# Training for Power in Older Adults: Effects on Functional Abilities

# Training for Power in Older Adults: Effects on Functional Abilities

By

Kim V. Hruda, B.Kin

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**Author:** Kim V Hruda, B Kin (McMaster University)

**Supervisor:** Dr Audrey L Hicks

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**Difficult times have helped me to understand better than before how infinitely rich and beautiful life is in every way and that so many things that one goes worrying about are of no importance whatsoever.**

**- Isak Dinesen**

*This thesis is dedicated to my mother, father and Shawn,*

*without whom I could never have fulfilled the requirements of this thesis. Their constant encouragement, love and understanding provided me with the strength to accomplish this goal and succeed in life.*

## PREFACE

This thesis is presented in two chapters Chapter I begins with a brief overview of the changes in muscle strength and power that occur with aging, followed by a section focusing on the relationship between strength and functional performance Chapter I concludes with a description and summary of exercise training studies that have been conducted to increase muscle strength, power and functional performance in the aging population Chapter II presents the thesis research related to training for power in older adults and the effects on functional abilities Chapter II is presented in manuscript style suitable for publication

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# REVIEW OF LITERATURE

## 1.1 Introduction

A major goal for researchers and practitioners throughout the world in recent years has been to find ways to prevent or delay the onset of physical frailty By the year 2030, the number of individuals 65 years and older will reach 70 million in the United States alone, and persons 85 years and older will be the fastest growing segment of the population (ACSM, 1998) As more individuals live longer, it is crucial to determine the extent to which, and mechanisms of how, exercise and physical activity can improve health, quality of life, functional capacity, and independence in this population

Aging is a complex process and is associated with a general decline in a variety of biological functions With respect to physical frailty, one of the more relevant age-related changes is a progressive decrease in muscular strength and power output (Bosco and Komi, 1980) The decrease in muscle strength has been thoroughly studied (Jette and Branch, 1981, Skelton et al , 1994, 1995, Young and Skelton, 1994), but only a few studies to date have focused on changes in muscle power with age (Bassey et al , 1992, Jozsi et al , 1999, Skelton et al , 1995)

This chapter begins with a brief overview of the changes in muscle strength and power with aging, accompanied by a discussion of the proposed mechanisms for these changes This will be followed by a section focusing on the relationship between strength and functional performance The chapter will conclude with a description and summary of exercise training studies that have been conducted to increase strength and power in the aging population, and what effects these training programs have had on functional performance

## 1.2 Description of Changes in Muscle Strength with Aging

A reduction in muscle strength is a major component of normal aging Muscle strength can be measured during isometric, isokinetic, concentric and eccentric contractions It is well established that with age there is a loss of isometric muscle strength and muscle mass (Frontera et al , 1991, Larsson et al , 1979, Vandervoort, 1992) In a classic study conducted by Larsson et al (1979), skeletal muscle strength was found to increase up to 30 years of age, plateau until about 50 years, and then decrease by 15% per decade between the ages of 50 and 70 years Porter et al (1995a) found that healthy adults in their seventh and eighth decades have, on average, 20 to 40% less voluntary strength than young adults Moreover, 50% or greater reductions in strength were seen in the very old Similar trends have been reported in studies testing upper and lower extremity muscles, from both proximal and distal locations (Doherty et al., 1993) The majority of studies in this area have used cross-sectional designs, but some longitudinal studies have been completed which also show age associated reductions in muscle strength (Aniansson et al . 1986, 1992, Bassey and Harries, 1993; Kallman et al , 1990, Winegard et al . 1996) The first report of a longitudinal assessment of ankle muscle function in very old adults (mean age 83 5 years) found that plantarflexor strength decreased 2 1% per year in females, and 2 5% per year in males (Winegard et al . 1996)

Cross-sectional investigations have shown similar age-related declines in concentric muscle strength as has been reported for isometric muscle strength (Harries and Bassey, 1990. Poulin et al , 1992, Vandervoort et al , 1990) For knee extension strength, Porter et al (1995b) found that peak torque values for older men and women (62 to 89 years) were 58 3 and 46 6% that of a younger control group (20 to 29 years) Several investigators have concluded that healthy men and women in their 7th and 8th decades demonstrate, on average, declines of 20 to 40% in maximal isometric strength as compared to young adults (Davies et al , 1986, Doherty et al , 1993, Kallman et al , 1990, Larsson et al , 1979. Vandervoort and McComas, 1986) A longitudinal investigation completed by Aniansson et al (1986) reported that isometric and concentric knee strength decreased 10 to 22% over a seven-year period, depending on the test velocity in 23 males ranging in age from 73 to 83 years

Eccentric (or lengthening) muscle actions are performed daily and examples include using the knee extensors to control body weight while one sits down or descends stairs, and during certain phases of the gait cycle when muscles exert braking forces by resisting lengthening Despite the importance of eccentric contractions in daily activities, less is known about eccentric strength changes with aging Some studies have found that eccentric losses in strength are not as great as concentric losses (Phillips et al , 1993, Porter et al , 1995b, Poulin et al 1992) In fact, one study found that at a velocity of

180°/s, older men were equal to younger men for eccentric knee extension peak torque (Poulin et al., 1992)

Possible mechanisms for the maintenance of eccentric strength have been credited to a slowing of contraction or neural factors in older adults (Porter et al., 1995b). Another explanation might be that changes in the kinetics of cross-bridge cycling, by slowing detachment, could produce greater eccentric torque capabilities but lead to lower concentric torque capabilities at faster velocities (Porter et al., 1995b)

## 1.3 Description of Changes in Muscle Power with Aging

Muscle power diminishes with increasing age and inactivity. The rate of decline in muscle power is reported to be greater than the rate of decline in muscle strength. Skelton et al. (1994) found that leg muscle power decreased at a rate of 3.5% per year, while the decrease in muscle strength is only 1-2% per year, across the age range of 65-89 years. Muscle power is the product of the force and the velocity of muscle shortening (Skelton et al., 1995). A recent study revealed that the velocity with which muscle force can be generated, declines in old age (De Vito et al., 1998). This decrease in contractile velocity in aging muscle may be related to a reduction in the relative proportion of fast-twitch fibres in the muscle cross-sectional area (Grimby et al., 1982, Lexell et al., 1988, Murray et al., 1985) and a diminishing number of motor units (Doherty et al., 1993, Roos et al., 1996) which together alter innervation patterns and contractile protein expression. In addition, a greater relative loss of isokinetic torque at high velocities compared with lower velocities has been reported in older adults (Bassey and Harries, 1990)

The force component of muscle power is affected by the loss in muscle mass that occurs with aging (Booth et al., 1994, Lexell et al., 1988). The age-related atrophy of the human vastus lateralis muscle is a function of both losses in the numbers of both fast-twitch and slow-twitch muscle fibres, and a preferentially greater loss of fast-twitch fibre cross-sectional area (Lexell et al., 1988). Since the power output of fast-twitch fibres is four times that of slow-twitch fibres (Faulkner, 1986), the selective atrophy of fast-twitch fibres in aging muscle may hasten decrements in power output with increasing years

## 1.4 Possible Mechanisms for Decreases in Muscle Strength and Power

### 1.4.1 Reduction in Muscle Mass, Volume and Cross-sectional Area

A decrease in the size of individual muscles occurs with aging, particularly beyond 60 years of age (Wilmore, 1991). Muscle strength and mass decline 30 to 50% between the ages of 30 to 80 years, with a loss of muscle mass accounting for most of the observed loss of strength (Aniansson et al., 1992, Frischknecht, 1998). The loss of muscle tissue with aging, or sarcopenia, is apparently due to both a decrease in number of muscle fibres and selective atrophy of fast-twitch muscle fibres (Lexell et al., 1988, Wilmore, 1991). A 26% reduction in the size of fast-twitch fibres from age 20 to 80 years is suggested as being partly responsible for the age-related loss of muscle mass (Lexell et al., 1988, Lexell and Downham, 1992)

According to autopsy studies by Lexell et al (1983, 1988), the decrease in the total number of fibres in the vastus lateralis accounts for most of the decrease in muscle volume with aging Unfortunately no in vivo human study exists to validate this finding because of the technical difficulties associated with such investigations Most of the obtainable estimates have been derived from a combination of computerized tomography and measurements of mean fibre size from muscle biopsy specimens A comparison of the calf muscles in young and 80-year-old men using muscle biopsy specimens supported the notion that the loss of muscle volume is closely linked to the decreased number of muscle fibres, with a resultant reduction in the cross-sectional area of a given muscle group (Grimby and Saltin, 1983)

Muscle cross-sectional areas have been indirectly estimated using radiological imaging techniques Ultrasound scanning was used to illustrate that the total knee extensor cross-sectional area of older women (71 to 78 years) was 33% less than young (20 to 29 years) women, and the cross-sectional area of older men (70 to 79 years) was 25% less than young (20 to 29 years) men (Young et al , 1984, 1985) Through computed tomography scanning, similar age associated declines in muscle cross-sectional area have been shown for the quadriceps femoris (Klitgaard et al , 1990a), brachial biceps (Klitgaard et al , 1990a), and triceps and plantar flexor muscles (Rice et al , 1989)

More recently, single muscle fibre area has been investigated (Trappe et al , 2000) In a study conducted by Trappe et al (2000), muscle biopsy samples were obtained from the vastus lateralis before and after a progressive resistance training program in older men The authors reported that muscle fibre diameter increased by

20%, along with a 13% increase in myosin heavy chain (MHC) I and IIa fibres, respectively

It has therefore been suggested that the primary reason for the age-related decrease in muscular strength is the decrease in muscle cross-sectional area caused by fibre atrophy and loss of muscle fibres (Lexell et al., 1988)

### 1.4.2 <u>Changes in Muscle Morphology</u>

#### 1.4.2.1 <u>Muscle Fibre Size</u>

It is generally agreed that the size of fast-twitch fibres is considerably reduced with increasing age, while the size of slow-twitch fibres remains relatively less affected (Aniansson et al., 1981, 1986, Essen-Gustafsson and Borges, 1986, Grimby et al., 1982, Lexell et al., 1988) Lexell et al (1988) found significantly smaller fast-twitch fibres in vastus lateralis muscles of old men, as compared to young men A similar study noted 10 to 30% decreases in fast-twitch fibre sizes in subjects aged 78 to 97 years in vastus lateralis muscles (Grimby et al., 1982) Numerous other studies have concluded that in tibialis anterior, vastus lateralis and biceps brachii, fast-twitch fibre size decreases with increasing age, whereas slow-twitch fibre size does not change with age (Grimby et al., 1984, Lexell et al., 1988, Porter et al., 1995a)

### 1.4.2.2 Muscle Fibre Number

The reduction in fibre size is considered moderate in comparision with the decrease in muscle fibre number In the first study of whole aging muscles (Lexell et al., 1983), the total number of fibres in the muscles of elderly individuals was significantly lower than in the young, while the mean fibre size did not differ significantly between the two age groups These early results suggested that the reduction in muscle volume as one ages, at least up to the age of 70, was due to a reduction in the total number of fibres with no obvious reduction in fibre size Decreases in muscle fibre number commences around 25 years of age, with the total fibre number decreasing by 39% by the age of 80 years (Aniansson et al., 1992, Lexell et al., 1983, 1998)

Lexell et al (1988) conducted a larger study to incorporate a bigger sample size with wider age ranges, to sanction more detailed references The results of this study revealed that old muscles contained significantly fewer fibres and the authors concluded that the aging atrophy of the vastus lateralis appears to be caused by both a reduction in fibre number and a decrease in fibre size

### 1.4.2.3 Distribution of Fibre Types

An age-related reduction in the total number of fibres could potentially include the loss of a specific type of muscle fibre This may in turn alter the fibre type proportion, provided that fibres do not retain their original histochemical characteristics throughout their life Several studies have attempted to determine the effects of age on the proportion of fibre types, but the findings are conflicting (Aniansson et al., 1986, Grimby et al., 1984, Essen-Gustafsson and Borges, 1986)

Originally, studies were published showing that there was a shift toward a distribution with a higher percentage of slow-twitch fibres and a lower percentage of fast-twitch fibres (Larsson and Karlsson, 1978) An early study by Larsson and Karlsson (1978) indicated that the quadriceps muscle in men aged 20 to 29 years had 39% slow-twitch muscle fibres, while men aged 60 to 65 years had 66% slow-twitch fibres

There is evidence from several empirical studies, however, which indicates that the extent of the age-related change in relative fibre type may vary from one muscle group to another. For instance, Aniansson et al. (1986) found a pronounced reduction in fast-twitch fibre size with age in vastus lateralis specimens, while Grimby et al (1982) found that the fibre distribution in vastus lateralis did not differ between young and old subjects, but that it did in specimens taken from the biceps brachii

Other investigations that have been conducted on muscles in elderly individuals reveal that fibre-type composition remains unaltered with age, but that fibre areas decrease, particularly in fast-twitch muscle fibres (Essen-Gustafsson and Borges, 1986, Grimby and Saltin, 1983) Essen-Gustafsson and Borges (1986) examined vastus lateralis muscles in both legs in 34 men and 31 women (aged 20 to 70 years) They discovered that the oldest age group had the smallest fibre areas Both the 70-year-old men and women had smaller areas of both slow-twitch and fast-twitch fibres as compared to the 60-year-old men and women Reduced fibre area with age may explain in part, the reduction in muscle mass and muscle strength that occurs with aging

Although fibre-type distribution may be unaltered with aging, fibre-type properties are not static as the histochemical profile of muscle fibres can change during one's life. Klitgaard et al. (1990b) used electrophoretic analysis of single muscle fibres to show that older subjects had a greater proportion of fibres with co-expression of myosin heavy chain Type I (slow-twitch) and Type IIa (fast-twitch), and Type IIa with Type IIb. The authors suggested that this may reflect an ongoing transition process between the fibre populations due to denervation and/or disuse.

### 1.4.3 Nervous System and Motor Unit Adaptations

#### 1.4.3.1 Fibre Type Arrangement

Aging results in extensive neurologic changes. A change in fibre type arrangement with aging has been interpreted by Lexell et al. (1983) to indicate that a neurologic process is likely to be one of the major contributors to the age-relaed reduction in muscle volume. Fibre type grouping within a motor unit results from repeated denervation and reinnervation (Campbell et al., 1973, Lexell et al., 1983, Stalberg et al., 1989), and significant increases in the incidence of fibre type grouping have been shown in studies of fibre type arrangement in old muscles.

