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The Effects of a Lower Body Moderate Intensity Resistance Training Program on the Vertical Force-Time Curve of a Chair Rise in the Elderly

by

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Abstract

The purpose of this thesis was to evaluate the change in the vertical force-time curve of a chair rise in the elderly after a 12-week moderate intensity lower body resistance training program. The resistance training consisted of elastic tubing and squat exercise classes three times a week. Eight subjects completed the resistance program, and six control subjects attended a stretching class three times a week. Mean age of the subjects was 73 years.

The results suggested that the training subjects gained lower body strength compared to the control subjects. It appears that this strength increase led to changes in the vertical force-time curve of a chair rise. Significant changes were seen in the training group's decreased Min2, which is the amount of undershoot caused by deceleration of the vertical forces following the vertical rise ($p=0.043$), and their increased peak slope, representing the peak power generated in the rise ($p=0.017$).

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CHAPTER ONE

INTRODUCTION

"By the year 2031, it is expected that 20% of Canada's population will be over the age of 65 - which is estimated to be more than eight million seniors."(Elliot, 1996). This trend of aging demographics in Canada brings to the forefront many health issues pertaining to the elderly. Included in these issues is the role of physical fitness and exercise in relation to the quality of life and health of senior citizens.

Physical fitness is described by the World Health Organization as the ability to perform muscular work satisfactorily (Shephard, 1985). Exercise increases physical fitness and is a critical part of a healthy lifestyle. More specifically for the elderly, physical fitness aims to widen the range of independent living and pleasurable activities (Shephard, 1985). This objective in itself is reason enough to promote exercise and fitness among the aged; however, the benefits of physical fitness do not stop at these lifestyle improvements. There is growing evidence that exercise has a positive influence, both long-term and short-term, on the health of the elderly population (Gorman & Posner, 1988). In addition to the improvements in cardiovascular health and exercise capacity, exercise may also have a role in preserving bone density and slowing some neurophysiological losses (Gorman and Posner, 1988).

In the past, both research and the mass media have focused on the necessity of aerobic activity to improve health. Aerobic exercise induces cardiovascular health benefits and perhaps prevents some neurophysiological decline, but the preservation of and increase in bone density appears to be seen primarily with weight bearing or resistance exercise (Elward and Larson, 1992). In addition, a large concern for older adults is the loss of muscle mass and muscle strength. It seems that some minimal level of muscular fitness is critical for individuals to retain their independence (ACSM,1995). In a young person, aerobic exercise is usually sufficient to sustain an adequate muscle mass. However, this is not necessarily true for older individuals (Shephard, 1985). More than any other form of exercise, strength training may have a larger impact on quality of life and health in the elderly.

1.1 Strength Loss

With aging, decreases occur in muscle cross-sectional area and motor unit number, activation and synchronization (Tseng et al., 1995). These decreases lead to a loss of muscle strength. Fisher et al. (1991) state that the strength loss is gradual until the age of 50 years, and thereafter a significant loss of muscle strength occurs. From age 69-80 years, there appears to be an approximate three percent per year decrease in muscle strength (Aniansson et al., 1992). This strength decline is prevalent in both arms and legs, (Whipple et al., 1987) and the decrease in the lower extremities leads to gait inhibition and difficulties with other movements that require lower body strength. It seems that strength is imperative for normal, independent function. Tseng et al. (1995) agree that strength loss prohibits independent living for the aging population and they state that this contributes to a major financial drain on the health care system.

1.2 Financial Ramifications

This financial drain can be partly attributed to both acute and chronic problems exacerbated by a lack of muscle strength leading to a loss of independence in the elderly. Strength loss leading to muscle weakness (particularly in the lower body) contributes to falls (Gehlsen et al., 1990). The acute care costs of fall-related fractures are ten billion dollars per year in the United States (USA) (Tinetti et al., 1994). Canadian costs are estimated at approximately ten percent of those in the USA due to population differences. A further seven billion dollars per year in health care costs in the USA can be attributed to insufficient muscle strength and endurance - a chronic problem. This muscle weakness leads to the inability to perform activities of daily living (Rowlands & Lyons, 1991). Both the acute and the chronic problems associated with muscle weakness primarily tend to affect the elderly. This is a particular concern due to the growth of the aging demographic segment.

Senior citizens constitute the fastest growing age group in the USA population (Hopkins et al., 1990). This is comparable in Canada where in 1991 11.6% of the population was at least 65 years of age, and in the year 2011 the projected percentage is 14.6%. If both the health problems associated with aging and the demographic trends continue, the health care system will be under great financial strain in the near future. Resistance exercise may be an important part of the solution. Even in the very frail and aged, exercise can build strength (Fiatarone et al., 1990; Fisher et al., 1991) thus arresting or even reversing some of the muscle weakness due to age. Muscle strengthening in the elderly can potentially save the health care system a significant amount of money.

1.3 Resistance Training

Resistance training has been shown to increase muscle mass and neural coordination which lead to increased muscle strength (Fox et al., 1993). Many studies have shown a strength gain in the elderly with resistance training (Fiatarone et al., 1990; Frontera et al., 1988; Grimby et al., 1992; McCartney et al., 1995; McMurdo and Burnett, 1992; Mikesky et al., 1994; Morganti et al., 1995; Pyka et al., 1994). The question may be whether these strength gains translate into increased functionality. Tests of functional mobility often include measures of gait, stairclimbing capability, adequate strength to carry packages, and the ability to rise out of a chair. However, there is no consensus on the benefits to the elderly of strength training in terms of minimizing functional dependence. Some studies show that these strength increases can translate into significant gains in mobility, as measured by walking velocity (Hunter et al., 1995) or by sit to stand time (McMurdo and Rennie, 1993). Other studies have shown either very small differences or no differences in functional ability after resistance training (Mulrow et al., 1994; Skelton et al., 1995; Topp et al., 1993).

1.4 Chair Rise

Rising from a chair is considered one of the most mechanically demanding functional tasks routinely undertaken during daily activities. This is due to high peak contact pressures and knee torques (Riley, 1991). The timed chair-rise is a common test of functional dependence. McMurdo and Rennie (1993) found an improved timed chair rise during a seven month strengthening program. However, other studies have shown no change in chair-rise time after a strengthening regime. Skelton et al. (1995) found no improvement in the speed of a chair rise or multiple chair rises after a 12-week resistance training program in the elderly. Likewise, Hoy and Marcus (1992) also determined resistance training to have no effect on chair rise time or on the magnitude of the chair rise vertical force peak in the elderly. Perhaps the timed measurements do not adequately assess change in functional ability.

Fleming et al. (1991) discovered that several parameters in the force-time curve of a chair rise, including minimums, maximums and slopes, change with age. These same parameters are also different between subjects who have fallen (fallers), and subjects who have not fallen (non-fallers) in the previous year. Compared to the fallers, the non-fallers appeared to have more similarities in their force-time curves with younger subjects. Falls are associated with many factors, one of which is lower extremity weakness (Tinetti et al., 1994; Tinetti et al., 1995; Whipple et al., 1987). These findings suggest that the chair rise force-time differences in older subjects and in the fallers as compared to younger subjects may be caused by muscle weakness in the legs.

1.5 Summary of the Problem

Age-related muscle strength loss contributes to health degeneration and decline in functionality of the elderly. This strength decrease in the elderly leads to an inability to perform the activities of daily living, which increases health care costs (Tseng et al., 1995). A portion of this decline in functional ability is thought to be caused by inactivity.

Research is needed to determine which modes of training contribute to gains in or maintenance of various measures of functional ability.

1.6 Purpose of the Study

The purpose of the present study is to determine whether a 12-week lower body resistance training program influences lower body strength in senior citizens compared to a control group that completes a gentle stretching program. If the training does affect lower body strength, the present study evaluates whether these changes modify the vertical force-time curve of a chair rise. Senior citizens are defined for this study as older adults belonging to a senior citizens group or living in a senior citizens home or lodge, who responded to an advertisement requesting "senior citizen volunteers".

1.7 Statement of the Research Hypothesis

The subjects completing the resistance training program will change their lower body strength as measured by a strength/endurance task as compared to the control subjects who did not participate in the strengthening program. Furthermore, the resistance training group compared to the control group, will change the following vertical force-time parameters in a chair rise:

- the peak slope (Pslope) defined as the peak rate of force development representing the peak power generated
- the maximum vertical force (Max) generated

- the second curve minimum (Min2) defined as the amount of undershoot caused by deceleration of the vertical forces following the upward movement
- the first curve minimum (Min1) defined as the amount of undershoot caused by momentum generation prior to the weight off the chair phase
- the ratio of maximal vertical force to the second minimum (Max/Min2) representing the ability to accelerate and decelerate the vertical forces

In addition, the subjects completing the resistance training program will change their self-reported perception of fitness level over the 12 weeks compared to the control subjects.

CHAPTER TWO

LITERATURE REVIEW

2.1 Strength Loss in the Elderly

There exists some dispute about the occurrence of strength loss due solely to aging. Aniansson et al. (1992) suggest that the loss of strength due to aging in a normal population is approximately three percent per year from age 69 years to 80 years. This research group found longitudinal evidence of significant reductions (25-35%) in knee extensor muscle strength in the elderly over an 11-year period (Aniansson et al., 1992) and found that there was a 10-22% strength loss in subjects from age 73 to age 83 over a 7-year period (Aniansson et al., 1986). However, this view of inevitable strength decline with aging does not receive universal support. Greig et al. (1993) observed no significant change in the isometric quadriceps strength of 14 men and women in the seven year period from age 74 to 81. This could be explained by the habitual physical activity beyond the norms for their age by the Greig et al. (1993) subjects. The Greig et al. (1993) study supports the use-it-or-lose-it skeletal muscle atrophy model, rather than the aging theory of atrophy supported by Aniansson et al. (1992; 1986). It appears that with aging, regardless of whether strength loss actually occurs, skeletal muscles become more inclined to lose strength.

According to Thompson (1994), the principal factors contributing to the strength loss with aging include:

- muscle atrophy
- motor unit adaptations
- enzymatic changes
- rate of calcium transport
- activity levels

Muscle atrophy is caused both by decreased muscle fiber number and decreased fiber cross-sectional area, although the primary atrophy-causing factor appears to be decreased fiber number (Aniansson et al., 1992). Lexell et al. (1988) looked at muscle volume in 43 previously healthy male cadavers age 15-83 years. This study clearly demonstrated a progressive reduction in muscle area in the vastus lateralis with increasing age. In addition, Lexell et al. (1988) found that muscle area was more closely related to fiber number than to mean fiber size. They therefore concluded that it is likely that fiber loss is the main explanation for reduced muscle area.

Booth et al. (1994) proposed a motor unit loss beginning at approximately 50 years of age. There is evidence (Lexell & Downham, 1991) that some of the muscle fibers from the lost motor unit become reinnervated by remaining motor units. This is termed collateral nervous sprouting (Booth et al., 1994). It results in the creation of larger motor units and could contribute to the age-related loss of coordination (Spirduso, 1995).

There is no consensus on the issue of enzymatic changes. Evidence exists both for and against decreased glycolytic enzymatic activity with age (Thompson, 1994). It seems that enzyme decline with age may depend on muscle fiber type. Carmeli & Reznick (1994) stated that the greatest decline of glycolytic enzymes was observed in muscles containing high proportions of Type II fibers. Likewise, the reduction of mitochondrial enzyme activity was more pronounced in oxidative muscles (Carmeli & Reznick, 1994). These issues continue to be investigated. Proctor et al. (1995) and Aniansson et al. (1992) agreed that age does not appear to affect aerobic enzymatic activity. Biochemical results seem to indicate that enzymatic changes are not the primary factor responsible for the loss of muscular capacity with age.

The rate of calcium transport in muscles decreases with age due to a reduction in the sarcoplasmic reticular volume and a decrease in the calcium pump activity (Thompson, 1994). These factors affect the contraction time in older muscles thereby reducing muscle strength.

Lastly, the proportion of the population who exercise vigorously has been shown to decrease with age (Gorman & Posner, 1988). This makes it very difficult to determine which are the characteristics of aging muscle and which are the characteristics of disuse due to decreased activity. A large portion of the aging phenomenon could very well be attributed to inactivity.

2.2 Influence of Exercise Design on Outcome Variables

One form of activity is resistance training. Various strength training programs with diverse protocols have been examined by many researchers. Weight training using isometric, isotonic and isokinetic muscle contractions all have been shown to provide strength gains in adult populations (Morrissey et al., 1995). It seems that the efficacy of the resistance training program depends not only on the type of muscle contraction, but also on the following three variables:

- Intensity
- Frequency
- Duration

It is not yet known how to manipulate these variables in order to optimize training effects. Furthermore, there are health and safety issues to be considered when designing programs for the elderly. Creating an appropriate training protocol is an intricate task.

2.2.1 Intensity

The intensity of training seems to be a critical variable (Porter and Vandervoort, 1995). The overload principle states that the strength of a muscle will increase only when the muscle performs for a given time period at its maximal strength capacity (Fox et al., 1993). Following this principle, a certain intensity of training must be achieved in order to elicit strength gains. Despite this, Gorman and Posner (1988) speculate that even very low level strength programs would counteract some of the detrimental health consequences of disuse in immobile and disabled older people and perhaps help in maintaining activities of daily living.

Intensity can be assessed by various physiological measures, number of repetitions to fatigue or by a perceived exertion rating. The Borg scale is used to quantify perceived exertion (ACSM, 1995). This method uses a 15-point scale numbered 6-20 representing descriptions to estimate exertional stress from "very, very light" to "very, very hard" (Leslie, 1989). The American College of Sports Medicine (1995) recommends training at a perceived exertion level of no higher than 12-13 (somewhat hard) for elderly participants. This recommendation is based primarily on minimizing risk to the exercisers. The unresolved issue continues to be the optimal level of exercise intensity for the aged.

The intensity of a training session also depends on the number of repetitions performed. There is less controversy surrounding this issue. The general consensus is that for high-intensity strength training each exercise should be performed for 8-12 repetitions as suggested by Fiatarone (cited in Drought, 1994) and the American College of Sports Medicine (1995). More conservatively, Hurley (1995) recommends 10-15 repetitions per exercise. In strength training for the younger population, maximum strength is best developed by performing sets to fatigue consisting of one to eight repetitions (Stone and Kroll, 1986). Conversely, many repetitions with less resistance maximizes local muscular endurance. However, the American College of Sports Medicine (1995) cautions when training the older adult, never to use a resistance that is too heavy to complete at least 8 repetitions. Therefore, 8-12 repetitions completed to fatigue or near fatigue would be classified as high-intensity training for senior citizens. Exercises should be performed for two to three sets each as the individual becomes conditioned enough to tolerate multiple sets as suggested by Fiatarone (cited in Drought, 1994). The number of exercise sets should depend on the number of exercises performed per set, and the muscle groups being trained as well as practical issues, such as the time available (Hurley, 1995). When more than ten exercises are used, and when some of the exercises overlap muscle groups, it may be counterproductive and unrealistic to expect older adults to perform multiple sets (Hurley, 1995).

It also becomes important to determine the cadence of the exercises performed. With senior citizens the movements should be completed slowly, through the entire range of motion (Drought, 1994). However, if light repetitions are performed slowly, very little work will be performed, and there will likely be little benefit in muscle adaptation (Stone and Kroll, 1986). There appears to be a trade-off between optimal muscle adaptation and training adjustments for the elderly.

Lastly, the amount of rest between sets and between exercises must be resolved. One to three minutes of rest between sets are recommended for rest intervals (Hurley, 1995). Ninety-five percent of muscle recovery from fatigue (defined as momentary failure) occurs in two and a half minutes (Stone and Kroll, 1986). Less time is necessary when muscles are not worked until failure.

Low-intensity programs have produced muscle strength increases of 18% after 6-weeks of training (Fisher et al., 1991), and of up to 30% after 32-weeks of training (McMurdo and Burnett, 1992). The definition of low intensity seems to vary from study to study. It is questionable in the Fisher et al. (1991) training protocol which included maximal isometric contractions. A maximal contraction program seems to be of a reasonably high intensity. McMurdo and Burnett (1992) simply described their training as "low resistance muscle strengthening". The actual intensity was never defined.

In order to make large gains in strength, high-intensity resistance is necessary (Porter and Vandervoort, 1995). Knee flexion can increase up to 227% in 12 weeks (Frontera et al., 1988). Fiatarone et al. (1990) found average strength gains in knee extension of up to 174% in 8 weeks. It appears that by completing at least one set of 8 reps at 70-80% of a one repetition maximum per training session, the elderly can attain exceptional strength gains (Porter and Vandervoort, 1995).

Contrary to the majority of the research, there is some evidence to counter the rationale for high-intensity training to maximize strength gains in senior citizens. Hunter and Treuth (1995) studied women aged 60-77 years. They found a negative relationship between the relative amount of weight used in training and the strength increase demonstrated by each woman. Individual subjects were responsible for their own intensity increases. Those who trained at relatively low intensities acquired a greater strength increase at the end of the study. Furthermore, the increase in strength was independent of age and initial strength levels. The authors speculated that recovery from high intensity exercise may be slower in older individuals. This would suggest the use of lower training intensities in order to optimize strength gains in an older population.

Despite the Hunter and Treuth (1995) result, it would seem that the majority of research endorses the principle of high intensity training to maximize strength gains. However, significant gains seem to be attainable with low-intensity training.

2.2.2 Frequency

The frequency of training is the second variable that determines the type of program. Referring to low-intensity exercises for the elderly, repetition is the most important factor; the exercises should be performed every day, preferably three times daily (Lonnerblad, 1984). Conversely, for high-intensity strength training, approximately 48 hours of recovery time between each exercise session is recommended (Hurley, 1995; Porter and Vandervoort, 1995).

The frequency most often recommended is three times a week (Stone and Kroll, 1986). However, Hicks et al. (1991) acquired comparable strength increases with only two training sessions per week. Speculation by Hunter and Treuth (1995) considers that two days a week of training may be more appropriate for the elderly because the older adult may need more recovery time.

2.2.3 Duration

The duration of each exercise session should be no more than one hour (ACSM, 1995; Leslie, 1989). No studies with older adults were found that utilized training sessions which lasted longer than one hour. It is assumed that very little can be accomplished in the weight room by training in excess of one hour, additional to the benefits gained within one hour.

