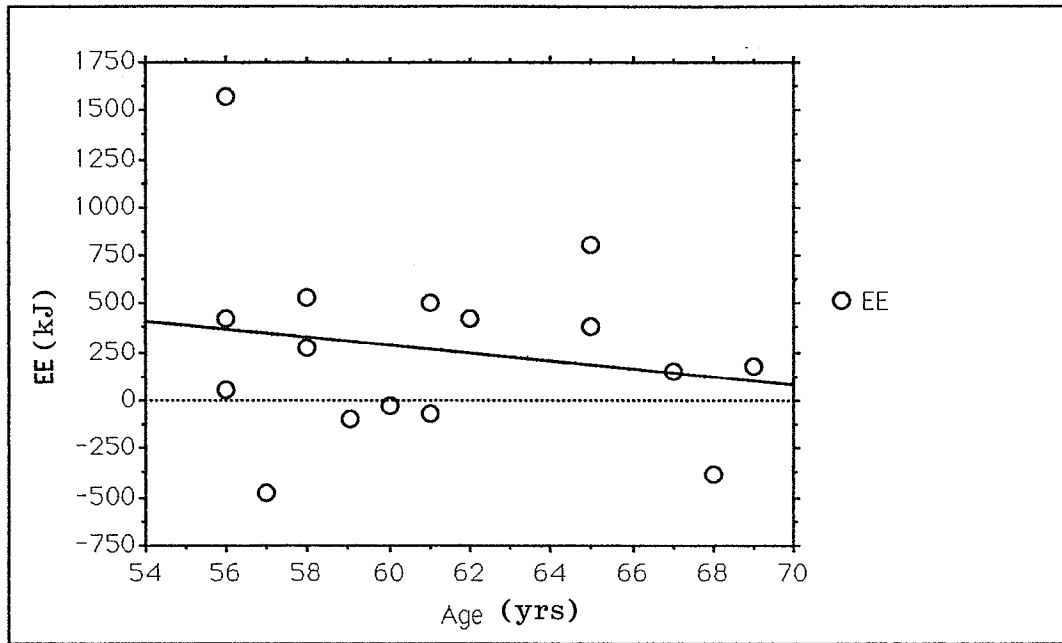


Figure 4-26. Relationship between change in EE and age (n = 16).

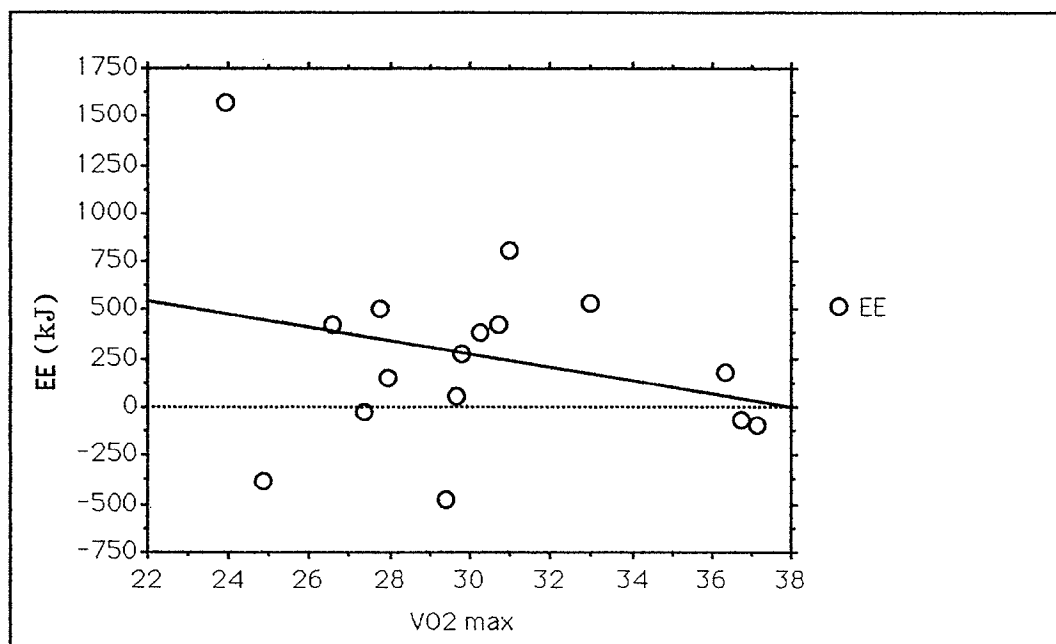


Figure 4-27. Relationship between change in EE and initial $\text{VO}_2 \text{ max}$ ($n = 16$).

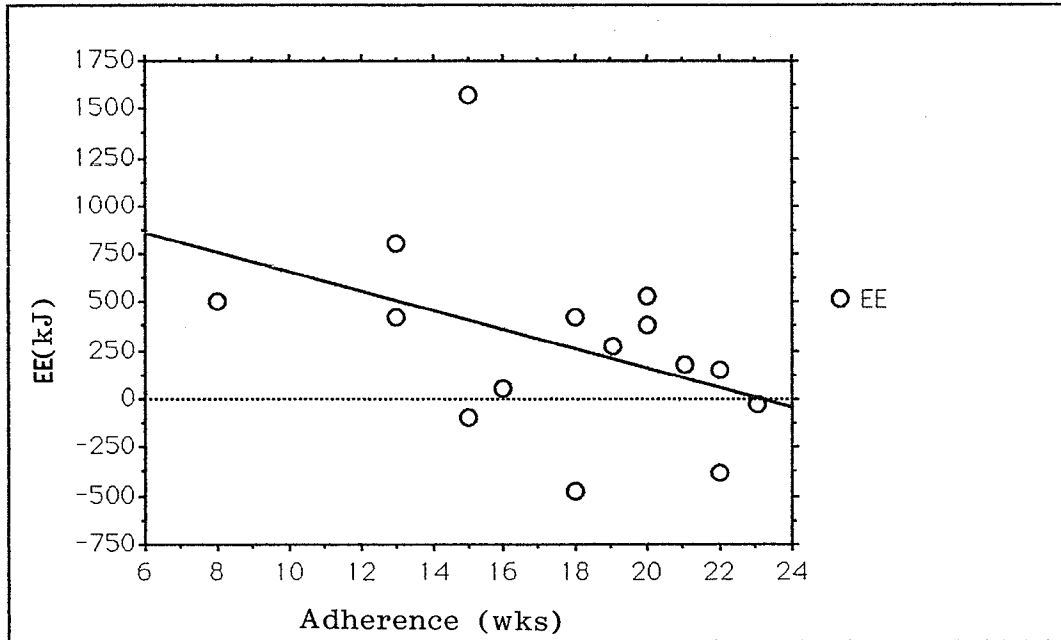


Figure 4-28. Relationship between change and EE and adherence (n = 16).

Chapter 5

Discussion

Introduction

This chapter will focus primarily on descriptive data pertaining to exercise prescription as well as on the effects of age, VO_2 , adherence, and injury on training progression.

Despite cardiovascular health gains associated with regular exercise in older adults, guidelines for exercise prescription for the elderly are not well documented. The ACSM guidelines (1990) recommend aerobic exercise for 20 to 60 minutes, 3 to 5 days per week, at an intensity of 60 - 90% of maximal heart rate, or 50 to 85% of maximum oxygen uptake ($\text{VO}_2 \text{ max}$) or heart rate reserve (HRR). These guidelines make only one recommendation with regards to the elderly in that a longer training adaptation period is required. It is also unclear as to what activity threshold is required for an improvement in fitness level (VO_2) versus actual health benefits (i.e. weight loss, decrease in total cholesterol, LDL-C, triglycerides, increase in HDL-C, bone density, and psychological benefits).

The purpose of this study was to determine the rate of training progression during a walking program involving elderly women with slightly elevated cholesterol levels. The rate of training progression was quantified by documenting frequency, distance,

duration, intensity (speed, time at target heart rate), and energy expenditure. These variables were examined in relation to age, initial fitness level (VO_2), adherence, and injury. Exercise prescription guidelines related to fitness and health benefits were also examined.