Lexell and Downham (1991) reported that subjects between the ages of 20 and 60 years had a spatial arrangement of muscle fibre types that was transformed from a mosaic distribution to one that included fibre type grouping after the age of 60 years. They reasoned that the loss of a motor neuron resulted in cessation of self-reinnervation so that either the muscle fibre was not reinnervated, or that another nerve terminal from adjacent motor neurons grows to innervate the denervated fibres Lexell and Downham (1991) proposed that fibre type grouping occurs in skeletal muscles of 60+ year old subjects in response to the cumulative cycles of denervation-reinnervation, and they concluded that the age-related reduction in motor units begins around the age of 50 years, and 10 years must first elapse for the fibre type grouping to become visible

**1.4.3.2 <u>Motor Units</u>**

Indirect evidence for age-related changes in the numbers and physiological properties of human motor units has come from studies of whole muscle contractile function and analysis of muscle fibres from biopsy samples or whole muscle sections obtained postmortem (Campbell et al . 1973, Doherty et al , 1993, Lexell et al , 1988) The most basic change in muscle morphology at the level of the motor unit is a decrease in total motor unit number (Campbell et al . 1973) Loss in motor unit number has been estimated to be approximately 1% of the total number per year, beginning in the third decade of life, and accelerating in rate beyond the age of 60 (Roos et al . 1997) Doherty et al (1993) found that by the seventh decade of life, men and women have approximately 50% of the number of motor units that young adults have in the biceps brachii and brachialis muscles

Macro electromyography (EMG) provides an estimate of motor unit size The amplitude and area of the EMG signal are determined by the constituent fibres of a motor unit (Stalberg, 1982), hence, greater amplitude and area means more MU recuritment

Stalberg et al (1989) used this macro EMG method because the amplitude of the motor unit action potential (MUAP) detected in conventional EMG represents only a small portion of the muscle fibres in a motor unit Macro EMG provided a more representative estimate of motor unit size, since the amplitude of the EMG signal is determined by more of the fibres in the motor unit The authors noticed a 27 and 36% higher amplitude in the MUAP from the quadriceps muscles of 60 to 70 year old males and females (Stalberg et al , 1982) Doherty et al (1993) also used the macro EMG method and found an increase of 23% in single MUAP peak-to-peak amplitude in 60 to 81 year olds, compared to the 21 to 38 year olds Shifts towards larger motor units with age are reflected by these increases in amplitudes.

### 1.4.4 Changes in Muscle Contractile Properties

Both contraction time (CT) and one-half relaxation time (1/2 RT) are prolonged with advancing age This has been demonstrated for the dorsi-flexor and plantar-flexor muscles (Vandervoort and McComas, 1986), the extensor digitorum brevis (Campbell et al , 1973), the triceps surae (Davies et al , 1986, McDonagh et al., 1984) and the elbow flexors (McDonagh et al . 1984) Slower contractions contribute to a reduced capacity for rapid force production in protective reflexes Klitgaard et al (1989) proposed that slowing of calcium release and/or reuptake mechanisms in the muscle may result in the slower contractile properties seen in aged versus young muscles Vandervoort and McComas (1986) however suggest that irrespective of the precise mechanism, the prolongation of the muscle twitch increases the efficiency of the older person such that a lower frequency of neural discharge is needed to result in a given torque

## 1.5 Relationship Between Strength and Function

The decline in muscle strength associated with aging carries with it significant consequences related to functional capacity. Although a relationship between a decline in muscle strength and limitation in performing functional tasks has been established in the literature (Bassey et al., 1992, Buchner and de Lateur, 1991, Evans and Campbell, 1993, Grimby, 1995), neither the nature of this relationship or the consequences of diminished muscle strength and functional limitation on disability in the daily lives of older people has been fully described (Buchner and de Lateur, 1991, Verbrugge and Jette, 1994)

It is well documented that the reduction in muscle strength that occurs with advancing age has negative consequences on gait and other aspects of physical performance capacity, particularly if the age-related decline in strength is exaggerated by inactivity or a debilitating disease (Aniansson et al., 1984; Bassey et al., 1988, 1992, Buchner et al., 1993, Evans and Campbell, 1993, Rogers and Evans, 1992). For example, a significant correlation between leg muscle strength and walking speed has been reported for both sexes (Bassey et al., 1988). In 1992, Bassey and colleagues reported a significant relationship between leg extensor power and rising from a chair, climbing stairs, and walking speed. In addition, a strong relationship was found between quadriceps strength and habitual gait speed in frail institutionalized men and women above the age of 86 years (Fiatarone et al., 1990). A study completed in 1997 by Rantanen and Avela examined the relationship between leg extension power and maximal walking speed. One hundred and thirty-one 80- and 85-year-old men and women performed a jump test to determine leg extension power, and maximal walking speed was measured in a laboratory corridor walk over a distance of 10m. It was found that leg extension power correlated positively with maximal walking speed in all groups. The correlations were 0.41 in the 80-year-old men (n=41), 0.62 in the 80-year-old women (n=56), 0.94 in the 85-year-old men (n=8), and 0.69 in the 85-year-old women (n=23). Furthermore, reduced lower extremity strength has been implicated as a factor contributing to nursing home placement (Guralnik et al., 1994b, Hubert et al., 1993, Simonsick et al., 1993) and an increased risk of falling (Gehlsen and Whaley, 1990, Lipsitz et al., 1994, Whipple et al., 1987).

There is a high degree of variability in reported strength-function relationships. Strength-performance relationships between knee extensors and walk time have been reported to be non-significant in men, and ranging between 0.4 and 0.45 in women aged 70 years (Aniansson et al., 1980). Bassey et al. (1992) reported correlations between 0.45 to 0.91 for men and between 0.83 and 0.93 in women who were older than 80 years of age. Variability exists in results of step test studies as well. Danneskiold-Samsoe et al. (1984) tested men and women between the ages of 78-81 years and reported a correlation of 0.62 between knee extensor strength and step performance in men, and no correlation in women. Aniansson et al. (1980), however, found the opposite as they reported a non-significant relationship for men, and correlations between 0.6 to 0.8 in women aged 70 years old Differences in the initial strength values, potentially indicative of habitual physical activity levels, of participants in various studies might partially explain why such variability is reported in the literature (Brandon et al., 2000) Participants that are stronger and have better functional mobility at the beginning of a study might be unable to readily increase mobility or any measure after strength training since they are already close to their highest ability As well, strength threshold and strength application appear to influence various mobility tasks differently (Rantanen et al., 1998)

### 1.5.1 Fullerton and Other Validated Tests for Measuring Functional Performance

A limiting factor in evaluating and managing physical decline during aging has been the lack of suitable measurement tools to assess the underlying physical parameters associated with functional mobility – strength, endurance, flexibility, balance, and agility (Chandler and Hadley, 1996, Fried et al., 1996, Rikli and Jones, 1997) Most traditional protocols for assessing fitness (cycle and treadmill ergometer tests, bench step tests, 1 RM strength tests, etc ) were developed and validated for younger people and have little generalizability to most functional tasks, and are generally unsuitable or unsafe for the majority of older adults

One of the few tests that have been developed precisely to estimate these physiologic parameters in older adults is the AAHPERD (American Alliance for Health, Physical Education, Recreation and Dance) functional fitness assessment battery (Osness et al., 1996) Although the AAHPERD has been an effective test and was a groundbreaking tool in the area of functional fitness assessment, it still has some limitations. One major limitation is that the AAHPERD test currently does not contain a measure of lower body muscle function, which is eminently important in maintaining physical independence and preventing disability (Gill et al., 1996, Guralnik et al., 1995, Lawrence and Jette, 1996).

Another test developed by Guralnik et al. (1994b) assessed lower extremity function in more than 5,000 persons aged 71 years and older in three communities. Balance, gait, strength, and endurance were evaluated by examining the ability to stand with feet together in the side-by-side, semi-tandem, and tandem positions, time to walk 8 feet, and time to rise from a chair and return to the seated position 5 times. This test was successful in classifying large populations of community-residing older adults into broad categories of functional status, but unfortunately significant "ceiling" or "floor" effects appeared on some of the items. Almost half of the people tested, for example, received perfect scores on the tandem balance task (Guralnik et al., 1994b; Seeman et al., 1994).

The first test designed to specifically to assess physiologic performance in the elderly was recently completed (Rikli and Jones, 1999a). Rikli and Jones (1999a) have developed and validated a battery of performance tests appropriate for assessing the most common underlying physical parameters associated with functional mobility in independent older adults, ages 60 to 90+ years. This functional fitness test was developed and validated through research at the Ruby Gerontology Center at California State University, Fullerton. The definition of functional fitness for their test is having the physiologic capacity to perform normal everyday activities safely and independently without undue fatigue The physiologic traits measured, each of which maintains the participants' ability to perform everyday activities, include upper and lower body strength, upper and lower body flexibility, aerobic endurance, and motor agility/dynamic balance As well, to obtain an estimate of body composition, body mass index (BMI) was calculated The test was intended to be proficient in providing continuous-scale measurements for a range of ability levels usually seen in the community-residing older adult population, in addition to being easily used in clinical or field (non-laboratory) settings

As a follow-up to Fullerton's newly developed Functional Fitness Test battery (Rikli and Jones, 1999a), a nationwide study was conducted to develop normative physical performance scores for community-residing older adults (Rikli and Jones, 1999b) This was the first nationwide study completed, which now provides continuous-scale physical performance norms that were collected on more than 7,000 individuals from 21 states Data are reported separately for men and women in 5-year age intervals, which makes it now possible to compare the performance of one individual with others of the same gender and age Some limitations do exist with these data, however, especially when generalizing the results of these functional tests and normative data to other populations The major limitation is that the participants in these studies were volunteers, generally active, and well-educated This means that the results may not apply to populations that do not have the same level of ability or socioeconomic status

An interesting study conducted by Podsiadlo and Richardson (1991) involved using the timed "Up and Go" test to determine functional mobility in 60 patients referred to a Geriatric Day Hospital (mean age 79 5 years) The authors felt that this test standardized most of the basic mobility manoeuvers and was quick and practical as well The subject was observed and timed while they rose from a chair, walked 3 metres, turned around, and walked back to the chair to sit down again This study found that the time score was reliable, and correlated well with scores on the Berg Balance Scale (Berg et al , 1989, r = -0 81), gait speed (r = -0 61) and the Barthel Index of ADL (Mahoney and Barthel, 1965, r = -0 78) They concluded that the timed "Up and Go" test was a reliable and valid test for quantifying functional mobility that it may also be useful in following clinical changes over time

A recent investigation by Jette et al (1999) evaluated the test-retest reliability of a battery of seven timed, performance-based measures used to assess the functional limitations of frail, older adults One hundred and five (65 to 94 years old) frail, elderly subjects were twice administered a battery of timed tests approximately 2 weeks apart It was found that performance-based protocols which reflected familiar tasks and had discrete starting and ending points were the ones that achieved the highest reliabilities in this context The 8-foot walk time, get-up-and-go time, and the repetitive chair stand time were the most reliable receiving intraclass correlation coefficients of 0 79, 0 74 and 0 67 These tests may be the most suitable choice for trials with frail, older persons, provided that appropriate training and quality control procedures are implemented It was concluded that tasks that are unfamiliar to subjects or have ambiguous elements in them have poor to fair reliability and may be suitable only for trials with a large number of subjects

## 1.6 Exercise Training Studies

### 1.6.1 Muscle Strength

#### 1.6.1.1 Short-term Studies

In the past several years, the decreased muscle strength of older adults has been shown to be partly reversible by resistance training (Hakkinen et al., 1998, Lexell et al., 1995, Welsh and Rutherford, 1996). Short-term weight training programs have resulted in significant increases in muscle strength and muscle hypertrophy in the elderly. For example, Lexell et al. (1995) investigated the short-term effects of heavy-resistance training on arm and leg muscles in older Scandinavian men and women. After 11 weeks of training (at 85% of 1RM), they found that both men and women (aged 70 to 77 years) had increased their elbow flexion and knee extension dynamic strength by 49% and 163%, respectively. A similar study conducted by Welsh and Rutherford (1996) investigated the effects of isometric strength training on quadriceps muscles in subjects 55 years or older. After the training group completed 6 months of training, a significant increase in quadriceps strength of 49% was reported. More recently, a 10-week lower body progressive strength training program was completed by 8 young men (29±5 years) and 10 old men (61±4 years) (Hakkinen et al., 1998). After the training period, maximal isometric peak force significantly increased by 16% in the young men, and by 17% in the old men.

### 1.6.1.2 Longitudinal Studies

In longitudinal studies, improved strength has been associated with an increase in muscle and bone mass, along with improvements in both mobility and balance (Fiatarone et al., 1990, 1994, Gutin and Kasper, 1992), all of which are thought to be meaningful factors in fracture and dependency prevention (Buchner and Wagner, 1992, Fiatarone and Evans, 1990, Guralnik et al., 1994a, 1994b, Speechly and Tinetti, 1991). Prolonged resistance training can also significantly increase both muscle strength and cross-sectional area in the elderly. A 42 week long resistance training study conducted by McCartney et al. (1995) on men and women (aged 60-80 years) revealed that muscle strength increases ranged from 32% for the leg press, to 90% for the military press, while strength in the control group remained unchanged. In addition, they found that the cross-sectional area of the knee extensors increased by 9% in the trained subjects, while again there was no change in the controls. These findings were continued into year 2 of the study and represent the largest, and longest, randomized controlled trial of strength training in elderly men and women (McCartney et al., 1996). By the same token, Morganti et al. (1995) evaluated the effects of progressive resistance training on strength gains over an extended period of time in postmenopausal women. Thirty-nine healthy women (59.5 ± 0.9 years) were randomized to either a control group or a progressive resistance training group that trained twice weekly for 12 months. Results showed that increases of 74, 35 and 77% occurred for knee extension, double leg press and lateral pull-down tests, respectively. Approximately 50% of the gains in knee extensions and lateral pull-downs, and 40% in the double leg press were seen in the first 3 months of the study. In all three exercises, strength gains in the progressive resistance training group continued over the entire 12-month period. This study revealed that strength continued to improve over an entire year of progressive resistance training in postmenopausal women.

The most recent longitudinal study was conducted on elderly women as the authors felt that there was a paucity of long-term exercise training studies completed in this population (Rhodes et al., 2000). They investigated the effects of one year of progressive resistance exercise on dynamic muscular strength in elderly women (mean age 68.8 years). Forty-four healthy, sedentary women were randomly assigned to either an exercise or control group. The exercise group completed 3 one-hour sessions per week, for a total of 52 weeks of training for large muscle groups. Results revealed significant gains in bilateral bench press (29%), bilateral leg press (19%), and unilateral biceps curl (20%).