Duration also refers to the length of the program. Until recently, it was believed that increases in strength levels due to resistance training in the elderly were caused entirely by neurological factors (Hurley, 1995). It is now thought that at the beginning of a strength training program, a rapid, dramatic improvement in strength and power occurs due to improved neurological coordination of the motor units (Spirduso, 1995). But, following the neural changes, muscle mass can also increase, even in the older adult. These increases can occur in as few as six weeks (Frontera et al., 1988), or eight weeks (Fiatarone et al., 1990). Most research looking at physiological adaptations to exercise in the elderly incorporate 12-week intervention programs (Frontera et al., 1988; Keen et al., 1994; Mikesky et al., 1994; Skelton et al., 1995; Topp et al., 1993). Twelve weeks seems to elicit significant strength changes, with an efficient cost and time investment.

2.2.4 Speed of Training

Ewing et al. (1990) demonstrated that after ten weeks of training the knee flexors and extensors on an isokinetic dynamometer, the greatest strength increases during testing occurred at the training velocities. The group that trained at fast velocities showed no strength gains in slow contraction testing, and the group that trained at slow velocities showed no strength gains in rapid contraction testing.

However, Behm and Sale (1993) provide evidence suggesting that the key factor in isokinetic strength training is not the actual speed of muscle contraction, but the attempted speed of contraction. They found the key to training for high velocity movements in the ankle dorsiflexors is to provoke a high rate of force development regardless of the contraction type or speed.

For safety, however, older adults should perform movements slowly, through the entire range of motion without swinging or bouncing at the end of the movement as suggested by Fiatarone (cited in Drought, 1994).

2.2.5 Angle of Training

Bandy and Hanten (1993) found that training at a specific angle was important in producing strength increases. Their research involved isometric training at various angles for the quadriceps femoris. The greatest torque increases in a training intervention were generated by training at the angle at which testing occurs. To elicit maximal gains, a training program must focus on angle specific training.

2.3 Elastic Tubing as a Special Form of Strength Training

There are disadvantages inherent in some resistance training programs for an elderly population. Older adults may not have adequate money or transportation to allow access to the necessary equipment for traditional weight training (Mikesky et al., 1994). Also, the older generation may be self-conscious and intimidated by the prospect of exercising with younger people in a weight room (Mikesky et al., 1994). Because of these factors, a portable, economical mode of resistance exercise is more suitable for the elderly.

Elastic tubing is inexpensive, compact and easy to use (Mikesky et al., 1994). Evidence shows that resistance training using elastic tubing can serve as a practical and effective means of eliciting strength gains in the elderly (Mikesky et al., 1994; Skelton et al., 1995; Topp et al., 1993). Mikesky et al. (1994) found significant increases in isokinetic eccentric knee extension and flexion in adults over 65 years of age after a 12-week home-based elastic tubing training program. In 12 weeks, Skelton et al. (1995) measured improvements in isometric knee extensor strength, isometric elbow flexor strength, and handgrip strength in women aged 75-93 years old. The Topp et al. (1993) study found after 12 weeks of training, that there was an improvement in isokinetic eccentric knee extension and flexion. All three of the aforementioned studies used randomized experimental designs to test the efficacy of elastic tubing resistance training.

The question remains whether strength gains produced by elastic tubing translate into increased functional ability as measured by a chair rise. Evidence supports exercise-type specificity; the greatest training effects occur when the same exercise type is used for both testing and training (Morrissey et al., 1995).

The research on speed of training suggests that the training program for a fast chair rise must include muscle contractions initiated by a high rate of force development. In addition, the speed of contraction must be at least the speed of execution of the chair rise.

The research on angle of training suggests that the muscles gain strength primarily in the positions at which they were trained. The maximal torques in the hip and knee both occur just following the seat off phase of a chair rise (Kelley et al., 1976). According to Wretenberg and Arborelius (1994), the peak power produced by the knee extensors occurs at a knee angle between 80-90°, and the peak power produced by the hip extensors occurs at a hip angle between 90-100°. These angles appear to correspond with the maximal torques at the seat off phase of the rise described by Kelley et al. (1976). To optimize functional gains, a training program for a chair rise should provide peak resistance at these angles where peak resistance is encountered.

2.4 Testing

2.4.1 Squat Testing

The success of a training study depends on accurate strength assessments. For accurate maximal strength testing results, one needs subjects who are motivated and comfortable both with the equipment and with the exercise required. This is difficult to generate with elderly subjects unaccustomed to strength training, and cautious in their physical output. A popular strength test with the general population is the one repetition maximum. This test utilizes a trial-and-error process to determine the greatest amount of weight an individual can lift (Howley and Franks, 1986). However, in the interest of safety, the American College of Sports Medicine (1995) recommends no resistance exercise using heavier weights than eight repetition maximums for the elderly. There are many studies that disregard the recommendations and proceed with one repetition maximum tests (Fiatarone et al., 1990; Frontera et al., 1988; Hunter and Treuth, 1995; Hunter et al., 1995; McCartney et al., 1995; McMurdo and Burnett, 1992; Morganti et al., 1995; Nelson et al., 1994; Pollock et al., 1991; Pyka et al., 1994). Aside from safety concerns, doing a proper weight-lifting exercise is a learned motor skill, therefore the results from one repetition maximum testing might not be a good measure of strength especially at the beginning of training when both the tester and the participant tend to be cautious (Porter and Vandervoort, 1995).

Another option in lieu of maximal strength testing may be the sit and stand muscular strength and endurance test. In this test, each subject stands upright from a seated position as many times as possible within 30 seconds (Spirduso, 1995). This test and similar chair stand tests are frequently seen in the literature, particularly with lower functioning subjects (Brill et al., 1995; Czuka and McCarty, 1985; Fiatarone et al., 1990; Fleming et al., 1991; Hoy and Marcus, 1992; Hunter et al., 1995; McMurdo and Rennie, 1993; Skelton et al., 1994; Skelton et al., 1995). The internal consistency, reliability and the test validity based on correlations with a one repetition maximum leg extension measurement on Cybex strength-testing equipment are high (Spirduso, 1995). However, there are flaws in this association. Training for muscular endurance as compared to strength will produce different adaptations in the neuromuscular system, so making improvements in one will not necessarily mean an improvement in the other (Porter and Vandervoort, 1995). The repetitive chair stand is testing the muscular endurance system, not the muscular strength system. Due to safety concerns and questions about the legitimacy of certain tests, there appears to be significant limitations in strength testing in the elderly.

2.4.2 Chair Rise Testing

Perhaps among the elderly it is more important to measure changes in function rather than to measure pure strength. Physiological functional ability decreases with age and eventually this decline in physical performance can produce functional impairment and can add to the morbidity of chronic diseases (Larson, 1991). Improvements in functional ability are difficult to quantify. However, the capacity to perform certain movements necessary for an independent life is one form of quantification.

One such movement is the ability to rise out of a chair without difficulty. Fast rising from a chair produces greater knee torques than either measures of gait or stair-climbing ability as suggested by Berger et al.'s study (cited in Riley et al., 1991). Wretenberg and Arborelius (1994) determined that during a chair rise, concentric work by the hip and knee extensor muscles is the most important muscle activity. They also found that there is a demand, although it is less significant, for eccentric work by both hip flexor and extensor muscles, and for concentric work by the hip flexor muscles. Hip extensors include the gluteus maximus, semitendinosus, semimembranosus, biceps femoris and adductor magnus. The knee extensors include the quadriceps group consisting of the rectus femoris, vastus lateralis, vastus medialis and vastus intermedialis. The hip flexors include the iliacus, psoas major, tensor fascia lata, rectus femoris, sartorius, adductor longus, adductor brevis and pectineus (Seeley et al., 1989). The vertical force-time curve of a chair rise is thought to reflect strength, power and the motor control ability of these muscles (Fleming et al., 1991).

Fleming et al. (1991) developed a chair rise test that quantifies a subject's ability to perform this movement. Using a force transducer, the vertical force applied onto the ground from the subjects' feet can be measured when subjects stand up from a chair. The protocol Fleming et al. (1991) developed, required that the chair rise be done as quickly and as forcefully as possible from an armless chair.

Faster speeds of chair rising require greater output from the hip flexors, knee extensors and ankle dorsiflexors as shown by Pai and Rogers (cited in Pai and Naughton, 1992). In addition, Pai and Lee (1994) found that a chair rise at various speeds had no variation in the momentum of the head-arm-trunk, but that the peak thigh and shank momentum increased with a more rapid movement. This suggests that a more dynamic chair rise depends primarily on leg strength rather than using the upper body.

According to Fleming et al. (1991), there are discriminating variables that differentiate levels of functional ability during the chair rise. They include the following:

- higher peak power rising from a chair
- higher overshoot (Max) and lower undershoot (Min2) prior to the standing plateau when rising from a chair
- higher ratio of Max to Min2 (Max/Min2)

These variables are shown in Figure 1. The power is represented by the slope of the force-time curve, assuming that the distance of the chair rise remains constant for each subject. The momentum generating phase is when the vertical force begins to drop to the first minimum (Min1). For normal or fast rising, generation of this forward momentum is necessary (Kralj et al., 1991). It could be that a larger drop to Min1 indicates greater generation of momentum.

The beginning of the vertical acceleration of body mass is detected by the rapid positive changing of the vertical force (Kralj et al., 1991). A greater change in force, caused by a greater acceleration would be seen as a steeper slope. Increased leg strength could cause this increased slope. The overshoot peak (Max) occurs just following the seat off event due to the transfer of all the body weight to the legs (Kralj et al., 1991). The peak undershoot (Min2) occurs just following the point at which deceleration of the upwards body mass begins (Kralj et al., 1991). Preliminary studies from an unpublished pilot study indicate that when the chair rise is done more ballistically, these discriminating variables respond (Appendix A). A more powerful, ballistic motion in the chair rise would be possible only if adequate leg strength exists.

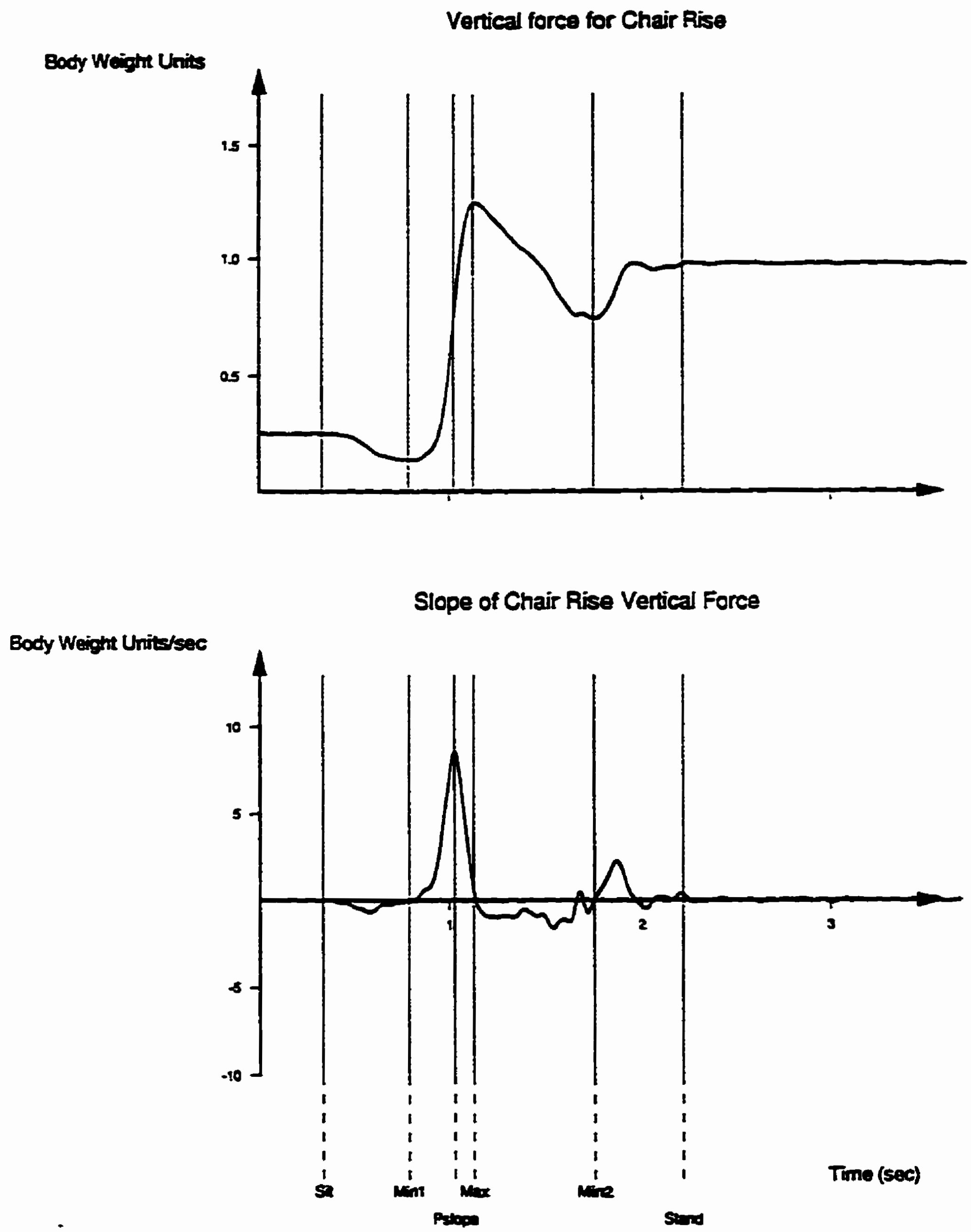

Figure 1. The vertical force-time curve and slope-time curve of a chair rise with marker positions indicated.

2.4.3 Self-Report of Functional Fitness

A method routinely used to determine the leg strength and other capabilities of the elderly is to simply ask them or their caregivers about their abilities (Spirduso, 1995). There are advantages to this form of assessment. Self-report presents no danger or risk to the subjects (Spirduso, 1995). It is cost-efficient and can be administered to many subjects without an exorbitant time committment. However, there are also disadvantages. In addition to the possible biases always inherent in self-report, the elderly are also sometimes afflicted by the following additional confounders (Spirduso, 1995):

- contextual influences (i.e.) the status of the interviewer
- poor memory
- strong desire to avoid being institutionalized

Although self-report does not always reflect reality the way the researchers may see it, it reflects very strongly the perceptions of the subjects. In research that is attempting to augment the quality of the subjects' lives, self-report may be the most valid assessment tool.

2.5 Other Considerations in a Strength Training Intervention with the Elderly

2.5.1 Control Group

Often very little time or effort is invested in the control group. Many studies incorporate a control group that undergoes no intervention (Hopkins et al., 1990; Morganti, 1995; Nelson et al., 1994; Pollock et al., 1991; Pyka et al., 1994; Sipila and Suominen, 1995; Skelton et al., 1995). This can potentially affect the validity of the results. The Hawthorne effect describes how subjects' performances change when attention is paid to them (Thomas and Nelson, 1996). In order to minimize the adverse effect of this reaction, a control group that undergoes an intervention is necessary. In addition, the control group and the training group should receive similar amounts of attention. To do this, exercising studies often conduct non-exercising classes for their control group. These include automobile driving safety classes (Mikesky et al., 1994; Topp et al., 1993), health education sessions (McMurdo and Burnett, 1992), music and reminiscence sessions (McMurdo and Rennie, 1993), friendly visits following a standard protocol (Mulrow et al., 1994; Tinetti et al., 1994), low-intensity walking classes (McCartney et al., 1995) and flexibility sessions (Brandon et al., 1995).

Flexibility classes are effective because stretching does not affect muscle strength in the lower extremity (Wiktorsson-Moller et al., 1983), yet subjects are doing something beneficial for their health. Maintaining adequate levels of flexibility will enhance an individual's functional capabilities and reduce injury potential, particularly among the aged (ACSM, 1995). A stretching control group reaps the psychological benefits of attending a class, and obtains the physical benefits of increased flexibility.

2.5.2 Dementia

The validity of any assessment tool should be closely examined when working with demented patients. Brill et al. (1995) states that the timed chair stand can easily be administered to patients with dementia. This is important when administering tests to the elderly. In 1991, 8% of adults in Canada at least 65 years old, and 35% of adults 85 years of age and older were suffering from dementia (Elliot et al., 1996). When deciding on an appropriate test, it is necessary to consider the demented senior citizen. There are several recommendations to facilitate programs with the demented adult. These include the following (Brill et al., 1995):

- structure and repetitiveness of the program
- programs in the morning find the patient more alert, with greater concentration skills
- familiarity of the routine
- one-on-one exercise training for the first few weeks
- therabands - elastic tubing for resistance
- persistence and gentle assertiveness by the leader

Evidence shows that strength training programs can be successful for participants with dementia. In nursing home patients with functional impairments and/or dementia, muscle function and work capacity has been improved through exercise programs (Brill et al., 1995; Fiatarone et al., 1990; Fisher et al., 1991; McMurdo and Rennie, 1993; Mulrow et al., 1994).

2.5.3 Safety

The benefits to the participants of a study should be obtained with a minimum of risk. In a training study, the safety of the subjects is of extreme importance. Pollock et al. (1991) found during one repetition maximum strength testing, 11 /57 subjects (19.3%) incurred an injury. They concluded that the elderly are more fragile and may be more susceptible to musculoskeletal injury during high-intensity, low-repetition strength testing. The American College of Sport Medicine (1995) concurs, and states that in the interest of safety, resistance training with seniors should not be done with a heavier weight than eight repetition maximums.

Heavy resistance exercise can lead to muscle injury, particularly among older individuals (Pollock et al., 1991). These researchers underline the importance of modification of the exercise prescription for the elderly population because they may be more susceptible to musculoskeletal injury during high-intensity, low-repetition strength exercises. However, Fiatarone et al. (1990) reported no musculoskeletal injuries in their study of strength training with a group of frail elderly subjects suggesting that perhaps the abilities of the elderly are routinely underestimated.

