A 12-month follow up study of strength, balance, and physical activity after a 20-week physical activity intervention to reduce fall risk factors in 65-75 year old women

by

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Abstract

OBJECTIVES: The overall objectives of this thesis were to conduct a 12-month Longitudinal Osteofit Follow-up study to: 1) evaluate changes in balance and strength in women with osteoporosis who participated in a 20-week randomized controlled exercise trial and 2) determine the effect of participation in a 20-week exercise intervention on physical activity participation.

DESIGN: 12- month prospective observational study.

PARTICIPANTS: 53 women aged 65 to 75 years who participated in the 20-week Osteofit randomised controlled trial.

PRIMARY OUTCOME MEASURES: Fall risk factors (knee extension strength, figure of eight test, Equitest) and physical activity participation at 20 weeks and 12 months follow-up.

RESULTS: This 12-month follow up study demonstrated that women originally allocated to the intervention group reported significantly more minutes spent in Osteofit in the follow up period than those allocated to the control group (23 ± 24 vs 9 ± 12, $P=0.02$). There were no significant differences in any fall risk factors between original intervention and control groups from baseline to follow-up. The level of participation in resistance activity for the entire cohort significantly increased from baseline to follow-up ($\chi^2= 29.56$, $p<0.001$).

CONCLUSIONS: Participation in 20 weeks of Osteofit does not effectively improve fall risk factors at 12 months follow up. However, involvement in a community based exercise intervention may provide sufficient motivation for women aged 65-75 to increase their level of participation in physical activity—particularly resistance training. Large prospective trials utilizing targeted exercise interventions are needed to determine if exercise reduces falls risk.

Table of Contents

List of Tables

List of Figures

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Chapter 1: Introduction

In North America, individuals over the age of 65 represent the fastest growing segment of the population (1). Unfortunately, it would appear that this demographic is largely inactive. In Canada it is estimated that 32% of women over the age of 65 are completely sedentary (less than 10 minutes of activity per day) and that only 22% are active enough to obtain the health benefits of a physically active lifestyle (2). The role of physical activity in decreasing all cause mortality and therefore increasing longevity has been well established (3-6). Physical activity also provides numerous other health benefits and interventions such as the Randwick Falls study (Australia) (7, 8), the Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) (United States) (9-11) and the Prevention of falls in the elderly trial (PROFET) (United Kingdom) (12) have provided evidence that physical activity can reduce falls and fall risk.

The potential of physical activity to decrease falls and falls risk has important public health implications as fall-related injuries and the resulting morbidity and mortality in older adults are a major health problem worldwide (13). Approximately 30% of individuals over 65 years of age fall at least once per year and about half of these may do so recurrently (13, 14). Nonfatal falls often result in an increased fear of falling and subsequent decrease in activity and independence (15).

Falling is a multifactorial problem. Risk factors for recurrent falling include: muscle weakness, impaired balance and gait, prolonged reaction time, poor health, the use of four or more prescription medications and the use of sedative medications (15). Physical activity improves muscle strength, coordination and balance, and thus, may reduce the risk of fractures and other injuries owing to falls (8, 16). Therefore, exercise intervention may provide one important part of the solution to this major public health problem (15).

'Osteofit' is a community-based exercise programme for women and men with osteoporosis. It was devised by staff from BC Women's Hospital and Health Centre Osteoporosis Program and it aims to improve balance and strength, and thus, reduce risk of falling. In February 2001, we completed a 20-week randomized controlled trial of Osteofit (17). As Osteofit is a recent initiative, and the only community based exercise intervention to date, it follows that there have been no studies of the medium or long-term effects of a community-based exercise programme in women aimed at ameliorating risk factors for falling. Additionally, there is limited information regarding the physical activity choices women make after participation in a community based exercise intervention.

In this thesis I followed a cohort of 53 women for one year after they participated in the 20-week Osteofit intervention. In Chapter 2 I review the literature regarding physical activity and the role it plays in preventing falls and modifying fall risk factors. Chapter 3 addresses the research questions and hypotheses of the Osteofit Follow-up study. Chapter 4 details the methods I used in this study. Chapter 5 outlines the results from this study, chapter 6 discusses the findings from this study and finally chapter 7 provides a summary and conclusion of this work.

Chapter 2: Literature Review and Background

First, the dimensions of physical activity will be discussed, with particular focus on the general benefits and the specific benefits to fall risk factors. Targeted interventions for fall risk reduction will be reviewed, followed by a review of physical activity promotion programming and delivery in the elderly. Finally background to the present research study will be detailed.

2.1 Physical Activity

By the year 2010, the percentage of individuals in North America over 65, 75 and 80 years of age will be 14%, 6.5% and 4.0% respectively and by the year 2025 it is estimated that this number will grow by 6.1%, 2% and 0.6% respectively (1). This group of individuals over the age of 65 represents the fastest growing segment of the population. The Canadian Fitness and Lifestyle Research Institute in 1999 estimated that 62% of Canadians are not active enough to reap the benefits of a physically active lifestyle. Further, 32% of women over the age of 65 years were completely sedentary and only 22% were considered active enough to generate health benefits (2). It follows then that as our population ages as projected, and if the proportion of sedentary individuals in this country remains constant, or increases, an even larger number of elderly women in Canada will not be physically active enough to achieve health benefits. There is a growing body of convincing scientific evidence that physical inactivity leads to a host of chronic degenerative conditions and premature death. Therefore, advocating physical activity is an important public health message (3-6, 18, 19). In 1998 the American College of Sports Medicine published their Position Stand regarding exercise and physical activity for older adults (19). They assert that: "As more individuals live longer, it is imperative to determine the extent and mechanisms by which exercise and physical activity can improve health, functional capacity, quality of life, and independence in this population. Aging is a complex process involving many variables (e.g. genetics, lifestyle factors, chronic diseases) that interact with one another, greatly influencing the way we age. Participation in regular physical activity (both aerobic and strength exercises) elicits a number of favorable responses that contribute to healthy aging." (19)

2.2 Dimensions Physical Activity

Generally, physical activity decreases with age (20). However, it is increasingly recognised that the elderly can benefit from the different dimensions of physical activity- specifically the aerobic and resistance training components. In this section I discuss the general benefits of aerobic activity and resistance activity before highlighting how these dimensions of physical activity can specifically influence fall risk factors.

2.2.1 Aerobic Activity

The American College of Sports Medicine/ Centers for Disease Control (Atlanta) guidelines recommend walking, running, swimming and cycling because they are large muscle rhythmic aerobic forms of exercise that were an integral part of the early years of most adults' lives (19, 21). Guidelines recommend light- to moderate intensity lifestyle physical activities to optimize health, moderate or high-intensity exercise may be required to elicit adaptations in the cardiovascular system and in cardiovascular disease risk factors.

2.2.1.1 General Benefits of Aerobic Activity

Longevity is a very basic measure of health as it helps to answer the question of whether or not physical activity adds years to life. A large proportion of the epidemiological literature in physical activity focuses on this aspect (22). There is overwhelming evidence that regular physical activity is an important component of a healthy lifestyle and four studies (3-6) in particular drive this message home.

In 1953 Morris, Heady, Raffle, Roberts and Parks published in *The Lancet* (5) what is now a cornerstone study. This was the first study to examine the relationship between physical activity and coronary heart disease. Approximately 31 000 men who worked for the London Transport Executive during 1949 and 1950 were included in the study. The main significant finding from this work was that the bus conductors had an incidence pattern of coronary heart disease that was different from that of the drivers- the bus drivers had a greater incidence of rapidly fatal "coronary thrombosis". The authors concluded that the physical effort required by conductors (climbing the stairs between the double-decker buses) offered some protection against immediately fatal myocardial infarction, that their more sedentary counterparts (drivers) suffered.

Of equal importance is the classic study of 17,000 Harvard alumni by Paffenbarger and colleagues (6). They found that all cause mortality was reduced by 53% among individuals who played at least three hours of sport per week compared to those who only played one hour. Additionally, they found that the men who walked 15 kilometers or more per week had 33% lower death rates compared to men who walked less than 5 kilometers per week which supports the idea that moderate intensity activity is effective in reducing death rates. Finally, when a comparison was made between active and inactive men it was found that the active men lived at least two years longer (6, 22).

Both the Morris and the Paffenbarger study have provided insight into the relationship between all cause mortality and physical activity. However, a shortcoming of these studies was that only men participated. Blair et al in 1996 examined the influences of cardiorespiratory fitness and other precursors on CV disease and all-cause mortality in both men and women (3). This study examined cardiovascular disease and all cause death rates for low, moderate and high fitness categories in 25 341 men and 7 080 women. In order to circumvent some of the problems encountered with self- reported physical activity, physical fitness was measured using a maximal treadmill exercise protocol. Using these results the participants were classified into fitness categories. The relative risk for mortality in men and women belonging to the low fitness category was 1.52 and 2.10 respectively. Additionally, fit persons with any combination of smoking, elevated blood pressure or elevated cholesterol level had lower adjusted death rates than low-fit persons with none of these characteristics (3). This study further supports the findings of Morris and Paffenbarger. It also lends support to the idea that lack of physical fitness in women is an important precursor of mortality.

All three of these studies support link participation in aerobic physical activity with decreased mortality and increased longevity. However, they do not offer insight into other factors that might contribute to these outcomes, such as genetics and the environment. In 1998, Kujala and colleagues published the landmark Finnish twin cohort study (4). Twin cohort studies are very powerful because they control for two important factors- genetics and the environment. Kujala et al. examined all cause mortality and discordant deaths between same sex twin pairs (9 400 men and 9 726 women) over a 17-year follow up period. At follow up the hazard ratio for death, adjusted for age and sex, was 0.71 (CI 0.62-0.81) in occasional exercisers and 0.57 (CI 0.45- 0.74) in conditioning exercisers compared to those who were sedentary. Among the twin pairs who were healthy at baseline and discordant for death at follow up the odds ratio for death was 0.66 in the occasional exercisers and 0.44 the conditioning exercisers compared to those who were sedentary. The authors concluded that even after controlling for genetic and environmental factors by virtue of the study design, those individuals who reported being physically active at baseline had reduced mortality rates. Unfortunately, a separate analysis of the female cotwins could not be performed, as there were not enough deaths in the follow up period.

A large proportion of the physical activity literature has focused on the relationship between levels of activity and, longevity and all cause mortality or else cardiovascular disease (22). There is however substantial evidence to support the positive health influences of physical activity on increased high density lipoprotein (HDL) cholesterol levels, decreased blood pressure, decreased body fat and central body fat, decreased incidence of Non Insulin Dependent Diabetes Mellitus (NIDDM), decreased risk of colon cancer and finally that it increased ability for the elderly to perform activities of daily living (22).

2.2.1.2 Specific Benefits of Aerobic Activity to Falls Risk Factors

Aerobic activity is not often studied or discussed in relation to falls prevention. That said, loss of aerobic capacity is associated with increased age, and difficulty performing activities of daily living. Further, difficulties walking and transferring have been consistently associated with an increased risk of falling (23).

Few randomised trials have examined the effect of endurance training on falls and fall risk factors. Lord et al (1993) compared women who took part in an exercise programme for one hour, twice per week for 12 months with non-participating controls (24). Twenty-one women aged 57-75 years took part in classes that consisted of gentle aerobic exercises, emphasizing balance and flexibility but designed to increase the heart rate to greater than 60% of maximum heart rate. Compared with age matched controls (non exercising) the exercisers performed significantly better in the tests of knee extension strength ($p<0.01$), reaction time ($p<0.05$) and sway with eyes closed on a foam rubber surface ($p<0.05$). These results suggest that an exercise programme of this type may help prevent falls in older women by improving modifiable risk factors.

As part of the larger Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) initiative, Buchner and colleagues examined the effect of three different training regimes on gait, balance, physical health status, falls and inpatient and outpatient use and costs (9). The three different training protocols were strength training (weight machines), endurance training (bicycles), strength and endurance training and a control group. Training took place for one hour, three times per week for 24-26 weeks. Each group consisted of 25 individuals, except for the control group that had 30 participants. At 9 months, the endurance training group showed significantly improved knee extension strength, +9 Nm ($p<0.05$), and a 9% increase in aerobic capacity ($p<0.05$) compared to their baseline measurement. Thus, the endurance training arm of this study improved one known fall risk factor-- lower extremity strength.

Rooks et al. randomised 131 independent living elderly persons to resistance training, walking or "waiting list" control (25). The resistance training and walking groups exercised for one hour three times per week for 10 months (note: the walking group gradually increased walking time from 12 minutes per session to 45 minutes per session). At 10 months, the walking group showed a 6% (non-statistically significant) loss in knee extension strength, improved performance on tandem stance ($p<0.05$ compared to the control group), decreased performance on one legged stand time (eyes closed)($p<0.05$ compared to baseline), improved tandem walk time ($p<0.01$ compared to baseline), decreased lower extremity reaction time ($p<0.0001$ compared to baseline), and improved stair climbing speed ($p<0.05$ compared to the control group). This study demonstrated that a progressive walking programme might help to ameliorate several known risk factors for falls- tandem stance, tandem walk, reaction time and stair climbing speed.