**1.6.1.3 <u>Studies Focusing on Older Adults</u>**

In 1990, Fiatarone and co-workers characterized the muscle weakness of the very old (90+ years) and investigated whether lower extremity strength could be improved in this age group through strength training. Ten frail, institutionalized volunteers aged 90 ± 1 years attempted to finish 8 weeks of high-intensity resistance training. The results revealed that quadricep strength gains averaged 174 ± 31% in the 9 subjects who completed the training. Similarly, McMurdo and Rennie (1994) investigated if participation in a seated exercise class would strengthen the quadriceps muscles in institutionalized elderly people The mean age of the volunteers was 83 years, and of the 65 residents assigned to the study groups, 55 completed the 6-month project The results revealed that quadriceps strength of the exercise group significantly increased, whereas the strength of the control group decreased This study demonstrated that regular, low-intensity seated exercise can improve quadriceps strength in a group of frail elderly people

More recently, a randomized, controlled study of strength-training in healthy women all aged ≥ 75 years (Skelton et al., 1995) was completed After 12 weeks of training 3 times a week, the women in the exercise group (N = 20, median age 79.5 years) showed 13 to 30% mean increases in isometric quadriceps and biceps strength which were not seen in the matched control group A comparable study was conducted on 11 very elderly subjects (8 women, and 3 men, age range, 85-97 years, Harridge et al., 1999) The subjects completed 12 weeks of strength training of the knee extensor muscles The results revealed that the maximum amount of weight that could be lifted once (1RM) by the knee extensors increased by 134% Maximal voluntary isometric strength of the knee extensors, measured as both force recorded at the ankle with the knee flexed 90° increased by 17%, while the torque with the knee flexed 60° increased by 37% Therefore, prolonged physical training can also significantly increase muscle strength

### 1.6.2 Mechanisms for Training-Induced Changes in Muscle Strength

The basic requirements for training-induced hypertrophy and strength improvement to occur in the elderly include an overall training intensity of 70 to 80% of 1RM, completing 2 to 3 sets of 8 to12 repetitions per exercise, 2 to 3 times a week (ACSM, 2000 Charette et al., 1991, Fiatarone et al., 1990, Frontera et al., 1988) Hakkinen et al (1998) examined neuromuscular adaptations in middle-aged and elderly men and women during a strength-training period of 6 months by utilizing a program that was intended not only for maximal strength development, but also included exercises of an explosive nature Dynamic explosive force characteristics of the leg muscles were measured on a force-platform by using the maximum height achieved during a vertical squat jump After the 6 months of training, maximal isometric and dynamic leg-extension strength increased by 36 and 22% in the middle-aged men (42 $\pm$ 2 years), by 36 and 21% in the elderly men (72 $\pm$ 3 years), by 66 and 34% in the middle-aged women (39 $\pm$ 3 years), and by 57 and 30% in the elderly women (67 $\pm$ 3 years), respectively The explosive force increased as well as the maximal vertical heights, and power values in the squat jumps increased by 12 and 25% in the middle-aged and elderly men, and by 15 and 19% in the middle-aged and elderly women Therefore, this study revealed that a progressive, heavy-resistance training program combined with explosive types of exercises led to great gains not only in maximal isometric and dynamic strength, but also in explosive force production characteristics of the leg extensor muscles in both middle-aged and elderly men and women

It has been suggested by some authors that strength gains in older subjects are primarily due to an improved neural recruitment pattern rather than hypertrophy of the muscle fibres (Hakkinen et al., 1998, Moritani and Devries, 1980). Hakkinen et al (1998) found that the increases in the cross-sectional area of the trained muscles over their 6-month training period were minor compared with the increases recorded in maximal strength of the subject groups. This led them to suggest that the contributing role of the nervous system, in particular to increased motor unit activation of the trained agonist muscles, for strength development during their training may have been more important than that of muscle hypertrophy. However, when sensitive techniques such as fibre area determination by muscle biopsy (Charette et al., 1991, Frontera et al., 1988) or muscle cross-sectional area determination by computed tomography, magnetic resonance imaging, or ultrasound scan (Fiatarone et al., 1990, Frontera et al., 1988) have been utilized, muscle hypertrophy can account for some portion of the training-induced strength gains in the elderly.

Many investigators have assessed strength in relation to muscle mass or cross-sectional area of muscle (specific tension) as an index of muscle quality (Hortabagyi et al., 1995, Tracy et al., 1999, Young et al., 1984). Hortabagyi et al. (1995) found no age-related changes in estimated muscle quality in either men or women in relation to eccentric strength. A different study investigated the effects of strength training on muscle quality (maximal force production per unit of cross-sectional area) in 65- to 75-year-old men and women (Tracy et al., 1999). The authors reported that quadriceps muscle volume and muscle quality increased significantly by 12 and 14% for both men and women, respectively. Muscle quality was calculated by dividing quadriceps 1RM strength by quadriceps muscle volume determined by magnetic resonance imaging. These results are in accordance with Narici et al. (1996) who also found a similar 12% increase in muscle quality with strength training.

### 1.6.3 Muscle Power

Cross-sectional comparisons have found that the decline of explosive leg extensor power from 65 to 89 years is about 3.5% annually (Skelton et al., 1994). Unfortunately, few investigations have focused on the capacity for older adults to maintain or increase muscle power and possibly prevent this estimated yearly loss (Jozsi et al., 1999; Skelton et al., 1995). As muscle power is a product of the force and velocity of muscle shortening (Skelton et al., 1995), training studies must incorporate some strength as well as velocity-specific training exercises in order to train to improve muscle power.

Skelton and colleagues (1995) investigated the effects of 12 weeks of progressive resistance strength training on the isometric strength, explosive power, and selected functional abilities of healthy women aged 75 and over. Pre- and post-training measurements were obtained from 20 exercisers (mean age 79.5 years) and 20 controls (mean age 79.5 years). The training was comprised of one supervised exercise session and two unsupervised home sessions per week for 12 weeks. The exercises followed a typical progressive resistance protocol, which included performing three sets of four to eight repetitions initially, and progressing with changes in resistance, and the number of repetitions. Outcome measures were isometric knee extensor strength measured as the force applied at the ankle, and leg extensor power measured with a slightly modified version of the Nottingham Power Rig. Results indicated that isometric knee extensor strength significantly increased by 27%, and leg extensor power (per kg) increased by 18%. Therefore, twelve weeks of progressive resistance strength training can significantly increase strength and leg extensor power (per kg) in very old women.

The most recent power training study examined the influence of progressive resistance training on muscle power output in 17 men and women aged 56 to 66 years, and compared their responses to 15 men and women aged 21 to 30 years (Jozsi et al., 1999). All subjects performed 12 weeks of progressive resistance training at a workload equivalent to 80% of the one repetition maximum (1RM). Subjects performed five exercises, three sets per exercise, twice weekly. Muscle power was measured (isotonically) at resistances equivalent to 40, 60, and 80% of the 1RM, on knee extension and arm curl machines. The results revealed that older and younger subjects had similar absolute increases in isotonic leg extensor power at 40, 60, and 80% of 1RM. All subjects increased their arm pull power similarly at 40 and 60% of 1RM, independent of age or sex, while there was no significant increase in arm pull power at 80% of 1RM. These data demonstrate that individuals in their sixth decade can still improve muscle power and strength with appropriately designed training regimes.

### 1.6.4 Training for Functional Performance

Leg extensor power is required to perform many basic activities in daily life, such as walking, climbing stairs, or simply rising from a seated position (Aniansson et al., 1980, Hyatt et al., 1990) Several studies have attempted to determine the effects of training on functional performance in the elderly, with many providing fairly encouraging results (Ades et al., 1996, Chandler et al., 1998; McMurdo and Rennie, 1994, Rantanen and Avela, 1997, Skelton et al., 1994, 1995)

Skelton and colleagues completed a study which examined the effects of upper and lower body resistance training on strength, power, and selected functional abilities of women aged 75 and older (Skelton et al., 1995) The functional ability tests were the chair rise, kneel rise, rise from lying on the floor, 118-m self-paced corridor walk, stair climbing, functional reach, stepping up, stepping down, and lifting weights onto a shelf Out of all of the above functional ability tests, the only improvements witnessed as a result of the exercise training were a reduction in normal pace kneel rise time (mean change of 21%, p=0 02) and a small improvement in step up height (mean change of 5%, p=0 005) They concluded that their null findings could partly be due to the fact that their training regime did not include practice of the functional tasks

Ades et al (1996) studied the effects of a resistance-training program on a different primary outcome measure walking endurance They conducted a 12-week randomized, controlled trial comparing a resistance-training group with a non-exercising control group Subjects were in the age range of 65 to 79 years, and they participated in a weight-training regimen 3 days per week After the resistance-training was completed, mean walking time until exhaustion for the resistance-training group increased by 38%, from 25 $\pm$ 4 minutes to 34 $\pm$ 9 minutes No change was seen in the control group Their findings are relevant for older persons at risk for disability, because walking endurance is an important component of physical functioning McCartney et al (1995, 1996) also reported an increase in walk time on the treadmill in their exercise group, while no change was reported for their control group These results suggest that low average leg extension power may be one of the factors explaining the greater prevalence of mobility problems among women than men

More recently, the effects of increased strength on functional mobility in older adults has been examined (Brandon et al , 2000, Chandler et al , 1998) The study by Chandler et al (1998) was conducted on one hundred functionally impaired community-dwelling men and women (77 6 $\pm$ 7 6 years) After random assignment, exercise participants received strengthening exercises to be completed in their homes, three times a week for 10 weeks A significant impact of strength gain was seen on only a few mobility skills The impact of strength gain on chair rise performance was significant in participants who were more impaired Strength gain was associated with increases in gait speed and in falls efficacy, but not with other balance, endurance, or disability measures These results support the general idea that strength training is an intervention that can potentially improve physical health status in many frail elders The most recent study evaluated the effects of a 4-month, lower extremity strength-training program on mobility in older adults (mean age 72 3 years) (Brandon et al , 2000) Eighty-five older adults were randomized to either an experimental group or a comparison group The experimental group strength-trained 1 hour/day, 3 days a week for 4 months Results indicated that the experimental group showed increases in both absolute (52%) and relative strength (53%) after training. The mobility tasks in which participants improved significantly were rising from the floor and getting out of a soft chair and walking 10 feet

### 1.7 Summary and Statement of Purpose

It is generally accepted that muscle strength appears to be relatively well preserved until the fifth decade of life, after which time a loss of about 15% per decade is seen (Vandervoort and McComas, 1986). More importantly, the rate of decline of leg extensor power across this age range may be more than twice as fast as in strength, estimated rates of decline are 3.5% per year (Skelton et al., 1995). Leg extensor power is needed for many basic activities in daily life, such as walking or rising from a seated position (Aniansson et al., 1980, Hyatt et al., 1990). The ability to do these things easily is taken for granted by healthy young individuals, but it is threatened in old age by various impairments which probably include a lack of muscle power

Many studies have established that the loss of muscle strength that occurs in older men and women can be increased quickly and without undue risk with resistance training (Brown et al, 1990, Fiatarone et al, 1990, 1994, Hurley et al, 1995, McCartney et al, 1995, 1996). However, relatively few studies exist that have focused on changes in muscle power with age (Bassey et al, 1992, Jozsi et al, 1999, Skelton et al, 1995). Unfortunately, both of the power training studies completed have limitations. The first one conducted by Skelton and colleagues (1995) only included women, and the exercises that the exercise group performed did not mimic any of the functional measurements that were tested. As well, the subjects completed some of the training sessions at a special facility The more recent power training study completed by Jozsi and co-workers (1999) only included assessments that were made on expensive Keiser pneumatic resistance machines Frail elders living in a residential facility may not have access to expensive pieces of equipment, and may not be capable of leaving their place of residence to undergo training sessions

Maintaining independence and being able to complete certain activities of daily living is important for many older adults It has been noted in the literature by some authors that the ability to stand from a seated position is perhaps the most important measure of physical function (Kelly et al , 1976, Rodosky et al , 1989) A number of variables including balance (Schenkman et al , 1990), upper and lower extremity strength (Hughes et al , 1996), and most importantly, muscle power (Bassey et al , 1992, Skelton et al , 1995), all influence the ability to rise from a chair and perform other daily activities As a result of the necessity of muscle power for performing daily habitual activities together with the demand for more generalizable power training studies, future research should focus on strategies to incorporate these needs, especially in the older adult population

The purpose of the present study was, therefore, to examine the influence of progressive lower body exercise training which focused on both strength and power, and the effects this had on functional abilities in older adults Consideration was given to implementing a simple-to-follow, minimally supervised and structured exercise program employing only Therabands® for resistance

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## CHAPTER II

## TRAINING FOR POWER IN OLDER ADULTS: EFFECTS ON FUNCTIONAL ABILITIES

### 2.1 Abstract

**Context.** The loss of muscle strength and power leading to a decline in functional status may be an inevitable consequence of aging Few studies have focused on changes in muscle power with age, but associations have been demonstrated between functional abilities and both strength and power

**Objective.** To determine the influence of progressive lower body exercise training for power on functional abilities in older adults

**Design.** Randomized controlled trial of 10-weeks duration

**Setting.** Residential, long-term care facility and exercise laboratory at McMaster University, Hamilton, ON

**Population.** Thirty residents, 75 to 94 years of age, participated in the study, 25 completed the study The subjects were able to walk across a room (with or without an ambulatory aid) and could follow directions

**Interventions.** Progressive lower body resistance exercises, specifically aimed at training for power were conducted 3 days per week (n=18) vs untreated controls (n=7)

**Main Outcome Measures.** Eccentric and concentric isokinetic contractions of the knee extensors, and performance on three functional tests 8-foot up-and-go timed test, 30-second chair stand test, and a 6m walk timed test

**Results.** Significant increases were found in the EX group for eccentric (44%) and concentric (60%) average power ($p<0.05$), and improvements were seen on each of the functional tests the 8-foot up-and-go, chair stand, and walk time all improved by 31%, 66% and 33%, respectively ($p<0.05$) No significant change occurred in the CON group

**Conclusions.** Training, even in the tenth decade, increases muscle power and is associated with an improved performance of functional activities using the trained muscles

## 2.2 Introduction

The loss of muscle strength and power leading to a decline in functional status is generally considered to be an inevitable consequence of aging. Few studies have focused on changes in muscle power with age (Bassey et al., 1992; Jozsi et al., 1999, and Skelton et al., 1995), but associations have been demonstrated between functional abilities and both strength (Hyatt et al., 1990) and power (Bassey et al., 1992). Cross-sectional comparisons imply a loss of strength and power at 1.5 and 3.5% per year, respectively (across the age range of 65 to 89, Skelton et al., 1994). The capacity for older adults to maintain or increase muscle power and possibly prevent this estimated annual loss has not yet been thoroughly examined.