2.5.4 Adherence and Attendance

Adherence and attendance problems can sabotage any training study. Adherence refers to whether a subject completes the program and attendance describes the number of sessions in which each subject participated. Pollock et al. (1991) found that in studies using subjects of various ages, adherence to exercise programs averaged 50-80% for the first five to six months of training. In a 26-week, three session a week strength training program with subjects at least 70 years of age, adherence was 87% (Pollock et al., 1991). Average attendance for the strength training in the aforementioned study was 97.8%.

Steps can be taken to maximize adherence and attendance among senior citizens. Barry et al. (1993) found that compliance increases with activities that are enjoyed with others. It seems that emphasizing the social component of the training sessions will encourage seniors to participate. Making available a variety of training times, providing feedback by periodic testing and conducting sessions in a pre-arranged, safe, well-lit facility all contribute to high adherence (Pollock et al., 1991). Limiting the expense of an exercise program also increases its likelihood of success (Barry et al., 1993).

2.6 Summary

It appears that the beneficial effects of strength training in the elderly are well-documented, and widespread. It certainly seems that strength can be increased at any age with appropriate training. Elastic tubing and squats are appropriate modes of training for older adults. Elastic tubing is inexpensive, mobile and easy to use. Body-weight squats are simple exercises requiring no equipment. Either can be done in a class setting or in a home-based exercise program.

The importance of appropriate outcome measures can not be overstated. In a resistance training protocol, it is necessary to have a measure of strength improvement to ensure that the training was effective. The repetitive chair stand seems to be one of the most cautious options available for strength testing. This may be suitable for an elderly population where the participants are not accustomed to maximal exertion. The chair rise is a good choice as a measure of functionality because of its necessity in daily living, and because of the generation of large forces during its execution. It appears to be a limiting activity for many older adults, as well as an indicator of functional ability.

CHAPTER THREE

METHODOLOGY

3.1 Subjects

Subjects were volunteers recruited through advertisements targeted at senior citizens' lodges, senior citizens' clubs and senior citizens' activity programs. The advertisements were in the form of posters, ads in a local newspaper and a seniors' newsletter, and word of mouth through adult day program instructors. Inclusion criteria for participants were as follows:

1. Subjects must be able to walk without an aid.
2. Subjects must be able to follow simple commands.

In addition, exclusion criteria for subjects were as follows:

1. Subjects must not have extreme arthritis that limits their range of motion.
2. Subjects must not be acutely ill.
3. Subjects must not be on anabolic steroidal medications.
4. Subjects must not be suffering from unstable cardiovascular disease or other uncontrolled chronic conditions that would interfere with the safety and conduct of the training protocol.
5. Subjects must not change either their medication profile or their activity profile during the course of the study.

All subjects completed a Par-Q health form, a Parmed-X form when necessary, a basic health questionnaire to ensure their fitness for the program, and a consent form endorsed by the ethics committee in the Faculty of Kinesiology at the University of Calgary (Appendix B). Once selected, the subjects were randomly divided into either the control (stretching) group or the resistance training group. To ensure that spouses were in the same intervention group, they were assigned together as one unit. 18 subjects volunteered for the study, therefore 9 participants were assigned to the resistance training group and 9 were assigned to the stretching group.

After the post-test, the control group subjects were offered instruction in resistance training with elastic tubing and the resistance training group was offered instruction in gentle stretching.

3.2 Testing

3.2.1 Chair Rise Testing

The functional leg power during a chair rise of each subject was tested using a force plate at the Human Performance Laboratory at the University of Calgary. Testing was done prior to the 12-week intervention, and again at the completion of the training. Testing was based on a protocol described by Fleming et al. (1990) that is thought to reflect strength, power and the motor control ability of the muscles in the lower body. Subjects were seated on an armless, backless, flat-seated bench that straddled the force plate. The seat height was kept constant at 40 cm from the floor. The subjects placed their feet on the force platform on pieces of tape used as markers to ensure that the force plate measurements were taken in the middle of the plate where measurements are most exact (35 cm from the back and 20 cm from the side). The bench location was moved to the most comfortable placement for the subject, however, the location was consistent between the pre- and post-tests. The subjects had their arms crossed in front of their chests for the entire test.

Prior to the first attempt, the procedure was fully explained to the subjects, emphasizing the necessity to stand as **fast** and as **forcefully** as possible. Data collection from the force plate was initiated and the subjects remained seated for up to approximately two seconds. A technician stated "Please stand", and the subject stood up as fast and as forcefully as possible, and continued standing for approximately two seconds. The entire procedure was done with the subjects' feet stationary on the tape markers. After one familiarization trial, three trials were completed by each subject with a brief rest (approximately one minute) between each trial. On several occasions there were problems recording the force-time curve. Therefore, following each chair rise, the technician would verify that the curve had been properly recorded prior to continuing the test. A spotter was present at all times for the comfort and security of the subjects, and in case a subject lost his/her balance.

The variables measured were Min1, Max, Min2 and Pslope. These variables are illustrated in Figure 1 shown on page 24 in Chapter 2. Min1 is the minimum point in the first reduction of vertical force. It occurs prior to the buttocks lifting off the chair and is associated with a decrease in the force exerted on the platform by the feet. Max is the maximum vertical force generated during the chair rise and is greater than the body weight force generated by static standing. Min2 is the minimum point in the second reduction of vertical force which occurs during the deceleration phase, after the maximum force has been generated. Pslope refers to the instantaneous peak slope measured during the acceleration phase leading to the maximum force. In addition, the ratio between Max and Min2 was assessed.

Subjects were considered to be standing when the vertical force plateaued and stabilized. The vertical force at standing was used as a reference point for the system's calibration. Measurements were considered accurate when the standing measurements were 1.00 ± 0.01 body weight units. When this did not occur, a correction factor was used to adjust the force measurements for all the variables (Appendix C). Testing was done in an enclosed lab area to limit the intimidation and possible embarrassment of having spectators watching.

3.2.2 Squat Testing

The subjects also completed a strength-endurance test to assess lower body strength. The test used was adapted from the sit and stand test. The sit and stand test has subjects standing upright from a seated position as many times as possible within 30 seconds (Spirduso, 1995). In order to minimize upper body contribution and to maximize lower body contribution to the rising action, subjects squatted at a controlled pace and were never actually seated. For some subjects, 30 seconds was not long enough to cause fatigue, so the test was administered for as long as the subject could continue.

A bench was chosen at a height of either 443mm, 513mm or 611mm from the ground. Each subject attempted the various heights, and chose the deepest squat that he/she could perform adequately. The squat height was kept constant between the pre-test and the post-test for each subject. A chair was placed in front of the subject on which he/she could balance. The subject stood with the feet shoulder width apart, far enough away from the bench that the buttocks touched the bench at the deepest point in the squat.

The subject started squatting, keeping knèes over the toes until the bench was touched with the buttocks. A metronome set at 35 pulses/minute was used to determine the cadence. The buttocks touched the squat bench as the metronome sounded. The subject then straightened up, timing the upright position to coincide with the next metronome pulse. The subject repeated the squat until he/she could not continue with proper form and cadence or until the chair was used as a support rather than a balance. A spotter was present at all times. Termination of the test was judged by a technician counting the squats who was blind to the subject's intervention group.

Any change in the number of squats performed between the pre-test and the post-test was calculated to evaluate changes in leg muscle strength/endurance.

3.2.3 Self-Report Assessments

The third assessment was a questionnaire measuring fitness for independent living (Appendix B). The questionnaire consisted of 22 questions measuring 4 different aspects of fitness. These aspects were flexibility, leg strength, endurance and balance. Subjects responded on a numerical scale rating how easily they could perform various selected tasks. The scale range was based on ability to complete the task:

1. Easily
2. With Some Effort
3. With Difficulty
4. With Extreme Difficulty
5. Never

NA Have not tried that activity recently

The questions were validated by several research experts. These experts included a sociologist, a geriatrician, a statistician and an exercise psychologist who all reviewed the questionnaire and offered suggestions. The questionnaire was adapted to incorporate their advice. Subjects in both groups responded to the questionnaire before and again after the 12-week intervention period. Changes in responses over the training period were evaluated.

Starting at six weeks into the training program, subjects at one venue were asked to complete journals outlining how they perceived the program. Five additional senior citizens became interested in the strength intervention six weeks into the training. They were invited to participate in the classes, and journals were incorporated into the assessments to accommodate feedback from the additional participants although the new participants were not included in the physical testing or in the questionnaire assessment.

Each journal contained a title page with the following inclusion suggestions:

1. How do you feel after the class today?
2. Were there any problems with any exercises?
3. Did you notice any improvements with any exercises?
4. Were there any negative effects due to the last class?
5. Have you noticed any improvements in leg strength?
6. Has it gotten easier to do any day-to-day tasks?
7. Any other comments about your health, or the exercise class?

Journals were completed after class approximately once a week for the last 6 weeks of the program. Only the training group at one venue participated in the weekly journals. However, upon termination of the training, all the participants were asked to detail any changes, problems or benefits they believed were due to the program.

At the post-test, the participants in both groups also completed a questionnaire detailing changes during the intervention period that may have affected the results (Appendix B). These changes included medication dosage and type, activity level, illness and hospitalization. This questionnaire was necessary to determine whether any subjects suffered from health changes independent of the training during the study.

3.3 Resistance Training Group

The training group participated in 12 weeks of resistance training using elastic tubing roughly following the American College of Sports Medicine (ACSM, 1995) guidelines. These guidelines include exercising with sets of 8-12 repetitions, each session not to exceed 60 minutes, and the sessions occurring at least two times a week. The training sessions occurred either at the subjects' residences, at a fitness club or at a senior citizens' center three times a week. Half the participants exercised Monday, Wednesday and Friday, and the other half exercised Tuesday, Wednesday and Thursday. All the classes took place between 11:30 am and 2:00 pm. The training focused on increasing the strength of the hip and knee extensors and flexors. The exercises included in the training sessions were the following:

- squats (body weight only)
- sitting knee extensions
- standing hamstring curls
- standing hip flexions
- standing hip extensions

All the exercises are explained in detail in Appendix D. In a chair rise, the peak power in the hip is generated between 90 and 100 degrees of flexion, and the peak power in the knee is generated between 80 and 90 degrees of flexion (Wretenberg and Arborelius, 1994). Therefore, the exercises attempted to maximize resistance at these angles.

The training was progressive in both intensity and volume. Volume was increased by increasing the number of sets or the number of repetitions for each exercise. Ideally, the number of repetitions remains between 8-12, and the number of sets increases (ACSM, 1995). However, the subjects were not exercising to fatigue at 12 repetitions, therefore the number of repetitions was increased to elicit muscle fatigue at the end of a set.

Intensity in the exercises was increased by changing the technique of the exercises as outlined in Appendix D. According to the American College of Sports Medicine (1995) guidelines, the exercises should be completed at a perceived exertion rating of 12-13 out of a possible 20 (somewhat hard). The subjects were periodically asked how hard they were working, and were encouraged to attain the "somewhat hard" ranking.

3.3.1 Squats

The basic technique used for the squats is described in Appendix D. The cadence used was approximately two seconds in the concentric phase and two seconds in the eccentric phase of contraction. To increase the squat intensity subjects were instructed to bring the buttocks closer to the ground (increase the knee bend). The exercises were progressive in intensity and volume.

3.3.2 Elastic Tubing

The intention was to increase the intensity of the tubing exercises by increasing the tension on the elastic. This can easily be done by adjusting the length of tubing to eliminate any slack. This did occur for some individuals, but others did not seem able to challenge themselves, thus a change in technique was necessary during the later weeks of the training. The technique changes to increase the exercise intensity are outlined in Appendix D. The optimal speed of training is determined by the speed of the activity one is training for (Morrissey et al., 1995). The present study attempted to increase the power of a chair rise, thus fast contractions in training were optimal. However, according to the

American College of Sports Medicine (1995) guidelines, elderly exercisers should execute their strength training slowly. Taking these opposing factors into account, the cadence of the exercises used a concentric phase of approximately one second, and an eccentric phase of approximately two seconds. The exercises were progressive in intensity and volume.

The sessions finished with five minutes of light lower body stretching. The total time of each session was approximately 30 minutes, and no more than 45 minutes. Subjects were expected to attend all the training sessions, and those who did not attend at least 65% of the sessions were excluded from the study.

3.4 Control Group

The control group was involved in a gentle stretching program to account for the psychological impact of attention on the experimental group. The areas stretched were primarily the neck, shoulders, back, legs and arms (Anderson, 1980). Examples of the stretches used are listed in Appendix E. Stretches were all done passively with no bouncing. Each stretch was held for 10-20 seconds, and the muscles were stretched to just before the point of pain. Each session lasted no more than 45 minutes. Subjects were expected to attend at least 50% of the classes or they were withdrawn from the study.

3.5 Data Collection and Analysis

A Kistler force plate and Kintrak 4.0 (Motion Analysis Corporation, 1993) data collection and analysis software were used to measure the forces. Sampling rate was 1000 measurements per second. Minimums and Maximums were determined precisely by the computer. Variables measured included Min1, Min2, Max, Pslope, Force at Standing and the times at which these variables occurred. The ratio Max/Min2 was calculated for later analysis. Changes in these markers (excluding Force at Standing) between the pre-test and the post-test were assessed.

For each subject there were three force-time curves compiled at each testing session, and the average markers from the three trials were analyzed. The plots were examined for trends indicating increasing or decreasing performance with successive trials. No trends were evident from trial to trial, thus average values over three trials was an acceptable method to ensure that the measurements analyzed were valid representations of the subjects' abilities. The data was measured in proportional body weight units to normalize for body weight and to eliminate changes in force due to weight fluctuations over the 12-week period.

A 2-tailed Multivariate Analysis of Variance (MANOVA) was used to determine the validity of the research hypothesis for all of the normal data with homogenous variance (parametric data). The Mann-Whitney U Test was used for variables that did not conform to this assumption of homogeneity of variance or normality as determined by Levene's test and normal quantile plots. For the parametric data, MANOVA was then used for a secondary analysis to determine if there was a weight effect, age effect or a height effect that was significant on its own, or that interacted with any training effect. This analysis was considered secondary due to the small number of subjects, and consequently low power for the test.

Consistency of the chair rise test was assessed by comparing the within subject differences from the three trials of each subject at the pre-testing session and assessing whether they were significantly different from the between subject differences. This shows whether the test is adequately sensitive to differentiate between subjects. The critical alpha value was set at $p=0.05$ for all the tests.

CHAPTER FOUR

RESULTS

The research hypothesis stated that the training group compared to the control group will have different changes due to the 12 weeks of lower body resistance training in the following variables:

- amount of peak power represented by peak slope (Pslope) while standing from a chair
- amount of peak vertical force (Max) while rising from a chair
- amount of undershoot (Min2) after the peak force while rising from a chair
- amount of undershoot (Min1) prior to the weight off phase while rising from a chair
- ratio of peak vertical force to undershoot after the peak force (Max/Min2)
- number of squats performed at a specific height and cadence
- fitness self-perceptions
    1. health
    2. leg strength
    3. endurance
    4. balance
    5. flexibility

4.1 Exclusion

Several subjects were dropped from the study because they did not meet the predetermined criteria. Three participants in the control group did not attend at least 50% of the stretching classes, therefore their data could not be used. One subject was excluded from the training group because his medication profile changed midway through the study. He was taking morphine due to a serious illness causing severe pain during the last week of training and during the post-testing. Another subject in the training group had mild dementia which did not seem to interfere with the training or with the physical testing, however, the questionnaire results did not appear valid. Although he appeared able to walk one city block, his post-test self-report indicated that he was unable to complete comparable activities. Pre-test results indicated that he could perform these activities easily, and his demeanor did not indicate such a drastic change. Therefore his physical test results were included in the study, but his questionnaire was excluded.
The remaining subjects were mobile, active and interested in their health as shown by their voluntary participation in the program. Subject characteristics are described in Table 1.

Table 1. Subject Characteristics

Training Group Subjects					Control Group Subjects				
Number	Sex M/F	Age yrs	Weight kg	Height cm	Number	Sex M/F	Age yrs	Weight kg	Height cm
3	F	67	82.0	156.0	5	F	52	53.0	157.8
4	F	71	66.0	157.5	7	F	73	82.2	160.5
6	F	76	59.6	156.1	12	M	82	80.4	174.5
8	F	79	59.2	156.1	13	F	82	57.0	150.0
9	F	76	70.4	150.5	14	F	66	63.4	150.0
10	M	78	81.9	165.0	15	F	75	73.6	156.0
11	F	70	93.7	160.5					
16	F	70	80.4	156.5					
Mean:		73.4	74.21	157.3			71.7	68.3	158.1
(± sd):		±4.4	±12.3	±4.2			±11.4	±12.3	±9.1

4.2 Exercise Progression

The exercises (both elastic tubing and squats) were progressive in intensity and volume. Figure 2 illustrates the progression of the tubing exercises, and Figure 3 shows the progression of the squats. Each intensity (Stages 1 through 3) were assigned arbitrary numbers (1 through 20) to illustrate the progression of intensity in the figures.