2.2.2 Resistance activity

Resistance activity is defined as training where the resistance against which a muscle generates force is progressively increased over time. Muscle strength has been shown to increase in response to training between 60% and 100% of the 1 repetition maximum (RM). The American College of Sports Medicine currently recommends that healthy older adults undertake a strength training programme of 8-12 repetitions of 8-10 exercises, twice per week (approximately 20-30 minutes) (19, 21).

2.2.2.1 General Benefits of Resistance Training

As individuals age, they lose muscular strength and function (26). Therefore, a potential way to stop or slow this process is through resistance training. Pyka et al randomised 25 sedentary individuals (8 men and 17 women, mean age 68.2) to either a progressive resistance programme or a sedentary control group. The exercise group met three times per week for 30 weeks for approximately one hour (27). Strength measurements and biopsies from the nondominant vastus lateralis muscle were obtained after 15 and 30 weeks. All strength parameters (leg extension, leg flexion, leg press, hip flexion, hip extension and bench press) increased significantly ($p<0.01$) in the exercise group at 30 weeks compared to the control group. The muscle biopsies revealed that the cross sectional area of type 1 muscle fibers increased in the exercisers at 15 and 30 weeks, and that the cross sectional area of type 2 fibers increased by 30 weeks of training.

Pyka et al demonstrated that sedentary, but otherwise healthy older adults could undertake and comply with a moderate resistance training programme. Nichols et al examined the effects of a heavy resistance training programme for active women over the age of 60 (28). Thirty six subjects who were engaging in aerobic activity three times per week were randomised to either isotonic training (three times per week) or to a control group, for 24 weeks. At 24 weeks, the exercise group showed significant increases ($p<0.05$) in muscle strength in the 7 exercises of the upper and lower extremities. The greatest strength gains were seen in the shoulder and trunk muscles. Therefore, women who are already active can benefit from a heavy resistance training programme.

2.2.2.2 Specific Benefits of Resistance Training to Falls Risk Factors

The general benefit of a resistance training programme is improved strength of the targeted muscle group. Decreased upper and lower extremity strength have been identified as risk factors for falling (14, 29, 30) and improvements can occur with resistance training. However, other risk factors such as impaired balance and decreased ability to perform activities of daily living are also important. In the previously described study by Buchner et al, the individuals randomised to the strength training group showed improvements in most of the strength parameters, including knee extension strength. However, they did not show any significant improvements in balance or gait parameters. Despite this finding, when the three exercise groups were pooled (endurance training, strength training and combination training) they had a significant decrease in time to first fall (relative hazard 0.53, 95% CI = 0.30-0.91) compared to the control group.

In contrast with the Buchner study (9), which delivered a highly supervised programme, Skelton et al (31) studied the effect of a resistance training programme performed both in a laboratory setting and in the home environment . Fifty-two healthy women, median age 79.5 years, were randomised to either a resistance programme completed three times per week (once in the laboratory and twice at home) or to a control group. Individuals' body weight, rice bags or elastic tubing were used to train the various muscle groups. At the end of the 12-week intervention, the exercise group showed significantly improved knee extension strength (27%)(P= 0.03) compared to the control group, a significant association between training and normal pace knee rise time (21% faster) (P=0.02) and a small improvement of step up height (5%) (p=0.005). This study demonstrated that significant improvements in fall risk factors (strength and activities of daily living) can be achieved with a programme that uses low cost equipment and is easily done in the home if supported by a video tape and instruction manual.

Finally, Rooks et al (25) (study described previously), examined the effect of a self-paced resistance training programme using low cost equipment (weighted skin (SCUBA) diving belt for stair climbing exercises, seated knee extensions and, a 1 gallon container and hand held weights for upper extremity training). Exercisers met three times per week for ten months and weight was added to the waist belt (or to the containers) as the participant felt they could handle more weight. Study participants were queried ("is the weight you are using too heavy or too light?") as to their choice of more weight once a week during weeks 2-4 and at each exercise session after that. At the end of the study period, the resistance trained group showed significantly increased ($p<0.05$) knee extension strength (65%), improved tandem stance time (16%) and on one legged stance with eyes open time (98%). Additionally, significant improvements ($p<0.05$) were seen in lower extremity reaction time improved 13%, stair climbing speed decreased by 9%, stair climbing time was reduced by 22% and a 24% improvement was see in the pen pickup task. This study provides additional evidence that activities that utilize low cost equipment can provide meaningful improvements in strength, balance and activities of daily living. Further, this study provides some new evidence that elderly women can appropriately choose a training intensity that improves neuromotor performance and functional capacity.

2.2.3 Agility

There is very little literature available regarding older persons and agility-type interventions, however it could be argued that the intervention used by Lord et al. had an agility component (8). There are no studies that examined the specific role of agility training in fall risk factor reduction, although one such study is currently underway in the University of British Columbia Bone Health Research Lab.

2.3 Targeted Intervention for Fall Risk Reduction

Prior to detailing specific intervention strategies used to decrease falls risk and in some cases actual number of falls, it is important to outline the epidemiological data regarding the incidence of falls, the health care costs due to falls and the risk factors that contribute to this problem.

2.3.1 Epidemiology of falls

In 1995 falls caused over 2,100 deaths (1%) among people aged over 65 (32) and these data likely under-report the true rate of fall-related deaths. Depending on the population studied between 22% and 60% of older people suffer injuries from falls, 10-15% suffer serious injuries, 2-6% suffer fractures and 0.2-1.5% suffer hip fractures (23). Superficial cuts, abrasions and bruises represent the most common self-reported injuries (23). The most common presentation for falls requiring hospitalization include femoral neck fracture, other fractures of the leg, fractures of the ulna, radius and other bones of the arm and fractures of the trunk and neck (23). Hip fracture is a major cause of fall-related death and over 90% of hip fractures occur from falling (33, 34). Women with low bone mineral density have increased risk of hip fracture (35). There were 17 823 hip fractures in Canadian women in 1993/94 (36) that resulted in 999 deaths in the acute care setting (36). These fractures were the second leading cause of hospital admission for women aged 65 years or older in 1995/96 (37). Canadian hip fracture rates increase exponentially with age (36).

Falls accounted for 86% of injury admissions to hospital among elderly people (38). The risk of entering into a care facility was 2.7 times greater in those who sustain an injurious fall than in those who do not (39). In Canadian women aged 75 years or older falls caused 80% of the most serious injuries that subjects reported (36).

In British Columbia, falls are the leading cause of hospitalization due to unintentional causes of injury for people aged 65 years and older. The direct medical expenditure for inpatient hospital stays involving fall-related injuries for all ages is well in excess of $134 million (40). This does not include costs for nursing care after discharge, physician services, or therapies needed as a result of fall-related injuries. Epidemiological studies show that fall-related injuries are increasing (13) and as BC's population is aging a larger proportion of the population will be at risk of falling than ever before.

2.3.2 Risk factors for falling

Given that falling in the elderly is a burden not only to the individual, but also to health service providers, it is important to identify risk factors that may predispose an individual to falling. Risk factors for falling can be divided into intrinsic (host) factors and extrinsic (environmental) factors. Grisso, Capezuti, and Schwartz (1996) (30) summarized these risk factors and the evidence for association with risk for falling in Table 1. Modifiable risk factors include gait, balance, strength, vision and number of prescription medications. Environmental home hazards (e.g. slippery floors, throw rugs and poor lighting) and other extrinsic risk factors are beyond the scope of this thesis project, and thus are excluded from this review (30). A large proportion of falls are clearly preventable (10, 12, 23, 41). As with many health issues several factors interact to manifest the problem and thus, there is no magic bullet. It would appear that multifactorial interventions are necessary and the literature suggests they may be effective (10, 12). However, if multifactorial interventions are to be used, the components need to be well defined. Exercise intervention to improve muscle strength and balance is a critical component of a falls prevention programme.

Given the epidemiological data that falls occur in about one third of people over the age of 65, very few intervention studies are powered to demonstrate a difference in fall rates between the experimental and control groups. However, surrogate measures of fall risk, for example muscle strength, measure of postural stability and reaction time, can provide useful outcome measures for smaller intervention studies. If such interventions prove successful they would then be tested in larger samples using falls, or ideally, injurious falls and fractures, as the primary endpoint. As my thesis will have fall risk factors as an outcome measure (and not falls) I will review some key studies reporting the effect of intervention on fall risk factors.

Table 1 Intrinsic Risk Factors for Falls among the Elderly

Risk Factor	Evidence for association
Demographic characteristics	
➢ Older age	++
➢ Gender, Women	+
➢ Race, White	+/-
Functional level	
➢ ADL/IADL	++
➢ Cane/Walker use	++
➢ History of falls	++
Gait, balance, Strength	
➢ Walking speed	++
➢ Postural sway	++
➢ Lower extremity strength	++
➢ Upper extremity strength	++
➢ Impaired reflexes	++
Sensory	
➢ Vision	++
➢ Lower extremity sensory perception	++
Chronic illnesses	
➢ Heart disease	+/-
➢ Parkinsons's disease	++
➢ Other neuromuscular disease	++
➢ Stroke	++
➢ Urinary incontienence	++
➢ Arthritis	+
➢ Acute illness	+
Medications, alcohol	
➢ No. medications used	++
➢ Hypnotics	++
➢ Sedatives	++
➢ Antipsychotics	++
➢ Antidepressants	++
➢ Antiparkinson drugs	++
➢ Cardiac	+/-
➢ Diuretics	+/-
➢ Antihypertensives	+/-
➢ Alcohol	+/-
Mental status	
➢ Cognitive impairment	++
➢ Depression	++

Note: ++, strong; +, moderate; +/- inconsistent
ADL= Activities of Daily Living, IADL= Instrumental Activities of Daily Living

Adapted from Grisso JA, Capezuti E. and Schwartz A. in Falls as Risk Factors for Fractures in Osteoporosis (1996).

2.3.3 Community based interventions targeting fall risk factor reduction and reduced number of falls

Lord *et al.* (8) randomized 197 community dwelling women aged 60-85 years (mean age 71.6, SD = 5.4) to either exercise class or control for 12 months. The exercise programme was community based and took place twice weekly for one hour. The classes consisted of a 5-minute warm up, 35 minutes of conditioning, 15 minutes of stretching and 5-10 minutes of relaxation. The conditioning component included aerobic, strengthening components as well as activities for balance, flexibility, endurance, hand-eye and foot-eye coordination. This study demonstrated an improvement in the exercise group in several lower limb strength measures; reaction time, neuromuscular control and three of four sway measures. As discussed in the previous sections, this study was underpowered to detect a significant reduction in falls but interesting trends developed indicating fewer falls in the intervention group. One of the key findings of this study was that a general community based exercise programme was successful in increasing strength and balance in elderly women. Lord et al. (8) noted that previous studies (28, 42-45) had shown that exercise could increase muscle strength, however they used heavy resistance exercises or specialized exercise equipment.

The "Osteofit Study" was a randomised controlled exercise trial of 85 women aged 65-75 with osteoporosis at the hip and/or lumbar spine (17). This study evaluated the efficacy of a community exercise programme in reducing fall risk factors (knee extension strength, dynamic balance and static balance). The intervention group participated in the Osteofit classes for one hour, twice per week for 20 weeks. At 20 weeks the intervention group showed significantly greater increase in knee extension strength and velocity traversing a figure of eight course (a measure of dynamic balance) compared to the control group. Thus, a programme that was already implemented within the community was effective in decreasing two known risk factors for falling.

2.3.4 Other Types of Interventions to Reduce Falls and Fall Risk Factors

The two previously mentioned studies, Lord et al and Carter el al. focused primarily on strategies that address specific risk factors for falling. However, many older individuals may have several risk factors for falling and in different combinations such that a programme that targets a specific risk factor may be too broad to address the multifactorial nature of falls (23).

Campbell et al. implemented a randomized controlled trial investigating the role of exercise and fall prevention in the elderly (46). In this study, 233 women aged 80 years and older living in the community were randomized to either an individually tailored programme of physical therapy in the home or to usual care and an equal number of social visits. The result of the intervention was decreased rate of falls in the exercise group compared to the control group (0.87 (1.29) vs. 1.34 (1.93) falls per year respectively; difference 0.47; 95% confidence interval 0.04 to 0.90). The exercise group also showed improved strength and balance compared to the control group. This study differs from Lord et al.(8) in that the population was older and the intervention was one on one with a physiotherapist. Although both studies showed improvements in strength and balance, Campbell was successful in showing a reduction in rate of falls using a home exercise programme.

In 1994, Tinetti and colleagues reported the results of their landmark multifactorial intervention to reduce the risk of falling among elderly community dwelling individuals (10). The 301 participants were randomised to receive either a multifactorial intervention targeting: postural hypotension, medication use (benzodiazepines and four or more prescription medications), transferring abilities, environmental hazards, gait impairment, balance impairment and leg or arm muscle strength, or to receive usual care. During the one year follow up phase of this novel intervention, 47% of the control group fell compared with only 35% of the intervention group (p=0.04) and an adjusted incidence rate ratio for falling in the intervention compared with the control group was 0.69 (95% CI (0.52 to 0.90)). Lord et al. (23) calculated the number needed to treat for this intervention and found that only 8 people need to be treated in order to prevent one fall. Further, subjects who presented with a particular risk factor at baseline, fewer subjects in the intervention group as compared with the usual care group presented with the risk factor after one year. Given the multifactorial nature of falls, it may be that targeted interventions such as this one will provide the most promise in reducing falls in the elderly.