An emerging area of interest to researchers is the possible role that muscle power (work per unit time) may play in functional independence in the elderly. Many basic activities in daily life such as walking, climbing stairs, or simply standing from a seated position, require leg muscle power. Muscle power is a product of the force and the velocity of muscle shortening (Skelton et al., 1995), both of which show significant age-related decreases. Therefore, it has been suggested that a decline in muscle power may be more directly related to impaired physical performance and a better indicator of functional potential than muscle strength alone (Bassey and Short, 1990, Bassey et al., 1992, Brown et al., 1995, Skelton et al., 1994). Moreover, muscle power, a product of force and velocity (Bassey and Harries, 1990), may be more sensitive to age-related losses in muscle strength, since both strength and velocity of shortening are dependent on fast-twitch fibres which have reduced area and number in older muscle (Murray et al.,

1985) Consequently, muscle power declines more rapidly (3.5% vs 1% per year) than muscle strength (Bassey et al, 1992, Bassey and Short, 1990, Bosco and Komi, 1980, Metter et al., 1997). Potentially, changes in muscle power could be a more relevant etiologic factor in age-related functional decline than muscle strength.

Maintaining independent function is an important goal for older adults. Independence in activities such as getting out of bed, getting dressed, shopping, visiting friends, and using public transportation require adequate physical fitness. The ability to stand from a seated position is considered by some to be one of the most important measures of physical function (Kelly et al., 1976, Rodosky et al., 1989). A number of variables have been determined to influence the ability to rise from chair and perform other daily activities. These include balance (Schenkman et al., 1990), upper and lower extremity strength (Hughes et al., 1996) and muscle power (Bassey et al., 1992, Skelton et al., 1995). Given the age-related decline in muscle power and the necessity of muscle power for performing daily habitual activities in elderly populations, the importance of determining the extent to which muscle power can be increased with training is substantial. Unfortunately, previous studies that have focused on training for power have used expensive equipment such as Keiser pneumatic resistance machines (Jozsi et al., 1999), have trained subjects at a special facility (Skelton et al., 1995), or have used exercises that were not similar, or relevant to basic functional tasks (Skelton et al., 1995). Frail elders living in a residential facility may not have access to expensive pieces of equipment, and may not be capable of leaving their place of residence to undergo training sessions Therefore, the purpose of the present study was to examine the influence of progressive lower body exercise training for power on functional abilities in older adults

## 2.3 Methods

### 2.3.1 Subjects

A total of 25 subjects (6 males, 19 females), who were residents in a long-term care facility participated in this study Inclusion criteria were the ability to follow directions and walk across a room (with or without an assistive device), and no recent history of cardiovascular, cerebrovascular, respiratory, systemic, muscular or uncontrolled metabolic disease Subjects were randomly assigned (≈1 2 ratio) to either a control group (CON n=7) or an exercise group (EX n=18) The EX group ranged in age from 76 to 94 years while the CON group ranged from 75 to 87 years old The use of ambulatory aids per group (walker, cane, wheelchair) and other subject characteristics are outlined in Table 1 All measurements and tests were completed by all subjects both pre- and post-training This investigation carried the approval of the Ethics Committee at McMaster University, and each subject gave their written informed consent to participate (Appendix A)

### 2.3.2 Assessment of Leg Extensor Strength and Power

A Biodex Multi-Joint Testing and Exercise Dynamometer® (Biodex Corp , Shirley, NY) was used to measure isokinetic knee contractions at an angular velocity of 180°/s Peak torque (PT) and average power (AP) were calculated by the on-line microsystem inherent to the dynamometer

During testing, subjects were seated on the Biodex® chair and straps were secured around their waist and thigh for stabilization Subjects were instructed to perform both eccentric (ECC) and concentric (CONC) contractions For ECC contractions, the non-dominant leg was tested and for CONC contractions the dominant leg was used The rotational axis of the dynamometer was positioned to be coaxial with the knee axis (lateral epicondyle) during testing Subjects were allowed to practice each trial before it was recorded and verbal encouragement was given A total of three test repetitions were completed on each leg and the best recorded torque and power output for each leg was used for subsequent analysis

### 2.3.3 Functional Fitness Tests

Three functional ability tests (Rikli and Jones, 1999a, Bassey et al., 1992) were chosen for a probable relationship with strength or power All tests were explained and demonstrated by the assessor before being performed by the subjects

#### 2.3.3.1 8-Foot Up-and-Go Timed Test

The subjects were asked to rise as fast as possible from a seated position, walk around a marker which was eight feet away, and then return to a seated position on the chair Timing started when the subject stood up and was terminated when the subject sat down after walking around the marker and back to the chair Subjects could use assistive devices if needed The test was performed twice and the fastest time (recorded with a stopwatch to the nearest $1/10^{th}$ of a second) was recorded

#### 2.3.3.2 30-second Chair Stand Test

The subjects were asked to rise up as fast as possible from a chair placed against a wall If needed, subjects could push off of the arm rests on the chair or hold on to the arm handles of their walkers The total number of times that subjects could fully stand in 30 seconds was recorded If subjects were more than half-way up at the end of the 30 seconds, it counted as a full-stand Subjects only performed this test once as it was very exhausting for most of them

#### 2.3.3.3 6m Walk Timed Test

The subjects were instructed to walk a distance of 6 metres as fast as they could, and, as in the other tests, they were aware that they were being timed They could use assistive devices if needed, and each subject was timed for two walks The faster of the two times was used for analyses

### 2.3.4 Interventions

#### 2.3.4.1 Control Group

No active or placebo intervention was prescribed for the control group They were asked to perform no more or less activity than accustomed to on a daily basis

### 2.3.4.2 Training/Intervention

The subjects in EX group attended exercise sessions in their residential facility three times a week, for a total of ten weeks. Each class began with a 10-minute warm-up and stretch of the main lower muscle groups being trained. The strengthening component of the class included seated and standing exercises. The exercises required that subjects use their own body weight or Therabands® for resistance, along with exercises that had an intrinsic speed component (to focus on improving power). Some of the exercises did mimic a couple of the outcome measurements of strength, power and functional ability as it has been previously shown that it is more advantageous to train a muscle in the same way as it is being tested (Skelton et al., 1994).

Following a typical progressive resistance protocol, each exercise was initially performed as one set of four to eight repetitions, with body weight, and later therabands for resistance. Initially, only a few exercises were completed, and as time went on, new exercises were introduced into the program. As subjects completed the repetitions and one set of exercises more easily, both were progressively increased. As well, any exercises that had a speed component to them were gradually performed more quickly, to train for power. At the end of the exercise session there was a 10-minute cool-down component which resembled the warm-up. The duration of exercise class was 20-minutes initially, and this was progressively increased up to one full hour over the course of the 10-week study Refer to Appendix B for a complete description of the exercises used

### 2.3.5 Statistical Analysis

Each of the dependent variables were analyzed with a two factor (group x time) between subjects analysis of variance (ANOVA) with repeated measures on the time factor The Tukey A post hoc test was used as needed to compare means when significant group x time interactions were found Correlations between functional tests and muscle strength or power were assessed by calculating Pearson's product moment *r* Statistical significance was established at $p < 0.05$ Unless otherwise stated, all results are expressed as means ± standard deviations All statistical analyses were carried out using the Statistica® (1997 version) package on a computer

## 2.4 Results

Out of the original 30 subjects, 25 subjects (19 women and 6 men), ranging in age from 75 to 94 years, successfully completed the study Five subjects dropped out due to health reasons All 25 subjects who finished the study were able to complete tests on the Biodex® dynamometer for measurements of isokinetic leg extensor torque and power, and performed the 6 metre walk timed test However, both pre- and post-training, one man in the EX group was unable to perform the 8-foot up-and-go timed test, and two men (one from each group EX and CON) could not complete the 30-second chair stand test Post-training, 2 women in the EX group no longer needed their ambulatory aids to complete the functional tests

The average number of training sessions attended by each subject in the EX group was 21 out of 30, representing a 71% adherence rate

### 2.4.1 Baseline Values

#### 2.4.1.1 Subject Characteristics

There were no significant baseline differences in age, height, or body weight between the CON and the EX group (see Table 1)

#### 2.4.1.2 Isokinetic Measurements of Strength and Power

Pre-training values did not significantly differ between the EX and CON group for ECC peak torque and average power (see Table 2) For CONC strength and power measures there was no difference between EX and CON in CONC peak torque, however, the CON group had significantly better CONC average power values than the EX group at baseline ($p<0.05$)

#### 2.4.1.3 Functional Tests

At baseline, there was a significant difference between the EX and CON group in performance in the 8-foot up-and-go timed test and the 30-second chair stand test ($p<0.05$) In both cases, the CON group performed slightly better than the EX group (see

Table 3) There was no significant difference between the EX and CON group for the 6 metre walk timed test pre-training

#### 2.4.1.4 Relationship Between Leg Extensor Strength/Power and Functional Performance

Table 4 shows the pre-training correlations between the isokinetic measurements of strength and power and the functional performance tests. The 8-foot up-and-go timed test and the 30-second chair stand test both had the strongest relationship with CONC average power ($r = -0.64$, $p<0.001$, $r = 0.56$, $p<0.05$), respectively. The 6 metre walk timed test had the strongest relationship with ECC average power ($r = -0.52$, $p<0.05$)

### 2.4.2 Effects of Training

#### 2.4.2.1 Isokinetic Measurements of Strength and Power

There was a group by time interaction found for all four isokinetic measurements of strength and power. Significant gains in isokinetic strength and power were seen in the EX group following training, while the CON group values did not significantly change over time (Table 2)

Following training, the EX group produced significantly greater ECC peak torques (68.1 $\pm$ 22.7 Nm vs 81.9 $\pm$ 23.3 Nm, respectively, see Figure 1), representing a 29.5 $\pm$ 50.2% increase ($p = 0.07$). There were no significant changes seen in the CON group. Similarly, the EX group had significantly higher ECC average power values post-training (44 9 ± 22.0 W vs 57 5 ± 24 0 W pre- and post-training, respectively), representing a 43 7 ± 73 8% (p<0 05) increase In comparison, the CON group had an 18 1 ± 25 1% (p>0 05) decrease in ECC average power post-training (see Figure 4)

Figure 2 illustrates the changes observed in CONC peak torque The CONC peak torque values for the EX group were significantly higher post-training (pre 29 4 ± 12 1 Nm vs post 35 8 ± 14.0 Nm, respectively), whereas the CON group experienced no significant change (pre 33 3 ± 14 4 Nm vs post 30 1 ± 14 7 Nm, respectively) The EX group increased their CONC peak torque values by 25 3 ± 24 9% (p<0 05) post-training, while the CON group had a decrease of 13 7 ± 15.1% (Figure 4) The CONC average power values also significantly increased in the EX group (pre 34 4 ± 20 6 W vs post 46 3 ± 23 2 W, respectively) which represented a 59 7 ± 67 7% (p<0 05) increase The CON group had no significant change in CONC average power post-training (Figure 4)

### 2.4.2.2 Functional Tests

There was a significant effect of training on performance in each of the functional tests, whereas the CON group demonstrated no change from baseline In the 8-foot up-and-go timed test, the EX group demonstrated a 6 3 ± 6 8 second decrease in the time taken to do the test, representing a 30 7 ± 18 0% (p<0 05) improvement in performance from baseline The number of chair stands that the EX group could complete in 30 seconds following training increased by 3 2, which represented a 66 2% increase in performance (see Figure 5) And finally, subjects in the EX group could complete the 6 metre walk timed test 3 5 seconds quicker following training which represented a 32 7% increase in performance (Figure 5)

#### 2.4.2.3 Anecdotal Observations

The dependence of the subjects on assistive devices for ambulation changed after training for the EX group The most significant changes occurred during both the 8-foot up-and-go timed test and the 6 metre walk timed test Three of the subjects in the EX group who originally needed their walkers to complete the 8-foot up-and-go timed test, were able to perform the test without using any assistive device post-training As well, one female in the EX group who initially needed her cane to complete the 8-foot up-and-go timed test did not feel the need to use it following training Similar changes were noted for the 6 metre walk timed test

## 2.5 Comment

The results from this study demonstrate that older individuals living into their tenth decade can improve muscle power and strength as a result of following a simple, structured progressive exercise regimen employing only body weight and Therabands® for resistance Although a number of investigations have demonstrated that similar increases in strength can occur in both younger and older adults, few studies have examined the effects of progressive resistance exercise on power in older adults (Jozsi et al . 1999, Skelton et al . 1995) Moreover, the question of whether a training-induced increase in muscle power or strength can translate into improved performance of functional tasks using the trained muscles has not been adequately addressed

### 2.5.1 Baseline Values

The subjects in the present study were in the same age category as previous power training studies (Jozsi et al . 1999, Skelton et al , 1995), with our mean age being 84 9 ± 4 8 years for the EX group, and 80 6 ± 4 6 years for the CON group Many strength training studies have been completed in this population which confirm that similar increases in strength can occur in both older and younger adults (Campbell et al , 1994, Charette et al , 1991, Fiatarone et al , 1990, Frontera et al , 1988, McCartney et al , 1996), but increases in muscle power are not as well documented

The subjects included in the present study all lived in a residential, long-term care facility and most employed the use of an assistive device A study conducted by Bassey et al (1992) did mention that half of their subjects (five men and eight women) spent most of their time in a wheelchair, and others used assistive devices While other studies have often only included independent/mobile individuals (Jozsi et al , 1999, Skelton et al , 1994, 1995), our philosophy in the present study was that safe and effective exercise should be made available to all older persons We excluded no volunteer on the basis of ambulation or concurrent medications, and the only requirements were the ability to walk across a room (with or without an assistive device), and to be able to follow simple directions In this regard, our findings can be more generally applied to other frail elderly people living either independently or in long-term care institutions

It is difficult to compare our baseline isokinetic measurements of strength and power to other studies, as they have all incorporated a slightly modified version of the Nottingham Power rig to measure power (Bassey et al., 1992, Skelton et al., 1994, 1995). The Nottingham Power rig requires the subject, in a seated position with folded arms, to give a maximal push to a large foot pedal. Power is measured by a single explosive effort of the extensors of the lower limb to accelerate a flywheel from rest. In the present study, a Biodex® isokinetic dynamometer was used to measure isokinetic strength and average power at a specific angular velocity of 180°/s. The values we obtained at baseline for concentric peak torque can only be compared to a reliability study conducted in elderly women for knee extension and flexion strength (Capranica et al., 1998). Our values for concentric peak torque are almost identical to those reported by Capranica et al. (1998) in 68 year old women (31.4 Nm vs. 38.2 Nm, respectively). However, the fact that the mean age of our subjects was approximately 15 years older could account for this small difference.