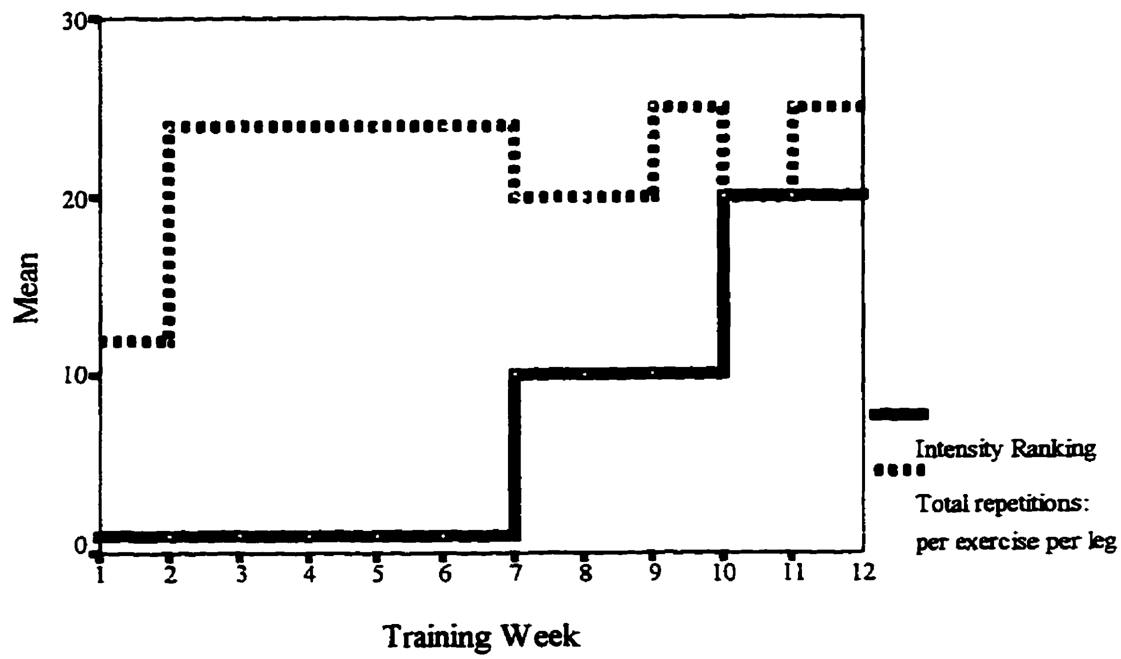

Figure 2. The progressive intensity and volume of the elastic tubing training. Intensity ranking: 1=Stage 1, 10=Stage 2, 20=Stage 3. Changes in the exercises to accommodate changes in intensity are outlined in Appendix C.

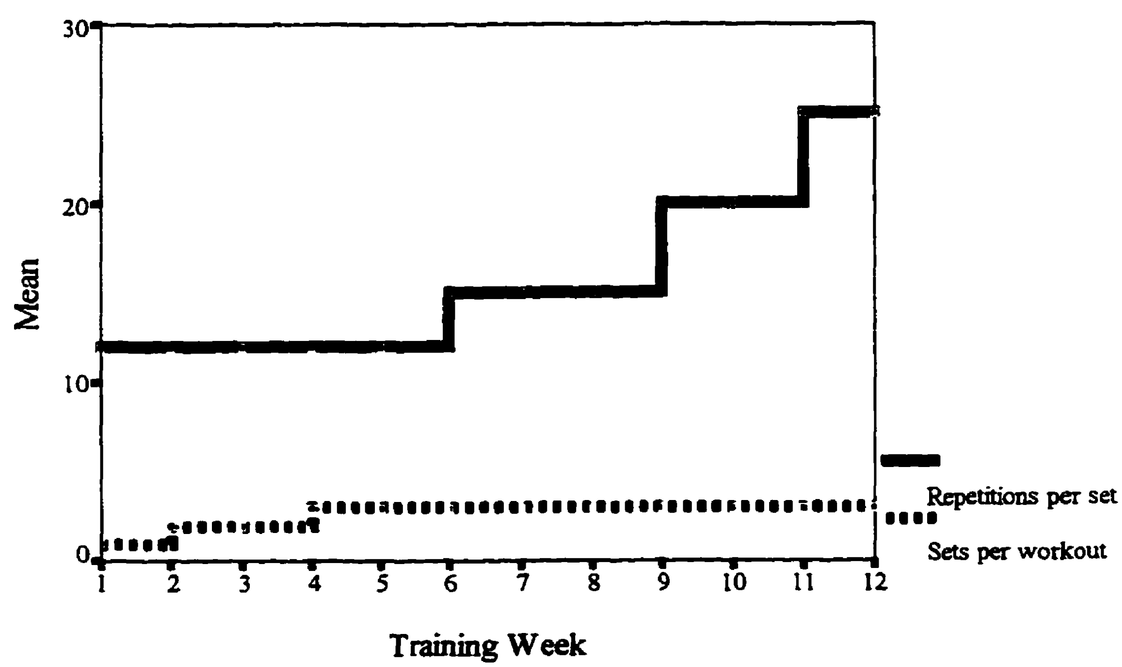

Figure 3. The progression of squat repetitions and sets for each training week.

4.3 Consistency

Using the pre-test data, the consistency of the curve markers was determined. ANOVA was performed on the data. For each curve marker, the within subject variance for the different trials was compared to the between subject variance to ensure the markers differentiated between subjects. The Max, Min1, Min2, PSlope and the Max/Min2 ratio all had significant p-values < 0.0001. These values are well below the critical alpha value of p=0.05. This shows adequate intra-subject consistency of the curve markers to proceed with the analysis. Figure 4

shows one subject's results for all three trials of the chair rise. The markers appear to be consistent therefore average values from the three trials were used for the remainder of the tests.

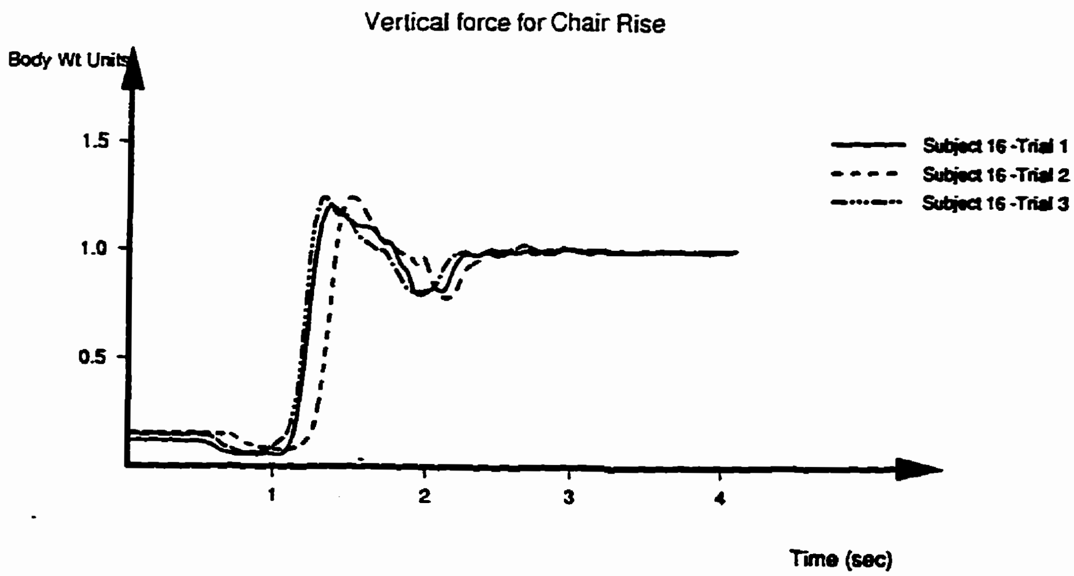

Figure 4. The vertical force-time curve of three chair rises for one subject at one testing session.

4.3 Group Comparability

Using the pre-test data, statistical tests were done to ensure there were no differences between the two groups in the curve markers or in possible interacting variables. A MANOVA shows no differences between the groups prior to the interventions in the Max, Min1, Min2, Pslope, Max/Min2 and Squats. Figure 5 shows the mean results for each chair rise variable separated by training group. The groups appear to be similar in all the variables assessed.

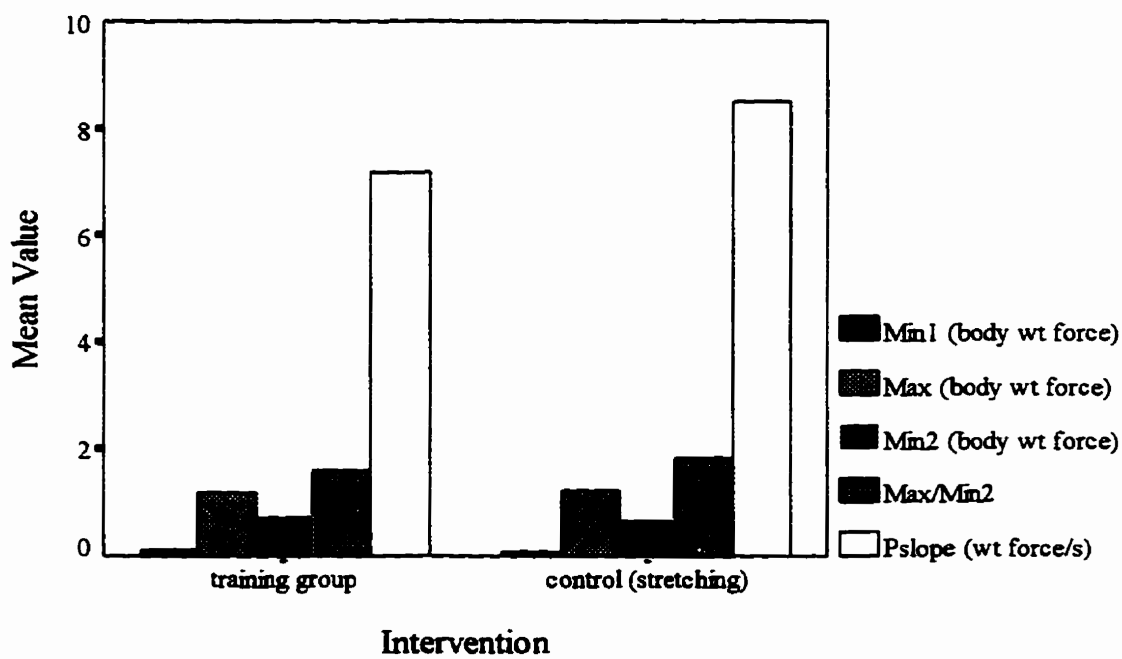

Figure 5. Comparison of the control group and the training group chair rise variables prior to the intervention.

MANOVA also ensured that there were no differences between the training group and the control group in age, height or weight. No significant difference was found in any of the variables using a critical alpha value of $p=0.05$. The p-value for age differences between groups was p=0.702, for height differences between groups was p=0.815, and for weight differences between groups was p=0.393.

The training group and the control group can be considered statistically not different in the chair rise parameters examined, as well as in age, height and weight.

4.5 Chair Rise Test

Data was analyzed to determine whether the change in each variable over the 12-week training program differed between the two groups. Table 2 shows the mean percent change for each variable in the two groups. The largest percent change was seen in the ratio between Max/Min2 in the training group at 77.5% increase over the 12-weeks. The control group increased that ratio 10.8%. This indicates that the change in force from the peak to the minimum representing the ability to accelerate and decelerate the vertical forces appeared to be enlarged by training.

Table 2. Percent change of the chair rise force-time curve markers after 12-weeks in a strength training group, or a control group.

Variable	% Change After 12 -weeks (Mean ± standard deviation)	
	Training Group	Control Group
Min1	-32.709 ± 42.389	-14.938 ± 22.099
Max	9.112 ± 7.382	1.767 ± 2.783
Min2	-30.085 ± 21.8415	-5.434 ± 15.593
Max/Min2	77.487 ± 71.368	10.842 ± 15.4042
Pslope	53.842 ± 49.218	8.192 ± 12.9062

Figure 6 shows that the majority of subjects in both the training group and the control group decreased Min1 between the pre-test and the post-test. The reference line denotes equal values for the pre-test and the post-test, thus no change over the 12-week program. All the subjects below the reference line decreased their Min1. The control group data is all located very close to the reference line indicating no change, whereas the training group has several participants who visibly decreased their momentum generation prior to the chair rise (Min1) over the training program.

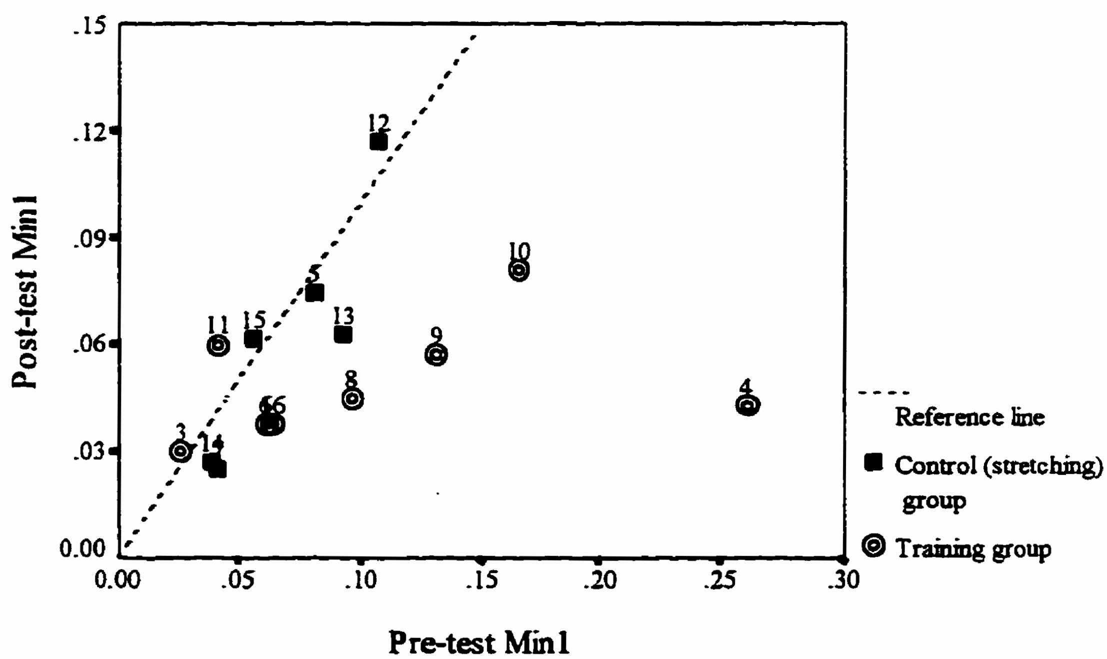

Figure 6. A comparison of the chair rise marker Min1, prior to any intervention and after 12-weeks in a training group or in a control group. The reference line indicates pre-test = post-test.

Over time, Max appeared to increase or stay constant for all of the subjects in the training group. Conversely, the control group seemed to change very little in the magnitude of the peak force measurement. Figure 7 shows the control group measurements clustered around the reference line indicating no change from the pre-test to the post-test, whereas the training group values tend to be well above the line indicating an increase in peak force.

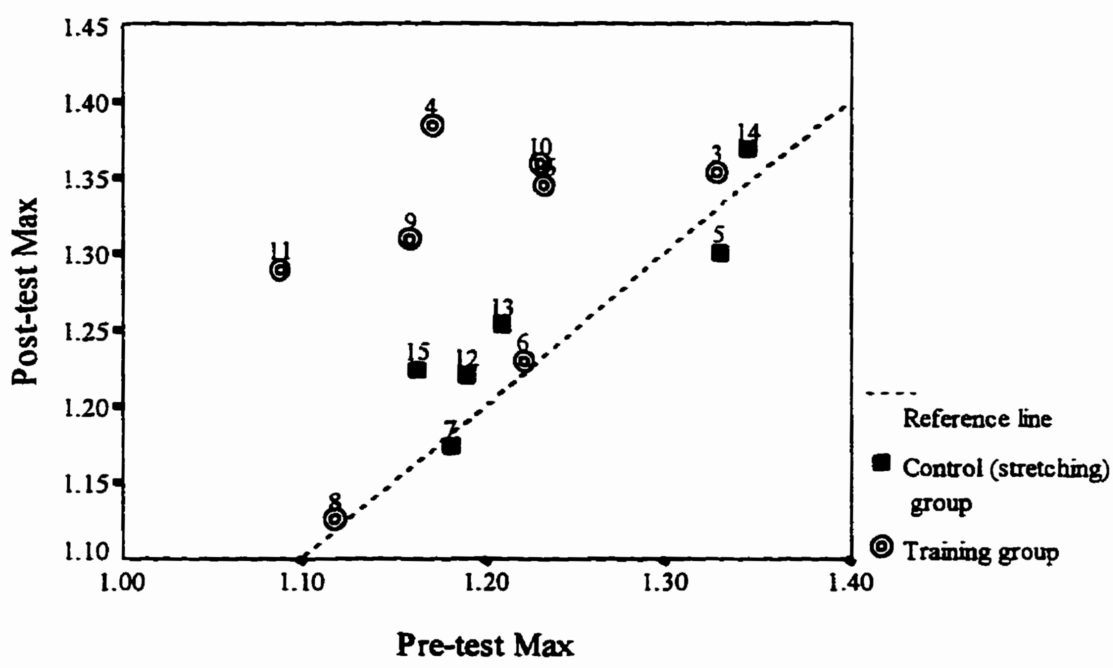

Figure 7. A comparison of the chair rise marker Max, prior to any intervention and after 12-weeks in a training group or in a control group. The reference line indicates pre-test = post-test.

There appeared to be a distinct difference between the two groups in the change of Min2 over time (Figure 8). The control group maintained approximately the same values for both tests, as shown by the marker locations close to the reference line. The training group consistently decreased the value of Min2 with training, illustrated by the markers located under the reference line.

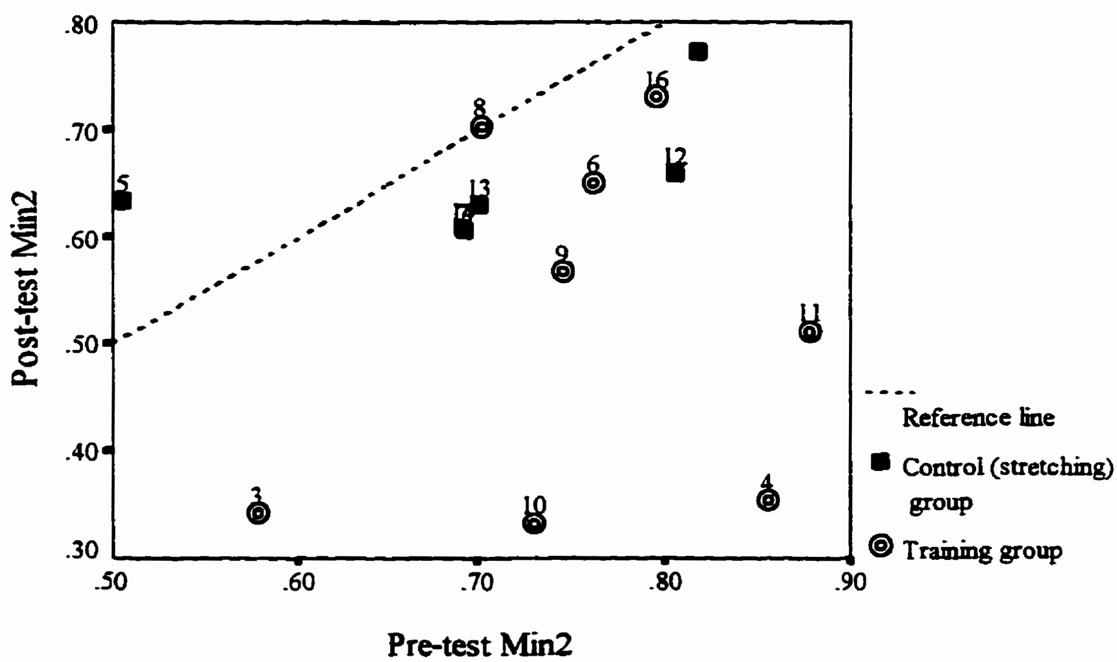

Figure 8. A comparison of the chair rise marker Min2, prior to any intervention and after 12-weeks in a training group or in a control group. The reference line indicates pre-test = post-test.