Both the Campbell (46) and Tinetti (10) studies targeted healthy community dwelling individuals and showed significant improvements in fall risk. An innovative study by Close et al. targeted a high risk population (individuals presenting to the emergency department due to a fall or fall related injury) to receive usual care or a medical and occupational therapy assessment which determined the individuals tailored intervention (12). At 12 month follow up, the intervention group reported 183 falls compared with 510 falls in the control group (p=0.0002) and, the risk of falling and the risk of recurrent falls was significantly reduced in the intervention group: odds ratio 0.39 (95% CI (0.23-0.66)) and 0.33 (95% CI (0.16-0.68)). Only six individuals need to be treated to prevent one fall (23). This study supports the idea of a multifactorial and multidisciplinary approach to fall prevention that was first documented by Tinetti et al.(10). Moreover, the effect size in this study was larger than any previously reported and supports the idea of targeting individuals at high risk for falls. The emergency department is an ideal location to capture such individuals.

A preplanned meta-analysis of the FICSIT (Frailty and Injuries: Cooperative Studies of Intervention Techniques) examined the effects of exercise on falls in elderly patients (47). The FICSIT trials are independent randomized controlled trials throughout seven centres across the United States. Each centre had an exercise component that varied from site to site and lasted anywhere between 10-36 weeks. Two nursing homes and five community dwellings were involved and study centre enrolment ranged from 100-1323 participants. The minimum age for enrolment was 60-75 years across centres. The exercise component varied across centres in terms of frequency, intensity, time and type and, training was performed in one area or more of endurance, flexibility, balance, Tai Chi and resistance. The adjusted fall incidence ratio for treatment arms, including general exercise, was 0.90 (95% CI 0.81, 0.99). For those treatment arms that included exercise as well as a balance component, the adjusted fall incidence ratio was 0.83 (95% CI 0.70, 0.98). Although these results should be interpreted with some caution, the conclusion from this meta-analysis is that treatment arms including exercise for elderly adults decreased the risk of falls (47).

2.4 Physical Activity Promotion Programming and the Delivery of Physical Activity in the Elderly

If physical activity can reduce falls risk it begs the questions— how active are older Canadians? The Canadian Fitness and Lifestyle Research Institute in 1999 estimated that 62% of Canadians were not active enough to reap the benefits of a physically active lifestyle. Further, 32% of women over the age of 65 years were completely sedentary and only 22% were considered active enough to generate health benefits (2). Katzmarzyk, Gledhill and Shephard investigated the economic burden of physical inactivity in Canada (18). They estimated that approximately $2.1 billlion, or 2.5% of the total direct health care costs in Canada, were attributable to physical inactivity in 1999. They estimated that a 10% reduction in the number of persons who are inactive would translate into a $150 million per year savings in direct health care expenditures. Thus, given the percentage of the elderly population who are inactive and the health care costs that are attributable to inactivity, it is imperative that health promotion strategies are implemented.

2.4.1 Successful interventions that promoted physical activity

King (48) recently reviewed interventions to promote physical activity in older adults. Program or regimen-based factors such as structure, format, complexity, intensity, convenience, and financial as well as psychological costs associated with the activity play an important role in determining whether older adults participate in physical activity. King, based on evidence to date, suggested that programs that may be particularly appealing are more moderate in intensity, simple and convenient to engage in, relatively inexpensive, noncompetivive and, particularly for older women, contain a social component. Several population based community surveys suggest that a large proportion of older men and women prefer undertaking physical activity outside of a formal class or group setting (64-69%) (48).

Environmental factors found to be significant correlates or predictors of physical activity include support from family members, friends, program staff, and other exercise participants (48). Another potentially important source of support and motivation for elderly persons is their family physician. However, many physicians do not discuss physical activity participation with their patients. Barriers include the physicians' lack of time, lack of reimbursement, and the lack of confidence in prescribing physical activity (49).

Targeting the appropriate settings for physical activity promotion is of paramount importance. Very little work has been done in this area in older adults, however the experience with younger adults has been somewhat positive. Heirich et al. (48) in a work site intervention study demonstrated that outreach counselling by trained staff led to greater physical activity rates across a 3-year period compared with offering on-site physical activity classes or building an on-site exercise facility. Other possible settings to target include places of worship, pharmacies and beauty salons.

Large scale comprehensive, community-based approaches that emphasize population-wide education but that also included changes in community organization, environmental changes, and incentives and contests have been evaluated (22). The Stanford Five City project included several elements designed to increase levels of physical activity participation in the intervention cities including delivery of information via electronic and print media in conjunction with face-to-face activities such as classes, contests and school-based initiatives (50). The cross sectional evaluation of the programme revealed, small but statistically significant increases in physical activity.

National physical activity campaigns are also an important population health promotion strategy. In Australia there were two nationwide physical activity campaigns promoted by the National Heart Foundation (51). These campaigns were promoted through television advertisement, public service announcements for radio, distribution of a newspaper, posters, leaflets, stickers, and T-shirts; publicity tours by two heart health experts; magazine articles; and physical activity themes in episodes of two nationally broadcast television drama series. Face to face home based interviews with a representative national sample were carried out 2 weeks prior to and 3 and 4 weeks following the campaign. The evaluation of the mass media campaign showed significant increases in the prevalence of walking following the campaign. These changes in self reported walking were most apparent among the elderly and the least educated (22, 51).

2.5 Background to the research study

2.5.1 Osteofit- A Randomized Controlled Trial (17)

In order for physical activity to be cost-effective at a population level, exercise prescription must be provided in the group setting. People with osteoporosis are often reluctant to join standard seniors exercise classes for fear of sustaining a low-trauma fracture. To meet this need, the Osteoporosis Program at BC Women's Hospital and Health Centre in Vancouver developed an exercise program suitable for people with osteoporosis. This program began in 1998 and over 300 women have participated in total, in over 50 different community centres. A number of similar programs have also been instituted in the US, Australia and Europe. To our knowledge, there have been no reports of the efficacy of these programs. Important outcome variables include static and dynamic balance, strength and quality of life. Our research group initiated a single-blind, randomized, controlled trial of a 20-week Osteofit exercise program, in community-dwelling women aged 65-75 years, who had osteoporosis. The methods of that study are outlined here in detail as my Master's proposal (chapters 3 and 4) involves women who were part of that study.

2.5.2 Subjects recruited into the Osteofit RCT

Eligible subjects were identified from a computerized database of community-dwelling women who had been referred for bone densitometry at the BC Women's Hospital and Health Centre Osteoporosis Program between 1996 and 2000. From the database, we identified women who were: (1) aged 65 to 75, (2) resident within greater Vancouver, Canada, and (3) had osteoporosis by dual-energy X-ray absorptiometry (Lunar Corp, Madison, WI) at the total hip or lumbar spine or both, i.e., bone mineral density (BMD) T-score at least 2.5 standard deviations below the young normal sex-matched BMD of the Lunar reference database (52) or who had a previous fragility fracture.

Four hundred and fifty-six women met these initial screening criteria and were invited by letter to participate in an exercise intervention study. All invitees were also telephoned to answer any questions about the study and to check that they met all study entry criteria. These were that the participant 1) was at least 5-years postmenopausal; 2) weighed less than 130% of ideal body weight; 3) did not expect to be absent from the city for more than 4 weeks in the upcoming year; 4) had no contraindications to undertaking physical exercise; and 5) was not currently engaging in a regular exercise program. A total of 108 (24%) women volunteered to participate and attended a group information session where entry criteria were again checked. Eight women declined to participate because of time constraints and three declined because they wished to take an exercise class rather than risk potentially being initially randomized to a non-exercising group.

Of the 97 women who agreeed to participate in baseline measurements, 93 were randomized to exercise intervention (n = 45) or control (n= 48) groups. Four women were not randomized as they chose not to participate after baseline measurements (n = 2) or were too active at baseline (n = 2). Five women in the intervention group and 8 women in the control group lost interest in the study. Data reported are on the 80 women (40 control, 40 exercise) who completed the 20-week study.

2.5.3 Osteofit - The Classes

Osteofit is a community-based exercise program for people with osteoporosis, that aims to reduce the risk of falling and improve functional ability, and thereby enhance quality of life. The twice-weekly exercise program targets posture, balance, gait, coordination, and hip and trunk stabilization. All instructors are certified by the BC Recreation and Parks Board and by the BC Women's Hospital Osteofit Training Instructor. A manual outlines the course curriculum (BC Women's Hospital).

All intervention classes consisted of a warm-up (10 minutes), the workout (40 minutes), and a relaxation component (10 minutes). The classes also include 'Osteofit Tips' - a 5 minute health education section prepared by BC Women's Osteoporosis Program. Instructors involved participants in discussion of important osteoporosis issues to help them learn more about the disease and possibly reduce anxiety about the condition.

The 10-15 minute warm-up was done to music, seated or standing, and commenced with gentle range of motion exercises for the major joints. There were no static stretching exercises. Walking and simple dance routines with a tempo of between 110 - 126 beats per minute followed.

The main workout consisted of strengthening and stretching exercises to combat medially rotated shoulders, 'chin poke' posture, thoracic kyphosis, and loss of lumbar lordosis. Exercises included heel raises and toe pulls, two-legged heel-toe rock, tandem walks and obstacle courses to improve balance and coordination. Hip stabilization was trained using leg exercises (e.g., hip abduction and extension) and balance exercises. Trunk stabilization was addressed when the participant was cued and positioned to do all standing exercises with resistance for the arms (e.g., biceps curls) and shoulders (e.g., lateral arm raises). Emphasis was placed on strengthening abdominal muscles as stabilizers rather than as prime movers. Exercises to improve functional ability included chair squats and getting up and down off the floor.

Exercise repetitions ranged from 8 to 16 and the weights were relatively light so that the participants did not work to fatigue with each set. Exercises were arranged so that the less strenuous exercises, such as hamstring stretches were performed at the end of the workout.

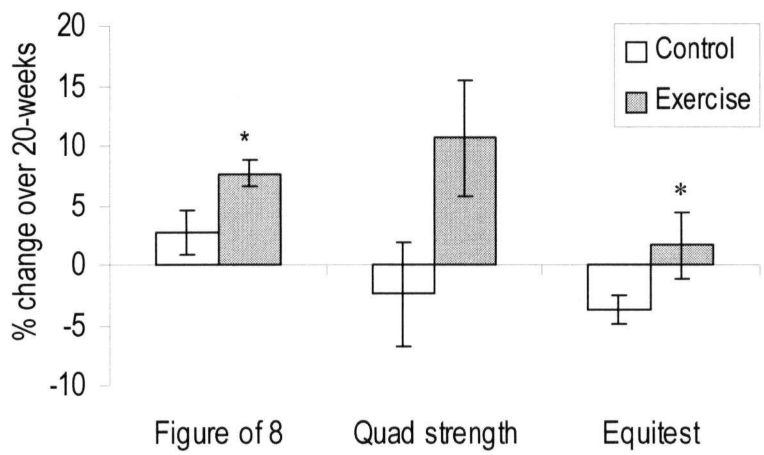
2.5.4 Results

The results from the Osteofit intervention study are summarized in Table 2 and Figure 1. The exercise group showed a significantly (P=0.04) greater increase in dynamic balance measured by figure of eight (8%) compared with the control group (3%). The exercise group also showed a significantly greater (P=0.047) increase in strength (11%), compared with the control group (-2%). There is a trend towards improved balance (static) however the sample may have been too small to detect these differences.

Table 2 Baseline characteristics between exercise and control groups. Mean (SD).

	Control	Exercise	P
N	40	40	
Age (y)	69.0 (3.5)	69.6 (3.0)	0.43
Height (cm)	157.7 (5.6)	156.6 (7.5)	0.46
Weight (kg)	59.1 (11.7)	62.9 (13.3)	0.19
Estrogen use (y)	2.0 (5.1)	3.6 (5.5)	0.18
Medications (#)	2.0 (1.6)	2.6 (1.6)	0.10
Activity (min/week)	14.7 (18.1)	9.2 (9.0)	0.09
Quality of life (total)	25.8 (13.8)	28.0 (13.5)	0.47
Quad/Ht (kg/cm)	15.8 (4.5)	15.2 (5.8)	0.61
Figure of 8 (sec)	23.5 (4.8)	26.6 (11.6)	0.13
Equitest	73.7 (7.9)	72.5 (10.4)	0.55

Figure 1 *Percent change over 20-weeks for figure of 8, quadriceps strength and equitest composite score for exercise (grey) and control (white) groups. Means adjusted for covariates. Bars are SE. * = signifcantly different from control group (p < 0.05).*



Although the results of the Osteofit study and other interventions are encouraging, longitudinal follow-up is necessary. For exercise to be beneficial at a population-wide level, programmes need to be designed and tested that easily implemented within a community-based setting and in which a large proportion of the population can, and will participate. Lord argues that the practical implication of a 'general' exercise programme administered in a community based setting is that "...older people will be more likely to participate, and remain in, exercise programs that employ enjoyable group activities rather than programs that base the intervention on specific, repetitive muscle group exercises (8)." Furthermore, he noted that the high adoption and adherence rates seen in their intervention indicate "exercise interventions of this nature may offer an effective health promotion strategy, with potential for improving quality of life and reducing health care costs (8)." Although the results from the Osteofit intervention and other exercise intervention programmes are encouraging, longitudinal follow-up is needed to determine if the benefits of such a programme are maintained over the short and long-term- in this case knee extension strength and dynamic balance. There have been no studies of the medium or long-term effect of community-based exercise programme aimed at reducing modifiable fall risk factors. Further, there is a lack of longitudinal data describing the physical activity choices that women make after participating in an exercise intervention.