Comparing our baseline functional test data to other published studies is also somewhat difficult, as once again there are differences in the subjects included in various reports. Both the 8-foot up-and-go timed test and the 30-second chair stand test were referenced from the most recent validated functional fitness test battery for older adults (Rikli and Jones, 1999b). Unfortunately, a direct comparison between our data and theirs is not possible as their participants were all volunteers who were generally active, community residing, functionally independent, and ambulatory without the regular use of an assistive device (Rikli and Jones, 1999b). Using the normative data of Rikli and Jones

(1999b), our subjects fell below the 10th percentile for the 8-foot up-and-go timed test, and were in the 25th percentile range for the 30-second chair stand test. However, the times achieved on the 6 metre walk timed test are definitely comparable to the data of Bassey and colleagues (1992). They reported a median time of 11.3 seconds for their eighty plus year old subjects, while our mean time for the EX group was 11.2 seconds and 11.9 seconds for the CON group.

The pre-training correlations among the various measures revealed that performance on each of the functional tests was most strongly correlated with leg extensor average power. The 8-foot up-and-go timed test and the 30-second chair stand test had the strongest relationship with concentric average power, while the 6 metre walk timed test had the strongest relationship with eccentric average power. Significant correlations between leg extensor power and performance on similar functional tasks have been reported previously (Bassey et al., 1992), making a compelling argument for the importance of training for muscle power in the frail elderly population.

The potential for older adults to improve muscle power was recently published (Jozsi et al., 1999), but the necessity for muscle power to perform daily habitual activities in older adult populations has still not been thoroughly investigated. Bassey and colleagues (1992) demonstrated that in older adults, approximately the same age as the current study population, leg muscle power was more important than strength for performing daily activities such as stair-climbing, rising from a chair, and walking.

### 2.5.2 Effects of Training

Ten weeks of progressive lower body exercise training significantly increased muscle strength and power in the EX group. The improvements in muscle strength and power in our subjects were equal to, if not greater than those seen in similar studies (Bassey et al., 1992, Jozsi et al., 1999, Skelton et al., 1995). It is likely that at the end of training, the EX group subjects were stronger than they had been for many years.

Compared to other training studies, this is the first one to yield significant improvements on all variables (Frontera et al., 1988, Jozsi et al., 1999, Skelton et al., 1995). Frontera and colleagues examined the effects of isotonic high intensity resistance exercise on isokinetic muscle power in older men, but did not see a significant change in power (Frontera et al., 1988). They demonstrated that although isotonic strength (1RM) showed a substantial improvement, isokinetic strength either was unchanged (at a rapid speed of contraction, 240°/s) or showed only modest improvements at a slow speed (60°/s). To date, only one training study has looked at the effects of training for strength and power on the functional abilities of elderly women (Skelton et al., 1995). However, of the 11 functional ability tasks that were tested post-training, only 2 showed statistically significant improvements. They concluded that the task-independent strength increases that they did see produced only limited improvements in functional ability, and that any training regimen incorporated in future studies should include practice of the functional tasks. The present study took this into consideration and some of the exercises were designed to mimic the functional tasks being tested.

The most recent training study conducted by Jozsi and colleagues (1999) found that 12 weeks of progressive resistance training in 56-66 year old adults resulted in improved strength and power, but only when muscle function was measured in the same way it was trained. The present study demonstrated that progressive lower body exercise training for power produced significant gains in eccentric (44%) and concentric (60%) average power and in eccentric (30%) and concentric (25%) peak torque.

The current study did not directly examine mechanisms for the muscle power gains seen after training. Several factors, including a decrease in muscle mass and cross-sectional area (Lexell et al., 1988, Wilmore, 1991), selective atrophy of fast twitch fibres (Grimby et al., 1982, Lexell et al., 1988), and a decrease in the number of motor units, particularly those innervating high-threshold, fast twitch fibres (Doherty et al., 1993, Roos et al., 1997), likely contribute to the age-related decline in muscle power. Although we do not have histochemical data from the subjects in this investigation, it is likely that the original measurements of muscle strength and power reflected a low muscle mass, small fast-twitch fibre area, and corresponding increases in slow contractile protein content per cross-sectional area of muscle. However, our post-training data demonstrate that older individuals living into their tenth decade can significantly improve muscle strength and power in response to progressive lower body exercise training.

In addition to the finding that older individuals can improve muscle power in response to 10 weeks of resistance training, our data support the existing literature which demonstrates that older people can increase their performance of functional tasks as a result of training (Ades et al., 1996, Chandler et al., 1998, Skelton et al., 1995). Although some investigations have shown that lower extremity strength gain is associated with improvement in functional performance, the reported improvements vary. Ades et al. (1996) specifically investigated the effects of weight training on walking endurance in healthy older persons and they found a significant relationship between the change in leg strength and the change in walking endurance ($r = 0.48$, $p<0.05$). Chandler et al. (1998) evaluated if lower extremity strength gain was associated with improvements in either physical performance or disability in frail, community-dwelling elders. They found that 10 weeks of thrice/weekly strength training had a significant impact on mobility skills, gait speed, falls efficacy, and chair rise performance in participants who were most impaired, but not in the less frail subjects.

In the present study, the enthusiasm of the subjects involved in the exercise classes was attested to by their attendance rates (each subject attended an average of 71% of the classes held) and their expressed hope that the program could be continued upon completion of the study. At follow-up, 3 months later, the classes were still being held three times a week, and the number of people attending has increased. The exercises used in the study have been supplemented with upper extremity exercises, and the duration of the class is still one full hour.

In conclusion, this study has demonstrated that a relatively simple training regime, utilizing no specialized equipment, is effective in increasing muscle strength and power in frail older adults. More importantly, significant improvements in the ability to perform functional activities requiring the use of the trained muscles was evident in all participants. Functional performance is affected by many different factors, two of which are undoubtedly muscle strength and power. Since both are modifiable consequences of deconditioning and aging, steps should be taken to ensure that muscle power and strength are maintained in the elderly. Our findings can be applied to other frail older adults in long-term care institutions, and opportunities should be provided for them to exercise in a way to prolong active life and delay dependency.

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**Table 1 - Subject Characteristics**
**( Values are means ± SD)**

| | *Exercise Group* | *Control Group* |
| --- | --- | --- |
| **N =** | 18 | 7 |
| **Age** | 84.9 ± 4 8 years | 80.6 ± 4 6 years |
| **Age Range** | 76 - 94 years old | 75 - 87 years old |
| **Gender** | 5 males; 13 females | 1 male: 6 females |
| **Ht.** | 156.9 ± 8.9 cm | 159.3 ± 7.0 cm |
| **Wt.** | 60.7 ± 11.3 kg | 70.0 ± 13.4 kg |
| **Ambulation** | No devices 8<br>Walkers 8<br>Wheelchair: 1<br>Cane 1 | No devices 6<br>Walker 1*<br>Wheelchair: 1* |

*same man uses both

**Attendance** Mean # of subjects per class 14
(therefore 74% attendance per class)

Mean # of classes attended by each Ss: 21
(each subject attended an avg. of 71% of the classes)

**Table 2 - Isokinetic Torque and Power (measured at 180°/s)**
**(Values are means ± SD)**

| | Exercise Group | | |
|---|---|---|---|
| | *Pre-training* | *Post-training* | ***Percent Change*** |
| ECC Peak Torque (Nm) | 68.1 ± 22.7 | 81.9 ± 23.3 * | **+29.5 ± 50.2%** |
| ECC Avg Power (Watts) | 44.9 ± 22.0 | 57.5 ± 24.0 * | **+43.7 ± 73.8%** |
| CONC Peak Torque (Nm) | 29 4 ± 12 1 | 35 8 ± 14.0 * | **+25.3 ± 24.9%** |
| CONC Avg Power (Watts) | 34.4 ± 20.6 | 46.3 ± 23.2 * | **+59.7 ± 67.7%** |

| | Control Group | | |
|---|---|---|---|
| | *Pre-training* | *Post-training* | ***Percent Change*** |
| ECC Peak Torque (Nm) | 76.3 ± 20 1 | 71.0 ± 22.2 | **-7.1 ± 15.5%** |
| ECC Avg. Power (Watts) | 54 9 ± 32.9 | 47.8 ± 32.5 | **-18.1 ± 25.1%** |
| CONC Peak Torque (Nm) | 33 3 ± 14.8 | 30.1 ± 14 7 | **-13.7 ± 15.1%** |
| CONC Avg Power (Watts) | 48 6 ± 17 2$^{+}$ | 45 3 ± 14 6 | **-3.9 ± 15.8%** |

* - significant increase from pre-training
$^{+}$ - significant difference from EX pre-training

**Table 3 - Functional Performance**
**(Values are means ± SD)**

**Exercise Group**

| | *Pre-training* | *Post-training* | ***Percent Change*** |
|---|---|---|---|
| 8-foot up-and-go test (s) | 20.7 ± 7.1 | 14 4 ± 6.5 * | **-30.7 ± 18.0%** |
| Chair Stand (# in 30 s) | 6.8 ± 3 1 | 10.0 ± 3 1 * | **+66.2 ± 79.9%** |
| 6m Walk Timed Test (s) | 11.2 ± 4 7 | 7.7 ± 3.9 * | **-32.7 ± 13.4%** |

**Control Group**

| | *Pre-training* | *Post-training* | ***Percent Change*** |
|---|---|---|---|
| 8-foot up-and-go test (s) | 15.5 ± 17.3⁺ | 16.3 ± 18.9 | **+4.0 ± 14.6%** |
| Chair Stand (# in 30 s) | 10 8 ± 3.1⁺ | 10.5 ± 2.3 | **-1.1 ± 11.6%** |
| 6m Walk Timed Test (s) | 11.9 ± 6 9 | 13 4 ± 9.4 | **+6.0 ± 13.8%** |

* - significant change from pre-training
⁺ - significant difference from EX pre-training

**Table 4 – Pre-training correlations between strength, power and functional performance (p-values)**

| | **8-Foot up-and-go** | **Chair Stand** | **6m Walk Time** |
|---|---|---|---|
| **ECC PT** | -0.49 ($p<0.05$) | 0 31 ($p=0.14$) | -0 14 ($p=0.51$) |
| **ECC AP** | -0.37 ($p=0.08$) | 0.38 ($p=0.07$) | -0.52 ($p<0.05$) |
| **CONC PT** | -0.62 ($p<0.05$) | 0.45 ($p<0.05$) | -0.17 ($p=0$ 41) |
| **CONC AP** | -0.64 ($p<0.05$) | 0.56 ($p<0.05$) | -0 16 ($p=0$ 43) |

ECC PT - Eccentric Peak Torque
ECC AP - Eccentric Average Power
CONC PT - Concentric Peak Torque
CONC AP - Concentric Average Power

## FIGURE LEGENDS

Figure 1 Eccentric peak torque (*above*) and average power (*below*) values for the Exercise (*left*) and Control (*right*) group, pre (*open bars*) and post (*filled bars*) training  Values are means ± SD  * denotes significant difference after training

Figure 2 Concentric peak torque (*above*) and average power (*below*) values for the Exercise (*left*) and Control (*right*) group, both pre (*open bars*) and post (*filled bars*) training  Values are means ± SD  * denotes significant difference after training

Figure 3 Functional test data, the 8-foot up-and-go timed test (*top*), the 30-second chair stand test (*middle*), and the 6-metre walk timed test (*bottom*)  Values are reported for the Exercise group (*left*) and Control group (*right*), pre (*open bars*) and post (*filled bars*) training  Values are means ± SD  * denotes significant difference after training

Figure 4 Peak torque (above) and average power (below) percent changes for concentric (left) and eccentric (right) measures on the Biodex  Exercise (striped bars) and Control (open bars).  Values are the percent change ± SD  * denotes significant difference between groups

Figure 5 Percent change in the functional test data, the 8-foot up-and-go timed test (*top*), the 30-second chair stand test (*middle*), and the 6m walk timed test (*bottom*)  Exercise (*striped bars*) and Control (*open bars*)  Values are the percent change ± SD  * denotes significant difference between groups