Figure 9 shows that all the subjects in the training group increased their peak slope over the course of the study. None of the control group subjects substantially increased their peak slope as seen by the marker proximity to the reference line. The training group subjects showed substantial gains in peak power with training as displayed by the location of the markers well above the reference line.

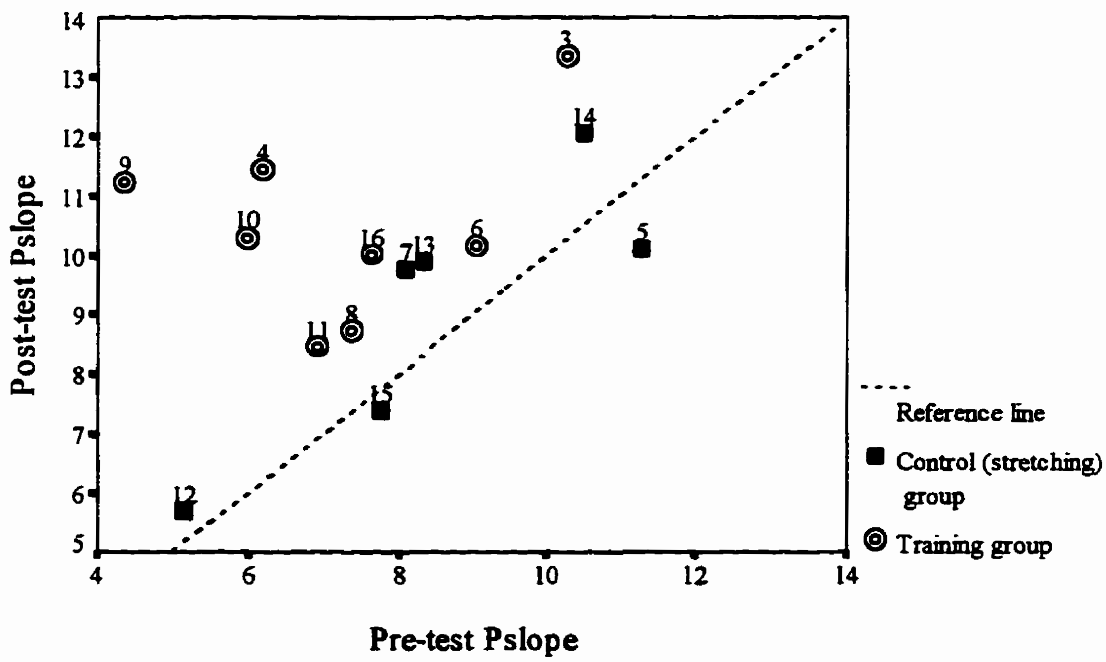

Figure 9. A comparison of the chair rise marker Pslope, prior to any intervention and after 12-weeks in a training group or in a control group. The reference line indicates pre-test = post-test.

The two intervention groups were visibly different in the Max/Min2 ratio (Figure 10). The training group appeared to increase the ratio substantially over the training sessions, whereas the control group did not display such overt changes. This is seen by the control group subjects clustering around the reference line indicating no change, and the training group subjects located above the line.

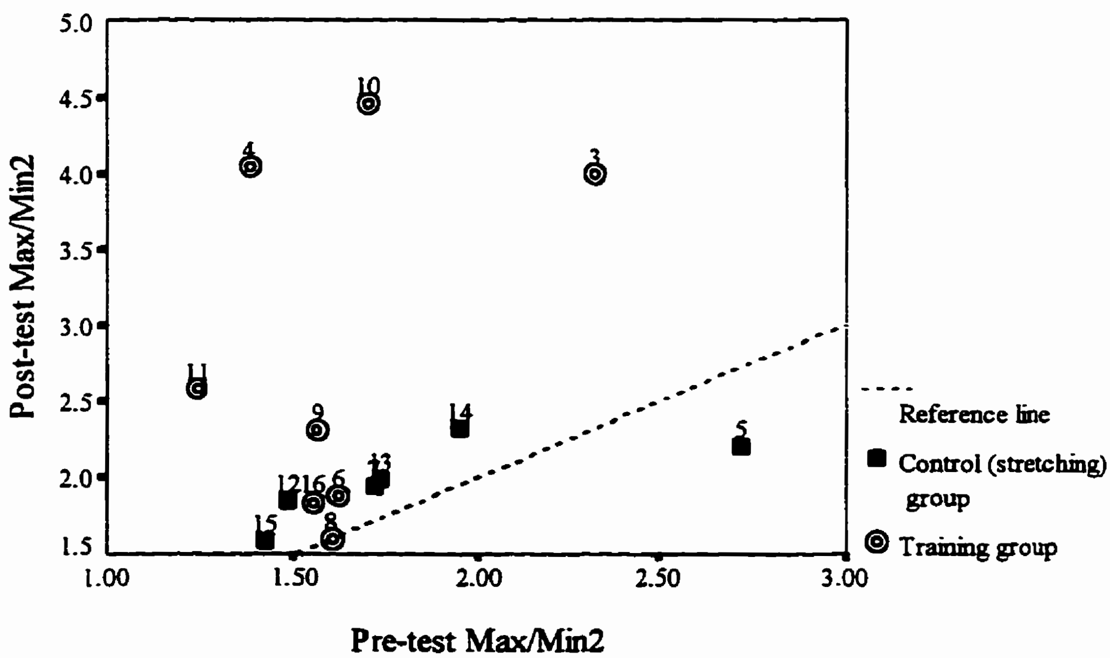

Figure 10. A comparison of the chair rise ratio Max/Min2, prior to any intervention and after 12-weeks in a training group or in a control group. The reference line indicates pre-test = post-test.

4.5.1 MANOVA

Levene's test was run to verify that the data holds the assumptions of homogeneity of variance necessary for a MANOVA. Only Min1, Min2 and Pslope met the assumptions adequately to perform the parametric test. Table 3 shows that Min2 and Pslope reached significance at the alpha level of $P < 0.05$ with p-values of .043 and .017 respectively. This illustrates a difference between the training and control groups in the change over time of the Pslope and Min2 variables.

Table 3. Multivariate Analysis of Variance for the chair rise markers.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
MIN1	.00815	.03964	.00815	.00330	2.46867	.142
MIN2	.11145	.26172	.11145	.02181	5.11016	.043
PSLOPE	23.70281	37.05820	23.70281	3.08818	7.67533	.017

Max and Max/Min2 had p-values of 0.028 and 0.011 respectively in Levene's test for homogeneity of variance, therefore non-parametric statistics were required. To compare the training group with the control group for these variables non-parametrically, the Mann-Whitney U Test was used. The p-value for the difference between groups in the Max curve marker was $p=0.0933$. The p-value for the difference between groups in the Max/Min2 ratio was $p=0.0528$. Neither of these values was considered statistically significant at a critical p-value of $p=0.05$. Therefore, no statistical difference between the groups was seen in the maximum force generated or in the ratio of the maximum force to the minimum force in the deceleration phase of the chair rise.

4.5.2 Modifying Factors

Age, height and weight were looked at as possible modifiers for the parametric variables: Min1, Min2 and Pslope (Appendix F). By separating the sums of squares in order to evaluate the additional factors, any significant training effect found in the previous MANOVA was lost due to the loss of power of the test. The group effects were no longer significant at a critical p-value of $p=0.05$.

There was no significant interaction among height, weight or age with each other, or with group differences in any of the variables. In addition, none of the three possible modifiers were found to be significant factors in Min1 or in Min2. However, there was a significant weight effect in Pslope ($p=0.034$). This effect is likely due to the weight categories assigned to the subjects. The ANOVA was calculated using two weight categories of under 65 kg or 65 kg and over. These categories could be poor representations of the data. When actual weights are shown in a scatterplot (Figure 11), it appears that there is a very minimal weight effect on Pslope. This is illustrated by the regression lines that are almost horizontal and parallel.

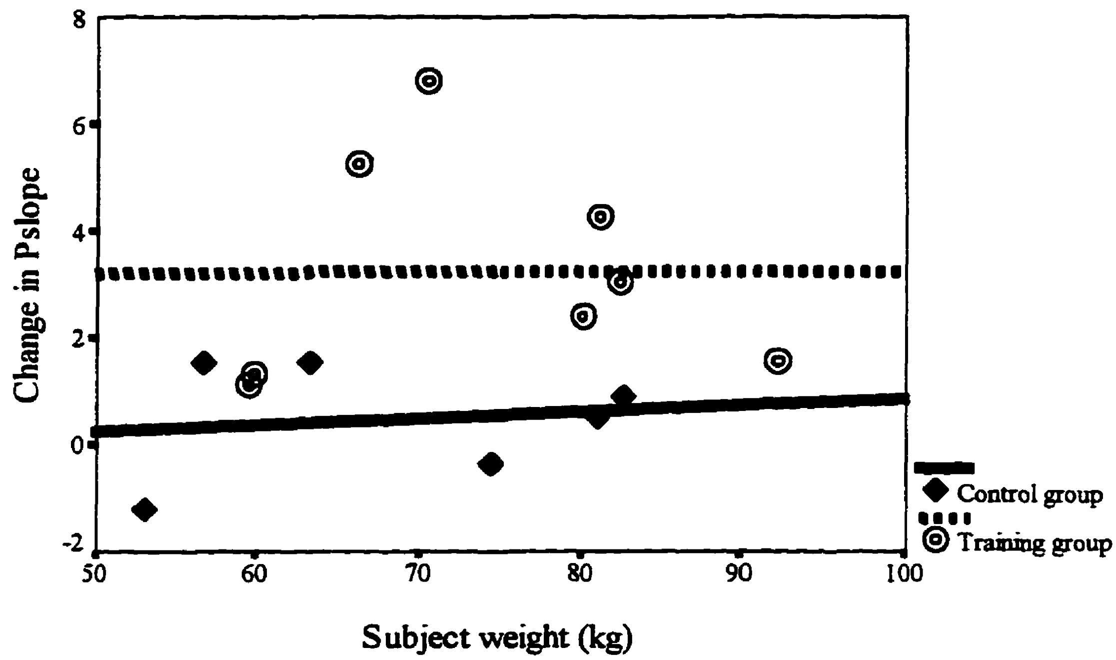

Figure 11. Change in Pslope in relation to subject weight categorically divided into control group and training group with linear regression lines.

4.5.2 Time Parameters

Although the only parameters examined with inferential statistics were the vertical force markers, it appeared that there were some time parameters in the chair rise that may have been affected by the training (Table 4).

The time parameters were measured from Min1 to standardize each measurement. Each subject responded at different rates to the "Please Stand" command, thus the beginning of the actual chair rise was difficult to quantify.

Table 4. Means and standard deviations by group of the percent time changes from Min1 to Min2, Min1 to Max and Min1 to Peak slope during the 12-weeks of the study.

Variable	Group	Mean ± Standard Deviation
Min1 - Max	Training	30.20 ± 22.33
	Control	4.04 ± 8.90
Min1 - Min2	Training	31.21 ± 16.41
	Control	6.81 ± 8.41
Min1 - Peak Slope	Training	34.30 ± 32.66
	Control	4.79 ± 16.49

Min1 to Max represents the time to reach peak force. The average time interval for the training group was 30% faster in the post-test compared to the pre-test. The same assessment was only 4% faster for the control group. Min1 to Min2 represents the time of upwards acceleration of the body mass (Kralj et al., 1990). The average time interval for the training group was 31% faster in the post-test than in the pre-test. The control group showed a 7% increase in speed. Min1 to Pslope represents the time to peak power generation (Fleming et al., 1991). The average change for the training group was 34% faster in the post-test compared to the pre-test. This time interval was only increased by 5% in the control group. Further statistical tests were not performed on these variables because there had been no prior intention to test them, therefore they had not been included in the hypothesis.

4.6 Squats

Over 12 weeks, all the training group subjects increased the mean number of squats performed. The range of increase was between 8% and 1045%. No training group subject demonstrated a negative change over the 12-weeks. Five out of the six control group subjects decreased the number of squats that they could perform from the pre-test to the post-test. The one control group subject who showed no decline, actually increased performance by 227%, which was greater than three of the training subjects. Table 5 displays the change in squats in both groups seen over the 12-week training period.

Table 5. Change in Squats (Pre-test, Post-test, Absolute Change and % Change) for the Subjects in The Training Group and in the control group, and the means and standard deviations (sd) of each measurement.

Training Group Subjects					Control Group Subjects				
Subject	SQUATS				Subject	SQUATS			
	Pre	Post	Change	%Change		Pre	Post	Change	%Change
3	17	35	18	**106**	5	65	42	-23	**-35**
4	32	136	104	**325**	7	12	8	-4	**-33**
6	14	154	140	**1000**	12	5	3	-2	**-40**
8	11	126	115	**1045**	13	15	9	-6	**-40**
9	25	27	2	**8**	14	15	49	34	**227**
10	11	35	24	**218**	15	39	31	-8	**-21**
11	5	37	32	**640**					
16	3	12	9	**300**					
Mean:	14.8	70.3	55.5	455.3		25.2	23.7	-1.5	9.6
(± sd):	9.8	57.7	54.8	396.2		22.7	19.6	18.9	106.6

Levene's test indicates that the assumption of homogeneity of variance is not adequately met (p=0.002) to allow for ANOVA to be performed to analyze statistical differences in the squats. The non-parametric Mann-Whitney U Test was used to analyze the Squat data. The p-value=0.0142 indicates that there is a significant difference between the groups in the change over 12 weeks in the number of squats performed. The training group subjects increased the number of squats they could perform after 12 weeks of training significantly more than the control group subjects. Figure 12 shows the squat test results divided categorically into training and control group, and the change in performance measured over the 12-weeks.

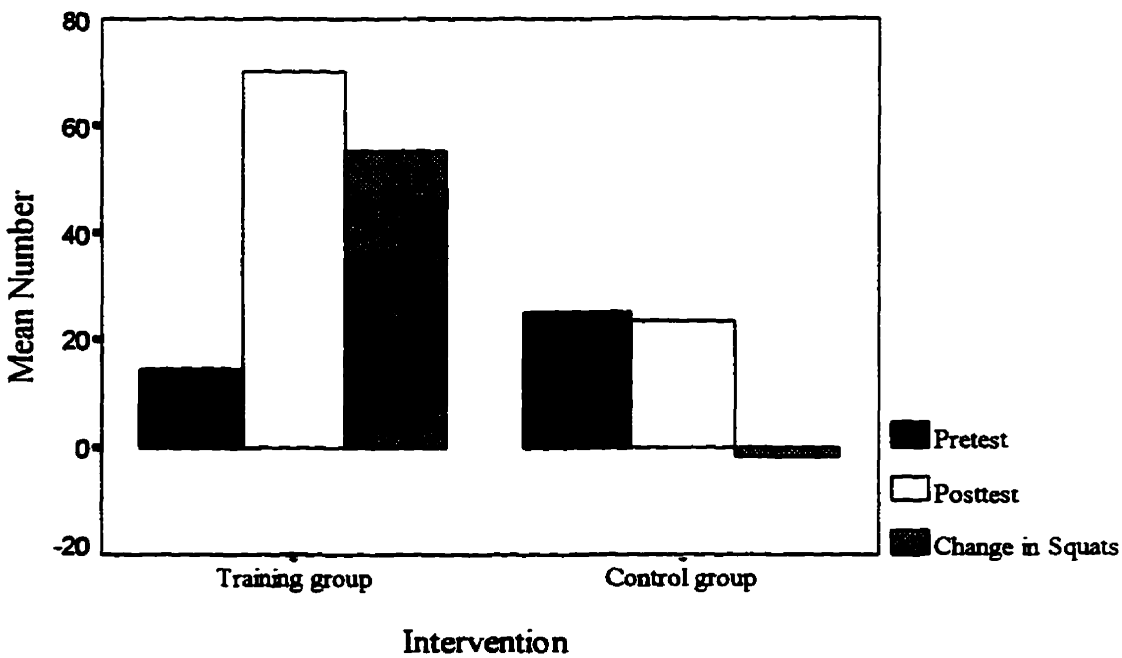

Figure 12. Total number of squats performed in the pre-test and the post-test, and the change in squat performance measured over the 12-weeks in the two study groups.

There were no differences in the height of the squat bench between groups. Furthermore, the height of the squat bench was neither a significant factor on its own with respect to the change from the pre-test to the post-test ($p=0.665$), nor did it modify the group effect ($p=0.592$).

4.7 Questionnaires

The questionnaire data met the assumptions of homogeneity of variance and normality necessary to complete a MANOVA. No difference was found between groups in how the answers changed over the 12 weeks of the program. Analysis was done on the complete questionnaire, each summed section (Strength, Endurance, Flexibility, Balance, and Health), and each question within the separate sections. Questions with four or more NA responses were eliminated as not representative of the sample. These questions were all from the endurance section: #12, #15 and #17. No significant differences were found in the questionnaire as a whole, or in any individual section of the questionnaire. Table 6 illustrates the answers for the various sections by each subject. An answer of "1" indicates that the activity could be completed easily, whereas an answer of "5" indicates an inability to complete the activity. Higher scores reflect lower function. Negative changes indicate an improvement in function over the 12-week protocol.