Chapter 3: Research Questions and Hypotheses

3.1 Objectives

The overall goals of this thesis were to conduct a Longitudinal Osteofit Follow-up study to; 1) explore the changes in balance and strength over 12 months in women with osteoporosis who participated in a randomized controlled exercise trial and 2) to determine the effect of participation in an exercise intervention on physical activity participation over 12 months. I have the following primary research questions:

Primary:

1. Is there a difference between the original control and intervention groups on performance parameters (knee extension strength, figure of eight test and Equitest) and on physical activity parameters (walking, total aerobic activity and resistance activity) 12 months after participating in the Osteofit study?
2. Is there a difference between those participants who meet and those who do not meet the American College of Sports Medicine (ACSM) guidelines for aerobic activity at 12 months on performance parameters?
3. Is there a difference between those participants who meet and those who do not meet the ACSM guidelines for resistance activity at 12 months on performance parameters?
4. What is the level of participation in aerobic, resistance and community based (Osteofit) activities before and after participation in the Osteofit study?

3.2 Hypotheses

Primary Hypothesis

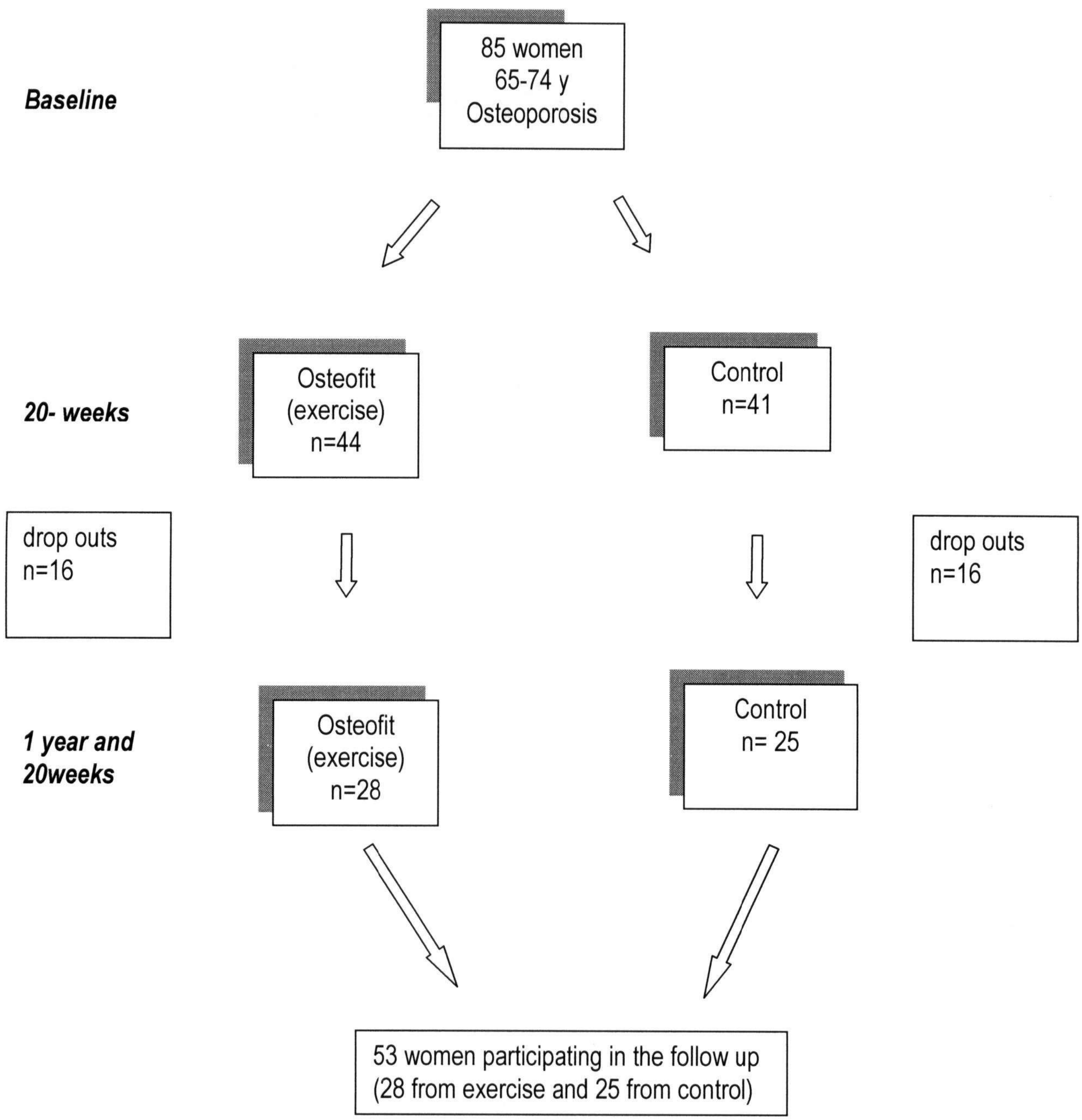
1.
    a. There will be no difference between the intervention and control group from baseline to follow up on knee extension strength, figure of eight test and Equitest.
    b. There will be no difference between the intervention and control group from baseline to follow up on number of minutes of walking and total minutes spent in aerobic activity. The intervention group will report a significantly greater number of minutes in resistance activity from baseline to 12-months follow up than the control group.
2. Participants who met the ACSM guidelines for aerobic activity will perform significantly better on knee extension strength, figure of eight and Equitest at 12-months follow up than those individuals who did not meet the guidelines.
3. Participants who met the ACSM guidelines for resistance training will perform significantly better on knee extension strength, figure of eight and Equitest at 12-months follow up than those individuals who are did not meet the guidelines.
4. Women who participated in the Osteofit study will be significantly more active at 20-weeks and 12 months compared to baseline for aerobic, resistance and community based activities.

Chapter 4: Methods

4.1 Subjects

The 85 women who participated in the 20-weeks Osteofit exercise intervention outlined in Chapter 2 were eligible to participate in the follow-up study. Inclusion criteria for the original study were: (1) aged between 65-75 years; (2) at least 5 years postmenopausal; (3) living within a 15 minutes car or bus ride of a community center that provides the Osteofit program; (4) osteoporosis by dual-energy X-ray absorptiometry (T-score < -2.5) at either the hip or lumbar spine or both, or diagnoses with previous fragility fracture; (5) weight less than 130% of ideal body weight; (6) expecting to be present in the city for at least 21 of the 24 weeks of the study period; (7) not engaging in any regular exercise program (no strength training and less than 20 minutes of aerobic exercise two times per week). Use of medication/or dietary supplements is not an exclusion criterion but was recorded in the baseline questionnaire.

Figure 2 Flow of subjects through the study



4.2 Design

The study was a one -year observational study. All women were recruited regardless of initial randomization.

4.2.1 Data Collection Procedures

In the Osteofit randomized controlled trial, participants were recruited in four groups (A-D) and were measured in July (A), August (B), November (C) and February (D). Therefore, measurement for the present study is shown in Table 3.

Table 3 Follow up measurement schedule

	Measurement Date
A	July 2001 (n=9)
B	August 2001 (n=15)
C	November 2001 (n=9)
D	February 2002 (n=20)

4.3 Measurements

Approximately one hour was required to complete the following measurements: anthropometry (height, sitting height, weight), balance measures (static and dynamic) and knee extension strength testing (quadriceps strength).

4.3.1 Anthropometry

(i) Stretch stature for height and sitting height: These was measured using a stadiometer using standard protocols. Height was measured to the nearest 0.1 cm.

(ii) Weight was measured using an electronic scale and was reported to the nearest 0.1 kg.

4.3.3 Balance Measures

(i) Static balance was measured using a computerized dynamic posturography platform (EquiTest, Clackamas, Oregon, US) according to standardized protocol (53). This instrument assessed the visual, vestibular and proprioceptive contributions to balance. It also evaluates the automatic responses induced by unexpected perturbations to the support surface (54). I have used this device in our previous studies (17).

(ii) Dynamic balance was evaluated with a timed figure-of-8 running test(55). The participant was asked to move (walk or run) as quickly as possible around two poles placed 10 meters apart describing a figure-of-8. Women were asked to complete two laps of the course as quickly and safely as possible. I have used this test in our previous studies (17).

4.3.4 Knee Extension Strength

(iii) Dominant leg knee extension strength was measured using a strap assembly incorporating a strain gauge according to the method of Lord et al (16). Participants are required to sit on a tall chair with angles of the hip and knee at 90 degrees. The strap was secured approximately 10 cm proximal to the ankle and the subject was asked to pull against the strap assembly with maximal force. The subject was allowed three trials and the best effort was recorded. I have used this device in our previous studies (17).

4.3.5 Physical Activity and Falls Diaries

(iv) Participants were asked to record their daily physical activity for one year on calendars provided. Participants were asked to mail the calendars to the UBC Bone Health Lab at the end of each month. If a diary is not received within the first week of the following month, a telephone call was made to the participant. "Falls" were also recorded in the daily diary. If a fall was noted in the diary, I called the subject to ascertain the cause of the fall and if any injuries were sustained. A nonsyncopal fall is defined as an event that "results in a person coming to rest inadvertently on the ground or other lower level and other than as a consequence of... sustaining a violent blow, loss of consciousness, sudden onset of paralysis, as in a stroke, (or) an epileptic seizure" (10). I have used this diary in our previous studies (17).

4.5 Statistical Analysis

4.5.1 Primary Research Questions

To address all two parts of the first research question, I used repeated measure analysis of variance (RM ANOVA), by initial randomisation. The second and third research questions were analysed using RM ANOVA, by whether or not the participants met the ACSM guidelines for aerobic activity and resistance activity. The fourth research question was analysed using non-parametric statistics, Chi square. Differences between groups were considered significant if $P<0.05$.

Chapter 5: Results

5.1 Characteristics of the cohort at baseline

In the Osteofit study, 85 women completed the 20-week assessment. Of these 85 women, 53 consented to participate in the follow up study and 32 women declined participation. All women in the control group who participated in the Osteofit study were subsidized to participate in the Osteofit classes during the follow up period if they so chose. All participants freely selected physical activities during the follow up period without facilitation or instruction from the Osteofit study research team. . The follow up cohort consists of 25 and 28 women originally allocated to the control and intervention groups respectively. The drop out- group consists of 19 and 13 women originally allocated to the control and intervention groups, respectively. This represents 38% attrition. This follow up study examines the 53 women who completed the one- year follow up.

5.1.1 Performance characteristics

5.1.1.1 Follow up Cohort

The average age, height and weight for the entire cohort was 70.9 +/- 3.6 (SD) years, 156.2 +/- 7.4 cm and 61.4 +/- 14.1 kg respectively. The average knee extension strength, figure of eight time and Equitest score were 24.6 +/- 8.8 kg, 24.5 +/- 7.0 seconds and 74.0 +/- 8.6 respectively. The control group was slightly faster in figure of eight performance (23.8 +/- 5.2 vs 25.1 +/- 8.3 seconds) and performed marginally better on Equitest (74.7 +/- 6.5 vs 73.3 +/- 10.2). (Table 4)

Table 4 Whole cohort by original allocation (control or intervention). KES= Knee extension strength (kg) or corrected for height (kg/m); Walking= walking (min/day) as reported by diary; $Aero_{tot}$= total aerobic activity (min/day) as reported by diary; Res_{tot}= total resistance activity (min, 2x/week) as reported by diary. 53 women returned for follow up, of these 46 women completed baseline PA diaries and 46 women completed follow up PA diaries. Baseline= entry into the study; Follow up= 1 year and 20 weeks from baseline. p values represent the difference between groups at follow up.