Figure 1

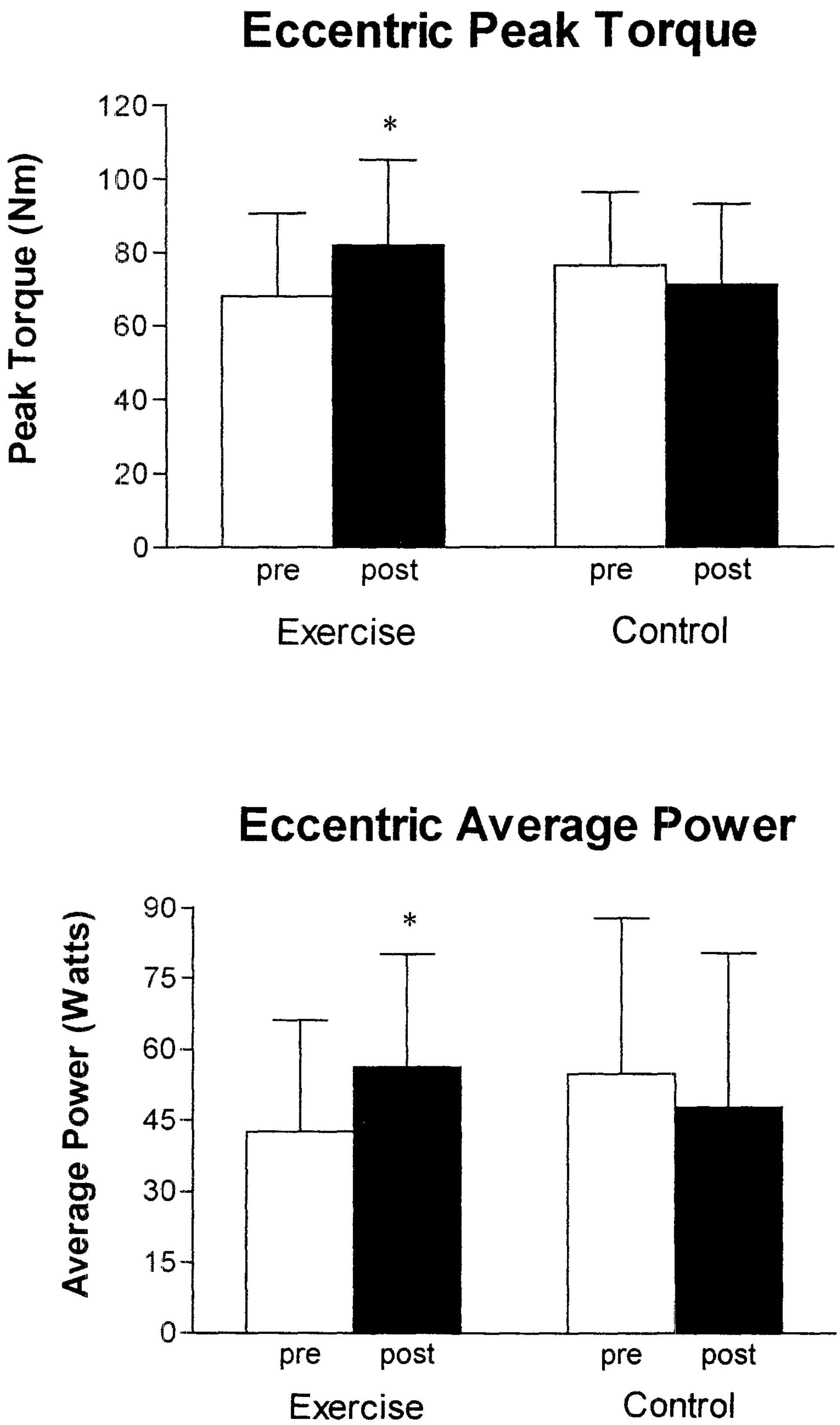
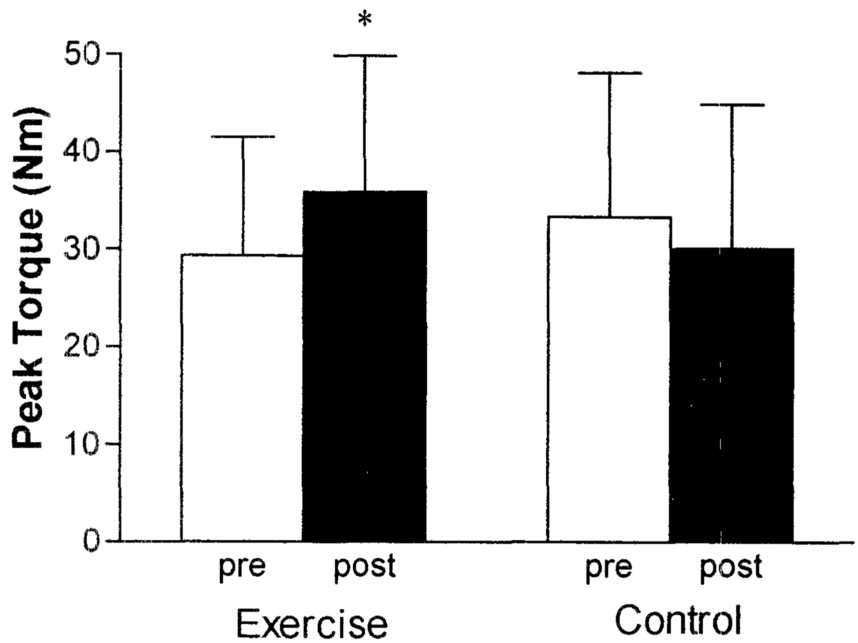

Eccentric Peak Torque
Peak Torque (Nm)
120
100
80
60
40
20
0
*
pre
post
pre
post
Exercise
Control
Eccentric Average Power
Average Power (Watts)
90
75
60
45
30
15
0
*
pre
post
pre
post
Exercise
Control

Figure 2



## Concentric Peak Torque




## Concentric Average Power

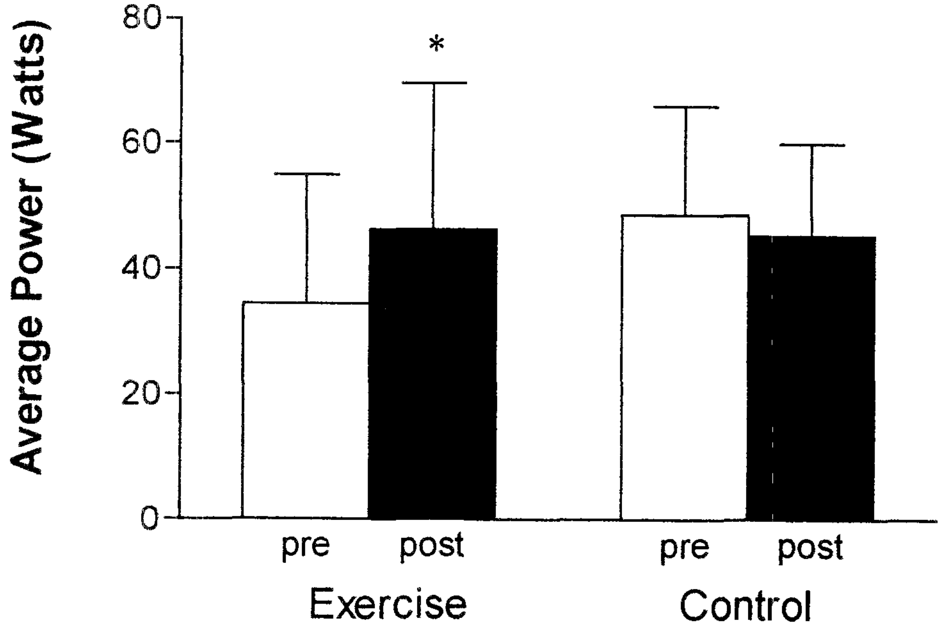
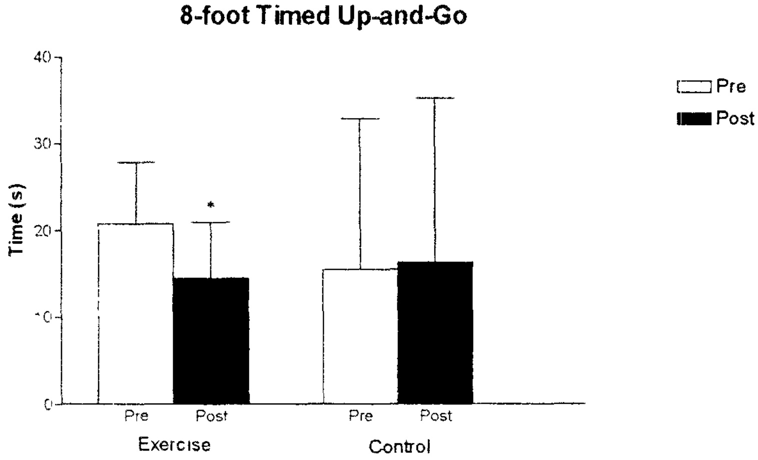
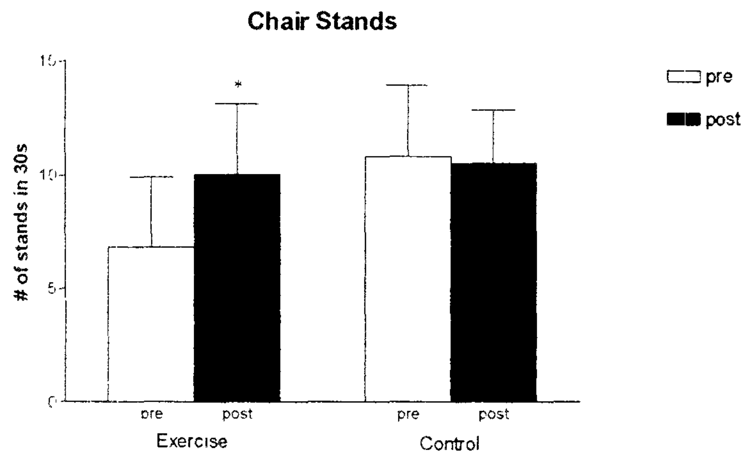


Figure 3




8-foot Timed Up-and-Go
Time (s)
40
30
20
10
0
*
Pre
Post
Pre
Post
Exercise
Control
Pre
Post


Chair Stands
# of stands in 30s
15
10
5
0
*
pre
post
pre
post
Exercise
Control
pre
post

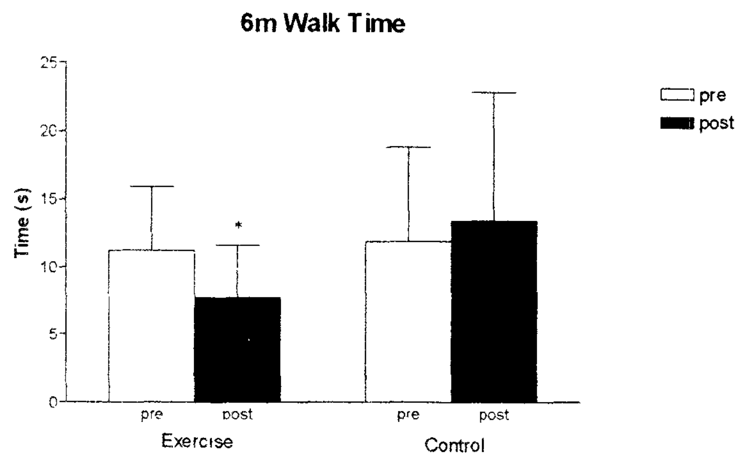

6m Walk Time
Time (s)
25
20
15
10
5
0
*
pre
post
pre
post
Exercise
Control
pre
post

Figure 4



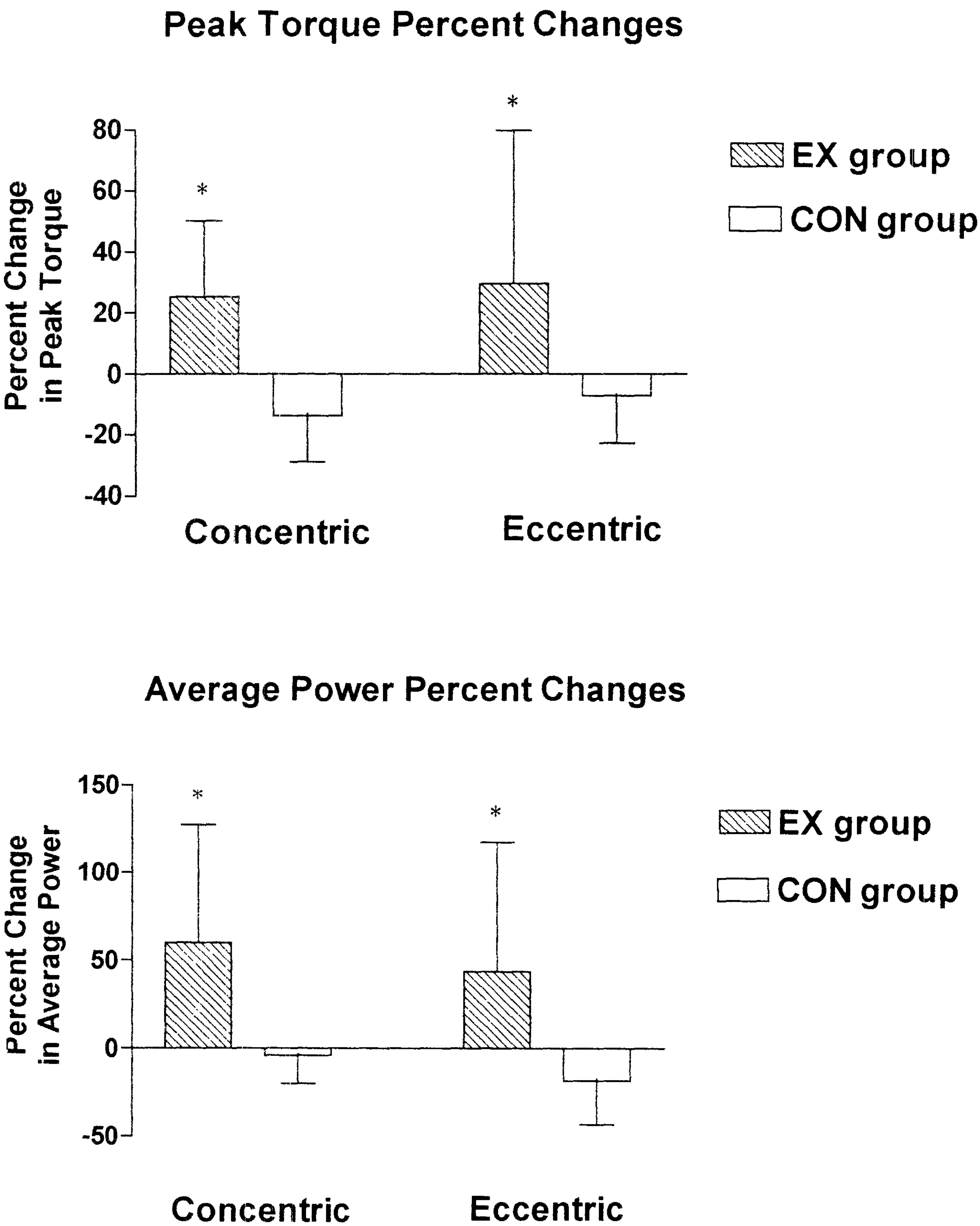
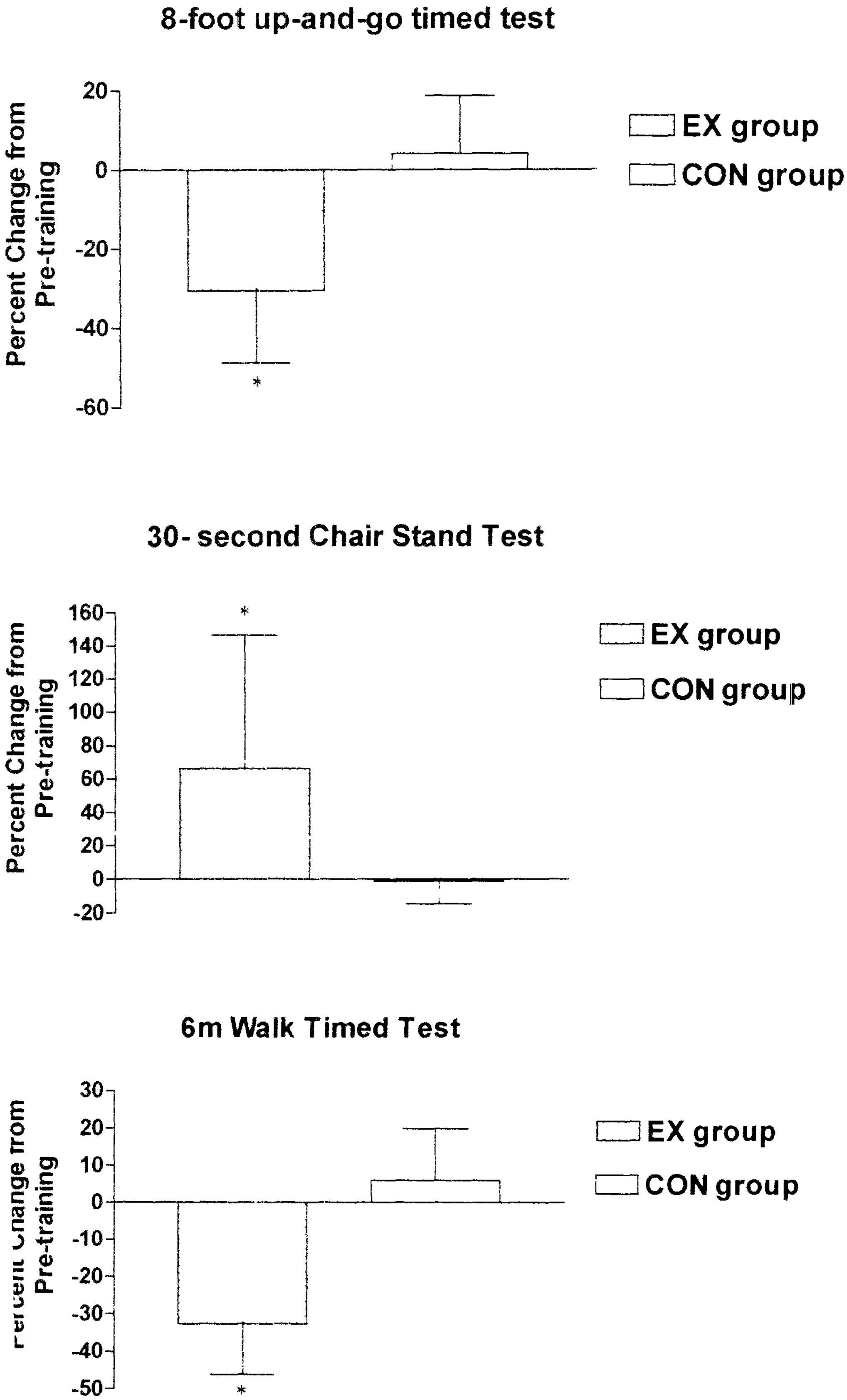