Table 6. Fitness For Independent Living Questionnaire Section Responses. Each number represents the summed answers for the various sections. Higher numbers represent lower function. Results in bold indicate an improvement in perceived fitness during the 12-week protocol. Underlined results indicate a decrease in perceived fitness.

Subject	Flexibility Pre	Flexibility Post	Leg Strength Pre	Leg Strength Post	Endurance Pre	Endurance Post	Balance Pre	Balance Post	Health Pre	Health Post
Training Group										
3	7	7	**11**	**10**	18	19	4	5	4	4
4	6	6	**8**	**6**	6	6	**3**	**2**	2	2
6	8	9	9	9	5	6	3	4	3	3
8	**9**	**8**	**8**	**7**	9	9	**4**	**2**	2	2
9	9	17	15	23	27	28	6	7	**5**	**4**
10*	5	13	16	18	6	30	4	10	4	5
11	12	12	13	15	**22**	**16**	**10**	**6**	4	5
16	**6**	**5**	**14**	**9**	**9**	**6**	2	2	2	2
Control Group										
5	11	13	**10**	**9**	**11**	**9**	3	4	**5**	**4**
7	5	7	**10**	**8**	**8**	**6**	**4**	**2**	2	2
12	**11**	**5**	**7**	**6**	**5**	**4**	**3**	**2**	3	3
13	7	7	9	11	8	9	**7**	**4**	4	4
14	5	5	7	11	6	8	2	2	2	4
15	11	13	**16**	**13**	**23**	**18**	5	6	5	5

*The results for Subject 10 are questionable due to dementia.

4.8 Journals

The subjects summed up their reactions to the training upon completion of the 12 weeks. In addition, some of the subjects completed journals approximately once a week, reflecting their thoughts about the training. There were several seniors who saw the training class, and expressed interest in joining midway through the program. They were not tested for the chair rise parameters or the squats, but they filled out journals six weeks into their training. No control group subjects completed journals. The following excerpts pertaining to changes caused by the resistance training program are outlined:

"I feel my upper legs have firmed up" A.M., Week 6.

"I try to walk up 3 floors to my apartment after each class and find it is getting a little easier" E.H., Week 6.

"I can actually do the squats now - I never thought I'd be able to do these" E.I., Week 6.

"I can get up out of a chair with much less effort…getting in and out of the car is much easier….I'm much more flexible and mobile than I was at the start of the program" G.W. Week 6.

"Stairs, cleaning windows etc. are much easier" H.J., Week 6.

"Legs feel stronger" J.I., Week 6.

"I feel more strength in my legs as I walk" M.H., Week 6.

"My legs feel stronger and more muscular" M.H., Week 8.

"I feel that the extra strength is helping with walking, especially on icy sidewalks" M.H., Week 9.

"My back is stronger" A.M., Week 10.

"Can climb stairs somewhat better since I started" E.H., Week 10.

"Had to have a skirt taken in down sides due not to weight loss, but more firming up" H.J., Week 10.

"Feel better, easier to go up and down stairs" H.J., Week 12.

"I'm sure it has made a difference in my legs. Find I can climb stairs a little better" E.H., Week 12.

"I have stumbled a few times but kept myself from falling due, I think, to the strength in my legs…I feel, too, the exercises will benefit my dancing (ballroom) as strong legs are necessary to perform the steps" M.H., Week 12.

"I feel that my knees are in much better shape than when I started" M.R., Week 12.

"My knees and my back are much better" R.S., Week 12.

There were no recorded comments about excessive pain, or negative effects due to the program. Based on the journals, the participants' perception of the resistance training appears to be very positive and beneficial to their well-being.

CHAPTER FIVE

DISCUSSION

This study was performed to detect whether a moderate intensity lower body strength training program would elicit changes in the vertical force-time curve of a chair rise in the elderly. The research hypothesis stated that the training group compared to the control group would have different changes in strength and in a chair rise due to the 12 weeks of lower body resistance training.

5.1 Chair Rise

The chair rise protocol used was similar to that of Fleming et al. (1991), with a minor difference in the chair height. In the present study, the chair height remained 40cm off the ground for all subjects, whereas in the Fleming et al. (1991) study the chair height was adjusted to achieve a knee angle of 90° for all subjects. Table 6 compares the results of the two studies. It appears that the chair rises analyzed in this study were comparable to those done by Fleming et al. (1991). The curve markers are very similar when comparisons are made between the non-fallers (Fleming et al., 1991) and the pre-test in the current study. However, the peak slope appears to be substantially higher in the present data. It is unknown whether Fleming et al. (1991) calculated average slopes rather than instantaneous slopes as was done with the present data. Or perhaps the sampling rate used by Fleming et al. (1991) was lower than 1000 per second as used in the present study. The peak slope occurs for such a short period of time, that either of the two aforementioned reasons could substantially reduce the measured peak slope. When average slope between Min1 and Max were measured in the current data, the values were much closer to the values reported by Fleming et al. (1991).

Table 7. Average vertical force-time curve parameters for two studies.

	Max	Min2	Max/Min2	Pslope (range)
Present Data				
Pre-test	1.22±.08	.71±.11	1.70±.37	4.36 - 11.25 sec^{-1}
Post-Training	1.30±.09	.53±.17	2.76±1.05	8.45 - 13.34 sec^{-1}
Post-Control	1.26±.07	.66±.06	1.92±.22	5.67 - 12.00 sec^{-1}
Fleming Data				
Non-fallers	1.23±.15	.73±.16	1.68±.64	2.44 - 4.02 sec^{-1}
Fallers	1.05±.05	.92±.13	1.14±.13	0.69 - 2.59 sec^{-1}

The non-fallers (Fleming et al., 1991) included a variety of ages, ranging from 21 years to 71 years of age. This is a much larger age range than the present study of older adults. Perhaps among healthy subjects there is very little age effect on the variables. A normative data base of chair rises for various age groups is necessary to quantify the expected change in the chair rise parameters due to age.

Wheeler et al. (1985) examined chair rises from two different types of chairs. They found that rising from a special chair (seat depth, posterior seat slant and backrest incline more pronounced) showed more vastus lateralis muscle activity than rising from a standard chair. Burdett et al. (1985) compared chair rises from a seat height of 0.43m and

0.64m. Significantly smaller hip and knee extension moments were recorded with the higher seat height. Perhaps seat height can explain the differences between our findings and those of Fleming et al. (1991). The seat height and/or type of chair used for the chair rise may have been different, thus eliciting different moments and different resultant forces.

5.1.1 Min1

There were no statistically significant differences between the training and control groups at marker Min1, however the trend indicated that the training group decreased Min1 over the intervention. Min1 occurs just prior to the point at which weight transfers from the chair to the feet (Hoy and Marcus, 1992). This undershoot seems to represent a gathering of momentum to aid in the chair rise. It was thought that a larger drop in forces would characterize greater strength capabilities due to a greater ability to generate momentum. There were no significant changes, so no evidence was found to substantiate that hypothesis. Perhaps when the legs are strengthened less momentum is needed to rise from the chair. Or, perhaps the amount of momentum is controled by the upper body, and the protocol in this experiment did not include any upper body strengthening.

5.1.2 Max

No significant difference between the training and the control groups was found in the maximum force generated (Max) although all the training subjects increased this variable over the 12-week intervention. The peak force occurs at the point when contact with the chair is lost (Hoy and Marcus, 1992). Hoy and Marcus (1992) also found that Max did not change with 12 weeks of strength training three times a week. However, they did find that the magnitude of the vertical force peak increased significantly with speed of movement (Hoy and Marcus, 1992). Max appears to be an indicator of the speed of a chair rise. The higher the Max, the faster the chair rise. Kralj et al. (1990) agree that for normal or fast standing up, the movement can be considered to be closer to a ballistic movement, thus would require greater peak force. Although statistical differences between groups were not found with this variable, when the data was included in the MANOVA, disregarding the violation of the homogeneity of variance assumption, differences were found. The p-value was below the critical value of $p \leq 0.05$ ($p=0.037$). Further research is needed to clarify the relationship of maximum force generation in a chair rise with strength increases.

In the present study, Max seems to reflect faster speeds of rising, as seen by the Pearson correlation between Max and the time between Min1 and Min2 ($r=0.7175$; $p=0.004$). As Max increases, so does the increase in speed between Min1 and Min2. This relationship also requires more study.

5.1.3 Min2

A significant difference between the control and the training groups was found in Min2 which is the peak undershoot that occurs after the peak force. The ascending phase of the chair rise occurs after the seat off event, and a short time into this phase the vertical acceleration is converted to deceleration. This is identified by the minimum slope of the curve (Kralj et al., 1990). Min2 occurs just after the deceleration commences, but prior to full knee extension (Kralj et al., 1990). It is characterized by the minimum force. Smaller Min2 values may indicate a greater ability to vertically decelerate or better motor control. Strengthening the leg muscles may contribute to this capability through neural factors. Changes in the recruitment pattern and synchronization of motor units brought about by strength training (Fox et al., 1993) may be responsible for the changes in Min2. These neural changes could induce more efficient force production and superior deceleration in the chair rise. The present study provides evidence to support the changes in Min2 with resistance training.

5.1.4 Max/Min2

No significant difference between groups was found in the ratio Max/Min2, although the trend indicates an increase in the ratio for the training subjects over the 12 weeks. The non-parametric analysis generated a p-value of $p=0.0528$, which is very close to the critical p-value of $p=0.05$. As a follow-up analysis, MANOVA was done with the Max/Min2 variable included. MANOVA is a reasonably robust test, therefore even with the breach of the homogeneity of variance assumption in this variable, it can still be considered a useful statistical tool. The p-value for Max/Min2 in the MANOVA was $p=0.038$. This would be considered significant. Therefore, although no differences were found in this variable within the parameters of the intended analysis, it is quite conceivable that differences do exist.

5.1.5 Pslope

Peak slope (Pslope) increased significantly in the training group compared to the control group. The peak slope of the chair rise represents the power of the rise. Strength training programs attempting to maximize power development focus on high intensity with low repetitions (Fox et al., 1993). The training program for this study used moderate intensity training with a high number of repetitions, so power acquisition was not targeted. This study provides evidence that significant gains in muscle power can be attained even with lower intensity strength training.

Young and Skelton (1994) state that in the presence of pathology, reasonably strong associations have been demonstrated between functional abilities and power. The chair rise test as a power assessment may be a reasonable evaluation of functional leg power. It is a non-threatening test for people unaccustomed to maximal exertion assessments. In addition, it appears to be a very sensitive evaluation in that it can identify changes due to a 12-week moderate intensity strength training intervention.

5.1.6 Modifying Factors

Fleming et al. (1991) found a significant correlation between pslope and age. This was not seen in the present study. Except one subject who was 52 years of age, the subjects in this study were relatively homogeneous in age, ranging from 66 years to 82 years. The 52-year old was included in the study because she belonged to a senior citizens' group and considered herself to be a part of the elderly demographic due to various health problems including diabetes and arthritis. However, this homogeneity was not apparent in the Fleming et al. study (1991). Their control subjects ranged in age from 23 years to 72 years, and the fallers ranged in age from 63 years to 92 years. The age heterogeneity explains the association between Pslope and age in the Fleming et al. (1991) results.

Due to the common chair height used for subjects of varied heights, results were examined for both interacting subject height effects, and height effects alone. Neither was found to be significant. It seems that in evaluation of intra-subject change over time, subject height relative to the chair height is of little importance. Research evidence shows that chair height may affect the chair rise (Burdett et al., 1985; Wheeler et al., 1985), however it may only be important when one is looking at inter-subject differences.

Weight of the subjects was the third factor examined for modifying effects on the treatment. There was no interaction between any of the group effects and weight, but there was a significant weight effect on the peak slope (Pslope) generated during the chair rise. As weight increased, so did the change in Pslope over the 12 weeks. This could be misleading because of the assignment of weight categories for the analysis. Perhaps the categories emphasized a less substantial weight effect. Figure 11 shows that the regression lines for the two groups are both parallel to the x-axis (weight axis). This suggests that there is no weight effect. However, the regression lines assume linearity. The control group markers appear to be linear, but the training group may not be. Figure 11 shows that the peak change in Pslope occured in subjects weighing approximately 70kg, and the distribution of the markers may be parabolic. Further research might assist in clarifying this relationship.

5.1.7 Time Parameters

Although previous literature has indicated no change in chair rise time with strength training (Hoy & Marcus, 1992; Skelton et al., 1995), it appears that portions of the chair rise curve may occur more rapidly with training. The present study provided evidence supporting approximately 30% increases in speed of rising at various points in the rise with lower body resistance training. The control group subjects tended to increase their speed by approximately 5%. This would suggest the need for further research to determine if these time parameters are more informative than the force parameters. A more informative variable would be one which distinguishes between functional and dysfunctional chair rises, and is sensitive enough to measure change.

5.2 Training Program

Initially the training program was meant to be done at a moderate to high intensity, however, intensity was very difficult to monitor. Elastic tubing is a self-monitoring type of resistance training. Subjects determine their own training intensity based on the amount of slack in the tubing. Other researchers have monitored the intensity by measuring the subject's ability to perform ten to twelve repetitions without sacrificing proper exercise form on the last repetitions (Mikesky et al.,1994; Skelton et al., 1995; Topp et al., 1993). These studies would change the tubing to a less elastic tension in order to increase the resistance when the exercises did not induce adequate fatigue. This may be a more effective way of maintaining an acceptable intensity, rather than attempting to adjust the slack on the tubing to modify the tension as was done in the present study.

Although the subjects were repeatedly told that the exercises should be completed at a difficulty rating of "somewhat hard" (ACSM, 1995), some subjects did not seem capable of reaching an intensity that would invoke fatigue at 12 repetitions. In order to fatigue the muscle, it seemed that more repetitions were necessary because the intensity was not high enough.

5.3 Differences Between Self-Report and Measured Assessments

The measured strength test clearly indicated increased strength due to the resistance training regime. However, the self-report questionnaire did not indicate any increased functional fitness in any area and most relevantly no change in leg strength due to the training. Conversely, the journal comments seemed to indicate the perception of increased leg strength which translated into increased functionality for a large proportion of the participants. The question remains whether the program successfully increased leg strength, and whether that leg strength translated into increased functionality.

Perhaps the questionnaire was not sufficiently sensitive for the population participating in the study. They were highly functioning senior citizens and were generally very active. The activities evaluated through the questionnaire were likely too basic for this group. No change can be measured when the activities are easily completed prior to the strength training. A tool which has greater increments of change in performance capabilities, and a greater range of functionality would have been more appropriate.

Another possibility is that their own baseline changed for their self-assessment. Once they started gaining strength, they may have expected more from themselves.

Completing an activity "with difficulty" may have become easier, but their internal ranking scale may have changed with their fitness level.

The third possibility is that the questionnaire was correct in assessing the lack of functional fitness increases, and the journal entries were exaggerated. Many of the subjects seemed very concerned about the success of the project. They wanted and expected to gain strength. The journal entries could be conscious or subconscious overestimations about the efficacy of the training in order to please the researchers, or because of prior expectations regarding strength training.

5.4 Efficacy of the Training

The tubing and squat training appeared to be effective in developing strength gains in the lower leg, however, the squat test used to monitor strength did not seem to be optimal. There was an extremely high variance of subjects' improvement. This could be caused by a high variance in actual strength changes, or it could be caused by an imprecise or inaccurate test. It seems that the method of testing may not have been valid because the control group also had a vast range of strength changes. Table 7 displays the strength gains assessed in various other 12-week studies for the older adult. It is evident that the mean change measured in the present study appears extraordinarily high compared with any of the other studies examined.

Table 8. Various 12-week strength training intervention studies of 12-week duration with older adults.

Authors	Measurements	% Change
Frontera et al. (1988)	Knee extensors	107.4%
	Knee flexors	226.7%
Topp et al. (1993)	Peak isokinetic knee extension	no change
Keen et al. (1994)	Isometric MVC (index finger)	41.2%
Mikesky et al. (1994)	Isokinetic eccentric knee extension	12%
Skelton et al. (1995)	Isometric knee extension	27%
	Chair rise time	no change
	10 chair rise time	no change
Present study Training	Number of squats	455%
Control	Number of squats	10%

It seems that elastic tubing training in conjuction with squats are ideal exercises for home-training with the elderly. This training allows participants to easily control their own intensity without the fear of injury due to excessive resistance. When given the freedom, subjects appeared to set their intensity at low to moderate rather than moderate to high. The present study provides evidence that moderate intensity is sufficient to acquire significant strength gains with elastic tubing and squat resistance training. This information could be valuable in the prescription of strength training programs for senior citizens.

5.5 Possible link with falling

Fleming et al. (1991) originally devised the force-plate chair rise test in order to assess risk of falling. Their research showed that people at higher risk of falling tended to have a non-existant overshoot (Max) and undershoot (Min2). They determined that the simple, non-stressful and potentially portable method to identify people at risk of falling is acceptable to both the clinician and the patient. Furthermore, they suggested that a rehabilitation program could be initiated for people found to be at risk. Prior to establishing such a program, it becomes important to determine whether certain interventions could change the force-time curve parameters. Skelton et al. (1995) found that neither the time of a single chair rise, nor the time of ten consecutive chair rises is changed with 12 weeks of strength training with tubing and 1-1.5 kg weights. In addition, Hoy and Marcus (1992) reported that the vertical force of a chair rise did not change with strength training using Universal weight training machines. However, the present study found that the parameters that may differentiate high risk fallers can be altered with resistance training.

To further substantiate the link of muscle weakness with falling, Whipple et al. (1987) showed that peak torque and peak power of the knee extensors and flexors, and the ankle plantar- and dorsi-flexors were significantly lower in fallers than age-matched controls. Falling is linked to many other factors in addition to lower extremity muscle strength including gait and balance. However, there seems to be a general consensus on the association of reduced lower body strength and falls (Phillips and Haskell,1995).

The present study made no association between the chair rise parameters and probability of falling in the subjects. Fleming et al. (1991) stated that the undershoot (Min2) and the overshoot (Max) were virtually non-existant in high-risk fallers. All subjects in the present study had measurable Min2 and Max, therefore would likely be considered low-risk fallers according to the Fleming et al. (1991) criteria.