	Baseline				Follow up					
Parameter	**n**	**Control mean (sd)**	**n**	**Intervention mean (sd)**	**n**	**Control**	**n**	**Intervention**	**p**	**power**
Age (years)	25	70.2 (3.3)	28	71.4 (3.8)					na	na
Height (cm)	25	157.4 (6.4)	28	155.1 (8.1)					na	na
Weight (kg)	25	60.4 (13.8)	28	62.3 (14.5)					na	na
KES (kg)	25	24.9 (7.6)	28	24.5 (9.9)					na	na
KES (kg/m)	25	15.7 (4.5)	28	15.6 (6.0)	25	15.2 (4.9)	28	16.4 (5.5)	0.425	0.191
Figure of 8 (seconds)	25	23.8 (5.2)	27	25.2 (8.4)	25	23.0 (6.3)	27	23.7 (7.5)	0.662	0.114
Equitest	24	75.0 (6.5)	28	73.3 (10.2)	24	73.6 (7.1)	28	74.0 (9.5)	0.308	0.251
Walking (min/day)*	20	42 (38)	25	30 (18)	20	35 (25)	25	32 (19)	na	na
$Aero_{tot}$ (min/day)*	20	43 (37)	25	34 (22)	20	41 (25)	25	36 (23)	na	na
Osteofit (min 2x/wk)	21	0	25	0	21	9 (12)	25	23 (24)	na	na
Res_{tot} (min 2x/wk)	21	0	25	0	21	28 (38)	25	25 (23)	na	na

*n= 45, One participant was excluded from aerobic analysis because she was an outlier

5.1.1.2 Drop out cohort

The average age, height and weight were 69.3 +/- 3.5 years, 158.9 +/- 4.0 cm and 60.5 +/- 8.9 kg respectively. The average knee extension strength, figure of eight time and Equitest score were 24.4 +/- 7.7 kg, 25.9 +/- 11.3 sec. and 71.3 +/- 10.5. The intervention group was 1.1 years younger than the control group (68.6 +/- 3.1 vs 69.7 +/- 3.8). The intervention group was also 5.3 seconds slower on the figure of eight test than the control group (29.1 +/- 16.6 vs 23.8 +/- 4.9). (Table 5)

Table 5 Baseline characteristics of performance tests of women *not* participating in the follow up. KES= Knee extension strength (kg) or corrected for height (kg/m).

	cohort		**control**		**intervention**	
	n	**mean (sd)**	**n**	**mean (sd)**	**n**	**mean (sd)**
Age (years)	32	69.3 (3.5)	19	69.7 (3.8)	13	68.6 (3.1)
Height (cm)	32	158.9 (4.0)	19	158.0 (3.7)	13	160.1 (4.2)
Weight (kg)	32	60.5 (8.9)	19	58.0 (7.4)	13	64.2 (9.8)
KES (kg)	32	24.4 (7.7)	19	24.7 (6.9)	13	23.9 (9.1)
Figure of 8 (seconds)	32	25.9 (11.3)	19	23.8 (4.9)	13	29.1 (16.6)
Equitest	32	71.3 (10.5)	19	71.2 (10.4)	13	71.5 (11.0)

The women who comprised the follow up cohort were on average 1.6 years older than the women who declined participation. The two groups have comparable mean height and weight. The follow up cohort and the drop outs had similar knee extension strength. However, the follow up cohort were 1.4 seconds faster on the figure of eight test and performed 2.7 units better on Equitest.

5.1.2 Physical activity

5.1.2.1 Follow up cohort

On average the women returned 206 +/- 107 days of physical activity diaries and returned for their follow up assessment 1.5 +/- 0.07 years from baseline (Table 6). The control group reported 42 +/- 38 minutes of walking per day and the intervention group reported 30 +/- 18 minutes. One woman was removed from the aerobic activity analysis because she was an outlier. She reported on average 4 hours of aerobic activity each day. She was not different from the cohort with respect to performance parameters and therefore was included in those analyses. Both the control and intervention groups reported no resistance activity at baseline (Table 4).

Table 6 Physical activity (PA) characteristics (by monthly diary) reported for one year for participants who returned both baseline and follow up PA diaries. 53 women returned for measurement at follow up (25 control (c), 28 intervention (i)) of these 43(19 c, 24 i) women provided both baseline and follow up diaries. KES= Knee extension strength (kg) or corrected for height (kg/m). PA diary days/365= total number of days of physical activity diaries returned in the follow up perio. Follow up period (yrs)= length of the follow up period from baseline to follow up measurement. $Aero_{tot}$= total aerobic activity (min/day) as reported by diary. Res_{tot}= total resistance activity (min, 2x/week) as reported by diary. Baseline= entry into the study; follow up= 1 year and 20 weeks from baseline. p values represent the difference between groups at follow up.

	Cohort n=43		Control n=19		Intervention n=24			
	Baseline	Follow up	Baseline	Follow up	Baseline	Follow up	p	power
	mean (sd)	mean (sd)	mean (sd)	mean (sd)	mean (sd)	mean (sd)		
Age (years)	71.0 (3.7)	72.4 (3.7)	70.3 (3.5)	71.8 (3.4)	71.5 (3.8)	72.9 (3.8)		
Height (cm)	156.2 (7.5)	156.0 (7.4)	157.9 (5.7)	157.6 (5.6)	154.8 (8.6)	154.7 (8.5)		
Weight (kg)	61.5 (14.3)	61.5 (13.9)	60.1 (13.6)	59.8 (12.7)	62.6 (15.1)	62.8 (14.9)		
KES (kg)	25.1 (8.5)	25.5 (8.4)	25.5 (7.5)	24.9 (8.2)	24.9 (9.4)	25.9 (8.6)		
KES (kg/m)	16.0 (5.1)	16.2 (5.1)	16.1 (4.5)	15.7 (5.0)	15.9 (5.7)	16.6 (5.3)	0.634	0.1
Figure of 8 (sec)	24.3 (7.3)	22.8 (6.6)	23.7 (4.6)	21.7 (4.6)	25.2 (8.7)	23.8 (7.8)	0.861	0.1
Equitest	73.9 (9.1)	73.4 (8.7)	74.5 (6.4)	72.8 (7.0)	73.4 (10.9)	73.9 (9.9)	0.373	0.214
PA diary days /365		206 (107)		212 (117)		203 102)		
follow up period (yrs)		1.5 (0.07)		1.5 (0.08)		1.5 (0.06)		
walking (min/day)*	33 (26)	35 (22)	40 (34)	37 (25)	28 (17)	33 (19)	0.145	0.306
$Aero_{tot}$ (min/day)*	36 (26)	39 (23)	41 (33)	40 (24)	32 (19)	37 (22)	0.146	0.304
Osteofit (min 2x/wk)	0	17 (21)	0	9 (12)	0	23 (24)	0.020	0.653
Res_{tot} (min 2X/wk)	0	26 (32)	0	28 (40)	0	25 (24)	0.777	0.059

*n=42, One women from the control group was excluded from aerobic analysis as she was an outlier

5.1.2.2 *Drop out cohort*

On average this group reported 28.7 +/- 25.1 minutes of walking no resistance activity at baseline (Table 7).

Table 7 Baseline characteristics of physical activity (reported by monthly diary) of women *not* participating in the follow up. $Aero_{tot}$= total aerobic activity (min/day) as reported by diary. Res_{tot}= total resistance activity (min, 2x/week) as reported by diary.

	cohort (n=23)	control (n=12)	intervention (n=11)
	mean (sd)	mean (sd)	mean (sd)
walking (min/day)	29 (25)	25 (18)	33 (32)
$Aero_{tot}$ (min/day)	30 (25)	26 (18)	34 (31)
resistance activity (min, 2X/week)	0 (0.0)	0 (0.0)	0 (0.0)
Osteofit (min, 2X/week)	0 (0.0)	0 (0.0)	0 (0.0)

The follow up cohort reported slightly greater number of minutes walking at baseline than the drop out cohort. Both groups reported no resistance training at baseline.

5.1.3 Health history

5.1.3.1 *Follow up cohort*

This cohort on average had a high school education, with 7 women in the control group and 5 women in the intervention group completing a university degree. At entry into the study, 47% of the women reported living alone. The percentage of women reporting known medical conditions included: 13% reported rheumatoid arthritis, 47% osteoarthritis, 6% experienced a stroke and 15% suffered depression. Nearly 40% of the women reported using tobacco products on a daily basis for at least 6 months. On average this cohort used 2.4 +/- 1.7 prescription medications and have suffered 1.6 +/- 2.2 fractures. (Table 8)

Table 8 Baseline health history of women participating in the follow up. Numbers represent those who answered "yes".

	Cohort n=53	Control n=25	Intervention n=28
	#(%) or mean(sd)	# (%) or mean(sd)	# (%) or mean(sd)
Education			
1.< grade nine	8(15)	4(16)	4(14)
2.gr. 9-13, no certificate	8(15)	1(4)	7(25)
3.high school certificate	16(30)	11(44)	5(18)
4.trades or profession cert	4(8)	2(8)	2(7)
5.some university	7(13)	3(12)	4(14)
6.university certificate	3(6)	2(8)	1(4)
7.university degree	7(13)	2(8)	5(18)
Live alone	25(47)	13(52)	12(43)
RA	7(13)	3(12)	4(14)
OA	25(47)	10(40)	15(54)
Stroke	3(6)	1(4)	2(7)
Depression	8(15)	4(16)	4(14)
Low BP	5(9)	1(4)	4(14)
Estrogen	23(43)	9(36)	14(50)
# yrs estrogen	3.1(5.1)	1.5(2.8)	4.5(6.3)
Provera	14(26)	7(28)	7(25)
# yrs provera	1.1(2.7)	0.8(2.0)	1.3(3.2)
bisphosphonate	30(57)	7(28)	15(54)
Tobacco	21(40)	9(36)	12(43)
# drugs	2.4(1.7)	2.2(1.7)	2.5(1.8)
# of fxs	1.6(2.2)	1.7(2.4)	1.6(2.1)

5.1.3.2 Drop out cohort

This cohort on average had a high school education, with 6 and 2 women in the control and intervention groups respectively completing a university degree. At entry into the study 53% of women reported living alone. Daily use of tobacco products for at least 6 months was reported in 40% of women. In this cohort, 9% had rheumatoid arthritis, 34% had osteoarthritis and 19% suffered from depression. On average this cohort used 2.0 +/- 1.3 prescription medications and has suffered 1.1 +/- 1.2 fractures (Table 9).

Table 9 Baseline health history of women *not* participating in the follow up. Numbers represent those who answered "yes".

	Cohort(n=32)	Control(n=19)	Intervention(n=13)
	# (%) or mean(sd)	# (%) or mean(sd)	# (%) or mean(sd)
Education			
1. < grade 9	1(3)	0(0)	1(8)
2.gr. 9-13, without cert	4(3)	2(11)	2(15)
3.high school certificate	10(31)	5(26)	5(38)
4.trades or professional cert	5(16)	4(21)	1(8)
5.some university	1(3)	1(5)	0(0)
6.university certificate	3(9)	1(5)	2(15)
7.university degree	8(25)	6(32)	2(15)
Live alone	17(53)	11(58)	6(46)
RA	3(9)	1(5)	2(15)
OA	11(34)	4(21)	7(54)
Stroke	0	0	0
Depression	6(19)	2(11)	4(31)
Low BP	4(13)	1(5)	3(23)
Estrogen	13(41)	8(42)	5(39)
# yrs estrogen	2.5(5.6)	3.2(7.0)	1.5(2.1)
Provera	10(31)	6(32)	4(31)
# yrs provera	2.1(5.6)	2.9(7.1)	1.0(1.7)
bisphosphonate	18(56)	11(58)	7(54)
Tobacco	13(41)	9(47)	4(31)
# drugs	2.0(1.3)	1.6(1.2)	2.7(1.2)
# of fxs	1.1(1.2)	0.9(1.4)	1.3(0.9)

The women in both follow up and drop out cohorts reported similar health histories in terms of levels of education attained, reported medical conditions, use of tobacco products, use of prescription medication and number of fractures suffered.

5.2 Hypothesis specific results

5.2.1 Comparison of performance related outcomes and physical activity parameters between previous Osteofit participants and controls.

Repeated measures ANOVA showed no significant differences between Osteofit intervention and control groups from baseline, 20 weeks and follow up for any of the performance parameters (Table 4). The repeated measure ANOVA showed no significant differences between Osteofit intervention and control groups for time spent in walking, in total aerobic activity and in total resistance activity. There was a significant difference between intervention and control groups for time spent in Osteofit at follow up (P=0.02). At baseline both groups reported 0 minutes of Osteofit, twice per week. At follow up the control group reported 9 +/- 12 minutes, twice per week and the intervention group reported 23+/- 24 minutes, twice per week (Table 6).

5.2.2 Comparison between participants who met ACSM guidelines for aerobic and resistance activities and those who did not

Participants who met the ACSM criteria for aerobic activity did not perform significantly better than those who did not meet the ACSM criteria at follow up on knee extension strength, figure of eight time or Equitest (Table 5). However, there was a trend for decreased time on the figure of eight test in those meeting the ACSM criteria as their time decreased by 2.2 seconds compared to those not meeting the criteria whose time decreased by 1.4 seconds (Table 10). There were no significant differences between groups at follow up on knee extension strength, figure of eight or Equitest (Table 11).

Table 10 Whole cohort by ACSM aerobic guidelines at follow up. KES= Knee extension strength corrected for height (kg/m). Baseline= entry into the study; follow up= 1 year and 20 weeks from baseline. p values represent the difference between groups at follow up.

	Baseline				Follow up					
Parameter	n	No mean (sd)	n	Yes mean (sd)	n	No	n	Yes	p	power
KES (kg/m)	18	16.1(4.9)	28	16.1(5.2)	18	15.8(5.7)	28	16.8(4.8)	0.244	0.295
Figure of 8 (seconds)	17	25.4(9.2)	28	23.4(5.7)	17	24.0(8.6)	28	21.8(4.6)	0.301	0.254
Equitest	18	71.4(12.3)	28	75.9(5.4)	18	70.8(11.7)	28	75.5(5.6)	0.719	0.100

Table 11 Whole cohort by ACSM resistance guidelines at follow up. KES= Knee extension strength corrected for height (kg/m). Baseline= entry into the study; follow up= 1 year and 20 weeks from baseline. p values represent the difference between groups at follow up.