Peak Torque Percent Changes
Percent Change in Peak Torque
80
60
40
20
0
-20
-40
*
*
Concentric
Eccentric
EX group
CON group
Average Power Percent Changes
Percent Change in Average Power
150
100
50
0
-50
*
*
Concentric
Eccentric
EX group
CON group

Figure 5


8-foot up-and-go timed test
Percent Change from Pre-training
20
0
-20
-40
-60
*
EX group
CON group
30- second Chair Stand Test
Percent Change from Pre-training
160
140
120
100
80
60
40
20
0
-20
*
EX group
CON group
6m Walk Timed Test
Pre-training
30
20
10
0
-10
-20
-30
-40
-50
*
EX group
CON group

## APPENDIX A:

CONSENT FORM

# CONSENT FORM

## Training for Power in Older Adults: Effects on Functional Abilities

I, ______________________________ , consent to participate in a study directed by Kim Hruda and Dr Audrey Hicks The purpose of this study is to observe if increases in leg power transfer to improvements in the performance of activities of daily living The results will be made available to the scientific community but will be of no direct benefit to us

I am aware that I will be required to visit McMaster University on two different occasions During these visits, my leg power will be recorded using one piece of equipment As well, I will perform 3 different tests of activities of daily living Each visit will last for approximately 1 hour and will be supervised by the same tester throughout The two visits will be 3 months apart and will consist of the exact same tasks each time

I understand that I may be selected to participate in a 12-week exercise training program at Shalom Village, involving chair exercises and light resistance training I realize that the exercise classes will be held 3 times a week and will be supervised My exercise prescription will be appropriate for my capabilities as well

I have been informed that it is normal to experience some temporary muscle soreness and general fatigue after performing all of the above tasks, especially after the first time I perform them Any symptoms should be resolved, without intervention, within 24 hours, and if not, I have been informed to contact Kim Hruda or Audrey Hicks who will advise me on the appropriate treatment

Neither my name nor any reference to me will be used in compilation of the results, nor in publication in any form whatsoever

I understand that I may withdraw from the study at any time without prejudice, even after signing this form

| | | |
|---|---|---|
| ______________________ | ______________________ | ____________ |
| Name (Print) | Signature | Date |
| | | |
| ______________________ | ______________________ | ____________ |
| Witness (Print) | Signature | Date |

# APPENDIX B:

EXERCISE ROUTINE

# Shalom Exercise Routine

## Warm-Up (10 mins)

- **Walking** on the spot normally (30 sec) and then lifting knees (30 sec) (if they can, add arm punches straight out in front at shoulder level)
- **Walking** with walkers or any aids, for 5 minutes using different variations with their arms and legs (ex Side steps, add arms swinging at sides, toe touches in front, etc )
- ARM SWING Seated on chair, with back not against chair, swing arms gently by sides (1 min)
- SIDE BENDS Seated, with arms at sides in line with hips, bend gently to one side keeping the head and neck in line with the spine (Do 5X each side)
- TWISTS Seated, with hands on hips, twist whole upper body to R, back to the center, and then twist slowly to the L (try to keep back long and tummy tight) (move head in line with the body) (Do 5X each side)
- WIGGLE Start by sitting at the back of the chair, and "wiggle" yourself to the front of the chair and then back again Lift your hips and buttocks as you "wiggle" forward and bring arms into mvmt as well for a total body mvmt (1 min)

## Training Exercises (30-40 mins) (Each exercise will be progressively sped up)

**SEATED**

- LEG CROSS In neutral sitting position, but with spine relaxed against the back of the chair, lift the R leg (knee bent) straight up (counts 1 and 2), cross it over the L knee (3 4), bring it back to center (5,6) and then return it to neutral (7,8) Repeat with the L leg crossing over the R knee (Do 4X more on each leg)
- HIP ROTATION In neutral sitting position with a resting spine, lift the R leg (knee bent) up to center (counts 1 and 2), open the leg to the R side (3,4), close to the center (5,6) and return back down to neutral (7,8) Repeat with the L leg opening to the L side (Do 4X more on each leg)

- ANKLE ROTATIONS Sitting forward in chair (back not touching), lift one knee slightly until foot is off of the floor Circle the ankle very slowly CW and then CCW, moving through the whole range of mvmt Repeat with the other leg (Alternate if Ss too weak, they can cross their legs and let their ankle hang freely before circling it)
- GETTING UP Seated, with feet flat on the floor, lean forward using arms if necessary to push on thighs or arm rests, and stand up from the chair Lower yourself back down into the chair and repeat 5X

**STANDING**

- HEEL RAISES Standing behind the chair with feet shoulder width apart, and holding onto the back of the chair for balance, rise up as high as you can on your toes, lifting your heels from the floor, and then bringing your heels back down (Do 5X)
- SQUATS Standing behind the chair with feet shoulder width apart, and holding onto the back of the chair for balance, slowly bend knees and lower yourself and then come right back up Try to keep your back upright and heels on the floor always (Do 5X)
- LEG LIFTS Standing behind the chair or beside the chair (depending on which exercise you're doing), while keeping legs straight, lift one leg up and straight out in front and then return it to the starting position Do 5X Now switch legs
  Next, lift one leg out to the side and then back to the starting position Do 5X and then switch legs
  Lastly, lift one leg straight out behind and then back down to the starting position Do 5X and then switch legs
- HAMSTRING CURLS Holding on to the back of the chair for balance, flex the R knee and lift the R heel towards the R buttock, and then return down to the starting position Repeat by lifting the L heel toward the L buttock Do 5X on each leg

**THERABANDS® (Seated)**

- LEG PRESS Seated, place the center of the band around the bottom of 1 foot Grasp the ends of the band with both hands, and bend the knee in towards the body, and then straighten the leg out in front Do 5X and then switch legs

- KNEE EXTENSION. Seated, place the center of the band around the bottom of 1 foot, with both feet on the floor Straighten your leg out to the front (a slow "kicking" motion) Do 5X and then change legs
- HIP SWING Seated, place the center of the band around 1 foot, straighten that leg and secure both ends of the band at the hip of the opposite leg Slowly take the leg away from the body (out to the side) and then bring it back in front, keeping the band taut at all times. Do 5X and then switch legs
- THIGH PRESS Seated, with your back supported by the back of the chair, circle the band around the thighs close to the knees and hold on to the crossed over ends securely Gently stretch out the band by separating your knees (out to the side) Hold for a count of 2 and then bring knees together again Do 5X

**Cool-down (5-10 mins)**

- Arm Swing, Side Bends, Twists, Deep Breathing exercises (same as warm-up but much slower)

(Example of the exercises performed during the last class)

**Date:** Fri Mar. 31/00 **Class #** 30 **(Last Class!)**

WARM-UP

- Toe touches; heel touches; leg lunges; arm swings; side bends; twists, lifting legs up and down; coming up on toes, etc. . .

EXERCISES **(2x through) (Focus on 1-side of the body and then switch)**

1) Seated, leg cross (7x); hip rotations (7x); ankle rotations (2x)
2) Seated, lift foot off floor and hold for 3 sec. (7x each leg)
3) Seated, knee extensions (5 kicks out one leg, switch legs; 7x each leg)
4) Seated, straight leg lifts up (7x each leg)
5) Seated, **TB:** leg press (7x on one leg, then switch legs; 2 sets)
6) Seated, **TB:** knee extensions (7x on one leg, then switch legs; 2 sets)
7) Seated, **TB:** hip swing (7x on one leg, then switch legs; 2 sets)
8) Seated, **TB:** thigh press (7x all together with 2 sec hold each time; 2 sets)
9) Seated, getting up to standing (8x)
10) Standing, squats (8x); heel raises (8x); hamstring curls (8x each leg)
11) Standing, lift one heel up, and do 3 press backs, keeping knee bent (switch legs and do 7 sets on each leg)
12) Standing, leg lifts back, leg lifts to the side, leg lifts to the front (8x each leg)
13) Standing, do touchouts with toes to the front, side and back (do 7x on one leg and then switch legs)
14) Standing, holding onto back of chair or walker, leg lunges to stretch
15) Seated, do some deep breathing to relax before 2nd set

16) **Now do everything above for a second set!! (#1-13 of exercises)**

17) Walking on the spot, getting ready to cool-down

COOL-DOWN

1) Seated, looking over shoulders for neck
2) Shoulder rolls; shrugging shoulders up and holding them
3) Stretching out arms in front of body (one arm at a time)
4) Seated, arm swings
5) Seated, twists; side bends
6) Seated, deep breathing (at least 3x)
7) Seated, give yourself a hug!!!!!!!
8) Shake hands with your neighbours!
9) Give yourself a hand!

# APPENDIX C:

PHYSICAL CHARACTERISTICS AND RAW DATA

## Physical Characteristics: Age, Height, Weight, & Assistive Device

| Subject | Gender | Group | Age(yrs) | Height (cm) | Weight (kg) | Assistive Device |
|---|---|---|---|---|---|---|
| DA | F | EX | 84 | 151 | 48 7 | NONE |
| SB | M | EX | 90 | 165 | 72.4 | NONE |
| LB | M | EX | 85 | 165 | 67 9 | NONE |
| SB | F | EX | 81 | 148 | 54 0 | WALKER |
| BB | M | EX | 91 | 156 | 69 0 | WHEELCHAIR |
| DC | F | CON | 76 | 156 | 63 4 | NONE |
| CE | M | EX | 87 | 163 | 65.3 | WALKER |
| HE | F | EX | 80 | 162 | 61.8 | WALKER |
| SE | F | CON | 81 | 158 | 69.0 | NONE |
| LG | F | EX | 94 | 149 | 45 9 | NONE |
| ML | F | CON | 75 | 155 | 63 9 | NONE |
| LL | F | EX | 88 | 143 | 44.8 | WALKER |
| EL | F | EX | 85 | 161 | 53.5 | WALKER |
| SL | M | EX | 76 | 178 | 88.8 | NONE |
| MM | F | EX | 81 | 165 | 57 6 | CANE |
| EM | F | EX | 83 | 156 | 57 8 | WALKER |
| SP | F | CON | 83 | 165 | 76 0 | NONE |
| ER | F | EX | 83 | 142 | 55.3 | WALKER |
| HR | M | CON | 87 | 149 | 63 0 | WALKER |
| ES | F | CON | 82 | 162 | 58.0 | NONE |
| AS | F | EX | 79 | 153 | 76.0 | NONE |
| JS | F | CON | 74 | 170 | 98 0 | NONE |
| MS | F | EX | 82 | 157 | 51 9 | NONE |
| RS | F | EX | 89 | 152 | 52 8 | NONE |
| LW | F | EX | 90 | 158 | 64 5 | WALKER |

## Biodex Data - Eccentric

| Subject | Gender | Group | Age(yrs) | Average Power(W) Trial 1 | Average Power(W) Trial 2 | Peak Torque(Nm) Trial 1 | Peak Torque(Nm) Trial 2 |
|---|---|---|---|---|---|---|---|
| DA | F | EX | 84 | 41.0 | 65.7 | 61.6 | 85.3 |
| SB | M | EX | 90 | 12.4 | 16.9 | 79.9 | 64.7 |
| LB | M | EX | 85 | 48.7 | 54.7 | 125.3 | 136.0 |
| SB | F | EX | 81 | 41.6 | 48.7 | 50.2 | 62.0 |
| BB | M | EX | 91 | 37.9 | 40.3 | 103.6 | 100.1 |
| DC | F | CON | 76 | 53.6 | 41.7 | 58.4 | 40.3 |
| CE | M | EX | 87 | 76.4 | 90.9 | 59.1 | 80.8 |
| HE | F | EX | 80 | 66.3 | 70.8 | 73.9 | 60.5 |
| SE | F | CON | 81 | 96.3 | 101.1 | 110.8 | 107.4 |
| LG | F | EX | 94 | 12.9 | 16.8 | 98.4 | 104.0 |
| ML | F | CON | 75 | 24.5 | 20.9 | 87.5 | 69.2 |
| LL | F | EX | 88 | 18.0 | 30.1 | 58.4 | 69.8 |
| EL | F | EX | 85 | 38.0 | 19.1 | 56.4 | 60.9 |
| SL | M | EX | 76 | 28.1 | 101.9 | 72.3 | 132.5 |
| MM | F | EX | 81 | 55.4 | 58.2 | 67.1 | 51.9 |
| EM | F | EX | 83 | 83.2 | 67.5 | 66.0 | 68.5 |
| SP | F | CON | 83 | 45.5 | 37.8 | 88.1 | 91.9 |
| ER | F | EX | 83 | 3.7 | 34.6 | 25.8 | 75.7 |
| HR | M | CON | 87 | 19.7 | 6.1 | 55.7 | 64.7 |
| ES | F | CON | 82 | 103.3 | 77.9 | 72.3 | 66.4 |
| AS | F | EX | 79 | 67.6 | 65.9 | 50.2 | 87.1 |
| JS | F | CON | 74 | 41.1 | 43.4 | 61.6 | 57.3 |
| MS | F | EX | 82 | 27.3 | 79.6 | 55.3 | 77.4 |
| RS | F | EX | 89 | 38.8 | 57.9 | 56.4 | 78.8 |
| LW | F | EX | 90 | 70.2 | 42.5 | 65.4 | 78.8 |

## Biodex Data - Concentric

| Subject | Gender | Group | Age(yrs) | Average Power(W) Trial 1 | Average Power(W) Trial 2 | Peak Torque(Nm) Trial 1 | Peak Torque(Nm) Trial 2 |
|---|---|---|---|---|---|---|---|
| DA | F | EX | 84 | 43.2 | 58.2 | 29.6 | 58.2 |
| SB | M | EX | 90 | 40.3 | 45.6 | 39.6 | 46.1 |
| LB | M | EX | 85 | 85.7 | 111.1 | 58.2 | 67.4 |
| SB | F | EX | 81 | 32.2 | 28.5 | 21.6 | 24.7 |
| BB | M | EX | 91 | 66.7 | 76.6 | 47.7 | 49.2 |
| DC | F | CON | 76 | 27.1 | 29.3 | 22.6 | 20.9 |
| CE | M | EX | 87 | 40.5 | 43.0 | 30.2 | 35.8 |
| HE | F | EX | 80 | 23.3 | 38.3 | 19.3 | 25.8 |
| SE | F | CON | 81 | 50.8 | 51.5 | 41.0 | 37.8 |
| LG | F | EX | 94 | 44.1 | 46.1 | 35.8 | 34.0 |
| ML | F | CON | 75 | 67.3 | 43.8 | 43.7 | 35.9 |
| LL | F | EX | 88 | 9.5 | 26.0 | 15.1 | 22.4 |
| EL | F | EX | 85 | 15.8 | 23.4 | 23.3 | 24.7 |
| SL | M | EX | 76 | 44.0 | 53.6 | 43.3 | 53.3 |
| MM | F | EX | 81 | 4.2 | 14.9 | 15.1 | 21.6 |
| EM | F | EX | 83 | 21.9 | 41.4 | 18.8 | 27.5 |
| SP | F | CON | 83 | 69.1 | 70.9 | 50.9 | 50.4 |
| ER | F | EX | 83 | 7.8 | 14.7 | 14.4 | 17.9 |
| HR | M | CON | 87 | 0.1 | 0.6 | 6.5 | 3.7 |
| ES | F | CON | 82 | 34.1 | 35.5 | 32.7 | 33.0 |
| AS | F | EX | 79 | 29.3 | 64.5 | 28.5 | 41.0 |
| JS | F | CON | 74 | 42.9 | 40.8 | 35.8 | 28.8 |
| MS | F | EX | 82 | 45.6 | 59.9 | 34.3 | 34.0 |
| RS | F | EX | 89 | 40.9 | 46.5 | 29.2 | 27.5 |
| LW | F | EX | 90 | 23.5 | 41.7 | 25.4 | 33.0 |

## Functional Test Data

| Subject | Gender | Group | Age(yrs) | 8-ft up-and-go time(s) Trial 1 | 8-ft up-and-go time(s) Trial 2 | 30-s Chair Stand Trial 1 | 30-s Chair Stand Trial 2 | 6m Walk Time (s) Trial 1 | 6m Walk Time (s) Trial 2 |
|---|---|---|---|---|---|---|---|---|---|
| DA | F | EX | 84 | 9.59 | 7.22 | 15 | 17 | 6.06 | 4.63 |
| SB | M | EX | 90 | 18 00 | 11 32 | 4 | 10 | 12 12 | 4.09 |
| LB | M | EX | 85 | 13 25 | 9.31 | 12 | 10 | 7.50 | 4 06 |
| SB | F | EX | 81 | 16 53 | 9 53 | 6 | 9 | 7.39 | 5.44 |
| BB | M | EX | 91 | n/a | n/a | n/a | n/a | 23 00 | 16.66 |
| DC | F | CON | 76 | 8 72 | 11.46 | 8 | 8 | 5 68 | 5.81 |
| CE | M | EX | 87 | 27.68 | 22.12 | 7 | 11 | 14.69 | 9.10 |
| HE | F | EX | 80 | 18.47 | 11.09 | 6 | 10 | 8.90 | 4.94 |
| SE | F | CON | 81 | 10 16 | 8.75 | 10 | 11 | 5.69 | 5.25 |
| LG | F | EX | 94 | 18 07 | 17.62 | 6 | 9 | 14.44 | 7.81 |
| ML | F | CON | 75 | 7 63 | 7 98 | 13 | 12 | 4.38 | 6.19 |
| LL | F | EX | 88 | 30 75 | 12 84 | 3 | 13 | 11 28 | 6 22 |
| EL | F | EX | 85 | 27.03 | 13 29 | 4 | 7 | 10 82 | 7.83 |
| SL | M | EX | 76 | 23.53 | 21.63 | 5 | 6 | 11.22 | 10 22 |
| MM | F | EX | 81 | 18.38 | 16.78 | 4 | 7 | 8.69 | 7.00 |
| EM | F | EX | 83 | 19.31 | 11.44 | 7 | 10 | 7.65 | 5 12 |
| SP | F | CON | 83 | 10.85 | 9.84 | 7 | 8 | 5.19 | 5.03 |
| ER | F | EX | 83 | 38 60 | 30 28 | 4 | 7 | 21 46 | 16.75 |
| HR | M | CON | 87 | 1.01 | 59.16 | n/a | n/a | 23 56 | 17.85 |
| ES | F | CON | 82 | 9.60 | 9.65 | 15 | 14 | 6.81 | 5.50 |
| AS | F | EX | 79 | 17 25 | 8.47 | 8 | 15 | 9 34 | 4.91 |
| JS | F | CON | 74 | 7.00 | 7 45 | 12 | 10 | 4 22 | 4.34 |
| MS | F | EX | 82 | 13 46 | 7.66 | 9 | 12 | 7.25 | 4.06 |
| RS | F | EX | 89 | 19 81 | 11 22 | 8 | 11 | 9 78 | 4 90 |
| LW | F | EX | 90 | 31 85 | 22.31 | 8 | 6 | 10.79 | 7 06 |

# APPENDIX D:

ANOVA TABLES

| **Age**<br>1 = Group | | | | | | |
|---|---|---|---|---|---|---|
| **Effect** | **df Effect** | **MS Effect** | **df Error** | **MS Error** | **F** | **p-level** |
| 1 | 1 | 93.94794 | 23 | 22.32574 | 4 208055 | 0.05179 |

| **Height**<br>1 = Group | | | | | | |
|---|---|---|---|---|---|---|
| **Effect** | **df Effect** | **MS Effect** | **df Error** | **MS Error** | **F** | **p-level** |
| 1 | 1 | 28.95365 | 23 | 71.61767 | 0 404281 | 0 531163 |

| **Weight**<br>1 = Group | | | | | | |
|---|---|---|---|---|---|---|
| **Effect** | **df Effect** | **MS Effect** | **df Error** | **MS Error** | **F** | **p-level** |
| 1 | 1 | 436.8029 | 23 | 141.2103 | 3 093279 | 0.091916 |

**Eccentric Peak Torque**

1 = Group 2 = Trial

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 17.4853 | 23 | 843.3688 | 0.020733 | 0 886764 |
| 2 | 1 | 184.0815 | 23 | 172.6124 | 1.066444 | 0.312487 |
| 1x2 | 1 | 926.5935 | 23 | 172.6124 | 5.368058 | 0 029765* |

**Eccentric Average Power**

1 = Group 2 = Trial

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 0 1138 | 22 | 1179.382 | 0.000097 | 0 99225 |
| 2 | 1 | 73 3992 | 22 | 174.667 | 0 420224 | 0 523534 |
| 1x2 | 1 | 956 4025 | 22 | 174.667 | 5.475582 | 0.028762* |

**Concentric Peak Torque**

1 = Group 2 = Trial

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 7.9431 | 23 | 347.9702 | 0 02283 | 0.881225 |
| 2 | 1 | 25.2067 | 23 | 18.6749 | 1.34976 | 0.257235 |
| 1x2 | 1 | 234.5915 | 23 | 18.6749 | 12.56184 | 0.001731* |

**Concentric Average Power**

1 = Group 2 = Trial

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 389.0756 | 22 | 816 1826 | 0 4767 | 0.49714 |
| 2 | 1 | 170 9556 | 22 | 44 1544 | 3 87177 | 0.061838 |
| 1x2 | 1 | 520.9807 | 22 | 44.1544 | 11 79906 | 0 002365* |

Tukey HSD test

**Eccentric Peak Torque**

Interaction: 1(Group) x 2(Trial)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 68.07222 | 81.93333 | 76.34286 | 71.02857 |
| 1 | | 0.021026* | 0.504221 | 0.957099 |
| 2 | 0 021026* | | 0.775686 | 0.271063 |
| 3 | 0 504221 | 0.775686 | | 0 872933 |
| 4 | 0.957099 | 0.271063 | 0.872933 | |

Tukey HSD test

**Eccentric Average Power**

Interaction: 1(Group) x 2(Trial)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 44.92941 | 57.47059 | 54 85714 | 47 75714 |
| 1 | | 0.51179 | 0.361259 | 0.963558 |
| 2 | 0.51179 | | 0.970839 | 0 379896 |
| 3 | 0 361259 | 0.970839 | | 0.748202 |
| 4 | 0.963558 | 0.379896 | 0.748202 | |

Tukey HSD test

**Concentric Peak Torque**

Interaction: 1(Group) x 2(Trial)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 29.37778 | 35.78333 | 33.31429 | 30.07143 |
| 1 | | 0.001122* | 0.201261 | 0.983648 |
| 2 | 0 001122* | | 0 582787 | 0.032584* |
| 3 | 0.201261 | 0.582787 | | 0.509766 |
| 4 | 0 983648 | 0 032584* | 0 509766 | |

Tukey HSD test

**Concentric Average Power**

Interaction 1(Group) x 2(Trial)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 34 36666 | 46.33333 | 48 55 | 45 3 |
| 1 | | 0 000266* | 0 001020* | 0.010439* |
| 2 | 0.000266* | | 0.89306 | 0.987343 |
| 3 | 0 001020* | 0 89306 | | 0.831479 |
| 4 | 0.010439* | 0.987343 | 0.831479 | |

**8-ft Up-and-Go Timed Test**

1 = Group 2 = Trial

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 26 1104 | 22 | 237.8139 | 0.10979 | 0.743515 |
| 2 | 1 | 75.8105 | 22 | 8.469 | 8 95151 | 0.006719* |
| 1x2 | 1 | 127.7502 | 22 | 8 469 | 15.0844 | 0.000800* |

**30-second Chair Stand Test**

1 = Group 2 = Trial

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 45 09804 | 21 | 14 75724 | 3.055995 | 0.095046 |
| 2 | 1 | 17.92413 | 21 | 3 28105 | 5.462931 | 0.029406* |
| 1x2 | 1 | 27.31543 | 21 | 3.28105 | 8.325221 | 0.008854* |

**6m Walk Timed Test**

1 = Group 2 = Trial

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 103 9604 | 23 | 60.7135 | 1.71231 | 0.203612 |
| 2 | 1 | 10.9667 | 23 | 2.10144 | 5.21866 | 0.031900* |
| 1x2 | 1 | 64 1674 | 23 | 2.10144 | 30 53501 | 0 000013* |

Tukey HSD test
**8-ft Up-and-Go Timed Test**
Interaction: 1(Group) x 2(Trial)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 20.71471 | 14.36059 | 15.50286 | 16.32714 |
| 1 | | 0.000174* | 0.003337* | 0.014113* |
| 2 | 0.000174* | | 0.818200 | 0.451810 |
| 3 | 0.003337* | 0.818200 | | 0.950948 |
| 4 | 0.014113* | 0.451810 | 0.950948 | |

Tukey HSD test
**30-second Chair Stand Test**
Interaction: 1(Group) x 2(Trial)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 6.82353 | 10.00000 | 10.83333 | 10.50000 |
| 1 | | 0.000399* | 0.000847* | 0.001896* |
| 2 | 0.000399* | | 0.768374 | 0.936680 |
| 3 | 0.000847* | 0.768374 | | 0.988534 |
| 4 | 0.001896* | 0.936680 | 0.988534 | |

Tukey HSD test
**6m Walk Timed Test**
Interaction: 1(Group) x 2(Trial)

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | 11.234440 | 7.668334 | 11.922860 | 13.402860 |
| 1 | | 0.000164* | 0.713083 | 0.013560* |
| 2 | 0.000164* | | 0.000166* | 0.000163* |
| 3 | 0.713083 | 0.000166* | | 0.251700 |
| 4 | 0.013560* | 0.000163* | 0.251700 | |

**Eccentric Peak Torque Percentage**

1 = Group

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 6756.214 | 23 | 1924.371 | 3.51087 | 0.073729 |

**Eccentric Average Power Percentage**

1 = Group

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 18937 17 | 22 | 4130.041 | 4.585225 | 0 043578* |

**Concentric Peak Torque Percentage**

1 = Group

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 7653.989 | 23 | 516.8631 | 14 80854 | 0 000820* |

**Concentric Average Power Percentage**

1 = Group

| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
|---|---|---|---|---|---|---|
| 1 | 1 | 18208.04 | 22 | 3598.646 | 5 059692 | 0.034829* |

| 8-Foot Up-and-Go Timed Test Percentage | | | | | | |
|---|---|---|---|---|---|---|
| 1 = Group | | | | | | |
| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
| 1 | 1 | 5993 088 | 22 | 293.9871 | 20 38555 | 0.000171* |

| 30-second Chair Stand Test Percentage | | | | | | |
|---|---|---|---|---|---|---|
| 1 = Group | | | | | | |
| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
| 1 | 1 | 20085.95 | 21 | 4900.745 | 4.09855 | 0.055824 |

| 6m Walk Timed Test Percentage | | | | | | |
|---|---|---|---|---|---|---|
| 1 = Group | | | | | | |
| Effect | df Effect | MS Effect | df Error | MS Error | F | p-level |
| 1 | 1 | 7578.016 | 23 | 181.2604 | 41.80733 | 0.000001* |