Subject Characteristics

Sixteen sedentary postmenopausal women with mildly elevated serum cholesterol (5.9-8.0 mmol/L) served as subjects in this study. The participants ranged in age from 56.0-69.0 years with an average age of 61.1 years. Initial VO_2 values ranged from 23.9-37.2 ml/kg-min with a mean value of 30.2 ml/kg-min, slightly above average for this population.

Elevated total cholesterol (CHOL) and LDL-C, as well as low levels of HDL-C are risk factors for CHD (Astrand, 1991). Women are also at increased risk for CHD following menopause as decreased estrogen leads to unfavorable changes in serum lipids including a rise in LDL-C and a possible decrease in HDL-C (Matthews et al., 1989). Therefore the women involved in this study were in a high risk group for CHD due to their elevated cholesterol levels, sedentary lifestyle, and postmenopausal status.

Use of Log Books to Record Training Data

The main focus of this study was to document and examine training progression variables over a 24 week walking program. The

variables recorded include distance (km), duration (min), frequency, intensity (velocity (m/s), time at target heart rate, percent time at target heart rate, actual percent of target heart rate), and energy expenditure (kJ). Results include overall totals, weekly totals, average values per week, and average values per session. Percent change over time was also documented in order to see actual change over each of the 24 weeks.

Walkers recorded frequency walked, distance (km), duration (min), and time at target heart rate for each walking session in a personally assigned log book. Personal target heart rate values were listed at the front of the log book (a 15 second count). Participants were informed of the importance of recording accurate values in the log books. All log books were kept in order and were found to be well documented and organized after the 24 week program. The majority of log books in our study were found to be complete and only a few pages appeared to be missing. The use of log books for this study was therefore an effective mode of documenting results over a prolonged time period.

Walkers were also encouraged to record comments related to environmental, physiological, and psychological conditions. Many of these comments related to psychological aspects of the walking program. Comments regarding energy levels, self-esteem, and day to day living were documented by the women. Although the area of psychological benefits related to exercise is a small part of this particular study, it is obviously an important one and requires future research. It was clear that many of the subjects attained mental benefits from their regular walking routine. Log books may

have served as a motivational tool as participants knew they were being monitored.

Prior studies have used self-recorded log books to document results (Seals et al., 1983). McAuley and Jacobson (1991) had female subjects complete and return weekly logs detailing all aerobic activity participation both in and out of exercise classes for 8 weeks. This addressed their concerns regarding the general assumption that nonattendance equates with nonparticipation in exercise behavior. Their results demonstrated that subjects participated in exercise programs on their own as well attending exercise classes.

Klesges et al., (1989) investigated the accuracy of self-reports of physical activity compared to observations obtained surreptitiously. Results indicated that their subjects were accurate in recording their physical activity levels but underestimated sedentary activities and overestimated aerobic activities by over 300%. Males overestimated their activity relative to females, and obese subjects underestimated their activity levels compared to normal weight subjects.

This raises the topic of individual perception of intensity as opposed to actual intensity. This needs to be taken into consideration when prescribing exercise, especially to a sedentary older adult. Many subjects in our study perceived their walking intensity to be moderate or high when in fact they hadn't achieved the target heart rate. This occurred more so at the onset of the study when sedentary participants were beginning the walking program. Specific target heart rate guidelines may need to be given

in order to ensure that the participant is achieving the recommended intensity as opposed to what they perceive as being an intense training session.

Program Length

At the onset of this study it was not known what constituted a realistic and achievable exercise prescription for the women involved. Many previous longitudinal studies involving the elderly have been shorter term ranging from 9 weeks (Badenhop et al., 1982), to 12 weeks (Jette et al., 1988), or 16 weeks (Adams et al., 1973; Steinhaus et al., 1990; Posner et al., 1992) . Other studies have continued for a prolonged time period and include 12 month training programs (Seals et al., 1984; Hardman et al., 1989; Kohrt et al., 1991; Probart et al., 1991). Sidney and Shephard (1978) also trained elderly subjects for 52 weeks in a long term exercise intervention study.

Twenty four weeks appeared to be sufficient time to document and monitor changes in training variables, however, a longer time period may have resulted in further changes in variables that may take a longer time to adapt (i.e. weight loss and management, serum lipids, or energy expenditure).

Walking Frequency

This study set a predetermined goal of 5 walking sessions per week, one hour per session at 60% HRR. Subjects were encouraged to first increase their frequency, then duration, followed by intensity. This amount of 5 times per week for one hour each session was more than the traditional prescription for fitness benefits (ACSM, 1990). Whether the participants could actually walk this often was unclear at the onset of the study.

The results indicate that the average frequency for week one was 4.5 times followed by 5.1 for week two (Table 4-4). These results are consistent for the 24 week period as walking frequency ranges from 4.4 to 5.3 times per week with an average of 4.9 times for the total 24 week period. Although the average is close to five times per week there was a fair amount of variability with some subjects walking close to three times per week and others close to 6 times times per week.

Overall, it appears that a frequency prescription for elderly females involved in this study of five times per week is reasonable and attainable. This may be explained by the fact that subjects were first encouraged to increase frequency before duration and intensity. This is further reinforced by the fact that there were only three minor injuries related to the walking program and that these occurred further on in the program. As the ACSM (1990) guidelines state that elderly participants need longer periods of time to adapt to the initial rigors of training, the results of this study indicate that this longer adaptation period may apply to

duration and intensity more so than frequency, and that in fact a walking prescription of five times per week is achievable fairly early in the program.

Frequency is an important variable in exercise prescription for the elderly. The frequency of exercise required for fitness benefits (VO_2) may be different than that required for certain health benefits. Owens et al., (1991) found that a walking frequency of three times per week for 20 minutes was not sufficient to produce an increase in HDL-C but was sufficient to support less weight gain over time than in nonactive women, as well as mental health benefits for their female subjects. Posner et al., (1992) documented a significant increase in VO_2 as well as decreased body weight, body fat, and resting systolic and diastolic blood pressure with an exercise frequency of three times a week. There were, however, no changes in resting heart rate or blood lipid values, the latter suggesting an increased frequency threshold for some health as compared to fitness gains. An increase in VO_2 involving a frequency of three times per week has been well documented (Posner et al., 1992; Seals et al., 1984; Probart et al., 1991). Other studies have found no additional improvement in VO_2 max when training more than three times per week (ACSM, 1990).

Significant health gains have been reported with a training frequency of four times each week (Sidney & Shephard, 1977; Kohrt et al., 1991), while Duncan et al., (1991) reported improvements in the lipoprotein profiles of women who walked five times each week during a moderate paced training program.

The results of our study indicate that a frequency of five times per week is adequate for significant gains in VO_2 max ($p = 0.0001$) as well as small but significant decreases in weight ($p = 0.0086$) and total cholesterol ($p = 0.0004$). It was not sufficient for body composition changes or other changes in the lipoprotein lipid profile. The initially elevated total cholesterol (TC) values of the subjects likely explains the significant decrease in this variable. The fact that these women were postmenopausal likely explains any lack of change in HDL-C values.

As mentioned previously, the ACSM (1990) guidelines recommend a frequency of 3-5 times per week. It appears that if one's goals are mainly to improve fitness level, then three times per week may be adequate. If goals extend into other health benefits then a greater frequency may be necessary.

Our results indicate that the lack of health changes may be related to energy expenditure. Regression analysis showed that although frequency was not significantly related to energy expenditure, there was a linear trend. Therefore frequency would have to increase in order to accommodate the great energy expenditure required for added health benefits. It would be difficult to expend a vast amount of energy during three exercise sessions per week as duration would be required to increase dramatically. An increase in frequency to five times per week would keep duration to a realistic time allowing for an increase in energy expenditure.

Walking Duration

The prescribed walking duration (minutes) was one hour per session, resulting in a total amount of 300 minutes each week. This amount was never quite achieved by the group, with a maximum average of 299.0 minutes during week 17 (Table 4-4). The duration for week one was the lowest at 203.8 minutes but saw a 29% increase between weeks one and two as duration increased to an average of 262.4 minutes. This increase may be due to the fact that week one was the introductory week and participants required some adaptation time to get started. The second largest increase occurred between weeks 19 and 20 with a 21% increase in duration.