	Baseline				Follow up					
Parameter	n	No mean (sd)	n	Yes mean (sd)	n	No	n	Yes	p	power
KES (kg/m)	22	15.6(5.5)	24	16.5(4.7)	22	16.3(5.5)	24	16.4(4.8)	0.709	0.102
Figure of 8 (seconds)	21	25.0(5.7)	24	23.4(8.4)	21	23.6(5.6)	24	21.9(7.0)	0.862	0.053
Equitest	22	73.8(7.7)	24	74.5(10.1)	22	74.0(8.5)	24	73.4(9.1)	0.601	0.129

5.2.3 Comparison of participation in aerobic, resistance and community based (Osteofit) activities before and after participation in a community based exercise intervention

Of the 53 women who participated in the follow up study, 46 women recorded physical activity in a diary for period of at least one month to a maximum of 12 months after their 20 week assessment. From these diaries it was determined that 26.1% of the women performed resistance exercise (exclusive of Osteofit) in the home, 45.6% who performed Osteofit did so in a community environment and 97.8% of women report home- based aerobic exercise, mostly comprised of walking (Table 12).

Table 12 Number of women participating in home or community based resistance, Osteofit and aerobic exercise in the Follow Up period (n=46).

Type of Physical Activity	Home based exercise or walking	Community based
Resistance Exercise	12 (26%)	3 (7%)
Osteofit Program	4 (9%)	21 (46%)
Aerobic Exercise	45 (98%)	17 (37%)

The most popular form of physical activity was walking, with 97.8% of women partaking. The two most frequent activities reported after walking were gardening, 56.5%, and Osteofit (both home (%) and community based (%)), 54.3% (Table 13).

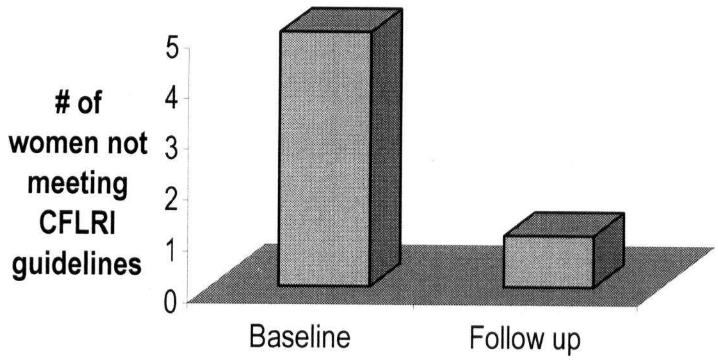
Table 13 Number of women reporting participation in various types of physical activity by diary in the follow up period (n=46)

Activity	Number of women	Percent (%)
Walking	45	97.8
Gardening	26	56.5
Osteofit (home and community based)	25	54.3
Resistance Exercise	15	32.6
Swimming	12	26.1
Dancing	4	8.7
Lawn Bowling	3	6.5
Other*	26	56.5

*2 or less women reported participation in downhill skiing, cross country skiing, pilates, yoga, tai chi, badminton, table tennis, singles tennis and doubles tennis

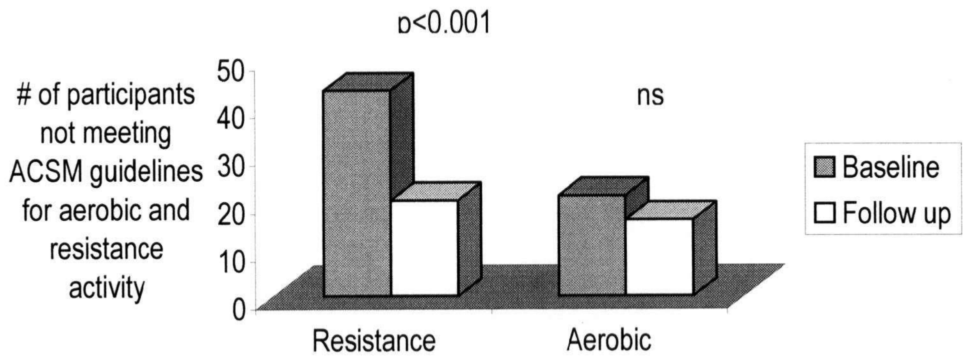
The Canadian Fitness and Lifestyle Research Institute (CFLRI) defines inactive as those individuals participating in less than 10 minutes of physical activity per day. At baseline, five individuals were not achieving 10 minutes per day of aerobic activity and at follow up only one individual was considered inactive (Figure 3).

Figure 3 Number of women considered inactive by CFLRI guidelines at baseline and follow up (n=43).



The American College of Sports Medicine guidelines for aerobic activity is "30 minutes of moderate aerobic activity on most, preferably all days of the week". From baseline to follow up, 4 women moved from not meeting this recommendation to meeting it. The ACSM guidelines for resistance activity is "20-30 minutes of resistance activity using all major muscle groups, 1 set of 12 repetitions". At baseline 43 women were not meeting this guideline and at follow up 21 women were not meeting this guideline- a significant change for 22 women. This difference was significant using Chi Square, χ^2= 29.56, $p<0.001$ (Figure 4).

Figure 4 The number of participants not meeting ACSM resistance and aerobic guidelines at baseline and follow up (n=43).



Chapter 6: Discussion

In the present study, I examined (a) whether or not benefits of an exercise intervention study were maintained in women once the study was completed; (b) whether there were differences in performance related outcomes based on current activity levels (aerobic and resistance); and (c) whether there were different levels of participation in physical activity after participation in an exercise study.

6.1 Comparison of performance related outcomes and physical activity parameters between previous Osteofit participants and controls.

To my knowledge, there are no follow up studies of falls risk factor profiles in the elderly after an intervention designed to reduce them. In fact only a few studies report any follow up data for the most part related to adherence to the programme. In this follow up study, the a priori design was acknowledged to allow some exploratory work regarding involvement in Osteofit and performance variables at 17 months follow up.

The Osteofit Study reported a significantly greater (P=0.047) increase in knee extension strength in the intervention group (11%), compared to control group (-2%). There was also a significantly greater (P=0.04) increase in dynamic balance in the intervention group measured by figure of eight (8%) compared to control group (3%) at 20 weeks. There was a trend towards improved balance (static) in the exercise group however; the sample may have been too small to detect these differences. In the follow up study, 12 months post 20-week assessment; there were no significant differences between the intervention and control groups on any of the performance parameters- knee extension strength, dynamic balance or static balance. It is however, interesting to note that while there were no significant differences, the intervention group had a greater increase in knee extension strength (+5%) compared to the decrease seen in the control group (-3%). Certainly the most obvious reason for not seeing any statistically significant differences between the two groups at follow up on knee extension strength and dynamic balance was lack of statistical power. In order to detect a 20% difference between groups in knee extension strength, 44 women per group were required and 24 women per group were required to detect a difference in dynamic balance.

At follow up, there were 25 and 28 women in the control and intervention groups respectively.

Although it is interesting and perhaps important to evaluate performance following participation in an exercise study we did not expect that gains observed after 20 weeks would be maintained 1-year later, as no formal exercise program was being facilitated during this period. Fiatarone et al trained frail male and female nursing home residents aged 86-96 years old. After 8 weeks of training three times per week, quadriceps strength increased by 174% in the training group. However, only 4 weeks after the subjects' ceased training, the increase in quadriceps strength was lost (42). The women participating in the Osteofit study were by definition healthier and younger than the cohort studied in Fiatarone et al study, (community dwelling versus care facility). We observed a much smaller (11%) increase in strength at 20 weeks and our follow up period was 52 weeks.

The ceiling effect may have played an important role in the results of the present study. In two studies Lord et al (8, 24) used the same knee extension dynamometer as the one used in the present study, and reported mean strength (corrected for height) in women after completing an exercise programme to be 16.7 kg/m compared with 12.2 kg/m for women who were sedentary (24). Our mean baseline values for intervention and control groups were 15.7 (kg/m) and 15.6 (kg/m) respectively. These values more closely resemble the knee extension strength reported by the women in Lord and colleagues work *after* completing the exercise programme. Further, Lord et al (8) reported mean baseline knee extension strength (not corrected for height) in a larger randomised controlled trial to be 20.9 kg and 22.3 kg in intervention and control groups respectively. This compares with mean raw strength scores at baseline for the intervention and control groups of 24.9 kg and 24.5 kg respectively, in the present study. Finally, the Physiological Falls Profile (Fall Screen-16), developed by Stephen Lord at the Prince of Wales Medical Research Institute, Australia, suggests that performance be graded the following way: poor <15 kg; fair 15-20 kg; good 20-30 kg; and, excellent is >30 kg (23). Therefore, the mean strength score for the present study cohort falls into the "good" category. It is possible that because these women already displayed good strength, it might be very difficult to induce further improvements, given Osteofit is a mild, introductory exercise programme.

Performance on Equitest showed a trend for improvement at 20 weeks and showed no trends in either direction at follow up. Thus the ceiling effect may be responsible for observed performance on this variable as well. The Equitest normative value for the composite score is approximately 68 (56). This is an approximation as normative values do exist in the Equitest users manual, however, they were developed on a very small sample size and the reported score is not one to which comparisons can be made (54). This estimate is based on the reference value reported with the individuals' printout of their performance. At baseline, the intervention and control group scored 73.3 and 75 respectively. Thus, the women in the current study were already exceeding normal expectations for their age and sex.

In terms of physical activity parameters, aerobic and resistance exercise, it became immediately apparent that our cohort was very active. At baseline intervention and control groups reported 28 minutes per day and 40 minutes per day of walking respectively. Similarly, women reported 37 minutes per day of total aerobic activity if in the intervention group and 40 minutes per day if in the control group. In addition, the average number of minutes spent in lifestyle activities (57) such as vacuuming, heavy housework, and gardening was 54 minutes per day (range 0- 254 minutes per day) for the entire cohort. On average, this gives a combined total time of 92 minutes per day spent in aerobic activity or performing lifestyle physical activities. This clearly exceeded normative physical activity levels reported for this age group in a Canadian survey. According to the 1997 physical activity survey by the Canadian Lifestyle and Research

Institute, 78% of women aged 65 and older are not active enough to derive health benefits (2). The CFLRI defines "not active enough" as expending less than 3 kilocalories per kilogram of body weight per day or roughly equivalent to walking less than a total of one hour per day. In the present study, aerobic activity patterns did not change during the follow up period for either group. At baseline none of the women reported undertaking any resistance training exercises, as this was a criteria for entry into the Osteofit study. In the follow up period, the intervention and control groups reported a mean of 25 minutes and 28 minutes of resistance activity twice per week. Interestingly, the majority of the total time spent in resistance training in the intervention group was derived from Osteofit participation (23 minutes) and the majority of the time spent in resistance training in the control group was from other avenues (e.g. at home with resistance bands, dedicated gymnasiums).

6.2 Comparison between participants who met ACSM guidelines for aerobic activities and those who did not

The American College of Sports Medicine (ACSM) in conjunction with the Centers for Disease Control (Atlanta) currently recommends that all healthy older person aim to achieve 30 minutes of moderate intensity activity on most, preferably all days of the week (21). This can be accomplished in one 30-minute bout, or in smaller increments throughout the day (e.g. three, 10 minute sessions). The ACSM suggests that this guideline can be accomplished through activities such as walking, gardening, yard work, housework, climbing stairs and active recreational pursuits. When the follow up cohort were analysed by whether or not they were meeting these guidelines in the follow up period, no significant differences were seen for knee extension strength, dynamic balance or static balance. However, there was a trend for those meeting the guidelines to have improved knee extension strength (+4% versus –2%). As discussed earlier, the number of subjects required per group to detect a 20% difference in strength was 44. In this analysis, 28 individuals were meeting the guidelines and 18 were not, giving less that 30% power to detect a difference.

In the present study, aerobic activities such as walking, swimming and cycling comprised the individuals' time spent in aerobic activity. Walking contributed most to time spent in aerobic activity. Activities such as gardening, yard work and housework were not counted towards this score. Therefore, the number of women who met the ACSM guidelines for aerobic activity was conservative-- that is; more women may actually have met these guidelines than reported. The United States Surgeon General's report on physical activity and health, released in 1996, estimated that the percentage of women aged 65-74 years who participated in regular sustained physical activity at least five times per week, for a minimum of 30 minutes was between 19.0% and 21.3% (58). In the present study, 58% of women in the follow up period met the ACSM guideline for aerobic physical activity.

Lord et al. in their review of physical activity and fall risk indicated that relatively few studies in the elderly examined the role of aerobic activity on fall prevention(23). The majority of the aerobic physical activity literature targeted cardiovascular disease and longevity outcomes (23). However, two studies are relevant (9, 25).

One hundred and thirty one men and women aged 65-95 years were randomised to one of three arms: novel resistance training, walking or control group (25). They participated in a self-paced walking programme three times per week for 10 months. Walking began at 12 minutes per session and increased weekly to 14, 17, 20, 23, 27, 32, 38 and 45 minutes and then remained at 45 minutes for the remainder of the intervention. Although no information was provided regarding baseline physical activity levels, after 10 months the walking group showed significant improvements in static and dynamic balance, reaction time and two measures of activities of daily living- a stair climbing task and a pen pickup task. However, no significant changes were seen in knee extension strength. It is impossible to determine if the individuals in the walking group in the Rooks et al. study were meeting ACSM guidelines, as no information was available regarding activity levels outside of the intervention. This also makes it very difficult to determine the activity levels of the control group outside of the intervention. In other words, were the walking group being compared to a non-active or active group? In the follow up cohort, even those women who did not meet ACSM guidelines participated in some form of aerobic activity 18 minutes per day, excluding other types of moderate intensity activities such as gardening and heavy housework. Thus, we compared a somewhat active group with an active group. The Rooks et al study suggested that if you already have decreased fall risk factors (e.g. leg strength), that aerobic activity, mainly in the form of walking, will help to preserve the advantage.