5.6 Limitations

As previously suggested, there are limitations in this study. Primarily, the small number of subjects involved prohibits conclusive statements about modifying factors or external influences due to few degrees of freedom.

Secondly, there were problems with the strength testing using repeated squats. The data can not be considered direct measurements of strength, but only indications of strength changes. Perhaps a maximal strength test may be more appropriate even with the greater associated risks to the participants.

Thirdly, because so many statistical tests were examined, there is an increased likelihood of detecting statistical significance in any one of the tests.

5.7 Future Directions

The chair rise is a functional limitation in itself. If one cannot rise from a chair adequately, ordinary tasks such as using the toilet may be difficult. Although the vertical force-time curve parameters may identify a more ballistic rise, or a more powerful rise, it is not known whether they identify a more functional rise. Research is needed to clarify this relationship.

Researchers need to identify the actual portions of a chair rise that become difficult with age, and determine if there are markers on the force-time curve (either force or time) that correspond with the troubled rise. The degree to which the force-time curve pertains to functional ability can then be assessed.

To assess the efficacy of the elastic tubing, resistance training needs to be done with only the elastic tubing exercises, eliminating the squats. In the present study, all the strength gains may have been induced by the squats, and the efficacy of the tubing remains to be determined.

A long-term study is warranted to evaluate lower functioning subjects at-risk for falling as compared to the highly functioning subjects in the present study. Subjects who have an initial chair rise in the risk zone targeted by Fleming et al. (1991) need to exercise in an attempt to modify the force-time curve. It can then be determined whether a modification of the force-time variables actually indicates an adaptation in the risk of falling.

More research needs to be done looking at the modifying factors involved in changing the force-time curve. The weight effect is still undetermined, and a study with more subjects could perhaps verify the relationship of weight on the vertical force-time curve of a chair rise.

Finally, the present study did not incorporate a follow-up assessment to determine whether any of the changes due to the training were temporary or long-term. This could easily be addressed in future research by including an evaluation several weeks and again several months post-intervention.

5.8 Conclusions

In conclusion, the results of this study indicate that a moderate 12-week lower body strength training program can influence several of the vertical force-time curve parameters of a chair rise in senior citizens compared with a non-exercising control group. These parameters include the following:

- the second curve minimum (Min2), defined as the amount of undershoot caused by deceleration of the vertical forces following the upward movement
- the peak slope (Pslope), defined as the peak rate of force development representing the peak power generated

The other chair rise variables (Min1, Max, Max/Min2) demonstrate trends indicating possible lower body strengthening effects. These variables may lead to clinical quantification of functional chair rise ability, which could be an indication of functional independence. This may be an important finding not only in functionality research, but also in risk of falling assessments.

In addition, the present study provides evidence indicating that strength gains can be achieved through a 12 week moderate intensity lower body resistance training program. This is important for senior citizens because maintained muscle strength into the aging years may be the key to functional independence. A high intensity training regime may not be necessary to elicit these gains.

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APPENDIX A

Pilot Study Findings

Subject 1: 25 year old female
competitive soccer player
visibly ballistic chair rise

Subject 2: 52 year old male
active in golf and squash
less ballistic chair rise

Table 9. Vertical force measurements in body weight units for the two subjects doing a chair rise.

Subject	Min1	Max	Min2	Peak Slope
1	0.0682	1.506	0.5837	15.03
2	0.1026	1.226	0.5622	8.289

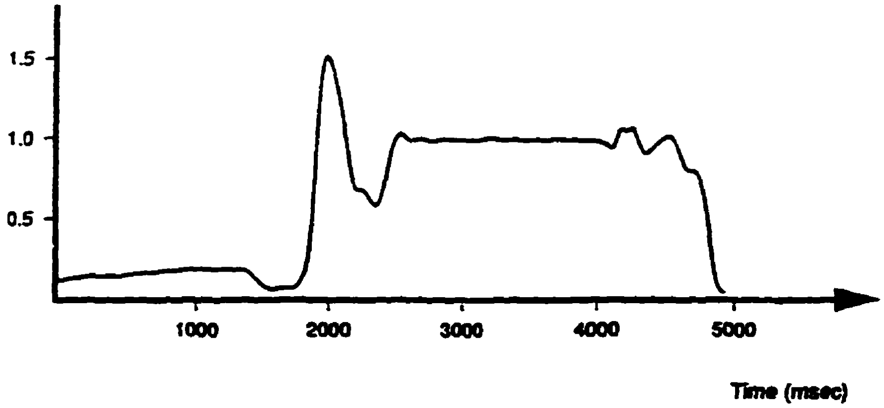


Figure 13. Chair rise force- time curve for Subject 1 in body weight units.

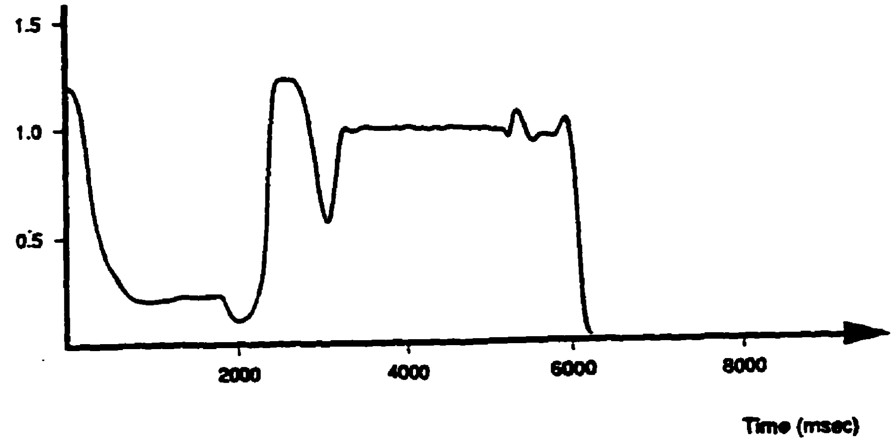


Figure 14. Chair rise force-time curve for Subject 2 in body weight units.

APPENDIX B

University of Calgary
Consent Form

Project Title: The effects of resistance training on the vertical force-time curve of a chair rise in the elderly.
Investigator: Jody Nicholson

This consent form, a copy of which has been given to you, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, please ask. Please take the time to read this form carefully and to understand any accompanying information.

The purpose of this research is to evaluate whether a resistance training program using elastic tubing can improve the ability to get in and out of a chair. You will have to stand up out of a chair as quickly as possible and sit back down in the Human Performance laboratory at the University of Calgary. A force platform in the floor will assess the forces upon the body. The ability to get in and out of the chair will be calculated by the slope in the force-time curve. Spotters will be present at all times, in case you lose your balance. Three chair rises will be measured.
The second test counts the number of quarter to half squats that can be performed in a row. You will be asked to perform as many knee bends (squats) as you can at the rate of 1 every 4 seconds. Again, spotters will be present at all times. The whole procedure will take about 15 minutes. The first test will be done before the training program, and the second test will be done after the training program.
Thirdly, you will be asked to fill out a questionnaire regarding your activity level and your fitness level.

You will be randomly assigned to one of two training programs. One group will meet 3 times a week for 12 weeks to do a gentle stretching program. At each 30 to 45 minute sessions, this group will learn overall body stretches and stretching techniques. The other group will meet three times a week for 12 weeks to do a 30 to 45 minute elastic tubing resistance training program. This program will be fully supervised and instructed and the sessions will take place at a convenient location for the participants.

There should be no ill effects from the testing or the training, apart from feelings of fatigue caused by the training. Rarely, exercise can result in muscle strain injury. Training should be done to the point of fatigue, not to the point of pain. It is possible that the training may aggravate any previous lower extremity injury so if you currently suffer from any injury you should review your participation in this study.

APPENDIX B

Consent form continued

All results will be kept confidential. Only those directly involved in the study will have access to information gained. Published material based on this research will in no way identify you.

The training program is free of charge, and all participants will receive their own elastic tubing to keep. Both training groups will receive instruction in the other group's training at the end of the study.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. If you have further questions concerning matters related to this research, please contact:

Jody Nicholson
Ph:220-2802

If you have any questions concerning your participation in this project, you may also contact the Associate Dean (Research) and ask for Kerry Courneya, 220-8741.

________________________ ________________________
(Name) (Signature of Subject)

________________________ ________________________
(Witness) (Signature of Witness)

____
(Date)

A copy of this consent form has been given to you to keep for your records and reference.

APPENDIX B

Participation Questionnaire

NAME____ **AGE**____________

PHONE_______________

1. Do you have extreme arthritis that limits your range of motion?

NO **YES** (Explain)

____

____

2. Can you walk without an aid? **NO** (Explain) **YES**

____

____

3. Are you on anabolic steroid medication? **NO** **YES** (Explain)

____

____

4. Are you suffering from unstable cardiovascular disease or another uncontrolled illness that could interfere with the safety and conduct of the training? Please specify the illness and explain: **NO** **YES**

____

____

____

5. Do you agree to "not start" a new exercise program or activity for the 12-weeks of the study? **Please sign in agreement:**____________________________

APPENDIX B

Fitness Assessment for Independent Living

Please rate the following statements by marking the corresponding number:

I can complete the activity:

1 - Easily
2 - With Some Effort
3 - With Difficulty
4 - With Extreme Difficulty
5 - Never
NA - Have not tried that activity recently

Flexibility

1. Scratching between your shoulder blades with your hand..1 2 3 4 5 NA
2. Picking money up off the floor .... 1 2 3 4 5 NA
3. Reaching above your head to get a can/dish

   out of a cupboard .... 1 2 3 4 5 NA
4. Looking back over your shoulder (shoulder checking) ...... 1 2 3 4 5 NA
5. Putting your socks on while sitting down .... 1 2 3 4 5 NA

Leg Strength

6. Running for 10 seconds .... 1 2 3 4 5 NA
7. Jumping on the spot .... 1 2 3 4 5 NA
8. Standing on your toes .... 1 2 3 4 5 NA
9. Walking up a flight of 15 stairs .... 1 2 3 4 5 NA
10. Getting in and out of a chair without armrests .... 1 2 3 4 5 NA
11. Getting in and out of a car .... 1 2 3 4 5 NA

APPENDIX B

Fitness Assessment for Independent Living continued

I can complete the activity:

1 - Easily
2 - With Some Effort
3 - With Difficulty
4 - With Extreme Difficulty
5 - Never
NA - Have not tried that activity recently

Endurance

12. Jogging, swimming or biking for 30 minutes .... 1 2 3 4 5 NA
13. Walking at a steady pace for 30 minutes .... 1 2 3 4 5 NA
14. Shoveling snow for 20 minutes without a break .... 1 2 3 4 5 NA
15. Mowing the lawn for 20 minutes without a break .... 1 2 3 4 5 NA
16. Raking leaves for 20 minutes without a break .... 1 2 3 4 5 NA
17. Scrubbing the floor for 20 minutes without a break .... 1 2 3 4 5 NA
18. Vacuuming for 20 minutes without a break .... 1 2 3 4 5 NA
19. Walking one city block .... 1 2 3 4 5 NA
20. Washing a sink-full of dishes without a break .... 1 2 3 4 5 NA

Balance

21. Tying your shoes while standing up .... 1 2 3 4 5 NA
22. Putting on your pants while standing up .... 1 2 3 4 5 NA

Please circle the correct answer:

23. Compared to others your age, would you say your health is:

Very Good   Good   Average   Poor   Very Poor

24. Does your current health prevent you from doing things you'd like to do?

Yes   No

APPENDIX B

Post-test Questionnaire

NAME________________________________ **PHONE**____________

Since September (when the training began) have you experienced any of the following?

Type of medication changes **Yes (Explain) No**

Medication dosage changes **Yes (Explain) No**

Changes in activity level not due to the training **Yes (Explain) No**

Dietary changes **Yes (Explain) No**

Weight loss of more than 5 pounds **Yes (Explain) No**

Weight gain of more than 5 pounds **Yes (Explain) No**

Illness lasting longer than a couple of days **Yes (Explain) No**

APPENDIX B

Post-test Questionnaire continued

Hospitalization **Yes (Explain) No**

____

____

Injury due to the training sessions **Yes (Explain) No**

____

____

Severe muscle soreness due to the training sessions **Yes (Explain) No**

____

____

APPENDIX B

• Revised 1994

Physical Activity Readiness Questionnaire (PAR-Q)

YES	NO	
____	____	1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?
____	____	2. Do you feel pain in your chest when you do physical activity?
____	____	3. In the past month, have you had chest pain when you were not doing physical activity?
____	____	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
____	____	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
____	____	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
____	____	7. Do you know of <u>any other reason</u> why you should not do physical activity?

NOTE:

1. This questionnaire applies only to those 15 to 69 years of age.
2. If you have temporary illness, such as a fever or cold, or are not feeling well at this time, you may wish to postpone the proposed activity.
3. If you are pregnant, you are advised to discuss the "PARmed-X for Pregnancy" form with your physician before exercising.
4. If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

I have read, understood and completed this questionnaire.

SIGNATURE________________________________ DATE________________

SIGNATURE OF PARENT____
OR GUARDIAN (for participants under the age of majority)

Witness____ Date________________

Informed use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

APPENDIX B

…cal Activity Readiness
…cal Examination
…sed 1995)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

The PARmed-X is a physical activity-specific checklist to be used by a physician with patients who have had positive responses to the Physical Activity Readiness Questionnaire (PAR-Q). In addition, the Conveyance/Referral Form in the PARmed-X can be used to convey clearance for physical activity participation, *or to make a referral to a medically-supervised exercise program.*

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. The PAR-Q by itself provides adequate screening for the majority of people. However, some individuals may require a medical evaluation and specific advice (exercise prescription) due to one or more positive responses to the PAR-Q.

Following the participant's evaluation by a physician, a physical activity plan should be devised in consultation with a physical activity professional (CSEP-Certified Fitness Appraiser). To assist in this, the following instructions are provided:

PAGE 1: • Sections A, B, C, and D should be completed by the participant BEFORE the examination by the physician. The bottom section is to be completed by the examining physician.

PAGES 2 & 3: • A checklist of medical conditions requiring special consideration and management.

PAGE 4: • Physical Activity & Lifestyle Advice for people who do not require specific instructions or prescribed exercise.
• Physical Activity Readiness Conveyance/Referral Form - an optional tear-off tab for the physician to convey clearance for physical activity participation, or to make a referral to a medically-supervised exercise program.

This section to be completed by the participant

A PERSONAL INFORMATION:

NAME ____________

ADDRESS ____________

____

TELEPHONE ____________

BIRTHDATE ____________ GENDER ______

MEDICAL No. ____________

B PAR-Q: *Please indicate the PAR-Q questions to which you answered YES*

❑ Q 1 Heart condition
❑ Q 2 Chest pain during activity
❑ Q 3 Chest pain at rest
❑ Q 4 Loss of balance, dizziness
❑ Q 5 Bone or joint problem
❑ Q 6 Blood pressure or heart drugs
❑ Q 7 Other reason: ____________

C RISK FACTORS FOR CARDIOVASCULAR DISEASE:
Check all that apply

❑ Less than 30 minutes of moderate physical activity most days of the week.
❑ Currently smoker (tobacco smoking 1 or more times per week).
❑ High blood pressure reported by physician after repeated measurements.
❑ High cholesterol level reported by physician.
❑ Excessive accumulation of fat around waist.
❑ Family history of heart disease.

***Please note:** Many of these risk factors are modifiable. Please refer to page 4 and discuss with your physician.*

D PHYSICAL ACTIVITY INTENTIONS:

What physical activity do you intend to do?

____

____

____

This section to be completed by the examining physician

Physical Exam:

Ht	Wt	BP i) /
		BP ii) /

Conditions limiting physical activity:

❑ Cardiovascular ❑ Respiratory ❑ Other
❑ Musculoskeletal ❑ Abdominal

Tests required:

❑ ECG ❑ Exercise Test ❑ X-Ray
❑ Blood ❑ Urinalysis ❑ Other

Physical Activity Readiness Conveyance/Referral:

Based upon a current review of health status, I recommend:

❑ No physical activity

❑ Only a medically-supervised exercise program until further medical clearance

❑ Progressive physical activity
❑ with avoidance of: ____________
❑ with inclusion of: ____________
❑ with Physical Therapy: ____________

❑ Unrestricted physical activity — start slowly and build up gradually

Further information:
❑ Attached
❑ To be forwarded
❑ Available on request

Supported by:

APPENDIX B

Physical Activity Readiness
Medical Examination
(revised 1995)

PARmed-X PHYSICAL ACTIVITY READINESS MEDICAL EXAMINATION

Following is a checklist of medical conditions for which a degree of precaution and/or special advice should be considered for those who answered "YES" to one or more questions on the PAR-Q, and people over the age of 69. Conditions are grouped by system. Three categories of precautions are provided. Comments under Advice are general, since details and alternatives require clinical judgement in each individual instance.