It therefore appears that a prescribed duration of 300 minutes per week was within reach but not quite attainable by the participants. One explanation for this may be that subjects were also encouraged to increase their intensity to try to achieve their target heart rate. Even though participants were told to increase duration before intensity, it is possible that duration was compromised in order that intensity could be increased. It is also possible that subjects perceived a lack of time in their personal schedule to complete this one hour requirement on a regular basis.

It is interesting to note that the average duration of the supervised sessions ranged from 39.2 minutes (week one) to 62.6 minutes (week 23) and was consistently high for the weeks in between (Table 4-7). The percent change between weeks for the supervised sessions was more consistent than for the unsupervised sessions with a 42% change between weeks one and two and low

percent changes for the remaining weeks. The 60 minute prescription was achieved during several of the supervised sessions whereas the average duration per each unsupervised walking session was 53.4 minutes (Table 4-3).

This may be explained by motivational and environmental reasons. It is possible that subjects were more highly motivated when they were being monitored as opposed to walking on their own (McAuley & Jacobson, 1991). It is also possible that environmental conditions for the indoor track were better than those elsewhere. Although participants were encouraged to walk indoors, some continued to walk outdoors and may have experienced environmental factors such as wind or ice which in turn may have limited the duration of the walking session.

Subjects walked an average of 6254.7 minutes over the entire 24 week period (Table 4-2). The significance of exercise duration for the attainment of health gains is described by Ballor and Keesey (1991) who found that for females, weeks of training and duration of exercise were significant predictors for changes in body mass, fat mass, and percent fat associated with aerobic-type exercise training. It is clear that exercise duration is related to changes in serum lipids and body composition and is an important component of exercise prescription involving health benefits.

Results of our study showed a significant correlation between total frequency and total duration of exercise ($r = 0.535$, $p = 0.0329$) with frequency being a good indicator of duration.

Walking Intensity

The prescribed walking intensity was 60% heart rate reserve (HRR). This falls within the intensity prescription recommended by the ACSM (1990) guidelines which is 60-90% of maximal heart rate (HR max) or 50-85% of maximum oxygen uptake (VO₂ max) or heart rate reserve (HRR). Sixty percent HRR was selected for this elderly group as it falls in the lower range of the ACSM prescription and would appear to be a safe and effective intensity. Intensity is a key issue in exercise prescription with regards to both fitness and health related benefits (Duncan et al., 1991).

The training intensity prescribed in our study was slightly higher than that prescribed by other studies. Posner et al., (1992) conducted a 4 month exercise intervention program of supervised low to moderate intensity exercise (prescribed training heart rate = 115 beats per minute $\pm$ 15 or about 45% MHRR) in a home program with 247 previously sedentary older men and women. The subjects experienced an 8% increase in VO₂ max, significant decreases in systolic and diastolic blood pressure, a slight increase in lean body mass, and a small change in ventilatory threshold (VeT). However total cholesterol and HDL-C did not change and there was a decrease in VeT/VO₂ max.

Badenhop et al., (1982) concluded that exercising at a lower intensity (30-45% HRR) was an adequate training stimulus in older individuals and produced changes in VO₂ max that were comparable to those elicited by high intensity (60-75% HRR) training (about a 16% increase in both groups). One explanation given for their results

was that the subjects had fairly low initial VO_2 max values compared to other studies such as that concluded by Sidney and Shephard (1978). Studies that prescribed a higher intensity for their exercise intervention programs have documented larger increases in VO_2 max than lower intensity studies (Seal et al., 1984; Sidney & Shephard, 1978).

Subjects with above-average aerobic capacities for their particular age may not show improvement with further training at lower intensities; however, subjects with lower initial capacities will likely respond to lower levels of exercise intensity because these levels represent a substantial increase in daily caloric expenditure (Badenhop et al., 1982).

A minimal intensity threshold appears to be the main factor involved in improvements in VO_2 max. Intensity may therefore be more important than energy expenditure for fitness benefits associated with regular exercise. Badenhop et al., (1982) reported that even though training heart rate intensities were considerably different between two groups (LI=38% HRR; HI=59% HRR), their training intensities based on VO_2 max (LI=57%; HI=70% VO_2 max) were both above the threshold indicated to produce favorable changes in aerobic capacity.

Participants walked at an average of 54% HRR which is above the minimal threshold of 50% HRR recommended by the ACSM (1990) guidelines and demonstrated an overall 10% increase in VO_2 max values for the 16 subjects (Table 4-1). This increase appears to be lower than the average change reported in the literature. Low intensity studies (Posner et al., 1992; Badenhop et al., 1982)

documented an 8% and 16% increase in VO_2 max, respectively. Intensity of these studies ranged from 38-59% HRR. Higher intensity studies document changes in VO_2 max ranging from 23-29% (Kohrt et al., 1991; Sidney & Shephard, 1977; Pollock et al., 1971; Steinhaus et al., 1990), an increase much higher than reported by our study.

Intensity was monitored by calculating the time spent at target heart rate in absolute and percent values (Tables 4-2 to 4-5). Actual percent of target heart rate was calculated for the 24 supervised sessions (Table 4-7) to determine how far below the prescribed intensity of 60% HRR the subjects were. Speed was also recorded over the 24 week period as an indicator of intensity and was used to calculate energy expenditure (Table 4-6).

Time at Target Heart Rate

The average duration walked over the 24 week period was 6254.7 ± 1252.7 minutes while the average time at target heart rate was 1638.3 ± 1596.0 minutes (Table 4-2). The average duration per session was 53.4 minutes while the average time at target heart rate was 21.3 minutes (Table 4-3). This demonstrates that the subjects walked at their target heart rates for about 40% of their total walking session, a lower amount of time than predicted. Although this amount is lower than expected, subjects were actually walking at 85-90% THR (54% HRR) for the majority of the study and were very close to 60% HRR. This amount (54% HRR) is above the minimal threshold recommended by the ACSM (1990).

Average total time at target heart rate for each of the 24 weeks is very inconsistent and ranges from 72.6 ± 83.0 minutes for week one to 113.0 ± 104.4 minutes for week 19 (Table 4-4).

Percent time at target heart rate was calculated to demonstrate the actual percent of total time each subject was spending at their individual target heart rate. Percent time at target heart rate ranged from 25% at week 9 to 52% at week 5. These results were quite unusual as one would normally expect the percent time spent at target heart rate to increase gradually during each session as the subject became more fit and found it easier to achieve target heart rate.

These unusual results may be explained by the fact that intensity was the last variable to be encouraged after frequency and duration and was therefore not attained by the participants. This however would not explain the inconsistencies throughout the total 24 weeks as one would still expect the percent time at target heart rate to increase at some point in the study after frequency and duration were attained. Although duration was never quite achieved it was closely reached near the onset of the program and intensity should have been attained at some point thereafter.

Another possible explanation would be that the prescribed target heart rates were too high for the participants. This would appear to be on an individual basis as some subjects progressed to target heart rates while some never achieved it throughout the entire 24 weeks. As previously mentioned, many of the women were quite fit when beginning the program. These women may have been too fit to reach their THR as their pace would have increased from a fast walk

to a run. Since their initial resting heart rates were lower than the average population they would have to work at a much higher intensity and a greater speed to achieve THR. Many of these women were already walking at speeds close to 6.0 km/hr (3.8 mph) and would have found it almost impossible to walk at a higher intensity without running.

The actual percent of target heart rate achieved was calculated for the 24 supervised sessions to account for the individuality of each target heart rate for all 16 subjects. As it appeared that the intensity of the supervised sessions was higher than the unsupervised sessions the percent of actual target heart rate achieved would probably be lower than the values listed in Table 4-7 for the supervised sessions. These values range from 85.5% for week one to 91.3% for week 21.

These values are very consistent for the entire 24 weeks and show a slight but nonsignificant increase in actual % of target heart rate achieved. The actual % of target heart is equal to 60% HRR for each individual. The average value for the 24 week period was 90% of target heart rate or 54% HRR. Therefore the participants walked at an average of 54% HRR for the 24 supervised sessions and probably at a slightly lower intensity for the unsupervised sessions. This is 6% lower than the prescribed intensity of 60% HRR. Therefore, although the intensity prescription was not achieved by all 16 subjects, the amount attained (54% HRR) was still within the ACSM (1990) recommendations for cardiovascular benefits.