Buchner et al randomised 105 older adults aged 68-85 to one of four groups: control, cycling, strength training or cycling and strength training (9). Eligible participants were below the 50th percentile for knee extensor strength for their height and weight. The exercise sessions were one hour long, three times per week for 24-26 weeks. After completing the 6 month programme, subjects were asked to continue exercising. Participants returned at 9 months for evaluation. The endurance training group (cycling), reported significantly greater increases in knee extension strength at 6 months and this difference persisted at 9 months. Although, knee extension strength was the only fall risk parameter ameliorated in this group, it is unknown whether these individuals moved into the upper 50th percentile for strength. A group of individuals with poor knee extensor strength showed improvement with stationary cycling. As our follow up study population was relatively strong at baseline, it was not surprising that strength did not improve further in the follow up period.

The value of endurance training for falls risk factors may be to improve the performance of activities of daily living. Lord et al alluded to this in their book arguing that simple physical activities such as walking across a room, getting dressed or climbing stairs have energy requirements associated with them and consequently a certain level of cardiovascular fitness is necessary to complete these tasks. In an unfit person, daily tasks, such as climbing stairs, will require the individual to operate at close to their maximum aerobic capacity (23), whereas those who are active will have little problems completing these simple physical tasks.

To summarize these findings, individuals who were inactive and had poor strength, participating in an aerobic programme of walking or cycling improve falls risk factors. However, 12 months appears to be insufficient time to further improve physical performance in women already meeting ACSM guidelines through self-designed training programs. The value of aerobic activity for fall risk factor reduction and fall prevention therefore may be best suited to those who are sedentary, those who are frail or those who are both.

6.3 Comparison between participants who met ACSM guidelines for resistance activity and those who did not

The ACSM guidelines state that elderly persons should be "encouraged to supplement cardiorespiratory endurance activities and an active lifestyle with strength-developing exercises." (21). Resistance training should be performed at least twice a week, with at least 48 hours of rest between sessions. Elderly persons should perform at least 1 set of 8 to 10 exercises that use all the major muscle groups. Each set should involve 10 to 15 repetitions that elicit a perceived exertion rating of 12 to 13 (somewhat hard). As a training effect occurs, overload should initially be achieved by increasing the number of repetitions, and then by increasing the resistance. If these recommendations are adhered to, training sessions should take no longer than 20 to 30 minutes to complete (21).

As with all physical activity parameters in this study, resistance activity was reported by daily diary. Activities that were classified as "resistance" activity include: Osteofit (home and community based), home based resistance activity (bands and hand weights), and gym-based weight training. They were classified as having met ACSM guidelines if in their diaries they reported a minimum of 20 minutes of resistance activity, twice per week. When we compared those individuals who were with those who were not meeting the ACSM resistance activity guidelines, no significant differences were found for knee extension strength, dynamic balance or static balance. There are a number of possible explanations for this finding. Power once again becomes the biggest issue. As was discussed earlier, 44 women were needed per group to achieve 80% power to detect a 20% difference between groups in knee extension strength. Similarly, 24 women were needed per group to detect a 20% difference between groups in dynamic balance. In this cohort, 24 women met the resistance guidelines and 22 women did not meet the guidelines- clearly these analyses were underpowered. However, given the paucity of follow up research, especially with regards to exercise programmes targeted at reducing fall risk factors, there is value in exploratory work that may serve to generate new hypotheses. In addition, we have no record of how active any of these women were prior to entry into the study. A lifetime of sport involvement may have benefits that persist into later life (59). In a retrospective study Perrin et al. (59) investigated physical activity in 65 elderly community dwelling men and women (43 women and 22 men) aged 60-85 years. They divided their study population into four sub groups: physical and sporting activities all their life (called active-active or AA), physical and sporting activities after retirement only (called inactive-active or IA), physical and sporting activities during youth but none for the last 30 years (called active-inactive or AI) and never participated in physical and sporting activities (called inactive-inactive or II). Balance was assessed under three separate conditions (static, fast dynamic and slow sinusoidal dynamic) performed with eyes open and closed. The authors concluded that postural control was best in subjects who had always practiced physical and sporting activities (PSA) (AA group) and was worst in those who had never taken part in any PSA (II group). Those who had just begun PSA (IA group) had good balance, as it was not different from the AA group. The authors concluded that recent periods of practice have greater beneficial effects on subjects' postural stability than never having participated in PSA or only having participated at an early age.

Currently there is no "gold standard" for assessing physical activity. In fact, what are often touted as the "gold standards" such as doubly labeled water and accelerometers, should according to Sallis and Owen, be awarded no more than a silver or a bronze (22). Because physical activity is a behaviour, it is very complex and difficult to measure. Thus, the best we are able to do is approximate the behaviour using methods such as diaries, motion sensors (accelerometers and pedometers) and recall questionnaires (22). Based on the physical activity literature regarding the elderly, questionnaires are validated against physical activity diaries or motion sensors and, the higher the correlation between the questionnaire and physical activity, the more valid the questionnaire (60, 61). There is a very real possibility that the diaries in the present study have under or over-reported physical activity. With respect to the null findings and participation in resistance activity, it could be that participants overestimated the amount of time spent in resistance training.

Finally, there is the issue of training stimulus. Although the women reported the duration and frequency of their resistance training sessions, for the most part we have no record of how intense each training sessions was. However, for the majority of women participated in community based Osteofit classes, we are able to discern the intensity of the resistance programme. The overall goal of Osteofit is to encourage inactive men and women with osteoporosis to become active. Osteofit, therefore acts as a "transition" programme. The idea being that after 10-weeks participants will have the confidence to either begin exercising on their own, or to register for an already existing senior's fitness class in the community. The exercises in the programme were designed to target posture, balance, gait, coordination, and hip and trunk stabilisation. Exercise repetitions range from 8 to 16 and the weights are relatively light (hand weights and TheraBands) so participants do not work to fatigue with each set.

Lord et al. intervened with a very similar (to Osteofit) community based exercise programme (8). During a 52- week intervention strength and balance parameters increased up to 22 weeks and remained constant from 22 weeks to 52 weeks. This cohort was not followed past 52 weeks, therefore it is unknown if the benefits of the programme persisted beyond the intervention period. Unfortunately, the authors did not measure baseline physical activity or physical activity during the study period. The only information provided was that women were not participating in any community based exercise programmes that were similar to the intervention programme. In the present study, on average, strength training was sufficient to maintain performance across the 20 week and 12 month follow up period.

It may be, however, that the resistance training programs were not intense enough to elicit a change in strength in these already active women. Nichols et al examined the effects of a heavy-resistance training programme in active women over age 60 years (engaged in aerobic activity at least 3 times per week for at least 6 months) (28). Women completed a progressive weight training programme and worked at 80% of their one repetition maximum (1 RM). The 1 RM was re-assessed at 6, 12, 18 and 24 weeks to ensure the programme was, in fact, progressive. At 24 weeks, the intervention group had significantly improved strength parameters compared to the control group. Interestingly, the gains in lower body strength were smaller compared with upper body strength. The authors hypothesized that the women recruited into the study already engaged in moderate to high intensity weight-bearing exercise, their legs had already undergone some degree of training. Thus, greater relative improvements due to weight training were less likely to occur. This is also likely the case for in our follow up study. Both groups of women, whether they were meeting the ACSM guidelines for resistance activity or not, were participating in moderate intensity, usually weight bearing, activity on a daily basis. However, the intensity of the training for those meeting ACSM guidelines was much less than women in the Nichols et al study.

In summary, there are several possible reasons why we did not observe a difference in performance parameters between those meeting and those not meeting the ACSM guidelines. There were not enough subjects per group to detect a difference, activity levels prior to enrolment in the study is unknown, participants may have over-reported the amount of time spent in resistance activities and finally, the training intensity of the resistance exercises was not high enough to elicit a strength response.

6.4 Comparison of participation in aerobic, resistance and community based (Osteofit) activities before and after participation in a community based exercise intervention

6.4.1 Aerobic Activity

Physical inactivity is an important modifiable risk factor for many chronic health problems, and in addition to positively effects muscle strength, aerobic capacity, and general well being in the elderly (62). Therefore, to initiate and maintain regular exercise are important public health objectives. Many physical activity interventions involving the elderly, however despite the benefits reported in these studies it is a challenge to persuade older adults to become physically active and to remain active (62). Although considerable effort is required to design studies, enroll participants and analyze data, it seems, from a public health perspective, that the most critical question is never asked. That is, "What impact does involvement in an exercise study have on an individual's ongoing participation in physical activity?"

In this follow up study, 5 women at baseline were considered sedentary by the Canadian Fitness and Lifestyle Research Institute (CFLRI) guidelines. At follow up, only 1 participant was considered sedentary by these same guidelines. Although this difference is not statistically significant, from an overall clinical perspective these findings are valuable. These women represent an approximate 10% of the follow up study cohort. In a recent Canadian epidemiological study (18), a 10% reduction in physical inactivity was estimated to reduce direct health care expenditures by $150 million a year. Paffenbarger et al. demonstrated the largest reduction in all cause mortality between those who were sedentary category and those in the next most active category (6). At baseline 20 women were not meeting ACSM aerobic guidelines compared to 16 women at follow up. Again, the public health implications of four more women now meeting aerobic physical activity guidelines supported by the ACSM, the Centers for Disease Control and the American Heart Association may be important.

6.4.2 Resistance training

A more startling contrast was observed when we examined the number of women who were or were not meeting the ACSM guidelines for resistance training. At baseline, none of the 46 women who completed both baseline and follow up diaries were meeting these guidelines. At follow up, only 21 women were not meeting this guideline. These statistically significant findings suggest that more than 50% of study participants had begun or continued resistance training one year after cessation of the formal Osteofit research study. Should these results be generalizeable to the larger population, they have significant health implications.

A recent review of the effectiveness of physical activity interventions in older adults showed that very few studies followed their study populations beyond the intervention period. Of the 34 studies of home or group based physical activity, only 7 reported follow up data- 6 aerobic studies and 1 strength training study (62). None of these 7 studies were related to fall risk factor interventions. In the present study, 46 women completed diaries in the follow up period. Of these 14 of 25 women in the intervention group and 9 of 21 women in the control group reported continued participation in Osteofit. That is 56% of the intervention group and 43% of the control group participated in at least 10 Osteofit classes (this represents 50% attendance in a 10 week programme) in the follow up period.

Campbell et al. (1997), reported after one year that, 42% of women in the exercise arm independently continued to perform exercises as prescribed by the physiotherapist (46). We invited women in the control group to participate in Osteofit at the end of the intervention period. As well, there was no formal obligation to attend Osteofit classes or to maintain usual activity patterns after the 20-week intervention period. The only contact that the research team had with any of the women during the 52 weeks of follow up was to recruit them for the study and to schedule their follow up assessment. Women were encouraged to continue with their usual activities, to feel free to continue with Osteofit, discontinue Osteofit or take up Osteofit at any time during the one year follow up period.

Although both control and intervention groups were on average, participating in the same amount of resistance activity, it becomes obvious that the exercise was derived from two different sources. The intervention group remained involved in Osteofit classes whereas the control group became involved in other programmes. The social network established during the 20-week Osteofit study likely promoted continued involvement for this group. Anecdotally, one of the Osteofit exercise groups hired their own instructor at the end of the study so that they could continue taking classes together. One of the participants in this particular group commented that although the class was no longer strenuous enough to elicit physical improvements, the social interaction was important enough to promote continued participation. This type of social phenomenon was reported by Skelton et al. (31) where study participants enjoyed the programme so much that they asked that the programme be continued. The programme had been developed specifically for their study, and took place three times per week- once at the medical center and twice at home. Six months after the study ceased, one weekly class was started in a participant's front room with three women attending, two women had joined other community classes and 12 women reported that they continued to exercise at home at least once per week. It is unknown if the programme was offered to the control group at the end of the study (31). In the Buchner et al. (9) study, although the control group was invited to exercise after 6 months, only 7 (of 30) controls chose this option. In the present study, although the control group was subsidized to participate in Osteofit after the study period among existing Osteofit classes was not sustained. This is likely attributed to them being dispersed among classes (if they chose to participate at all) which does not provide the same degree of socialization as the intervention group experienced in the dedicated classes.

There may be several other reasons that explain why participation in Osteofit remained high after the study period. The programme was already in place across the province of British Columbia and therefore there was ready access to classes. The cost of the class is relatively inexpensive, $3 CDN per class. The Osteofit instructors were all highly trained and are certified by both the British Columbia (BC) Recreation and Parks Board and by the BC Women's Hospital Osteofit Training Instructor. A final reason that the programme remained popular may be because of its affiliation with BC Women's Hospital Osteoporosis Programme. Women who are seen at the Osteoporosis Programme are encouraged by the physicians and physiotherapists to participate in physical activity. There is recent evidence that supports the role of physician counseling to promote the adoption of physical activity. Calfas et al randomised 17 physicians to counsel their patients about exercise or to continue with their usual care (49). Two hundred and fifty five healthy, sedentary adults were recruited from these practices. Intervention physicians delivered 3 to 5 minutes of structured physical activity counseling during the patient's visit. When the patients were contacted 4 to 6 weeks after their appointment, the intervention patients reported increased walking more than the control patients, 37 minutes per week compared to 7 minutes per week. More evidence is needed to support this type of physical activity promotion. Interestingly neither the Canadian Medical Association (CMA) nor the College of Family Physician of Canada has developed explicit general policies on exercise or exercise for special populations (63).

To develop effective interventions to promote physical activity in the elderly, it is important to know what types of activities already active elderly persons engage in. The Physical Activity Monitor for the year 2000 reports that among those persons over the age of 65 who engage in some type of activity, 80% walk, 69% garden, 50% do home exercises, 12% take exercise classes and 11% weight train. Interestingly, the most popular recreational activity across all age groups is walking and from the age of 25 and older, gardening is the second most popular activity (2). There is a negative relationship between age and participation in home exercise, exercise classes and weight training, however, these results are from cross-sectional data. In our follow up cohort, 98% of the women walked regularly, 57% gardened, 54% participated in Osteofit, and 33% participated in other resistance exercise. These data are consistent with the Physical Activity Monitor- although our cohort reported more resistance activity. It is also interesting to appreciate where physical activity is taking place. Resistance activity, other than Osteofit, was mostly performed in the home- 26%. Osteofit participation was mostly community based- 46%. Aerobic activity was done primarily in the home environment (walking), however 37% of the women engaged in community based programmes such as swimming or other senior's exercise classes.

The women involved in our follow up study were highly active. Even though there were no statistically significant differences among women for fall risk parameters, the larger body of physical activity literature suggests that their current average activity patterns will provide overall general health benefits.

Chapter 7: Summary and Conclusions

7.1 Summary

7.1.1 Primary Objectives

(a) This 12-month follow up study of 53 women involved in the Osteofit study demonstrated that those women allocated to the intervention group reported significantly more minutes spent in Osteofit in the follow up period than the control group. Despite this, there were no significant differences in fall risk factors (knee extension strength, dynamic balance, static balance) between those who had been randomized to intervention and control groups at the start of the original study.

(b) There were no significant differences in fall risk factors between women who were meeting the American College of Sports Medicine guidelines for *aerobic* activity and those who were not.

(c) There were no significant differences on fall risk factors between women who were meeting the American College of Sports Medicine guidelines for *resistance* activity and those who were not.

(d) The level of participation in resistance activity for the entire cohort was significantly different from baseline to follow up.

7.2 Conclusion

7.2.1 Primary Objectives

(a) Participation in 20 weeks of Osteofit does not improve fall risk factors (knee extension strength, dynamic balance and static balance) at 12-months follow up.

(b) Women reporting high levels of aerobic activity at baseline and at follow up may not see positive benefits in fall risk factors such as knee extension strength, dynamic balance and static balance in response to a moderate intensity intervention such as Osteofit.

(c) Women who report meeting the American College of Sports Medicine guidelines for resistance activity may not be performing the exercises at a high enough intensity to benefit fall risk factors.

(d) A community based exercise intervention may be an effective way to encourage women aged 65 to 75 to increase their level of participation in physical activity -- particularly resistance training. However, further studies of different exercise interventions need to be tested if the goal of the exercise is to reduce the risk of falls.

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Appendix I: Consent Form

Procedures:

Two questionnaires and the physical testing require your participation once during the course of this follow-up study. This will take place at the Neuro-otology Laboratory at Vancouver General Hospital (Willow Pavillion, Ground Floor). You will have your balance tested (computerized dynamic posturography) at this venue, and for convenience, will have height, weight and quadriceps strength and walking (40 meter "figure of 8" walk) measured at the same visit. We will also administer questionnaires concerned with osteoporosis quality of life and back disability in a room adjacent to the balance testing. The questionnaires will take about the same length of time as the physical tests (30 minutes). As well, you will be contacted once every two months via telephone to complete a physical activity questionnaire (5 minutes). You are also asked to keep a physical activity diary on the calendars provided.

Physical measures:

Balance using computerized dynamic posturography: We will measure sway using a computerized, dynamic posturography platform. You will be asked to stand on both feet on this platform so that the visual and sensory components of balance can be assessed. This procedure, including instruction, takes 15 minutes.
Quadriceps muscle strength: will be measured with you sitting. A strap will be placed above the ankle and you will be asked to pull against the strap assembly as forcefully as possible. This measure will be repeated three times and the greatest force exerted will be recorded. This procedure will take approximately 10 minutes.
Height and weight: will be measured using standard techniques.
Figure of 8 walk: will be measured by timing you to walk 2 laps of a 20 meter "figure of 8" course.

These procedures are commonly used in medical practice and should not cause you any discomfort. A trained research assistant and a medical specialist will be available on every occasion to explain the procedure, answer any questions and assist you as required.

RESEARCH PROJECT CONSENT FORM

Rights and Welfare of the Individual:
It is understood that you are free to withdraw from any or all parts of the study at any time without penalty. Your identity will remain confidential and only those directly involved in the study (the investigators previously named) will have access to your records and results. All individual results will remain confidential.

Please be assured that you may ask questions at any time. We will be glad to discuss your results with you when they have become available and we welcome your comments and suggestions. Should you have any concerns about his study or wish further information please contact Dr. Karim Khan (822-1891) or Meghan Donaldson (822-0056) at the University of British Columbia. If you have any concerns about your treatment, please contact Dr. R.D. Spratley at the office of Research Services and Administration at UBC (822-8598).

Participant Consent:

I,____
(please print your name)
understand the purpose and procedures of this study as described and I voluntarily agree to participate. I understand that at any time during the study I will be free to withdraw without jeopardizing any medical management, employment or educational opportunities. I have received two pages of the consent form and understand the contents of both pages, the proposed procedures and possible risks. I have had the opportunity to ask questions and have received satisfactory answers to all inquiries regarding this study. I have received a copy of the consent form.

____________________________ ____________________________
Signature of Participant Date

Appendix II: CaMOS questionnaire

Questionnaire A

MODIFIED CaMOS QUESTIONNAIRE

To begin the questionnaire I would like to ask you general questions about yourself.

1. SOCIO-DEMOGRAPHIC INFORMATION

1.2 Date of Birth: _____/ ________/ ________ (Present age _________)
Day Month Year

1.3 In what country were you born?

1.8 How may years of school have you finished? (Mark the highest grade completed)

- ❑ less than grade 9
- ❑ grades 9-13, without certificate or diploma
- ❑ high school certificate or diploma
- ❑ trades or professional certificate or diploma (CEGEP in Quebec)
- ❑ some university certificate or diploma
- ❑ university degree

1.9 What is your current employment status?

- ❑ Employed full time
- ❑ Homemaker (full time)
- ❑ Employed
- ❑ Disability
- ❑ Retired → How old were you? ______ years
- ❑ Other (specify ____________________)

1.10 Do you live alone? o Yes o No

Do you live with another adult?
o Yes o No

1.11 Do you have a particular doctor or clinic that you would call your regular doctor or clinic? o Yes o No

Now we'll review your past health.

2. MEDICAL HISTORY

2.1 Has a doctor ever told you that you have any of the following conditions?

	DIAGNOSIS			TREATMENT			
	Yes	No	DK	Yes	No	DK	N/A
Osteoporosis							
Rheumatoid arthritis							
Osteoarthritis							
Thyroid disease: 1 = Hyperthyroidism 2.= Hypothyroidism							
Liver disease							
Scoliosis							
Eating disorder							
Breast cancer							
Uterine cancer							
Inflammatory bowel disease							
Kidney stones							
Hypertension							
Heart attack							
Stroke TIA (Transient Ischemic attack)							
Neuromuscular Disease 1 = Parkinson's Disease 2 = Multiple Sclerosis 3 = Other							
Diabetes: Age____ 1 = Insulin Dependent 2 = Non Insulin Dependent							
Kidney disease							

2.2 Which of the following surgeries have you had in the past? How old were you?

	Yes	No	Age
Parathyroid			
Thyroid			

Stomach			
Intestine			
Gall Bladder			

2.4 Have you fallen in the past week? o Yes o No

↓

How many times? ____

2.5 Have you fallen in the past month? o Yes o No

↓

How many times? ____

Now I will ask you about any medicines you may have taken.

3. DRUGS AND MEDICATIONS

3.1 Have you ever taken ay of the following medications daily for more than one month?

If YES: For approximately how may months total have you taken it?

	Yes	No	Total # of Months Taken
Thyroid pills (Synthroid®)			
Dilantin (Seizure Pills) / Phenobarbital			
Tamoxifen (Nolvadex)			
Calcitonin (Calcimar)			
Didronel® / Etidronate			
Fosamax® / Alendronate			
Actonel® / Risedronate			
Fluoride (Fluatic)			
Diuretics – Thiaide / Other			
Laxatives			
Cortisone / Prednisone			
1 = Oral			
2 = Inhaled			
			FREQUENCY OF INJECTION
3 = injection a) Intravenous			
b) Intramuscular, Subcutaneous			

3.2 Current medications and or self administered supplements taken on a regular basis.

Medications: From contents of medicine cabinet		
NAME	DOSE	FREQUENCY

4. FRACTURES

4.1 Have you ever fractured any bones? o Yes o No → Go to 5.1 If female

↓

Complete the table below

(Refer to picture of body skeleton (if necessary)

Use the following trauma codes to indicate how it

1 = severe trauma

2 = minimal trauma

3 = other disease

(See manual for definitions)

			BONE SITE										OTHER			
Incident(s)	Trauma Code	Age(years)	BACK		RIBS		PELVIS		FOREARM/ WRIST		HIP		Bone Site		Bone Site	
			#	X	#	X	#	X	#	X	#	X	#	X	#	X

# = fracture
X = x-ray

In this section I would like to ask you questions that will help us understand how women's hormones relate to bone structure. We ask everyone these questions.

5. REPRODUCTIVE HISTORY (FEMALES)

5.1 Before menopause, have you ever gone 3 months or more without a menstrual period?

o Yes o No
↓ ↳ Go to 5.2

What was the longest single period of time without a menstrual flow? _____ months

If you count all the periods you have missed throughout your Menstruating years, how many months would that be? ______ months
(this question asks for the cumulative time)

5.2 At what age did your menstrual periods stop. ________ age

5.3 Have you had your uterus removed (hysterectomy)?
o Yes o No
↓ ↳ At what age? ________years

5.4 Have you ever had one or both ovaries removed:

- ❑ Yes, one ovary removed at what age? _____
- ❑ Yes, both ovaries removed at what age? _____
  (if ovaries were removed on separate occasions, write the age at which the second ovary was removed)
- ❑ Yes, do not know how many at what age? _____
- ❑ No

5.5 Do you or did you ever take estrogen for menopause or for any other reason?

- ❑ Yes, currently o No
- ❑ Yes, but not now ↳ Go to 5.6

↓
What type(s)?
(Interviewers to show Ogen®, Premarin® pills, colours and doses and Estraderm®, Estracomb® patches, sizes and doses)

o Pill

Pill No.	Number of Days/month	Age Started	Age Stopped	Total number of Months taken

o Patch

Patch No.	Number of Days/month	Age Started	Age Stopped	Total number of Months taken

o Injection How many times/year? _________

How many years _________

o Vaginal cream How frequently? _________

5.6 Do you or did you ever take Provera®, for menopause or for any other reason?

❑ Yes, currently
❑ Yes, but not now
↓
What type(s)? (Interviewers to show Provera® pills, colours and doses)

o No
↳ Go to 5.7

o Pill

Pill No.	Number of Days/month	Age Started	Age Stopped	Total number of Months taken

o Injection How many times/year? _________
How many years _________

Now I will ask about your family history.

7. FAMILY HISTORY

7.1 How many brothers and/or sisters do/did you have? (not adopted)

________siblings o do not know

7.2 I would like to ask about the following family members and their medical history

Diagnosis	Parents			Siblings				Children			
	Yes	No	DK	Yes	No	DK	NA	Yes	No	DK	NA
Fracture											
Osteoporosis											
Osteoarthritis											
Scoliosis											
CVD, stroke, aneurysm, hypertension											
Breast cancer											
Ovarian cancer											
Uterine cancer											

In this section I will ask you about diet, exercise programs and eating habits.

8. PHYSICAL CHARACTERISTICS

8.1 What was your greatest adult height? ____feet ____inches -or- _____cm o do not know

Now the questions I will ask will relate to the use of tobacco

9. TOBACCO

9.1 Have you ever used any of the following tobacco products daily for at least 6 months?

Cigarettes	o yes	o no	
Pipes	o yes	o no	
Cigars	o yes	o no	
Chewing tobacco	o yes	o no	If NO to all: go to 9.3

9.2 Complete the following table for each product used.

- At what age did you begin to ________ daily? (for at least 6 months)
- Are you currently smoking?
- At what age did you stop?
- Approximately how many every day? (number of cigarettes, bowls of pipe tobacco, number of cigars, number of chews)
- Have you temporarily stopped ______and started again? (total up all periods and convert to years)

	Age Started	Currently Smoking		Age Stopped	Amount Per Day	Temporarily Stopped (Years)
		Yes	NO			
Cigarettes						
Pipe						
Cigar						
Chewing tobacco						

Appendix III: Physical Activity Diary Instructions