	Absolute Contraindications	Relative Contraindications	Special Prescriptive Conditions	ADVICE
	Permanent restriction or temporary restriction until condition is treated, stable, and/or past acute phase.	Highly variable. Value of exercise testing and/or program may exceed risk. Activity may be restricted. Desirable to maximize control of condition. Direct or indirect medical supervision of exercise program may be desirable.	Individualized prescriptive advice generally appropriate: • limitations imposed; and/or • special exercises prescribed. May require medical monitoring and/or initial supervision in exercise program.	
Cardiovascular	❑ aortic aneurysm (dissecting) ❑ aortic stenosis (severe) ❑ congestive heart failure ❑ crescendo angina ❑ myocardial infarction (acute) ❑ myocarditis (active or recent) ❑ pulmonary or systemic embolism—acute ❑ thrombophlebitis ❑ ventricular tachycardia and other dangerous dysrhythmias (e.g., multi-focal ventricular activity)	❑ aortic stenosis (moderate) ❑ subaortic stenosis (severe) ❑ marked cardiac enlargement ❑ supraventricular dysrhythmias (uncontrolled or high rate) ❑ ventricular ectopic activity (repetitive or frequent) ❑ ventricular aneurysm ❑ hypertension—untreated or uncontrolled severe (systemic or pulmonary) ❑ hypertrophic cardiomyopathy ❑ compensated congestive heart failure	❑ aortic (or pulmonary) stenosis—mild angina pectoris and other manifestations of coronary insufficiency (e.g., post-acute infarct) ❑ cyanotic heart disease ❑ shunts (intermittent or fixed) ❑ conduction disturbances • complete AV block • left BBB • Wolff-Parkinson-White syndrome ❑ dysrhythmias—controlled ❑ fixed rate pacemakers	• clinical exercise test may be warranted in selected cases, for specific determination of functional capacity and limitations and precautions (if any). • slow progression of exercise to levels based on test performance and individual tolerance. • consider individual need for initial conditioning program under medical supervision (indirect or direct).
			❑ intermittent claudication	progressive exercise to tolerance
			❑ hypertension: systolic 160-180; diastolic 105+	progressive exercise; care with medications (serum electrolytes; post-exercise syncope; etc.)
Infections	❑ acute infectious disease (regardless of etiology)	❑ subacute/chronic/recurrent infectious diseases (e.g., malaria, others)	❑ chronic infections ❑ HIV	variable as to condition
Metabolic		❑ uncontrolled metabolic disorders (diabetes mellitus, thyrotoxicosis, myxedema)	❑ renal, hepatic & other metabolic insufficiency	variable as to status
			❑ obesity ❑ single kidney	dietary moderation, and initial light exercises with slow progression (walking, swimming, cycling)
Pregnancy		❑ complicated pregnancy (e.g., toxemia, hemorrhage, incompetent cervix, etc.)	❑ advanced pregnancy (late 3rd trimester)	refer to the "PARmed-X for PREGNANCY"

References:

Arraix, G.A., Wigle, D.T., Mao, Y. (1992). Risk Assessment of Physical Activity and Physical Fitness in the Canada Health Survey Follow-Up Study. J. Clin. Epidemiol. 45:4 419-428.

Mottola, M., Wolfe, L.A. (1994). Active Living and Pregnancy, In: A. Quinney, L. Gauvin, T. Wall (eds.), **Toward Active Living: Proceedings of the International Conference on Physical Activity, Fitness and Health.** Champaign, IL: Human Kinetics.

PAR-Q Validation Report, British Columbia Ministry of Health, 1978.

Thomas, S., Reading, J., Shephard, R.J. (1992). Revision of the Physical Activity Readiness Questionnaire (PAR-Q). Can. J. Spt. Sci. 17:4 338-345.

The PAR-Q and PARmed-X were developed by the British Columbia Ministry of Health. They have been revised by an Expert Advisory Committee assembled by the Canadian Society for Exercise Physiology and the Fitness Program, Health Canada (1995).

You are encouraged to copy the PARmed-X, but only if you use the entire form

Disponible en français sous le titre
«Evaluation médicale de l'aptitude à l'activité physique (X-AAP)».

Continued on page 3...

APPENDIX B

Physical Activity Readiness Medical Examination (revised 1995)

	Special Prescriptive Conditions	ADVICE
Lung	☐ chronic pulmonary disorders	special relaxation and breathing exercises
	☐ obstructive lung disease ☐ asthma	breath control during endurance exercises to tolerance; avoid polluted air
	☐ exercise-induced bronchospasm	avoid hyperventilation during exercise; avoid extremely cold conditions; warm up adequately; utilize appropriate medication.
Musculoskeletal	☐ low back conditions (pathological, functional)	avoid or minimize exercise that precipitates or exasperates e.g., forced extreme flexion, extension, and violent twisting; correct posture, proper back exercises
	☐ arthritis—acute (infective, rheumatoid; gout)	treatment, plus judicious blend of rest, splinting and gentle movement
	☐ arthritis—subacute	progressive increase of active exercise therapy
	☐ arthritis—chronic (osteoarthritis and above conditions)	maintenance of mobility and strength; non-weightbearing exercises to minimize joint trauma (e.g., cycling, aquatic activity, etc.)
	☐ orthopaedic	highly variable and individualized
	☐ hernia	minimize straining and isometrics; stregthen abdominal muscles
CNS	☐ convulsive disorder not completely controlled by medication	minimize or avoid exercise in hazardous environments and/or exercising alone (e.g., swimming, mountainclimbing, etc.)
	☐ recent concussion	thorough examination if history of two concussions; review for discontinuation of contact sport if three concussions, depending on duration of unconsciousness, retrograde amnesia, persistent headaches, and other objective evidence of cerebral damage
Blood	☐ anemia—severe (< 10 Gm/dl) ☐ electrolyte disturbances	control preferred; exercise as tolerated
Medications	☐ antianginal ☐ antiarrhythmic ☐ antihypertensive ☐ anticonvulsant ☐ beta-blockers ☐ digitalis preparations ☐ diuretics ☐ ganglionic blockers ☐ others	NOTE: consider underlying condition. Potential for: exertional syncope, electrolyte imbalance, bradycardia, dysrhythmias, impaired coordination and reaction time, heat intolerance. May alter resting and exercise ECG's and exercise test performance.
Other	☐ post-exercise syncope	moderate program
	☐ heat intolerance	prolong cool-down with light activities; avoid exercise in extreme heat
	☐ temporary minor illness	postpone until recovered
	☐ cancer	if potential metastases, test by cycle ergometry, consider non-weight bearing exercises; exercise at lower end of prescriptive range (40-65% of heart rate reserve), depending on condition and recent treatment (radiation, chemotherapy); monitor hemoglobin and lymphocyte counts; add dynamic lifting exercise to strengthen muscles, using machines rather than weights.

*Refer to special publications for elaboration as required

The following companion forms are available by contacting the Canadian Society for Exercise Physiology (address below):

The Physical Activity Readiness Questionnaire (PAR-Q) - a questionnaire for people aged 15-69 to complete before becoming much more physically active.

The Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for PREGNANCY) - to be used by physicians with pregnant patients who wish to become more physically active.

To order multiple printed copies of the PARmed-X and/or any of the companion forms (for a nominal charge), please contact the:

Canadian Society for Exercise Physiology
1600 James Naismith Dr., Suite 311
Gloucester, Ontario CANADA K1B 5N4
Tel. (613) 748-5768 FAX: (613) 748-5763

Note to physical activity professionals...

It is a prudent practice to retain the completed Physical Activity Readiness Conveyance/Referral Form in the participant's file.

Supported by: Health Canada Santé Canada

Continued on page 4...

APPENDIX B

ysical Activity Readiness
ical Examination
vised 1995)

Physical Activity & Lifestyle Advice

We know that being physically active provides benefits for all of us. Physical inactivity is recognized by the Heart and Stroke Foundation of Canada as one of the four modifiable primary risk factors for coronary heart disease (along with high blood pressure, high blood cholesterol, and smoking). Physical activity has also been shown to reduce the incidence of hypertension, colon cancer, maturity onset diabetes mellitus, and osteoporosis. It can also reduce stress and anxiety, relieve depression, and improve self-esteem.

People are physically active for many reasons — play, work, competition, health, creativity, enjoying the outdoors, being with friends. There are also as many ways of being active as there are reasons. What we choose to do depends on our own abilities and desires. No matter what the reason or type of activity, physical activity can improve our well-being and quality of life. Well-being can also be enhanced by integrating physical activity with enjoyable healthy eating and positive self and body image. Together, all three equal VITALITY. So take a fresh approach to living. Check out the VITALITY tips below!

Active Living:

- make meaningful and satisfying physical activities a valued and integral part of daily living
- accumulate 30 minutes or more of moderate physical activity most days of the week
- choose from an endless range of opportunities to be active according to your own abilities and desires:
  - take the stairs instead of an elevator
  - get off the bus early and walk home
  - join friends in a sport activity
  - take the dog for a walk with the family
  - follow a fitness program

Healthy Eating:

- follow Canada's Food Guide to Healthy Eating
- enjoy a variety of foods
- emphasize cereals, breads, other grain products, vegetables and fruit
- choose lower-fat dairy products, leaner meats and foods prepared with little or no fat
- achieve and maintain a healthy body weight by enjoying regular physical activity and healthy eating
- limit salt, alcohol and caffeine
- don't give up foods you enjoy — aim for moderation and variety

Positive Self and Body Image:

- accept who you are and how you look
- remember, a healthy weight range is one that is realistic for your own body make-up (body fat levels should neither be too high nor too low)
- try a new challenge
- compliment yourself
- reflect positively on your abilities
- laugh a lot

Enjoy eating well, being active and feeling good about yourself. That's VITALITY.

Physical Activity Readiness Conveyance/Referral Form

Based upon a current review of the health status of ______________________________, I recommend:

- ☐ No physical activity
- ☐ Only a medically-supervised exercise program until further medical clearance
- ☐ Progressive physical activity
  - ☐ with avoidance of: ________________________
  - ☐ with inclusion of: ________________________
  - ☐ with Physical Therapy: ________________________
- ☐ Unrestricted physical activity — start slowly and build up gradually

Further information:
☐ Attached
☐ To be forwarded
☐ Available on request

Physician/clinic stamp:

______________________________ M.D.

____________________________ 19____
(date)

APPENDIX C

Correction Calculation

This calculation is used when a subject's plateaued force at standing was not within the range of 1.00±0.01 body weight units. The correction was done for all the force measurements, with the assumption that the force discrepancy was constant for the entire force-time curve.

1.00 - Measured Force at Standing = Correction Factor

Correction Factor + Chair Rise Marker = Corrected Chair Rise Marker

Chair Rise Markers Include: Min1
Max
Min2

APPENDIX D

Resistance Training Exercises

Intensity Rating: Stage 1. Basic Exercises

Stage 2. Heightened Intensity for the 2nd half of each set

Stage 3. Heightened Intensity for the entire set

Sitting Knee Extensions - in chair

tubing around one ankle, braced under opposite foot

extend out the lower leg (the one with ankle tubing)

keep the thigh stationary

More Intense - At full extension (knee not locked straight) lift the upper leg off the chair (1 sec). Lower the upper leg back down to the chair (1 sec) and flex the lower leg back to starting position.

Standing Hamstring Curls - standing behind a chair

tubing around one ankle, braced under opposite foot

flex lower leg (with ankle tubing) back towards buttocks

keep knees together and the upper thigh stationary

More Intense - At full flexion hold the position (1 sec) and increase the contraction trying to increase the hamstring flexion (1 sec).

Standing Hip Flexions - standing, using chair for support / balance

tubing around one ankle, braced under opposite foot

lift up leg with ankle tubing by flexing at the hip and bringing knee up towards chest

try not to move the upper body

More Intense - At full hip flexion, hold the position (1 sec) and increase the contraction trying to increase the hip flexion (1 sec).

APPENDIX D

Resistance Training Exercises continued

Standing Hip Extensions - lean forward over a chair so that hip is at 90°
tubing around one ankle, braced under opposite foot
extend one leg at a time back and up, pushing heel toward the wall behind
keep extended leg straight, do not bend at the knee
More Intense - At full leg extension, hold the position (1 sec) and increase the contraction attempting to increase the hip extension (1 sec).

Squats - use chair for support / balance or stand against a wall
feet should be at least shoulder width apart
bend knees 45° (2 secs) and then straighten up (2 secs)
keep knees aligned directly over 2nd toe
More Intense - Bend knees to a greater degree.

APPENDIX E

Stretching Program (Anderson, 1980)

Stretches For Those

Over 50

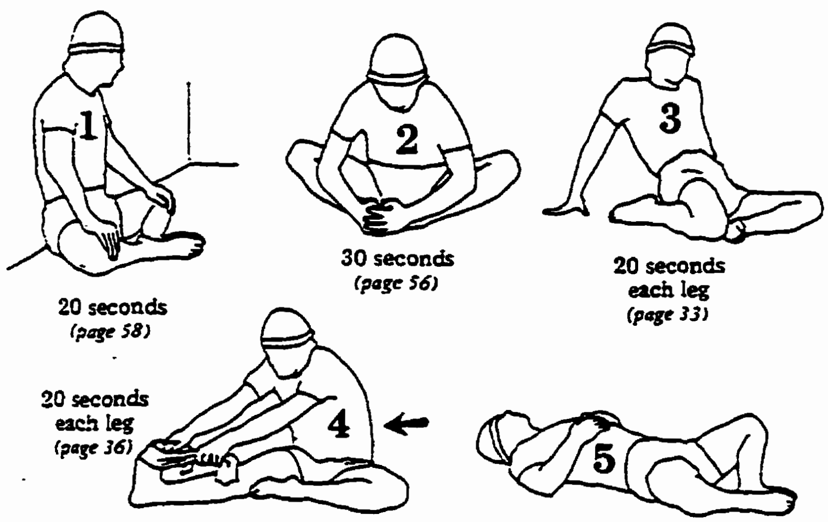
Approximately 5-6 Minutes

It is never too late to start stretching. In fact, the older we get, the more important it becomes to stretch on a regular basis.

With age and inactivity, the body gradually loses its range of motion: muscles can lose their elasticity and become weak and tight. But the body has an amazing capacity for the recovery of lost flexibility and strength if a regular program of fitness is followed.

The basic method of stretching is the same regardless of differences in age and flexibility. *Stretching properly means that you do not go beyond your own comfortable limits.* You don't have to try to copy the drawings in this book. Learn to stretch your body without force; stretch by how you feel. It will take time to loosen up tight muscle groups that have been this way for years, but it can be done with patience and regularity. If you have any doubts about what you should be doing, consult your physician *before you start.*

Here is a series of stretches to help restore and maintain flexibility.



20 seconds
(page 58)

30 seconds
(page 56)

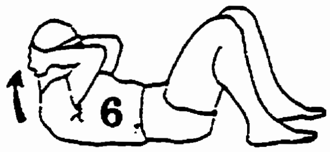
20 seconds
each leg
(page 33)

20 seconds
each leg
(page 36)

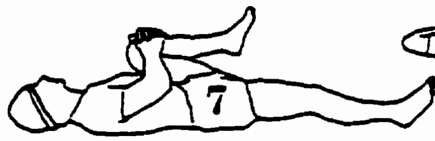
30 seconds
(page 24)

APPENDIX E

Stretching Program continued



5 seconds each
3 times
(page 25)

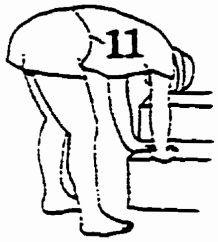


20 seconds
each side
(page 23)

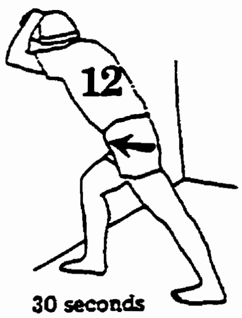
20 seconds
each side
(page 24)

3 times
5 seconds each
(page 28)

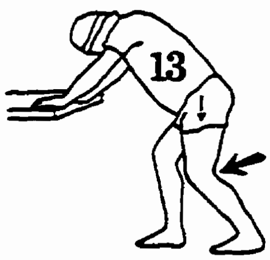
20 seconds
(page 53)



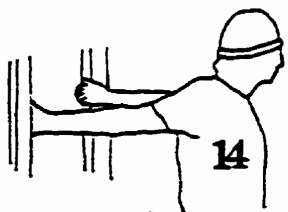
20 seconds
(page 54)



30 seconds
each leg
(page 71)



15 seconds
each leg
(page 71)



15 seconds
(page 44)

10 seconds
each arm
(page 41)

10 seconds
(page 43)

APPENDIX F

Analysis of Variance Tables for Possible Modifying Factors

Table 10. Analysis of Variance for Min1with possible modifying factors: Age, Height (Ht) and Weight (Wt).

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
Age*Ht	.00359	.02937	.00359	.00979	.36691	.587
Wt*Ht	.00020	.02937	.00020	.00979	.02012	.896
Wt*Age	.00323	.02937	.00323	.00979	.32968	.606
Group*Ht	.00439	.02937	.00439	.00979	.44880	.551
Group*Age	.00421	.02937	.00421	.00979	.43053	.559
Group*Wt	.00636	.02937	.00636	.00979	.65002	.479
Ht	.00001	.02937	.00001	.00979	.00056	.983
Age	.00370	.02937	.00370	.00979	.37780	.582
Wt	.00063	.02937	.00063	.00979	.06429	.816
Group	.00022	.02937	.00022	.00979	.02260	.890

Table 11. Analysis of Variance for Min2 with possible modifying factors: Age, Height (Ht) and Weight (Wt).

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
Age*Ht	.00442	.10270	.00442	.03423	.12909	.743
Wt*Ht	.01601	.10270	.01601	.03423	.46769	.543
Wt*Age	.00032	.10270	.00032	.03423	.00925	.929
Group*Ht	.00098	.10270	.00098	.03423	.02857	.877
Group*Age	.00020	.10270	.00020	.03423	.00581	.944
Group*Wt	.00649	.10270	.00649	.03423	.18972	.693
Ht	.00002	.10270	.00002	.03423	.00061	.982
Age	.00008	.10270	.00008	.03423	.00241	.964
Wt	.03245	.10270	.03245	.03423	.94786	.402
Group	.01971	.10270	.01971	.03423	.57570	.503

APPENDIX F

Analysis of Variance Tables continued

Table 12. Analysis of Variance for Pslope with possible modifying factors: Age, Height (Ht) and Weight (Wt).

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
Age*Ht	.07813	4.50584	.07813	1.50195	.05202	.834
Wt*Ht	5.74002	4.50584	5.74002	1.50195	3.82171	.146
Wt*Age	.06158	4.50584	.06158	1.50195	.04100	.852
Group*Ht	4.97354	4.50584	4.97354	1.50195	3.31139	.166
Group*Age	3.89536	4.50584	3.89536	1.50195	2.59354	.206
Group*Wt	9.83760	4.50584	9.83760	1.50195	6.54989	.083
Ht	6.92304	4.50584	6.92304	1.50195	4.60937	.121
Age	1.91038	4.50584	1.91038	1.50195	1.27194	.341
Wt	**20.64610**	**4.50584**	**20.64610**	**1.50195**	**13.74621**	**.034**
Group	.05088	4.50584	.05088	1.50195	.03388	.866