Measurement error may have affected these results as heart rates were self measured and recorded at 15 minute intervals over

each one hour session. Although the Sport Tester confirmed reliability, many of the subjects disliked taking and recording heart rates.

Walking Distance

The average distance walked was 569.5 ± 201.5 km (Table 4-2) for the 24 week period while the average distance walked per session was 4.9 ± 1.7 km (Table 4-3).

Average distance (km) walked per week ranged from 17.4 ± 11.3 km for week one to 30.2 ± 16.2 km for week 20. Average distance walked per session for each of 24 weeks ranged from 3.8 ± 1.9 km for week one to 6.3 ± 4.2 km for week 20. The largest percent change was found between weeks 19 and 20 where a 21% increase occurred. Otherwise the percent change between weeks remained low and fairly consistent (Table 4-5).

The average distance walked for each of the supervised sessions ranged from 3.4 ± 2.0 km for week one to $6.0 \pm .6$ km for week 24. This represents a substantial increase as the distance walked almost doubled from the beginning to the end of the study. A probable explanation would be that as walking velocity consistently increased, the participants were able to cover more distance. It appears that the distance walked during the supervised sessions increased at the immediate onset of the study while distance did not increase as much for the unsupervised sessions. Although the largest average distance covered was 6.3 km during week 20 of the unsupervised sessions, the supervised sessions showed a more

consistent and larger increase in distance covered over the 24 week period.

Interaction of Intensity, Duration and Distance

The combination of frequency, intensity, and duration of chronic exercise has been found to be effective for producing a training effect. the interaction of these factors provide the overload stimulus (ACSM, 1990). The results of this study indicate that duration and distance are closely related while intensity fluctuates in relation to these variables.

Although time at target heart rate, percent time at target heart rate, and actual percent of target heart rate did not appear to consistently increase, duration (min), distance (km), and velocity did consistently increase throughout the 24 weeks. These results are further demonstrated by documenting an actual percent change for each of the 24 weeks for average duration, average distance, and average time at target heart rate (Table 4-5). Percent change is also documented for these same variables for each of the 24 supervised sessions (Table 4-7).

Both duration and distance follow a similar pattern over the 24 weeks with a sharp increase during week two, a slight decrease during week three, and then a fairly consistent pattern with percent changes ranging from -7 to 9%. Percent change for time at target heart rate followed a slightly different pattern with a similar initial increase during week two and a fairly inconsistent pattern for the remainder of the 24 week period. Percent change for time at

target heart rate ranged from -46 to 140%, demonstrating a large variability between the time each subject spent at target heart rate.

When comparing the percent changes between duration, distance, and time at target heart rate our results indicate an increase in time at target heart rate when there is a consistent level or slight increase or decrease in duration and distance. Also in opposition, time at target heart rate may slightly drop when duration and distance are at a higher level (Figures 5-9, 5-10, 5-11). This may be explained by the fact that when walking duration and distance are consistent, the intensity (time at target heart rate) is increased by the walkers. The same would explain the reverse in that when duration and distance are at a higher level, the intensity level drops. These results suggest an inverse relationship between walking distance and duration and walking intensity (Porcari et al., 1989).

With increased intensity the participants would be walking at an increased velocity and therefore also increasing their energy expenditure per minute. However, since the walkers were encouraged to first increase frequency, then duration, then intensity, one would expect the percent change of all three variables to consistently increase at the end of the 24 weeks as all three goals were attained. Although a gradual increase is not seen, there is a more consistent leveling off at week 22 when all three variables remain at similar levels.

Effect of Supervision

As mentioned previously, participants were required to attend one supervised session per week for the 24 week walking program. The purpose of these sessions was to monitor subjects and confirm that participants were following the program and accurately recording results in their log books. Walking speed was timed and recorded for each subject during this time.

The number of sessions attended out of 24 served as an indicator of adherence. Participants handed in log book pages and were given the opportunity to discuss any concerns or injuries they may have sustained during walking. The sessions also served as a motivational tool as walkers were encouraged to walk to their full potential. The women may also have been motivated by the social aspect of meeting up with other participants.

Although supervision did not predict compliance, walking data may have been more accurate for these sessions than for the nonsupervised sessions (Table 4-7). As the environment was constant, exact distance could be calculated as opposed to calculating unsupervised distance in other locations. Heart rates were monitored consistently every 15 minutes and the Sport Tester was used on several occasions to check accuracy of palpation.

The results obtained during the supervised sessions demonstrated larger increases in some exercise prescription variables than the nonsupervised sessions. Both distance and duration were greater and more time was spent at target heart rate.

Probart et al., (1991) reported significant fitness gains among elderly women (mean age 72.0 years) after treadmill walking three times each week for 26 weeks under supervision. Contrary to our results, supervision was a significant indicator of compliance as 100% of their subjects completed the study with no injuries.

Although supervision appears to have an effect on the accuracy of reported data, the majority of studies utilize minimal supervision (Kohrt et al., 1991; Thomas et al., 1985; Seals et al., 1984). Even though control is crucial for valid and reliable studies, complete supervision for the general public is unrealistic. Due to cost, availability of trained supervisors, accessible locations, time management problems, and numerous other factors it is unlikely that the majority of the exercising public can train under supervision.

Supervision appears to have a psychological effect on participants that affects their physiological response to exercise and may motivate them to exercise at a greater potential. Supervision may also allow for greater accuracy of recorded data in a controlled environment. The effect of supervision is a significant topic that requires further research.

Velocity and Energy Expenditure

Velocity increased consistently over the 24 week period. Energy expenditure (kJ) was individually calculated from the velocity values and duration walked for each subject. This was based on previous research which concluded that walking speed is the most

important determinant of the energy cost of level walking when body weight is held constant (Blessey et al., 1976). The relationship between walking speed and energy cost is linear at speeds approximating 4 to 6 km/hr, and becomes curvilinear between 6 and 8 km/hr. At any given speed, the relationship between energy cost and grade is linear. These relationships allow the prediction of energy expenditure using regression equations (Ebbeling et al., 1988).

The results of this study are consistent with other walking studies that monitored an increase in speed over time. Thomas et al., (1985) stated that an increased ability by elderly male participants to perform aerobic activity was indicated by a progressive increase in average speed of walking. Cunningham et al., (1986) also documented an increase in the normal walking speed of elderly men during a one year training program. The average speed of walking has been used to describe intensity of walking (Thomas et al., 1985; Zarrugh & Radcliffe, 1978; Blessey et al., 1976; Waters et al., 1988).

Average total energy expenditure was 139518.1 kJ (33,333.7 kcals) over the 24 week training program. This amount is equivalent to an average of 5813.25 kJ (1388.9 kcals) for each of the 24 weeks (Table 4-2). Total energy expenditure per week was significantly greater ($p = 0.00457$) for the final weeks (21-24) of the study with a mean of 6486.5 kJ (1549.8 kcals) compared to the initial weeks (2-5) mean value of 5372.1 kJ (1283.5 kcals), a difference of 1114.4 kJ (266 kcals).

The average energy expenditure per minute was 22.2 kJ (5.3 kcals/min) for the entire program (Table 4-2). These results are similar to a walking study by Hardman et al., (1989) whose subjects had an estimated weekly energy expenditure of 3139.1 kJ (750 kcals) to 6278.3 kJ (1500 kcals) over a 12 month program. Females involved in a walking or cycling program conducted by Ballor and Keeseey (1991) had an average weekly energy expenditure of 3892.5 kJ (930 kcals) for the walkers and 3243.8 kJ (775 kcals) for the cyclists. Kohrt et al., (1991) monitored walkers for 9 months and documented gradual increases in energy expenditure per week; from 4043.2 kJ (966 kcals) at month 3, 4542.3 kJ (1085 kcals) at month 6, and 5227.7 kJ (1249 kcals) at month 9.

Sidney and Shephard (1977) conducted training sessions with elderly men and women and estimated that weekly energy expenditure increased progressively over the 14 weeks from 3013.6 kJ (720 kcals) to 5022.6 kJ (1200 kcals). In a cross sectional study with middle-aged women, Owens et al., (1990) found that the mean kilocalorie exercise energy expenditure for a one week period was 1408 kcals (5893.2 kJ) and that in general, the women in the sample were participating in only moderately strenuous activities such as walking. Owens et al., (1991) documented that women during menopause who expended about 300 kcals (1255.7 kJ) per week experienced no significant change in their HDL-C over a three year period. However it should be noted that a control group who decreased activity below 300 kcals (1255.7 kJ) per week experienced a decline in HDL-C.

Astrand (1991) and Paffenbarger et al., (1990) state that one requires an extra weekly energy output of approximately 8371 kJ (2000 kcals) for better health. This energy expenditure is a combination of 60 minutes of daily physical activity (5 times per week), not necessarily vigorous or continuous (1255 kJ or 300 kcals), combined with exercises, 30-45 minutes, three times per week (3139 kJ or 750 kcals). This combination of unstructured and structured activity will exceed the recommended 8371 kJ (2000 kcals).

Small but significant health gains were achieved during our study including a decrease in body weight ($p = 0.0086$) as well as total serum cholesterol ($p = 0.0004$). The fact that no other significant changes occurred in lipoprotein profile may reflect the postmenopausal status of the women, or the total energy expended. Average weekly energy expended was 5813.25 kJ (1388.9 kcals), therefore it appears that a greater amount may be required for other health related changes. The difference between our energy expenditure results and Astrand's recommendations is an additional 2558 kJ (600 kcals) per week which would necessitate an additional two walking sessions. Energy expenditure in this study was sufficient for fitness-related (VO_2) changes.

Average velocity for the participants in this study started at about 5.5 km/hr for week one and increased to 5.6 km/hr during week 7. Velocity continued to gradually increase and reached 6.0 km/hr at week 22 where it remained for the final two weeks of the study. Percent change ranged from 0-2% throughout the 24 weeks and was consistently positive. Energy expenditure/minute also

gradually increased each week over the 24 week training period due to an increase in walking velocity.

Participants expended an average of 20.8 kJ/min (4.97 kcals/min) during week one and progressed to 23.5 kJ/min (5.6 kcals/min) during week 24. Percent change also remained positive and ranged from 0-2%. Average total energy expenditure ranged from 4179.0 kJ (998.4 kcals) for week one to 6707.0 kJ (1602.0 kcals) for week 24 but did not progress as consistently as velocity and energy expenditure/min.

Velocity and energy expenditure/minute results demonstrate a gradual progression which would be related to the exercise prescription guidelines given to the subjects. These results suggest a gradual increase in intensity despite lack of increased time at target heart rate.

Walking Thresholds for Gains in Fitness and Health

The energy expenditure required to elicit specific physiological and health benefits remains to be determined. The energy expended by these women is consistent with the literature and the ACSM (1990) guidelines concerning the recommended amount of energy expended per week to achieve fitness benefits. It is however, still below the value it would have been if participants had completed the predetermined amount of walking. This may be of importance when considering the main goals of the participants involved in a walking program. If goals are to gain cardiovascular benefits such as an increased VO_2 max, then an exercise prescription with the

above mentioned weekly energy expenditure may be more than sufficient. These goals are more closely related to intensity than energy expenditure. If goals are geared towards health benefits or to reduce risk factors associated with CHD, then the energy expenditure required may be greater than that of this study.

Losses in body mass are related to total caloric expenditure (Porcari et al., 1989). Ballor and Keeseey (1991) state that exercise-induced changes in body mass, fat mass and percent body fat can be generally accounted for by pre-intervention body mass and exercise energy expenditure and state that these factors play an important role in determining the effects of exercise training on body weight and composition. They also state that it is important to note that there may be large individual variations in the response to different exercise stimuli, some of which may be genetic.

Porcari et al., (1989) found that if dietary patterns remained unchanged, as they did with this particular study, walking can result in moderate decreases in body mass which are directly related to energy expenditure. When walking is combined with a weight loss diet, the greatest proportion of weight loss comes from stored fat while lean body mass (LBM) is maintained. The ACSM (1990) states that walking programs designed primarily for weight loss should emphasize longer duration and lower intensity.

The ACSM (1990) recommends an intensity of 50 to 60% of VO_2 max, with duration gradually increasing to expend 200 to 500 kcals (837 to 2092 kJ) per session. While exercising three to five times per week is recommended, 5 to 6 times per week is optimal. Therefore if one considers weekly energy expenditure it ranges

from 4186 kJ (1000 kcals) to 12,557 kJ (3000 kcals) per week, with the high end of this range being a greater than average amount prescribed for the elderly female.

The average amount of energy expended per each walking session in this study ranged from about 837 kJ (200 kcals) at the onset to 1339 kJ (320 kcals) at completion (Table 4-6). This is in the range of 200-500 kcals/session recommended by the ACSM (1990).

Although the amount of weight loss experienced by our subjects was significant, it was small. As our subjects walked about 5 times per week for an average duration of 53.4 minutes each session, at about 54% HRR, one would expect them to lose weight as well as achieve numerous health benefits and reduce CHD risk factors.

Our results show a significant correlation between total duration and total energy expenditure ($r = 0.719$) as well as total distance and total energy expenditure ($r = 0.484$). This is almost self explanatory as the greater distance walked as well as the longer the duration spent walking, the more energy would have to be expended by an individual to accomplish this. Although the relationship between total frequency and total energy expenditure was not significant, it followed a similar linear pattern.

Change in total energy expenditure per week was not significantly related to age, fitness level or adherence.

Influence of Age on Training Progression

Age was not significantly related to any walking program variable, with the exception of intensity. This is in agreement with

results of Kohrt et al., (1991) who found a weak nonsignificant association between improvement of VO_2 and age. Our results are also similar with those of Cunningham et al., (1982) who found that speed of walking was not related to age. It should be noted that the relatively young age (average 61.1 years) of our subjects may have been a contributing factor which may have influenced our results.

In a simple regression analysis, age was significantly and negatively correlated with total percent time spent at target heart rate ($r = -0.515$). Therefore the older the participants were, the less time they spent at target heart rate. These results imply that age may be inversely related to intensity, and that the older the participant the less able they are to walk at a given high intensity.

These results agree with those of Elia (1991) who states that more than for other age groups, activity programs for elders must be tailored to the individual's age, fitness level, and health status. General principles cannot be applied to the elderly without modifications. Most elderly people will find it difficult at first to maintain vigorous activity over a 30 minute session. Inactivity will also lead to an inability to approach an exercise intensity equivalent to 60% of maximal oxygen uptake. In these individuals a lower intensity of exercise should be initiated at 50% maximal oxygen uptake.

The ACSM (1990) recommends low to moderate intensity training with longer duration for most older adults. The minimum training intensity threshold for improvement in VO_2 max is approximately 60% of the HR_{max} or 50% of VO_2 max or HRR. As a result of the age related change in maximum heart rate, the absolute heart rate to

achieve this threshold is inversely related to age and can be as low as 105-115 bpm for older persons.

As age was not significantly related to frequency or duration, and all participants were close to achieving the prescribed amount, either the intensity of 60% HRR was too high for this subject population, or this particular group was unable to achieve an otherwise realistic intensity prescription. As many studies have shown elderly women to successfully achieve higher intensities (Sidney & Shephard, 1977), it may be that these particular women did not walk at a high enough intensity. This may also be explained by the fact that this prescribed walking program of 5 days per week for 60 minutes each session was in itself an adjustment with intensity not being a priority to the walkers.

Initial fitness level of our subjects may also help explain their inability to consistently attain target heart rate. As many of the women were quite fit when beginning the program, they may have actually had to jog to reach their target heart rate.

Age was not significantly related to any of the other variables in question (distance, duration, frequency, or energy expenditure and was not a good predictor for the change in VO_2 max after 24 weeks.

Influence of Initial Fitness Level on Training Progression

Initial level of fitness (VO_2) has been shown to be an indicator for exercise prescription guidelines, especially when dealing with the elderly (Elia, 1991; Seals et al., 1984). The ACSM (1990) guidelines state that initial level of fitness, along with age, is an

important consideration in prescribing exercise. The person with a low fitness level can achieve a significant training effect with a sustained training heart rate as low as 40-50% of HRR, while persons with higher fitness levels require a higher training stimulus. Steinhaus et al., (1990) state the amount of improvement in a fitness program may be dependent upon initial fitness levels (i.e. the less fit, the greater the improvement).

Contrary to the literature, initial fitness level of our subjects was not significantly related to any of the other walking variables (change in VO_2 , intensity, distance, duration, frequency and energy expenditure).

The initial average VO_2 max score of the 16 women was 30.2 ± 4.0 ml/kg/min and increased to 33.3 ± 4.9 ml/kg/min after the 24 weeks of training, showing an approximate 10% increase. Out of all 16 subjects, 9 had initial VO_2 max scores that ranged from 23.9-29.8 ml/kg/min. The remaining 7 had scores above 30 that ranged from 30.2-37.2 ml/kg/min. Contrary to the literature, the three largest gains were seen in three of the scores in the above 30 ml/kg/min group.

Badenhop et al., (1983) found that subjects with lower initial capacities responded to lower levels of exercise intensity because these levels represented a substantial increase in daily caloric expenditure. Thomas et al., (1985) state that the best predictor of improvement in VO_2 max after one year of training in the elderly is their initial VO_2 max. A high activity level before entering a training program should reduce the increment in VO_2 max which is observed.

Porcari et al., (1989) state that energy cost data indicate that the intensity of walking can range from light to heavy, depending on the initial fitness level of the subject. This is in agreement with Jette et al., (1988) who found that the ability to achieve target heart rate was significantly related to VO_2 max. Porcari et al., (1989) also state that the walking speed required to achieve cardiorespiratory benefits is related to initial level of fitness.

Pollock et al., (1971) attributed an unusually large improvement in VO_2 max scores of 28% to the relatively low initial fitness level of the male subjects (VO_2 max = 29.6 ml/kg/min). Cunningham et al., (1982) found that VO_2 max was significantly related to speed of walking while age was not.

Sidney and Shephard (1977) found that variations of initial fitness among elderly subjects have little influence upon their response to a training program; presumably, the greater trainability of the least fit is counteracted by their unwillingness to take more than low frequency light intensity activity. Therefore even though most subjects may be sedentary when first recruited, it is quite likely that those who chose not to volunteer for the exercise program had an even lower level of initial fitness. This explanation may be relevant when looking at our 16 female subject population. Even though screening criteria included sedentary women, these women may have been more fit than those who would not be interested in an exercise intervention program. Most of the women involved were very busy and lead active lives, with many still involved in the work force. This may help explain the nonsignificant relationship between initial VO_2 and the exercise prescription

variables (duration, distance, frequency, intensity, and energy expenditure).

Relationship Between Age and Initial Fitness Level

Age and initial fitness level (VO_2) were found not to be related in this study ($r = 0.14$). This is unusual as there is usually a given relationship between age and VO_2 that must be accounted for in that there is a given decrease in VO_2 with an increase in age (Astrand, 1991; Seals et al., 1984). This may be explained by the fact that the subjects made up a small homogeneous group with similar characteristics. Subject's ages ranged from 56-69 years with an average age of 61.1 ± 4.4 years. The fact that the volunteers were generally more fit than someone from the average population may account for this particular age/ VO_2 relationship. The average VO_2 max was 30.2 ml/kg-min which appears to be above average. Kohrt et al., (1991) reported the initial VO_2 max values of subjects (average age 64.0 years) to be 21.6 ± 2.9 ml/kg-min. Steinhaus et al., (1990) documented similar VO_2 values for their elderly (average age 62.2 years) subjects (19.4 ± 5.7 ml/kg-min) along with Badenhop et al., (1983) who reported initial VO_2 values of 20.6 ± 3.8 ml/kg-min for elderly subjects.

Our results are similar to Duncan et al., (1991) who reported average initial VO_2 values of 30.6-32.4 ml/kg-min for female subjects. It should be noted that their subjects ranged in age from 20-40 years, further demonstrating that our particular subject population had higher than average initial VO_2 max values.

Influence of Adherence on Training Progression

The average number of supervised sessions attended was 17.5 ± 4.2 or approximately 73% of the 24 mandatory supervised sessions. Adherence was not significantly correlated with any of the training variables and was therefore not a good predictor of frequency, duration, distance, time at target heart rate, velocity, or energy expenditure.

Frequency may serve as another predictor of adherence and was entered into a simple regression analysis. Total frequency was significantly related to total duration ($p = 0.0329$). Therefore the more frequently the subjects walked, the longer their duration. Although not significant ($p = 0.0867$), frequency followed a similar trend with total energy expenditure in that the more frequently the subjects walked, the greater their total energy expenditure. Frequency was not significantly related to any of the other variables.

These attendance results appear to be a bit lower than those documented in similar studies. Pollock et al., (1991) had an attendance rate of $99.4 \pm 1\%$ ($n=17$) for their 26 week walk/jog training program with the elderly. Compliance to training (total number of sessions attended divided by total number of sessions possible) exceeded 85% for all three walking groups in a 24 week walking intervention program for women (Duncan et al., 1991). These results are similar to those of Posner et al., (1992) who recorded an attendance rate of 81% for 116 subjects during a 4

month cycling program. Steinhaus et al., (1990) recorded a 77% attendance rate during their 4 month aerobic conditioning program with older adults. Most studies document attendance as average frequency per week as opposed to total overall compliance. It should be noted that although our results suggest a lower adherence rate by definition of attendance of supervised sessions, our overall frequency average of 4.9 times/week is above the normal three times per week used in most studies (Thomas et al., 1985).

McAuley and Jacobson (1991) state that one of the more problematic issues in exercise adherence research is the definition of exercise behavior. A common approach is to monitor program attendance. However, absence from activity classes is not synonymous with nonactivity. These results support our findings that even though our supervised session attendance was only 73%, this doesn't mean that the participants were in fact not exercising, thus supported by the average frequency data of 4.9 times each week over the 24 week period.

An explanation for this may be that participants were not motivated to attend the supervised sessions at the University perhaps for time or parking inconvenience reasons. Some of the participants took extended holidays during which they maintained their walking and recorded results in their log books. Others may have preferred to stick to their individual walking routes even though all were encouraged to attend the supervised sessions.

Pollock et al., (1991) reviewed numerous studies involving the elderly and stated that it didn't appear that either age or program duration up to 72 weeks affected the average adherence rates. Other

factors may play a role in determining adherence to exercise training. Program or environmental factors such as social support from the spouse and/or family, the peer support consequent to participation in a group program, convenience, a conducive environment, socioeconomic status, injuries, feedback, and professional leadership have all been cited as factors affecting exercise adherence. However, most training studies do not report the strategies used to maximize adherence.

Steinhaus et al., (1990) state that long term adherence to a regular exercise program is generally poor and that drop-out rates may reach 50% or more after 6 months. Sidney and Shephard (1977) found that the attendance of their high frequency high intensity group did not drop off as the program continued past 6 months and the intensity of effort continued to increase progressively.

The attrition results in our study indicated that 18 out of the initial 24 subjects (75%) completed the 6 month walking program. However only 16 women completed all of the tests and information required over the 24 weeks. Two subjects were dropped as they failed to attend the final testing procedures due to personal reasons, two dropped out due to lack of motivation, three dropped the program due to illness, and one women passed away due to an unrelated illness.

These attrition results appear to agree with other similar exercise intervention studies. Pollock et al., (1991) kept 81% (17/21) of subjects involved in a walk/jog program for the elderly. Seals et al., (1984) retained 79% (11/14) of subjects who participated in a 12 month endurance training program. Two other

similar studies had a much higher rate of subject retention. Posner et al., (1992) retained 95% of participants involved in a 4 month cycle ergometer study while Probart et al., (1991) retained all 16 female subjects (100%) over 70 years of age throughout a 26 week moderate aerobic exercise program. It is interesting to note that these last two studies involved complete training supervision throughout the program.

Overall subject retention was fairly high considering the length of the program as well as the vigorous amount of exercise expected from the women.

Role of Motivation

Motivation is a current topic of research in the exercise adherence field. Motivation played a key role in our study, especially due to its longevity and the vigorous amount of walking required. McAuley and Jacobson (1991) point out that high levels of motivation are required to sustain an exercise program since exercise behaviors may be somewhat resistant to change. The initial interest and desire which encourage individuals to begin exercising may not be sufficiently strong to ensure maintenance over time. As initial motivation wanes, a number of real and perceived barriers including inconvenience, inaccessible program locations, work conflicts, lack of time and energy, and medical problems can hinder long-term exercise participation. However these reasons may actually be due to a lack of motivation, rather than reasons for inactivity.

One of the ways we tried to combat a possible lack of motivation was to give each participant their individual log book. Research has shown that log books are not only an efficient way to document results, but also serve as a motivational tool for participants who know they are being monitored (Klesges et al., 1989). A comment section was included on each log book page and it was interesting to read the detailed comments relating to the environmental conditions, and physiological and psychological aspects in regards to the walking program. There appeared to be a general consensus in improved mental health with relation to self esteem, confidence, and energy level.

Having one mandatory supervised session per week was thought to be an effective way of monitoring the participants as well as keeping them motivated by offering verbal encouragement on a regular basis. McAuley and Jacobson (1991) state that instructor enthusiasm and support significantly impact adherence to exercise regimens. The instructor or fitness leader (as in our case) can provide considerable information regarding progress or improvement which, according to psychologist Albert Bandura influences self-efficacy, as well as acting as an important source of social support or encouragement. Self-efficacy is defined as one's belief in personal capabilities to perform the specific actions that will lead to outcomes.

Lewthwaite (1990) suggests goal orientation as a motivational tool. This is consistent with our initial prescription of a predetermined amount of walking for the women to work up to. This predetermined amount may have served as a goal for the

participants to strive towards. This may help explain the fairly high average frequency of 4.9 times per week for the 24 week period.

Lewthwaite (1990) also suggests incentives as having a positive influence on goals. Our study offered certain incentives in order to keep the participants motivated. All participants were given walking t-shirts and a contest was held for the best walking slogan which was printed on the back of the t-shirt. This appeared to be fairly successful as many of the women wore these special t-shirts during their supervised walking sessions and treadmill tests. Prizes were given away which included tickets to the theater and a free manicure. Social gatherings including a potluck dinner were held so the women could get together with the people involved with the study. The women were also given a list of the 16 participants and were encouraged to car pool or walk together. A bulletin board with current walking news and photographs was posted near the weigh in center where participants were kept up to date with current research and upcoming testing dates.

One of the largest incentives offered was that each participant would receive feedback and results regarding different aspects of the study. Many of the women were truly interested in their cholesterol, bone density, and weight loss results and wanted to hear of any improvements related to the walking program. This was very positive as many of the participants became better educated and aware of their health throughout the study.

Influence of Injury on Training Progression

Each participant filled out an injury questionnaire after completing the 24 week walking program. Participants were individually interviewed as to their responses. Only three injuries occurred throughout the entire program and all were quite minor in nature. One participant had a build up in scar tissue in her ankle which came to light because of the walking but was not in fact caused by the walking. A second participant slipped on the ice and strained her ankle. The third injury involved tendonitis in the knee joint which was apparently fairly minor in nature. All three participants saw a physician and all stated that the injuries were not severe and only affected their walking for a one to two week period. Overall the program appeared to be quite safe as no injuries were sustained during testing and no subjects dropped out due to injury.

These results are similar to other walking programs where injuries appear to be fairly minimal. Probart et al., (1991) stated that based on the fact that 100% of their female subjects over 70 years completed the 6 month program, no injuries or serious discomfort were reported, and informal interviews and feedback to staff were positive, the program appeared to be tolerated by subjects. Sidney and Shephard (1977) encountered no more than occasional muscle strains during their 52 week training period with elderly adults. Their explanation for this was that walking produced less injuries than if they had prescribed jogging instead.

Other studies reported greater injury rates which appeared to be related to the intensity of the exercise program. Seals et al., (1984) found that orthopedic injuries were much more common and of greater severity during high intensity training compared with the low intensity program. Kohrt et al., (1991) stated that their vigorous exercise program resulted in occasional orthopedic problems. Approximately 66% of the participants who completed the study experienced painful episodes that limited the ability to exercise for up to one week. Only three subjects incurred injuries that resulted in cessation or modification of exercise for greater than one week.

A large number of injuries occurred in a study by Pollock et al., (1991) where 9 out of 21 subjects in the walk/jog program sustained an injury. Eight of these injuries were sustained when the group increased intensity of training by alternating either moderate and fast paced walking intervals or walking/jogging intervals. All injuries involved the lower extremity but only 1 injury was serious enough to necessitate that the subject discontinue training.

Other explanations for the low injury rate in our study could be due to preventative measures taken at the onset of the study. All participants were shown a series of stretches to include in their warm up and cool down, before and after each walking session. Participants attended a talk by a Certified Athletic Therapist and were given a stretching handout which they could keep with them in their log books.

Elia (1991) stated that warm up and stretching exercises and careful progression of activities help to avoid injuries. A general

preliminary stretching of the large muscles for 10 to 15 minutes is appropriate for most activities. The first few minutes of exercise such as walking should be kept to a moderate pace, with the intensity increasing only after the limbs have become comfortably warm. Programs should include adequate cool down periods which allows the opportunity for central venous return, thereby reducing the likelihood that fainting or arrhythmias will develop during the recovery period. A cool down also helps remove lactate from muscles that have been working above anaerobic threshold and may decrease the chance that stiffness and muscle pain will develop.

Subjects in our study were encouraged to start at a comfortable pace and gradually increase their intensity of walking to work up to their target heart rate. All participants were told to listen to their bodies and immediately report any injuries. The floor surface on the indoor track served as a safe environment to walk and participants were encouraged to walk inside as opposed to outdoors, although this was not always the case. All subjects were educated as to proper safe footwear and were encouraged to wear good supportive walking shoes.

The results of this study agree with the ACSM (1990) guidelines which recommend that elderly participants need longer periods of time to adapt to the initial rigors of training, and that although age in itself is not a limiting factor to exercise training, a more gradual approach in applying the prescription at older ages seems prudent.

Summary

Sixteen hyperlipidemic sedentary women aged 56 to 69 years (mean age 61.1) participated in a 24 week brisk walking program. Subjects were encouraged to work toward a predetermined goal of walking 5 times per week, one hour each session at 60% HRR. The women were encouraged to first increase their frequency, followed by duration, then intensity and to begin at a gradual comfortable pace.

The women walked an average of 4.9 times each week for 53.4 minutes at approximately 54% HRR and covered an average distance of 4.9 km per session. Participants expended an average of 5813.25 kJ (1388.9 kcals) for each of the 24 weeks or 22.2 kJ/minute (5.3 kcals/min) for the entire program. Total energy expenditure per week for weeks 21-24 was significantly greater ($p = 0.0457$) than for the initial weeks 2-5. Subjects were encouraged to attend one mandatory supervised session each week at an indoor track and maintained an average of 17.5 out of the 24 sessions. Daily walking data (frequency, distance, duration, time at target heart rate) was recorded in individual log book pages which were handed in regularly to a walking supervisor.

All subjects were treadmill tested (Balke protocol submaximal treadmill test) at the onset of the study and at the end of the 24 week period to determine predicted VO_2 max values. An average 10% increase in VO_2 max of the 16 subjects was seen over the 24 week training period. Participants also took part in a 4 stage steady state treadmill test based on individual velocities at specific points

throughout the study. Energy expenditure was calculated from these test results using the caloric equivalent for a liter of oxygen at the measured R value (Gardner et al., 1988).

Descriptive data including changes in frequency, duration, distance, time at target heart rate, percent time at target heart rate, actual percent of target heart rate, and velocity were documented to monitor actual walking participation.

Results of our study showed a significant correlation between total frequency and duration of exercise ($r = 0.535$, $p = 0.0329$) with frequency being a good indicator of total duration. A gradual progression was seen between velocity and energy expenditure/minute indicating a consistent increase in speed and energy expended/minute over the 24 weeks. Average velocity for the participants in this study started at about 5.5 km/hr for week one and increased to 5.6 km/hr during week 7. Velocity continued to gradually increase and reached 6.0 km/hr at week 22 where it remained for the duration of the study. Percent change ranged from 0-2% throughout the 24 weeks and was consistently positive. Energy expenditure/minute also gradually increased each week over the 24 week training period. Participants expended an average of 20.8 kJ/min (4.97 kcals/min) during week one and progressed to 23.5 kJ/min (5.6 kcals/min) during week 24. Percent change also remained positive and ranged from 0-2%. Average energy expenditure ranged from 4179.0 kJ (998.4 kcals) for week one to 6707.0 kJ (1602.0 kcals) for week 24 and was changed significantly ($p = 0.0457$) from the initial weeks (2-5) to the final weeks (21-24).

These results demonstrate a gradual positive progression which would reflect on the exercise prescription guidelines pertaining to frequency, duration and intensity recommended to the participants.

Total energy expenditure was 139518.1 kJ (33,333.7 kcals) for each subject over the 24 week training program. This amount is equivalent to an average of 5813.25 kJ (1388.9 kcals) for each of the 24 weeks (Table 4-2). The average energy expenditure per minute was 22.2 kJ (5.3 kcals) for the entire program. Our results show a significant correlation between total duration and total energy expenditure ($r = 0.719$, $p = 0.0329$) as well as total distance and total energy expenditure ($r = 0.484$, $p = 0.05$). This is almost self explanatory as the greater distance walked as well as the longer the duration spent walking, the more total energy would have to be expended by an individual to accomplish this. Change in energy expenditure was not significantly related to age, initial fitness level or adherence.

Age was not significantly related to any variable with the exception of intensity (% time at THR). In a simple regression analysis age was significantly and negatively correlated with total percent time spent at target heart rate ($r = -0.515$). Therefore the older the participants were, the less time they spent at target heart rate. These results imply that age may be directly related to intensity and that the older the participant, the less able they are to walk at a given high intensity. It is also possible that these results pertain solely to our subject population and that our subjects were unable to attain the intensity prescribed. A possible

explanation for this may be that the subjects were quite fit and may have had to actually jog to attain the target heart rate.

Although the majority of the literature reports that initial fitness level is a good predictor of magnitude of improvement, our results showed no relationship between initial VO_2 and change in fitness or health parameters.

The average number of supervised sessions attended was 17.5 ± 4.2 or approximately 73% of the 24 mandatory supervised sessions. Adherence was not significantly correlated with frequency, duration, distance, velocity or energy expenditure.

Eighteen of the initial 24 subjects (75%) completed the 6 month walking program. Sixteen women completed all of the tests and information required over the 24 weeks. Two subjects were dropped as they failed to attend the final testing procedures due to personal reasons, two dropped due to lack of motivation, three dropped the program due to illness, and one woman passed away due to an unrelated illness. Only three injuries occurred throughout the entire program and all were quite minor in nature. All three injured participants saw a physician and all stated that the injuries were not severe and only affected their walking for a one to two week period. No injuries were sustained during testing.

The results of this study provide useful information which can be used to develop exercise prescription guidelines for fitness and health benefits in elderly women.

Recommendations

Although exercise prescription guidelines are important for optimal fitness and health benefits for elderly women, they are not clearly defined in the literature. Rate of training progression to achieve the exercise prescription is an important factor to consider.

The first variable to be considered in exercise prescription is frequency. Subjects in this study were able to walk close to 5 times each week at the initial start of the program. Therefore a frequency of 5 times per week was a realistic guideline for this elderly population.

When considering duration of exercise, it is useful to relate back to the ACSM (1990) guidelines which recommend a longer adaptation period for the elderly in order to prevent injuries. If a longer warm-up is required then a longer duration may be required to accommodate this. Although duration may be minimal (20 minutes at THR) for fitness gains, it must be substantially longer for health related benefits. Thus an initial prescription may be for a short duration but the optimal goal should be for a longer duration up to 60 minutes.

Although greater intensity (70-80% max HR or 60-70% HRR) appears to produce greater gains in VO_2 , it may come at the cost of injury. A gradual progression to a higher intensity may alleviate the problem of injuries. It may therefore not be a question of whether or not an elderly adult can attain a higher intensity, but more so the time and gradual progression it takes to achieve it.

While intensity appears to be the main factor in producing changes in VO_2 , energy expenditure is crucial for health related changes. Although most of the literature recommends increasing energy expenditure by 300 kcals/day, our results suggest that this may be a minimal amount required to attain specific health benefits such as weight loss, body composition changes and changes in lipid profile.

Target heart rate and self-monitoring are important factors to consider when prescribing exercise in order to assure the participant is in reality achieving the recommended intensity as opposed to what they perceive as being an intense training session.

Individual variability among the elderly was evident in this study. The variable results suggest that individual goals must be taken into consideration when prescribing exercise for the elderly. An amount of 5 days per week, 60 minutes each session at an intensity of 60-70% HRR may be a general guideline for the elderly to achieve a combination of fitness and health related benefits. However the adaptation period needs to be longer than for younger individuals and a gradual progression appears to be very important.

It appears that regular exercise may have a positive psychological impact on the individual. The women in our study reported greater self confidence and self image, an increase in energy, and the use of the walking program as a coping mechanism to reduce stress.

Education is important and women at risk for CHD need to understand the risk factors involved and how exercise may play a key role in minimizing or preventing these factors.

It is apparent that there is a need for similar studies that focus on individual physiological goals and the amount of exercise and energy expenditure required to achieve each goal. Although more research is being done with elderly women, there is still a need for more. Studies that focus on psychological benefits and adherence of this population are also recommended.

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APPENDICES

Appendix 1 - Consent form

Appendix 2 - Log book front page

Appendix 3 - Log book sample page

Appendix 4 - Submaximal Steady State Treadmill Test Data Sheet

Consent Form

Low Intensity Endurance Training in Women

I have read the description of the study and understand the measurement procedures involved.

I also understand that my participation in this study is voluntary and that I may withdraw from it at any time without prejudice.

All information will be kept confidential.

I understand that the research team will be made aware of any data collected during the study on my eating and exercise behaviour as well as my assessment results, but such data will not be made known to any others.

I understand that participation in this research study is done at my own risk and I hereby release the University of Manitoba, their agents, officers, and employees from any liability, with respect to any damage or injury (including death) that I may suffer during my participation in the research study.

Date

Participant

Date

Witness

Investigators: A.E. Ready, Ph.D., Assoc. Professor, Principal investigator;
D.T. Drinkwater, Ph.D., Asst. Professor, Co-investigator;
D.W. Fitzpatrick, Ph.D., Assoc. Professor;
and J. Ducas, M.D.;
Sport and Exercise Sciences Research Institute, Department of
Foods and Nutrition, and Faculty of Medicine, University of
Manitoba.

UNIVERSITY OF MANITOBA
WALKING PROGRAM

ACTIVITY RECORD BOOK

Name:

Address:

Phone:

As part of the University of Manitoba Walking Study we request that you walk five times per week at your specified heart rate for a one hour duration. It is crucial to record your heart rate, the duration, and the total distance.

Your target heart rate zone is between ? and ? for a 15 second count!

Thank you for your participation!

**SPORT AND EXERCISE SCIENCE RESEARCH INSTITUTE
UNIVERSITY OF MANITOBA**

Please bring this book with you each time you come to the Max Bell Center.

Name: _____ Phone: _____

Week of _____ to _____

	Duration(Min)	Distance(Km)	Average Exercise HR	Comments
Day:				
Mon				
Tue				
Wed				
Thu				
Fri				
Sat				
Sun				
Other Activities:				

Exercise Leader's Signature: _____ Check in Date: _____

Submaximal Steady State Treadmill Test

Name:

Date of birth:

THR:

Resting HR:

Stage 1 V1:

HR:

Time:

VO2:

RER:

Stage 2 V2:

HR:

Time:

VO2:

RER:

Stage 3 V3:

HR:

Time:

VO2:

RER:

Stage 4 V4:

HR:

Time:

VO2:

RER: