THE EFFECTS OF A STRENGTHENING PROGRAM ON MUSCLE FUNCTION AND MOBILITY SKILLS IN AN ELDERLY INSTITUTIONALIZED POPULATION

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The Effects of Exercise on Strength and Mobilty in Elderly Men

ABSTRACT

The purpose of this study was to evaluate the effects of a high intensity strengthening program on both muscle function and mobility in an elderly, institutionalized population. Thirty male subjects were randomly assigned to a training group three times per week or to a control "attention" group. Dynamic and isometric strength of the quadriceps, shoulder extensors and elbow flexors were measured by the one repetition maximum (1RM) and a hand-held dynamometer (Nicholas Manual Muscle Tester), respectively. Mobility skills were evaluated with the timed "Up & Go" (TUG) test and by an average walking speed over 30 m. Following the 12 week intervention, post-training evaluations demonstrated significant differences between groups with improved 1RM of both quadriceps (47%), isometric strength of the right shoulder extensors (15%), TUG scores (39%) and average walking speeds (17%). In conclusion, high intensity strength training was found to be not only feasible in the reversal of muscle weakness but also as an effective strategy in attenuating the potential loss of mobility often observed in an elderly, institutionalized population.

RÉSUMÉ

Le but de cette étude était d'évaluer les effets d'un programme de renforcement intensif sur la mobilité d'une clientèle âgée hospitalisée. Trente sujets mâles ont été répartis au hasard dans deux groupes: le premier groupe a reçu un entraînement intensif (3 x semaine) et le deuxième que de l'attention. Les deux groupes ont été évalués avant et après l'intervention de 12 semaines. L'évaluation consistait à tester la force musculaire dynamique avec le "one repetition maximum" (1RM) et la force isométrique (Nicholas Manual Muscle Tester) des extenseurs des genoux, les extenseurs des épaules et les fléchisseurs des coudes, le "timed Up & Go" et la vitesse de marche sur 30 m. L'entraînement a augmenté significativement le 1RM des extenseurs des genoux (47%), la force isométrique de l' épaule droit (15%), le "timed Up & Go" (39%) et la vitesse de marche (17%). En conclusion, un programme de renforcement intensif est réalisable auprès d'une clientèle âgée hospitalisée et pourrait être une formule efficace pour atténuer leur perte d'autonomie potentielle.

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INTRODUCTION

There is little doubt that muscle strength declines with increasing age (Aniansson et al, 1986; Danneskiold-Samsoe et al, 1984; Larsson et al, 1979). Because aging is a complex phenomenon, this loss may be the result of the aging process per se (Grimby and Saltin, 1983), the effects of a sedentary lifestyle (Grimby, 1986) and the complications of underlying chronic disease (Jette et al, 1990) or any combination of these situations. Major limitations of physical function rise sharply with age (Verbrugge, 1984) and it may be the deterioration of some basic functional skill which precipitates the need for institutionalization among elderly people (Branch and Myers, 1987).

It is postulated that an increasing number of older people may be living at or just above the threshold of their physical capacities (Astrand, 1992; Young, 1986) and therefore, a loss of strength may become important from a clinical perspective. The present causal assumption is that a reduction in muscle strength may lead to mobility impairment (Schultz, 1992) and the eventual need for institutionalization (Branch and Myers, 1987; Jette and Branch, 1981). The ability to maintain an independent lifestyle may well depend on the maintenance of sufficient strength to perform activities of daily living (Lair and Lefkowitz, 1990).

Many rehabilitation programs designed for an elderly population focus on the improvement of functional skills through strengthening exercises. While it has been demonstrated that the capacity to improve muscle strength through exercise training is preserved into very old age (Fiatarone et al, 1990), the relationship between these gains in muscle strength and any improvement in performance of various activities of daily living is only beginning to be established in some objective manner (Guralnik et al, 1989).

It was the intent of this research study to determine the effects of a strengthening program on both the muscle strength and functional mobility in a group of institutionalized patients who suffer from chronic disability and mobility impairment. This was accomplished by recruiting 30 patients from a long term care in-patient facility. The subjects were randomly assigned to either a control "attention" group or a supervised exercise group that trained three times per week for a period of 12 weeks. Blind testing before and after training evaluated changes in muscle strength and changes in mobility function that may have occurred as a result of the training program. Mobility was assessed with performance-oriented instruments and strength was measured with the one repetition maximum (1 RM) and a hand-held dynamometer. By undertaking this type of research study, it may be determined whether the improvement in strength observed in an elderly population leads to an improvement in functional mobility.

CHAPTER 1

LITERATURE REVIEW

1.1 Age-Related Decline in Muscle Strength

One of the potentially debilitating processes that accompanies old age is a loss of muscle strength (Aniansson et al, 1986; Danneskiold-Samsoe et al, 1984; Larsson et al, 1979). Whereas this loss is well documented for an elderly population (Aniansson et al, 1980a, 1981, 1983, 1986; Danneskiold-Samsoe et al, 1984; Frontera et al, 1991; Larsson et al, 1979), it may be only partially explained by the intrinsic changes associated with the aging process (Campbell et al, 1973; Frontera et al, 1991; Grimby and Saltin, 1983; Reed et al, 1991). Other factors that may lead to this gradual age-related decline in strength include a decrease in physical activity level (Grimby, 1986), poor nutritional status (Evans, 1992), co-morbidity (Jette et al, 1990) and the aging process of other biological systems (Fiatarone et al, 1990; Lexell et al, 1988). The relative contribution of these mechanisms is not clearly understood (Brown et al, 1990) and it may be especially difficult to separate the effects of aging from those of disease and inactivity (Grimby, 1986). Furthermore, in a frail institutionalized elderly population, all of these factors may be commonly observed in the same individual, having a significant impact on the functional capabilities of that person.

1.1.1 Reduced Muscle Mass

The expression of voluntary strength is a function of the muscle's cross-sectional area (Larsson, 1982; Maughan et al, 1983; Young et al, 1985) and the individual's ability to adeqautely recruit muscle fibres at the appropriate firing rate (Vandervoort, 1992). This ability is dependent on the integrity of the central nervous system, specifically the motor pathways from the cerebral cortex. Motor drive in an elderly population has been assessed using the twitch interpolation technique (Belanger and McComas, 1981) and the evidence indicates that the ability to fully activate the muscle is retained in elderly subjects (Philips et al, 1992; Vandervoort and McComas 1986). Therefore, the decline in muscle strength that is associated with aging has been attributed mainly to a loss of muscle mass (Frontera et al, 1991; Overend et al, 1992; Reed et al, 1991). This process may be due to a decrease in the total number of fibres, (Aniansson et al, 1986; Grimby et al, 1984; Larsson et al, 1979; Lexell et al, 1988) and indeed, a decrease in the total number of type I and type II fibres has been reported in both human (Aniansson et al, 1986; Lexell et al, 1988; Tomonago, 1977) and animal studies (Caccia et al, 1979; Klitgaard et al, 1989; Larsson et al, 1991). While the etiology of muscle fibre loss remains unclear, it appears to be neurogenic in nature. Electrophysiological studies have reported a decline in the number of functioning motor units which may begin as early as 60 years of age (Brown, 1973; Campbell et al, 1973; Doherty et al, 1993; McComas et al. 1973; Vandervoort and McComas, 1986).

Initially, the accompanying muscle fibre denervation from motorneuron loss can be compensated by motorneuron sprouting and collateral reinnervation (Brown, 1973; McComas, 1977). This denervation/reinnervation process leads to fibre type grouping which has been observed in the aged muscle using biopsy technique (Aniansson et al, 1986) and autopsy examination (Lexell et al, 1988). Rearrangement of the motor unit pool has been observed in both animal (Kanda et al, 1986; Larsson et al, 1991) and human studies (Campbell et al, 1973; Vandervoort and McComas, 1986) and may provide an adaptive mechanism to maintain muscle mass despite substantial motor unit loss. However, the extent to which this sprouting counterbalances the neural deficits may also be limited by the aging process (Larsson et al, 1991; Pestronk et al, 1980). Animal studies, for example, have failed to demonstrate a substantial increase in the peripheral field following partial denervation of the 26 month old rat medial gastrocnemius (Einsiedal and Luff, 1992). The eventual loss of muscle fibre is permanent (Lexell et al, 1988) with muscle being replaced by non-muscle tissue such as fat and fibrous tissue (Borkan et al, 1983; Rice et al, 1990).

A reduction in fibre size also contributes to the decrease in muscle mass observed with the aging process (Frontera et al, 1991; Lexell et al, 1988). A preferential atrophy of type II fibres has been reported (Grimby et al, 1982; Larsson et al, 1979; Lexell et al, 1988) with some evidence for a predominant decrease in type IIb fibres (Aniansson et al, 1986). This atrophy may be associated with the adoption of a more sedentary lifestyle (Annianson et al, 1981; Grimby et al, 1982). For example, a greater amount of type II fibre atrophy has been observed in elderly subjects with a reduced activity level due to osteoarthritis of the hip, in comparison to age-matched controls (Sirca and Susec-Michiele, 1980). Also, selective atrophy of type II muscle fibres has been observed in a sedentary age-matched control group in comparison to elderly men with varied training backgrounds (Klitgaard et al, 1990).

Functionally, this preferential atrophy of type II fibres, observed with increasing age may lead to a greater force deficit with increasing speed of movement during concentric movements (Aniansson et al, 1986; Larsson et al, 1979). In fact, isokinetic concentric strength appears to be compromised to a greater extent than isometric strength, especially at the higher velocities (Aniansson et al, 1983; Borges, 1989; Klitgaard et al, 1990; Laforest et al, 1990; Larsson et al, 1979; Overend et al, 1992).

1.1.2 Time Course of Strength Losses

It has been observed that not all individuals age at the same rate and that age-related changes in strength differ depending on the muscle group, the site or the function under investigation (Aniansson et al, 1986; Frontera et al, 1991; Larsson et al, 1979). A variety of limb muscles have been compared between groups of young, middle-aged and old adults, showing that voluntary strength in men appears to peak at approximately 25 years of age, remain constant until the late 40's and then demonstrate an apparent decline at about 60 years of age (Aniansson et al, 1983; Danneskiold-Samsoe et al, 1984; Larsson et al, 1979). In women, this peak in muscle strength has been reported to appear sooner and to decline earlier than in men (Aniansson et al, 1983; Asmussen and Haeboll-Neilson, 1962), although differences in absolute strength between men and women, like age-related changes are usually diminished or even eliminated when corrected for height, weight and lean body weight (Frontera et al, 1991; Laforest et al, 1990). Healthy adults aged 70-80 years have demonstrated 20-40% decrements in strength when compared to younger aged groups (Klitgaard et al, 1990; Lexell et al, 1988; McDonaugh and Davies, 1984; Young et al, 1984, 1985) and the very old, aged 90-100 years, have shown an even greater (50% or more) reduction in strength (Murray et al, 1980; Vandervoort and McComas, 1986). While these studies have examined strength in the older subject under either isometric or dynamic concentric conditions, there are very few studies that have evaluated the muscle's capability under eccentric loading (Poulin et al, 1992; Vandervoort et al, 1990a). Results of these studies suggest that eccentric strength may be less affected by age in both men (Poulin et al, 1992) and women (Vandervoort et al, 1990b).

There have been many reports of differential loss of strength between upper and lower extremities in old age (Aniansson et al, 1986; Danneskiold-Samsoe et al, 1984; Frontera et al, 1991; Lundgren-Linquist et al, 1983). Between the ages of 30 and 80 years, upper extremity muscle strength may decrease an average of 30%, while in the lower extremity this decline may average 40% (Aniansson et al, 1986; Grimby et al, 1982; Larsson et al, 1979). It has been suggested that there may be an inherent difference in the aging process between muscle groups (Grimby et al, 1982). However, a more reasonable explanation may be the differences in physical activity patterns between the upper and lower extremity (Aniansson et al, 1986; Grimby and Saltin, 1983). The activities of daily living accomplished by the upper extremity muscles may involve patterns that result in the more frequent recruitment and activation of type II motor units (Grimby et al, 1982). In contrast, the adoption of a more sedentary lifestyle (car versus walking or taking the elevator versus stair-climbing) may result in non-optimal usage of type II motor units in the lower extremity with subsequent morphological changes in the muscle fibres (Aniansson et al, 1986; Grimby, 1986). In support of this, there is evidence of a slower rate of decline in muscle mass in the upper extremity (Frontera et al, 1991) and a more pronounced reduction in type II fibre area in the lower extremity (Aniansson et al, 1986).

1.1.3 Clinical Implications of Strength Loss

The impact of these quantitative changes in muscle mass for the elderly individual may be a reduction in strength which may be more pronounced as the speed of movement increases. Because of this strength loss, activities of daily living such as walking at sufficient speed to cross an intersection safely or rising from a chair without arm support may become more difficult for the elderly individual (Grimby, 1986; Young, 1986). This may eventually compromise the functional independence of that individual.

1.2 Muscle Strength and its Relationship to Functional Mobility

Mobility problems may be the first symptom of declining muscle strength in an elderly population. At least 56% of nursing home residents over the age of 65 years required assistance in walking with this number increasing to 69% for those residents over the age of 80 years (Lair and Lefkowitz, 1990). In addition, 83% of these older residents needed personal assistance with one or more activities of daily living. The loss of strength in the elderly patient becomes important from the clinical perspective as muscle strength is an essential component required for the safe and adequate performance of various functional activities (Aniansson et al, 1980b; Grimby and Saltin, 1983; Judge et al, 1993; Young, 1986).

The "threshold model" (Young, 1986) emphasizes that the safety margin between the maximum force-generating capacity of the individual and the threshold value for the muscles subserving various activities of daily living may narrow with increasing age. For example, in a recent study (Judge et al, 1993), the nature of the relationship between lower extremity strength and average walking speed supported this concept with evidence of a critical lower extremity strength value to maintain an acceptable gait velocity. This threshold may be imperceptible to the healthy older person who may manage to cope reasonably well with the age-related decline in strength (Vandervoort et al, 1986). However, crucial values may be reached sooner or even exceeded when strength loss is exacerbated by an acute illness, stress or an extended period of bedrest which may then make it impossible for the older person to function independently (Young, 1986). A deterioration in functional status may, therefore, be measured in terms of the performance of certain activities of daily living (Schultz, 1992).

Studies investigating the relationship between muscle strength, especially in the lower extremity and performance of common activities of daily living remain scant (Young, 1986). Further biomechanical studies have been recommended to establish strength requirements for adequate performance of everyday functional activities in order to relate these requirements to the strength capacities in the elderly adult (Schultz, 1992). Rising from a chair (Ikeda et al, 1991) and adequate walking speed (Judge et al,1993), for example, are prerequisites to many other activities of daily living.

1.2.1 Sit-to-Stand Manoeuvre

It has been suggested that the sit-to-stand manoeuvre may be a valid functional test of quadriceps strength (Aniansson et al, 1980b; Csuka and McCarty, 1985). Kinematic studies have demonstrated that the average time taken to rise from a chair is 1.56 seconds for a group of young subjects compared to 1.83 seconds for a group of 72 year old healthy, community-dwelling subjects (Alexander et al, 1991). Beyond this age, there appears to be a more rapid and significant increase in the time needed to rise from a chair, (Alexander et al, 1991; Ikeda et al, 1991; Fiatarone et al, 1990). There is even evidence that a critical time of over 2 seconds may provide a clinical correlate to increased risk of falls in ambulatory, frail elderly people (Nevitt et al, 1989). In a recent study of institutionalized, frail elderly patients (Bassey et al, 1992), the average time taken to rise from a chair was 1.75 seconds; however, less than half of the subjects were able to rise independently, the others needing to use an alternate strategy involving the upper extremity while one subject was unable to rise unaided. As a result of this variation in performance, the range of chair rise speeds was found to be between 1.2 seconds and 3.6 seconds with significantly slower performance by those who used the arms of the chair as an alternate strategy.

The average time taken to rise from a chair has been found to be inversely related ($r = -0.65$, $p < 0.05$) to quadriceps strength (Fiatarone et al, 1990; Bassey et al, 1992). The rate of decline in the "timed-stand" test (the average time needed to rise from a chair 10 times) was also found to be comparable to the rate of decline in lower extremity strength associated with the aging process (Csuka and McCarty, 1985). This evidence may indicate that the timing of a performance-oriented test may be an important functional index to demonstrate a relationship between lower extremity strength and a particular mobility task.

1.2.2 Average Walking Speed

Normal gait requires adequate muscle strength in addition to neuromuscular control and available lower extremity range of motion. A decline in average walking speed may be a sign of deterioration in one or more of these parameters (Judge et al, 1993). Average walking speed in meters per second (m/s) has been reported to decrease with increasing age (Aniansson et al, 1980b; Danneskiold-Samsoe et al, 1984; Lundgren-Linquist et al, 1983) and because of the strong association between walking speed and level of mobility in the elderly population (Imms and Edholm, 1981), it may have an important functional impact on the mobility of elderly individuals.

A normative value of between 1.2 and 1.4 m/s has been established as the average speed required to cross signalized, urban crosswalks (Aniansson et al, 1980b; Hoxie and Rubenstein, 1994; Robinett and Vondran, 1988). A group of 70 year old men and women were found to have average walking speeds of 1.2 m/s and 1.1 m/s, respectively (Aniansson et al, 1980b). This evidence was in agreement with earlier work done to describe the walking patterns of healthy older men (Murray et al, 1969). A recent study (Ferrandez et al, 1990) was undertaken to better comprehend the slowing of elderly gait in relation to other kinematic gait variables. The results demonstrated that by age 65, subjects showed a characteristic lowering of gait velocity (1 m/s), with further slowness occurring after ages 75 and 85 years (.82m/s and .6m/s, respectively). It must be emphasized that these average walking speeds have been established based on data using groups of healthy, older subjects who were not affected by any mobility impairment. Among older groups of subjects with mobility problems further declines in average walking speeds have been demonstrated (Fiatarone et al, 1990; Leiper and Craik, 1991; Lipsitz et al, 1991; Wolfson et al, 1990). In addition, in the frail elderly population who may rely on some type of walking aid for ambulation, the average walking speeds have been reported to be considerably below these norms, varying from 0.1 m/s to 0.64 m/s (Bassey et al, 1992; Podsiadlo and Richardson, 1991).

Walking speed over a distance of 30 meters was found to be related ($r = 0.40-0.45$, $p < 0.05$) to isokinetic quadriceps strength at velocities of 30, 60 and 120°/s in a group of 70 year old healthy subjects (Aniansson et al, 1980b). A significant inverse correlation ($r = -0.60 - 0.75$) between the time taken to walk 6 meters and quadriceps strength, measured by the 1 repetition maximum (1 RM) has been reported in a group of 90 year old frail institutionalized subjects (Fiatarone et al, 1990). Further support of a significant relationship ($r = 0.5 - 0.6$, $p < .01$) was provided in a recent study of the effects of exercise on gait velocity in the older adult (Judge et al, 1993).

1.2.3 Stair Climbing

Another mobility task that requires adequate quadriceps strength is stair-climbing (Aniansson et al, 1980b; Dannsekiold-Samsoe et al, 1984). A positive correlation ($r = 0.62$, $p < 0.05$) was found between step height and dynamic strength at 60°/s in a group of 78-81 year old subjects (Danneskiold-Samsoe et al, 1984). This evidence is in agreement with an earlier report of a positive correlation ($r = 0.59 - 0.79$, $p < 0.01 - 0.001$) between step height and both dynamic and isometric quadriceps strength in a group of 70 year old subjects (Aniansson et al, 1980b). More recently, a positive correlation ($r = 0.81$, $p < .001$) has been demonstrated between stair-climbing and triple extension of the lower extremity, a movement which includes knee extension (Bassey et al, 1992).

1.2.4 Relationships Between Mobility Functions

Significant relationships between walking speed and ability to rise from a chair (Friedman et al, 1988) as well as walking speed and maximum step height (Aniansson et al, 1980b) have also been observed in groups of older subjects indicating the interdependent and/or predictive nature of mobility tasks. Following the rehabilitation of one group of older subjects, walking speed was found to be a good predictor of discharge potential and thus independent mobility (Friedman et al, 1988). Deterioration of mobility functions has also been found to be a good indicator of "at-risk" behaviours, such as falls, in the elderly population (Lipsitz et al, 1991; Tinetti and Ginter, 1988; Topper, 1993; Vandervoort et al, 1990a). The evaluation of several mobility functions such as rising from a chair and walking have been included in several screening tools used to identify these behaviours (Nevitt et al, 1989; Winograd et al,1991; Wolfson et al, 1990).

Many rehabilitation programs are designed for elderly individuals with mobility impairment. One of the primary goals of exercise interventions in an elderly population is to maintain adequate performance of activities of daily living and functional skills such as rising from a chair, walking or stair-climbing. Strengthening the muscles that are implicated in these functional activities may be an appropriate strategy to improve performance in essential activities of daily living (Fiatarone et al, 1990).

1.3 Strength Training and Adaptive Capacity of Elderly Adults

Increasing attention has been given to the role of exercise in an elderly population (Larson, 1991). In the past, studies on the effects of exercise training in this population have concentrated on the physiological changes associated with strength gains (Brown et al, 1990; Frontera et al, 1988; Moritani and deVries, 1980). Considerable variation in the intensity of the exercise stimulus (Agre et al, 1988; Aniansson et al, 1984; Brown et al, 1990; Fiatarone et al, 1990; Frontera et al, 1988; Larsson, 1982; Moritani and deVries, 1980; Morey et al, 1991), the length of the training period (Aniansson and Gustafsson, 1981; Buchner et al, 1993; Frontera et al, 1988; Pyka et al, 1994) and the measurement techniques utilized (Buchner, 1993; Lexell et al, 1992; Roman et al, 1993) have made comparison among studies difficult. Furthermore, there has been some reluctance on the part of physiotherapists to use a high intensity approach to training that is so often used in a younger population because of the apparent risks that may be involved with this type of program (Shepherd, 1990), the multiple chronic medical problems of the elderly patient (Jette et al, 1990) and the close supervision that may be required for this population (Morey et al, 1991). Several studies have now demonstrated that muscle strength can be dramatically improved using a high resistance, low repetition approach to training (Brown et al, 1990; Charette et al, 1991; Fiatarone et al, 1990; Frontera et al 1988, 1990; Lexell et al, 1992; Rice et al, 1993), without any serious or deleterious side effects to the participant (Brown et al, 1990; Fiatarone et al, 1990; Frontera et al, 1988, 1990; Nichols et al, 1993; Pyka et al, 1994).

1.3.1 Mechanisms of Strength Gains in the Elderly

The mechanisms involved in strength gains in the elderly remain unclear (Frontera et al, 1988; Larsson, 1982; Lexell et al, 1992; Moritani and devries, 1980). It is speculated that the underlying processes which could account for the training induced augmentation in dynamic muscle strength observed in an elderly population are: 1) intrinsic morphological changes, ie. muscle fibre hypertrophy, and/or 2) changes in neural activation, specifically improvement in neuromuscular co-ordination.

1.3.2 Muscle Hypertrophy Versus Neural Adaptation

While early training studies demonstrated significant increases in muscle strength in an elderly population, (Aniansson and Gustafsson, 1981; Moritani and deVries, 1980) the lack of sufficient evidence of changes in muscle morphology (Larsson, 1982; Moritani and deVries, 1980) supported the hypothesis that improved neural adaptation was the main physiological basis for these strength gains. One explanation of this may be that traditional single site muscle biopsy (Lexell et al, 1988) or anthropometric methods (Moritani and devries, 1980) that were previously employed may have underestimated the potential for hypertrophy in the elderly muscle. In addition, the level of training intensity may play a pivotal role (Brown et al, 1990; Charette et al, 1991; Fiatarone et al, 1990; Frontera et al, 1988; Pyka et al, 1994). However, with the introduction of the more sensitive computed tomography (CT) technique and the more frequent use of a high intensity training approach, significant increases in muscle mass have been observed (Brown et al, 1990: Fiatarone et al, 1990; Frontera et al, 1988; Rice et al, 1990). While these studies have demonstrated significant increases in muscle mass in the order of 12% - 20%, accompanied by a pattern of either type I and type II muscle fibre hypertrophy (Charette et al, 1991; Frontera et al, 1988; Pyka et al, 1994) or type II hypertrophy alone (Brown et al, 1990) they failed to demonstrate a proportional change in both strength and muscle size. It would appear, that both muscle hypertrophy and more efficient neuromuscular activity may be important factors in the training-induced strength gains in an elderly population, however the relative contribution of each still needs to be ascertained.

1.3.3 Specificity of Training and Exercise Design

While the safety and efficacy of strength training programs have been demonstrated in older groups of subjects (Agre et al, 1988; Brown et al, 1990, Charette et al, 1991 Frontera et al, 1988, 1990; Pyka et al, 1994; Thompson et al 1988), including a group of very old institutionalized patients (Fiatarone et al, 1990), the reported increases in muscle strength have varied from a few percent to 200% (Fiatarone et al, 1990; Frontera et al, 1988; Thompson et al, 1988). In young subjects, greater gains in strength are usually observed when the testing mode closely resembles the training mode (Sale and MacDougall, 1981). Whether or not strength training specificity also occurs in elderly individuals has not been studied to any great extent and there are arguments both for (Brown et al, 1990; Fiatarone et al, 1990; Frontera et al, 1990) and against (Connelly and Vandervoort, in press; Rice et al, 1993) response specificity. Indeed, significant strength gains of between 48% and 107% of the 1 RM have been documented using high resistance (75-80% of the 1 RM) and low repetition (8-10 reps) as the training stimulus (Brown et al, 1990; Frontera et al, 1988), with either no or minimal gains in isometric or isokinetic strength. In contrast, significant improvement in both dynamic and isometric strength have been reported in the knee extensors following moderate intensity training (Connelly and Vandervoort, in press) and in the elbow extensors following high-intensity training (Rice et al, 1993). While there may not be a consensus concerning the extent of specificity of response in the elderly, the design of exercise programs should utilize the overload principle in addition to exercises that simulate the daily tasks that are required to maintain functional independence in an elderly population.

1.4 Performance-Oriented Outcome Measures

The recent emphasis on the feasibility of strengthening programs in an elderly, institutionalized population has led to the assumption that strength gains may translate into improved functional performance (Brown et al, 1990; Fiatarone et al, 1990; Fisher et al, 1991). Yet, the focus of these studies remained on the effects of exercise in the reversal of muscle weakness (Fiatarone et al, 1990; Fisher et al, 1991) and the exploration of the underlying physiological mechanisms (Brown et al, 1990; Frontera et al, 1988; Moritani and deVries, 1980). To a lesser extent, the clinical consequences of strengthening have been considered, but they have been usually presented in a descriptive or anecdotal manner (Tinetti, 1986). Traditional evaluation tools often rely on the observer's perception of the performance which may make it difficult to establish a relationship between strength and functional mobility. In one particular study, the performance testing of mobility tasks provided important clinical information which was not detected by standard neuromuscular examination alone. (Tinetti and Ginter, 1988). It has been suggested that one way to assess the physical function in an elderly population may be the use of a performance-oriented evaluation (Guralnik et al, 1989). In this way, actual performance of the functional task is either timed (Podsiadlo and Richardson, 1991) or compared to some pre-determined criteria (Nevitt et al, 1989). This approach to evaluation may provide the necessary data to facilitate the demonstration of a correlation between changes in muscle function and functional performance in an elderly population.

CHAPTER 2

DEVELOPMENT OF THE STUDY

2.1 Rationale

Exercise programs are among the therapeutic interventions advocated to address the functional mobility problems encountered by an aging population. While the feasibility of improving strength through training has been documented, the assessment of improved functional skills has been empirical and therefore requires more direct evidence to support the hypothesis that improved strength relates to improved function. The results of this study may demonstrate that the use of performance-oriented instruments aid in evaluating the effectiveness of strength training in terms of functional outcomes. By determining the relationship between strength and function, the clinician may be able to plan and provide effective treatment programs that may assist in preventing the further deleterious effects caused by the mobility problems of an aging population.

2.2 Objectives

The overall objective of this study was to determine the <u>effectiveness</u> of a high intensity, individualized exercise program for the lower extremities on both strength and functional mobility in a group of elderly, institutionalized subjects who suffer from physical disability. Particular attention was given to the high intensity aspect of the training protocol, although task-specific exercises were also included. This combination was designed to reinforce the concept that any gains in strength as a result of the training protocol would also transfer to improvement in functional mobility.

2.3 Clinical Setting

The study was carried out over a 1 year period and took place in the Physiotherapy Department of Ste Anne's Hospital. This is a 700-bed long-term care facility administered by the Government of Canada's Department of Veteran's Affairs and is located in the West Island of Montreal. The population is approximately 95% male, who suffer from chronic disabilities requiring skilled nursing care as well as medical and paramedical services.

2.4 Study Population

Subjects were drawn as a sample of convenience from the in-patient population of the hospital. Following the initial computerized screening process, it was determined that there were 90 potential subjects among the patient population. This excluded any and all patients on the basis of the age criteria (70 years and under), the diagnostic category (Parkinson's disease or Cerebral Vascular Accident with sequela causing physical disability) or participation in lower extremity strength training of any intensity within the past year. The average age of this population was 81.7 ± 5.6 years (range 73-98 years). All potential subjects were then screened by the investigator on their nursing units using the screening tool developed for this study (Appendix A). This further excluded patients with any unstable medical conditions which may have precluded their participation in an exercise program. Patients who were included had to be independent in ambulation with or without a walking aid, over a distance of 40 meters and walked with an average speed of <0.90 m/s. This criteria was the main source of the large number of patients who were excluded, as many of the 90 potential subjects were bedridden. Subjects scored 20 seconds or higher on the Timed "Up & Go" (TUG) test, indicating that there was some degree of mobility impairment (Podsiadlo and Richardson, 1991). They also had 90° of available range of motion (ROM) at both knees. All subjects were able to follow three step commands and could participate in an individualized exercise program conducted in a group environment. Baseline characteristics, including age, height and weight were also collected in order to provide a profile for group comparison. All subjects received medical clearance by their attending physician who approved their participation in the study. If the subject agreed to participate in the study both verbal and written informed consent were obtained (Appendix B and C).

2.5 Research Design

The study consisted of a two-way, between subjects design. Subjects who met the inclusion/exclusion criteria, received medical clearance and agreed to participate in the study were stratified according to the use of a walking aid and randomly assigned to the experimental or control group. This was performed by a person independent to the study using a systematic block randomization scheme. There were two independent variables: the individualized exercise program and time and four dependent variables: dynamic strength, isometric strength, the TUG score and the average walking speed.

The primary outcome measurements included dynamic strength of the lower extremity and the TUG score. Greater strength gains were expected dynamically rather than isometrically due to the specificity of the muscle training stimulus and the inclusion of task-specific exercises which used the quadriceps in both a functional and dynamic mode. Specificity of training response has been observed in both young (Rutherford and Jones, 1986; Sale and MacDougall, 1981) and old populations (Brown et al, 1990; Fiatarone et al, 1990; Frontera et al, 1988). Since the main focus of the exercise protocol was placed on the dynamic training of the quadriceps, isometric strength was considered as a secondary outcome measure. The data concerning the possible differences between dynamic and isometric strength gains were used to further delineate the role of specificity in strength training in an elderly population. The TUG test combines the mobility tasks of rising from a chair and walking. Both of these skills are related to the dynamic strength of the quadriceps (Aniansson et al, 1980b; Fiatarone et al, 1990; Csuka and McCarty, 1985). As quadriceps strength was more strongly related to rising from a chair than to walking ($r = -0.65$ versus $r = 0.40$-0.45), the TUG was considered a primary outcome while average walking was considered as a secondary one.

When lower extremity strength is compromised in an elderly person the upper extremity may be used as an alternate strategy for the performance of certain activities of daily living such as rising from a chair and the use of a walking aid (Alexander et al, 1991). Therefore, in addition to evaluating strength gains in the lower extremity, it was felt to be important to investigate strength gains in the upper extremity for possible effects on functional performance. Thus, upper extremity strength was considered as a secondary outcome.

2.6 Determination of Sample Size

Pre-trial data was collected for a sub-sample of 10 subjects (Appendix D). This data established the mean and standard deviation values for the primary and secondary outcome variables. As well the expected clinically important differences were calculated from the training results of two subjects. With an alpha level of 0.05 and a beta level of 0.20, corresponding to a power (1-ß) of 0.80, the following formula was used to estimate the total number of subjects required for this study:

$$N = 4(z\,\alpha + z\,\beta \times \text{standard deviation/difference})2$$

where $z\,\alpha = 1.96$

$z\,\beta = 0.84$

standard deviation =value of the source population standard deviation

difference = the expected clinically important difference

A total sample size of 30 subjects was determined based on the following criteria obtained from the pre-trial data collection:

Timed "Up and Go": A total sample of 24 subjects would be needed, based on a standard deviation of ± 8.48 seconds, previous clinical experience and reported results of changes in the score following intervention (Podsiadlo and Richardson, 1991). An expected clinically important difference would be demonstrated by a decrease in score of 10 seconds.

Dynamic Strength: A total sample of 22 subjects would be needed, based on a standard deviation of ± 3.55 kg and an expected clinically important difference of 4.25 kg improvement in strength as measured by the 1 RM, previous clinical experience and pilot data collected prior to the study.

Average Walking Speed: A total sample of 24 subjects would be needed, based on a standard deviation of ± 0.19 seconds, and previous clinical experience with the same type of source population. An expected clinically important difference would be demonstrated by an improvement in the average walking speed by 0.22 m/s.

However, a drop-out rate had to also be considered as an important factor in this population due to the advanced age, chronic disability and co-morbidity presented by most of the subjects. In a similar type of exercise group in the same clinical setting, the drop-out rate over a 4 month attendance period had been calculated at 28%. This is in agreement with two previous clinical studies (Fisher et al, 1991; Morey et al, 1989) which reported a drop-out rate of between 22% and 26%. The impact of this factor necessitated the addition of four to six subjects to the sample.

CHAPTER 3

METHODS AND PROCEDURES

3.1 Data collection

Prior to the start of the intervention phase of the study, both groups of subjects were evaluated by a single evaluator, who was a licenced physiotherapist and external to the study. Pre-study training in the appropriate application of the evaluation procedures was received by the evalautor. This training was conducted by the investigator and also provided the necessary basis to establish the interrater and test-retest reliability of the evaluation procedures. In order to maintain objectivity, the evaluator was blinded to the study.

The total evaluation time was approximately $1^1/2$ hours and was conducted over three sessions. This separated the evaluation of dynamic and isometric strength into two sessions with all functionally-oriented tests performed during the third session. This was felt to control for muscle fatigue which may have occurred upon subsequent testing of both strength variables. The approximate time of day for testing was maintained during all three sessions.

3.1.1 Muscle Strength

In both subject groups, the strength of the knee extensors, elbow flexors and shoulder extensors was evaluated before and after the training intervention. Dynamic strength measurements were obtained by the one repetition maximum (1 RM) technique and isometric strength by a hand-held dynamometer.

The 1 RM is a clinical measurement which determines the magnitude of the load that can be successfully lifted through one full ROM with proper technique and acceptable form (McDonaugh and Davies, 1984). This means that the exercise is performed primarily by the specified muscle group, without limb or body momentum or any substantial changes in body position that are otherwise required to lift a weight. These measurements were obtained for the lower extremity using a quads table (N-K Table, The N-K Line, California) and for the upper extremity using a system of wall-mounted weighted pulleys (Cardon Inc.). The 1 RM was established using a protocol developed by the evaluator and investigator during the pre-trial reliability phase of the study. The initial load was selected for each muscle group to achieve the maximum within four to five attempts. The starting weight was based on clinical experience with this patient population. Subjects performed one to two lifts without weight to familiarize them to the task and to warm up. Minimal resistance was then added to determine acceptable performance of the lift. For the lower extremity this also established the point of maximum knee extension that the subject was able to perform with minimum resistance. For the quadriceps, the minimum load was set at 2.2 kg, whereas, for the upper extremity groups the minimum was 1 kg. Resistance was then increased based on the subject's perceived difficulty and the evaluator's observation of the ability to maintain acceptable form, until the subject could not complete a lift (failure). Thirty to 60 seconds (s) rests were given between lifts. Each lift was performed slowly and was held at the end of the range of movement for 3 s. While the protocol goal was to reach the 1 RM in four to five attempts, on occasion six to seven lifts were required before a failure occurred. Verbal encouragement was given to the subject during each lift. This protocol established both the pre-intervention baseline strength level for all subjects and set the initial training load for the experimental group.

Strength (1RM) measurements for lower extremity were performed in the sitting position, with the back well supported by a wedge-shaped foam cushion. Testing of the knee extensors, both the hip and knee were positioned at 90° flexion. For all the upper extremity groups, the subject sat in a straight-backed chair facing the testing apparatus. For the shoulder extensors, the shoulder was positioned at 90° of forward flexion with the elbow held in full extension and the forearm pronated. For the elbow, the arm was held at the side of the body, the elbow was in full extension and the forearm was supinated. These testing positions simulated the training positions and were easily maintained by the subjects.

The 1 RM procedure has recently been used to determine quadriceps strength in a frail, institutionalized population (Fiatarone et al, 1990) and to evaluate elbow flexor strength in a group of 60-70 year old men (Brown et al, 1990). It was reported to be tolerated in both groups. Although this is a well recognized method of evaluating dynamic strength there was little information in the literature regarding the interrater and test-retest reliability. These were established for this study during the pre-trial training period of the evaluator.

A hand-held dynamometer (Nicholas Manual Muscle Tester - Model 01160) using a "break test" technique was used to measure isometric strength. This method required the examiner to push against a statically-held contraction of the muscle group for 3-5 s until the maximum muscular effort of the subject is overcome (Bohannon, 1988). The test-retest reliability has been reported in an elderly population for different muscle groups (elbow flexors r = 0.99, shoulder extensors r = 0.97 - 0.99 and knee extensors r = 0.97 - 0.98) (Bohannon, 1986). Interrater reliability has been investigated to a lesser extent (Agre et al, 1987).

Isometric strength measurements for lower extremity were performed in the sitting position, with the back supported by a wedge-shaped foam cushion and both the hip and knee positioned at 90° flexion. This testing position simulated the training position and was easily maintained by this patient population. For the shoulder extensors and elbow flexors, the subject was positioned in supine on a high treatment table. While this position did not simulate the training position as in the lower extremity, it did control for the extraneous joint and trunk movements as well as the various muscle substitution attempts on behalf on the subjects. This had been an uncontrollable problem during the pre-trial training of the evaluator, when the seated position for testing of the upper extremity was used. For the testing of the shoulder extensors, the shoulder was maintained at 90° of shoulder flexion with the elbow fully extended and the forearm pronated. In the testing of the elbow flexors, the upper arm was held by the body, the elbow was positioned at 90° of flexion and the forearm was held in the neutral position. The arm was stabilized against the trunk by the evaluator when necessary.

3.1.2 Mobility Function

The timed "Up and Go" (TUG) test (Podsiadlo and Richardson, 1991) is a modification of an earlier version of the "Get-Up and Go" test (Mathias et al, 1986). Timing was felt to improve the performance-oriented aspect of this tool. The subject wore usual footwear and used whatever walking aid was customary. No physical assistance was given by the examiner during the testing procedure. The subject's back was in contact with the back of a straight-back chair and the arms were resting on the arm rests of the chair. The height of the seat of the chair was 46 centimeters (cm) and the height of the armrests was 63 cm. Upon the command "go", the subject got up, walked 3 meters (m) at a comfortable and safe pace to an "X" marked on the floor in red tape, turned and walked back to the chair and sat down. The subject was given one practice trial to become familiar with the task and to overcome any learning effect. The second performance was subsequently timed using a stop-watch to the nearest 100^{th} of a second. The interrater reliability of the timed "Up and Go" test has demonstrated an intraclass correlation co-efficient (ICC) of 0.99 and intrarater reliability ICC of 0.99, in previous testing (Podsiadlo and Richardson, 1991). In addition, validity has been demonstrated by significant correlations between the timed test score and the log-transformed scores of the Berg Balance Scale (r = -0.81), the Barthel Index of Activities of Daily Living (ADL) (r = -0.78) and gait speed (r = -0.61) (Podsiadlo and Richardson, 1991).

Habitual walking speed is a timed performance-oriented outcome measure of a person's comfortable walking speed. It was performed over 40 m, with the first 5 m as a warm-up and the last 5 m as a deceleration period. Only the middle 30 m were timed and the subject was unaware of the exact commencement of the timing process. All subjects used their usual walking aid. While this method has been used by several authors (Aniansson et al, 1980b; Danneskiold-Samsoe et al, 1984; Lundgren-Linquist et al, 1983), there are no reports of the interrater and test-retest reliability of this measurement. Reliability was calculated for this study during the pre-trial training of the evaluator.

Both mobility measurements were timed to the nearest 100^{th} of a s using the chrono mode of a Timex Quartz Ironman watch.

3.2 Treatment Procedure

The experimental group participated in a supervised individual program of exercises (Appendix E), three days per week, for 12 weeks. This 12 week protocol allowed for the traditional one day rest between exercise sessions (Fleck and Kraemer, 1987). The duration of training was based on reported results (Brown et al, 1990, Charette et al, 1991; Fiatarone et al, 1990; Frontera et al, 1988; Lexell et al, 1992) which suggested that the greatest strength gains in an elderly population appear to occur during the initial 8 - 12 weeks of training with the rate of improvement demonstrating only a slight trend for improvement between 15th and 52nd week of training (Pyka et al, 1994).

All training sessions were conducted under the supervision of the investigator, who was a licensed physiotherapist, in order to ensure proper technique and decrease the risk of injury. In order to provide adequate supervision, no more than three to four subjects exercised at any given time. Each session lasted approximately 30-45 minutes. There was a warm up period of 5 minutes on a stationary bike with no resistance.

The strength program was designed to utilize a high resistance, low repetition training stimulus that was incorporated into a routine of functionally-oriented exercises. The intensity of the training was set at 80% of the 1 RM and three sets of 8 -10 repetitions were performed with several (2-3) minutes rest between sets. The weight resistance for all exercises was adjusted and progressed according to the subject's response. This occurred when the subject easily completed all three sets to the maximum of 10 repetitions. This schedule was well-tolerated by all subjects with no reported complaints of muscle discomfort or observed joint effusion. The functionally-oriented exercises were designed to simulate the strength-requiring tasks likely to be encountered in daily life by the institutionalized elderly population and therefore the main focus was placed on the lower extremity. For example, rising from various chair heights were repeated to a maximum of 10 times and stair-climbing using a graded step height was integrated into the exercise routine. Exercises for the upper extremity were also included as the use of the upper extremities has been reported as an alternate strategy used by the elderly population for rising from a chair, in the absence of adequate lower extremity strength (Alexander et al, 1991). As well, adequate upper extremity strength would be required by those subjects using a walker for ambulation.

The control group received attention the 12 weeks of the training period. This consisted of an organized activity such as cribbage which does not involve upper or lower extremity strength or friendly visits with a focus on discussion of current events. In the case of three subjects, the conservative management of pain using hot pack treatments were transferred to the investigator in order to provide the "attention" stimulus. This approach was felt to ensure that any changes in the outcome variables were a result of the intervention and not the attention received by the subjects.

3.3 Data Analysis

Standard descriptive statistical methods were used to calculate the means and standard deviations. Student's t-test were used to determine if the following variables differed between the two groups: age, height, weight, initial strength, mobility scores and the use of walking aids. The data was then analyzed using multivariate linear models with repeated measures. Variables for which clinically or statistically significant differences between groups were observed were then entered in the multivariate model as covariates. The following variables were tested for this purpose because they were considered to be potential predictors of the outcome and as a result could be confounders: age, pre-training levels of strength, TUG scores and average walking speed. The Pearson Product-Moment correlation coefficients were calculated to determine the relationship between changes in strength and the TUG score and between changes in strength and average walking speed. Prior to the start of the intervention, intraclass correlation coefficients (ICC 2,1) were calculated for the baseline values of strength, TUG scores and average walking speed to determine the inter-rater and test-retest reliability of these measures. All tests were conducted at a significance level of $p < 0.05$.

3.4 Ethical Considerations

This proposed research study was submitted to and received approval from the Ethics committee of the School of Physical and Occupational Therapy of McGill University as well as the Research Committee of Ste. Anne's Hospital.

Every subject who participated in the study signed an informed consent (Appendix B and C). The objectives, the methodology and the randomization process were explained to the subjects before they signed this consent. Strict confidence was maintained relating to the patient's identity and participation in the study.

The subjects who were assigned to the experimental group were supervised by a physiotherapist at all times, including all transfers to and from the training equipment and assistance was given when necessary. Progression through the exercise program was paced according to the individual's response to the treatment intervention. Subjects were reminded frequently not to hold their breath during any of the exercises in order to avoid the consequences of the Valsalva manoeuvre.

The subjects who were assigned to the "attention" control group were given the opportunity to participate in the exercise program, upon completion of the study. A subject had the right to withdraw from the study at any time, without prejudice or could be withdrawn for a medical reason. Any subject who refused to participate in the study returned to a normal ward routine during the duration of the study.

No invasive procedures took place during the course of the study.

CHAPTER 4

RESULTS

4.1 Subject Characteristics

Thirty male subjects were recruited as a sample of convenience from the in-patient population of Ste. Anne's hospital. These subjects were stratified on the basis of their ambulatory status (independent/independent with a cane, n = 15; use of walker, n = 15) and then randomly assigned to either the experimental/training group (n=15) or the control / "attention" group (n = 15).

Prior to the start of the study, one subject died and one subject fell, injuring his hip and preventing him from further participation. Both of these subjects belonged to the experimental group. In addition, one subject withdrew from the exercise protocol as the exercises did not meet his expectations. As a result, the experimental group consisted of a final sample size of 12 subjects. Three subjects from the control group died before the completion of the study, leaving the control group with a final sample size of 12 subjects. In total, 24 subjects completed post-training evaluations. The experimental and control groups were comparable in age, height, and weight (Table 1). The experimental group averaged an attendance rate of 86% for the 36 sessions. Any subject who missed three consecutive sessions was asked to continue for an additional week. This situation occurred with one subject.

TABLE 1

Baseline Physical Characteristics
N = 24

	Experimental n = 12	Control n = 12
AGE (YRS)		
Mean ± SD	83 ± 8.2	81.8 ± 6.0
Range	72 - 97	76 - 92
HEIGHT (CM)		
Mean ± SD	160 ± 10	160 ± 10
Range	160 - 180	160 - 170
WEIGHT (KG)		
Mean ± SD	64.6 ± 15.7	67.4 ± 14.7
Range	43.0 - 90.7	40.5 - 89.0

4.2 Reliability of the Outcome Measures

Prior to the study, inter-rater and test-retest reliability was determined for the strength measurements of the right upper and lower extremity muscles and for the two performance-oriented measures, using an intraclass correlation coefficient case 2,1 (ICC 2,1). This was accomplished by testing a sub-sample of 10 subjects on three separate occasions by two different raters.

Interrater reliability was very good to excellent for all strength measurements (ICC 0.75 - 0.97), while the test-retest reliability was excellent (ICC = 0.83 - 0.97). Both interrater and test-retest reliability of the mobility tests were determined to be excellent (ICC = 0.88 - 0.98) (Table 2).

TABLE 2

Reliability
Intraclass correlation coefficients
N = 10

	Interrater	Test-retest
QUADRICEPS		
1 RM	0.97	0.97
HHD	0.82	0.85
SHOULDER EXTENSORS		
1 RM	0.79	0.86
HHD	0.80	0.93
ELBOW FLEXORS		
1 RM	0.93	0.96
HHD	0.75	0.83
TIMED "UP & GO" (s)	0.98	0.98
AVERAGE WALKING SPEED (m/s)	0.90	0.88

1 RM = one repetition maximum
HHD = hand-held dynamometer

4.3 Muscle Strength

Dynamic strength was measured using the one repetition maximum (1 RM) recorded in kilograms (kg), whereas isometric strength was measured using a hand-held dynamometer (HHD), also recorded in kg. Pre-training comparison did not indicate any significant group differences in either dynamic or isometric strength of the muscle groups that were evaluated (Table 3).

4.3.1 Strength at Post-training

Multiple linear regression of experimental versus control group controlling for age, height, weight and value of strength measurements at pre-training indicated a significant group difference in dynamic strength at post-training, for the right quadriceps ($p = .0001$) and for the left quadriceps ($p = .002$), thus demonstrating a training effect (Figure 1). The percentage increase in the 1 RM of the right and left quadriceps following 12 weeks of training was 50% and 43%, respectively, whereas there was a deterioration in the control group of 38% and 23%, respectively. In contrast, there was no group difference demonstrated for isometric strength in either quadriceps (Figure 2). The only significant training effect observed in the upper extremity was for isometric strength of the right shoulder extensors (Figure 3,4,5 and 6).

TABLE 3

Dynamic and Isometric Strength
Pre-training values for all muscle groups

N = 24

	Experimental n = 12	Control n = 12
Quads		
1 RM (kg)		
Right Mean ± SD	10.1 ± 6.9	9.8 ± 6.7
Left Mean ± SD	10.8 ± 7.1	11.2 ± 5.8
HHD (kg)		
Right Mean ± SD	14.1 ± 4.6	14.2 ± 4.1
Left Mean ± SD	15.3 ± 5.6	14.2 ± 4.1
Sh Extensors		
1 RM (kg)		
Right Mean ± SD	3.8 ± 1.5	3.8 ± 1.7
Left Mean ± SD	3.6 ± 1.5	3.9 ± 1.8
HHD (kg)		
Right Mean ± SD	10.2 ± 2.8	11.4 ± 2.9
Left Mean ± SD	9.9 ± 3.6	9.6 ± 3.7
Elb Flexors		
1RM (kg)		
Right Mean ± SD	3.0 ± 1.3	3.8 ± 1.9
Left Mean ± SD	2.8 ± 1.3	3.9 ± 1.4
HHD (kg)		
Right Mean ± SD	10.5 ± 3.8	10.3 ± 4.0
Left Mean ± SD	10.8 ± 3.5	9.8 ± 4.2

1 RM = one repetition maximum
HHD = hand-held dynamometer
Quads = quadriceps
Sh Extensors = shoulder extensors
Elb flexors = elbow flexors

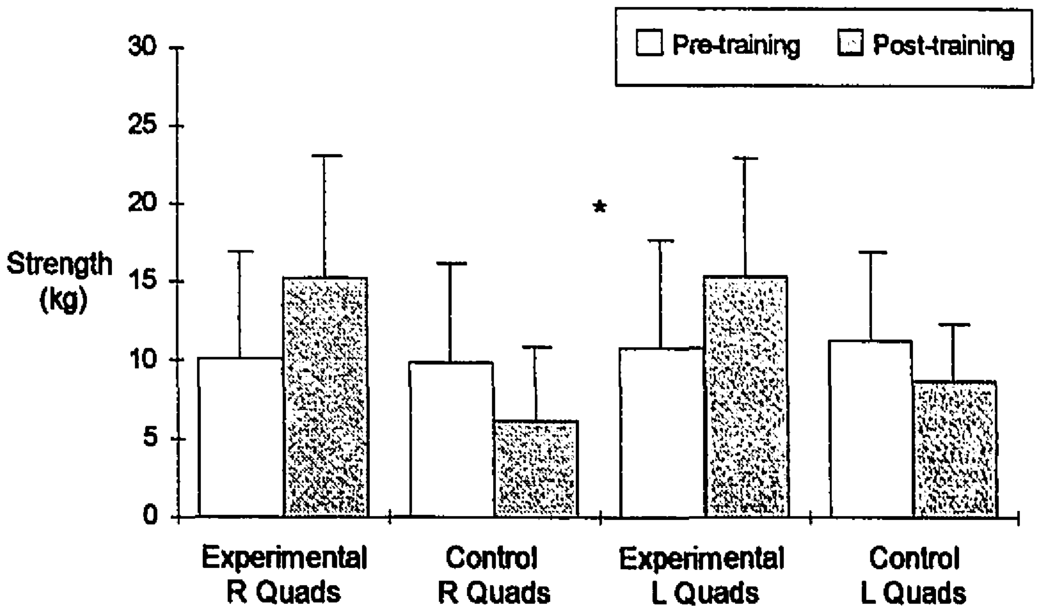

Figure 1. Pre- and post-training comparison of dynamic strength in the right (R) and left (L) quadriceps (quads) under experimental and control conditions.
Strength measured in kilograms (kg) using the one repetition (1 RM) and plotted using means and standard deviations.

* $p < 0.05$

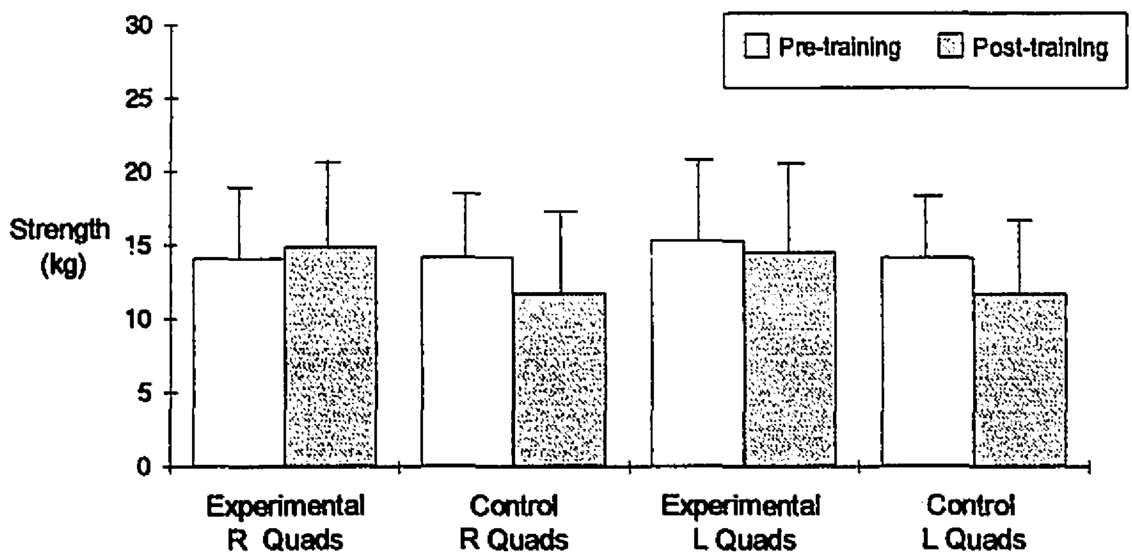

Figure 2. Pre- and post-training comparison of isometric strength in the right (R) and left (L) quadriceps (quads) under experimental and control conditions.
Strength measured in kilograms (kg) using a hand-held dynamometer and plotted using means and standard deviations.

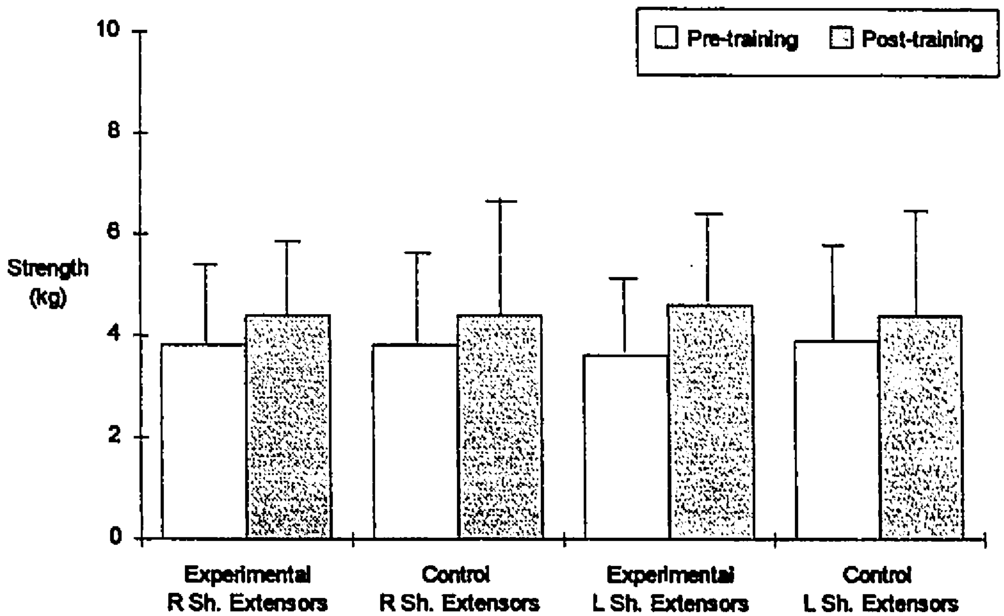

Figure 3 Pre- and post-training comparison of dynamic strength in the right (R) and left (L) shoulder (Sh) extensors under experimental and control conditions.
Strength measured in kilograms (kg) using the one repetition (1RM) and plotted using means and standard deviations.

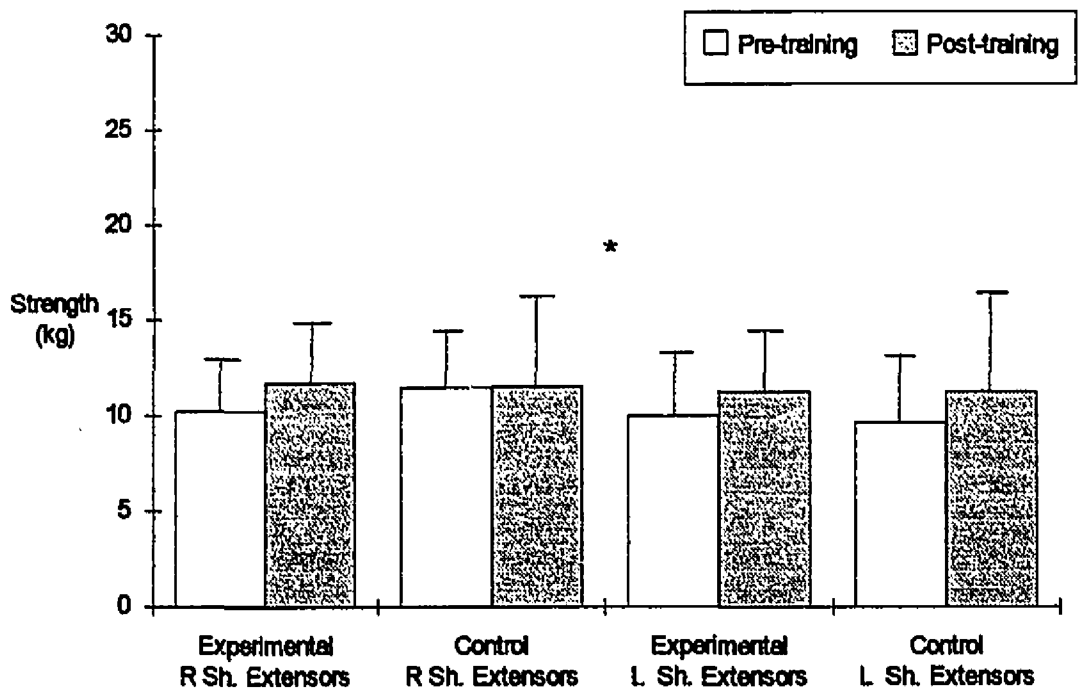

Figure 4. Pre- and post-training comparison of isometric strength in the right (R) and left (L) shoulder (Sh) extensors under experimental and control conditions.
Strength measured in kilograms using a hand-held dynamometer and plotted using means and standard deviations.

* $p < 0.05$

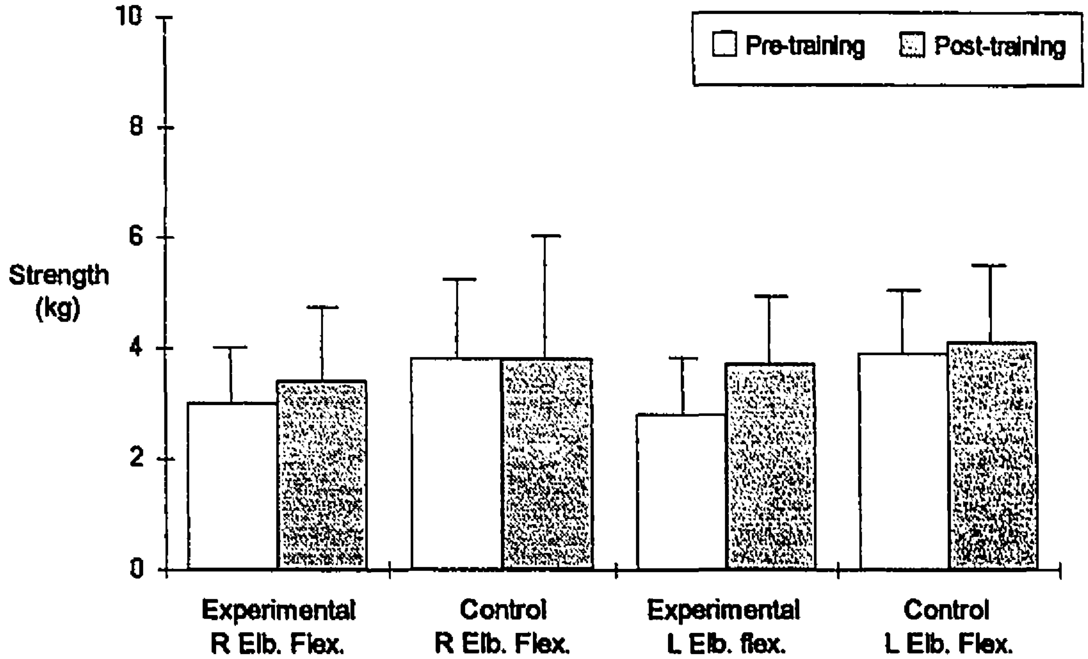

Figure 5. Pre- and post-training comparison of dynamic strength in the right (R) and left (L) elbow (Elb) flexors under experimental and control conditions.
Strength measured in kilograms (kg) using the one repetition maximum 1RM) and plotted using means and standard deviations.

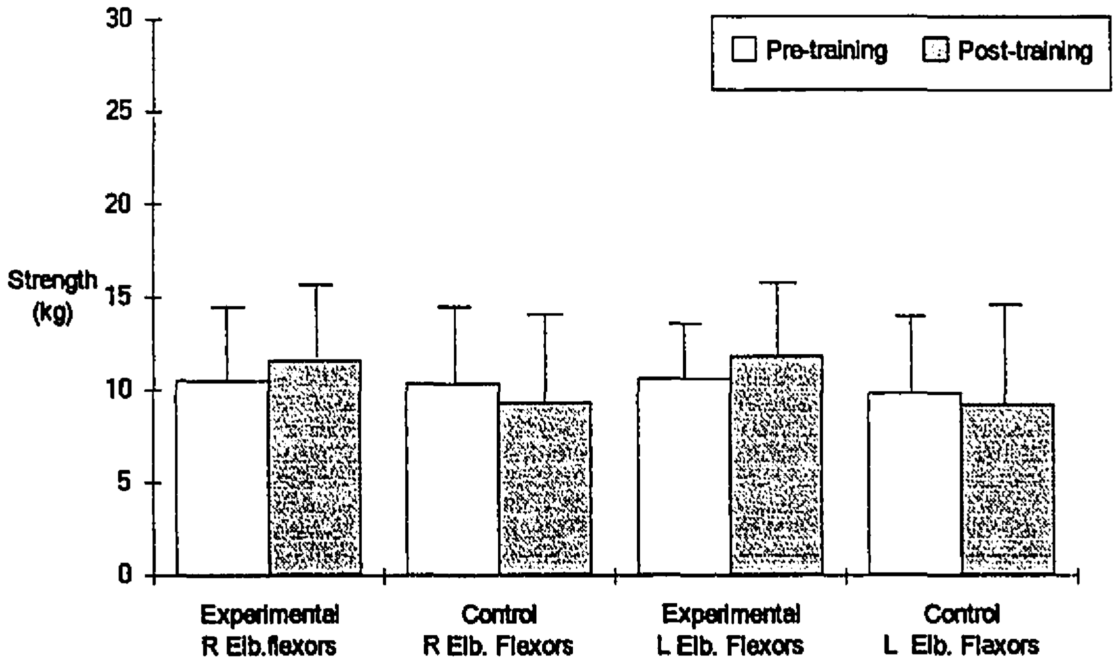

Figure 6. Pre- and post-training comparison of isometric strength in the right (R) and left (L) elbow (Elb) flexors under experimental and control conditions.
Strength measured in kilograms (kg) using a hand-held dynamometer and plotted using means and standard deviations.

4.4 Mobility Functions

Pre-training comparison did not indicate any significant group differences in either mobility function (Table 4).

4.4.1 Mobility Functions at Post-training

Multiple linear regression of experimental versus control group controlling for age, height, weight and value of mobility function at pre-training demonstrated a significant group difference in both the Timed "Up & Go" scores ($p = .02$) and the average walking speed ($p = .004$) at post-training (Figure 7 and 8). A 39% time reduction in the TUG and a 17% increase in average walking speed occurred following 12 weeks of high intensity exercises, indicating that this type of training had an impact on these two functional mobility activities. In contrast, there was a deterioration in both the TUG and average walking speed of 29% and 17%, respectively in the control group.

TABLE 4

Performance-Oriented Outcome Measures
Pre-training values for mobility scores
N = 24

	Experimental n = 12	Control n = 12
Timed "Up & Go" (s)		
Mean ± SD	35.4 ± 11.1	34.1 ± 11.7
Range	20.1 - 53.1	21.1 - 67.4
Average Walking Speed (m/s)		
Mean ± SD	0.6 ± 0.2	0.6 ± 0.2
Range	0.3 - 0.9	0.4 - 0.9

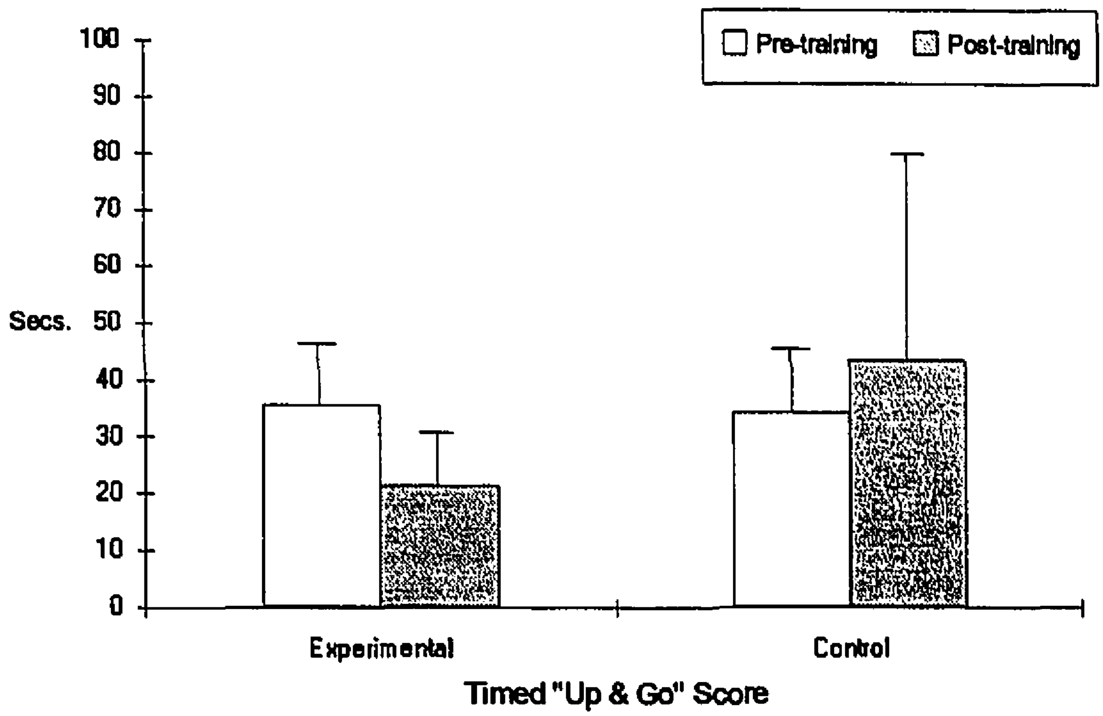

Figure 7. Pre- and post-training comparison of the Timed "Up & Go" scores under experimental and control conditions.
Score measured in seconds (sec) and plotted using means and standard deviations.

* $p < 0.05$

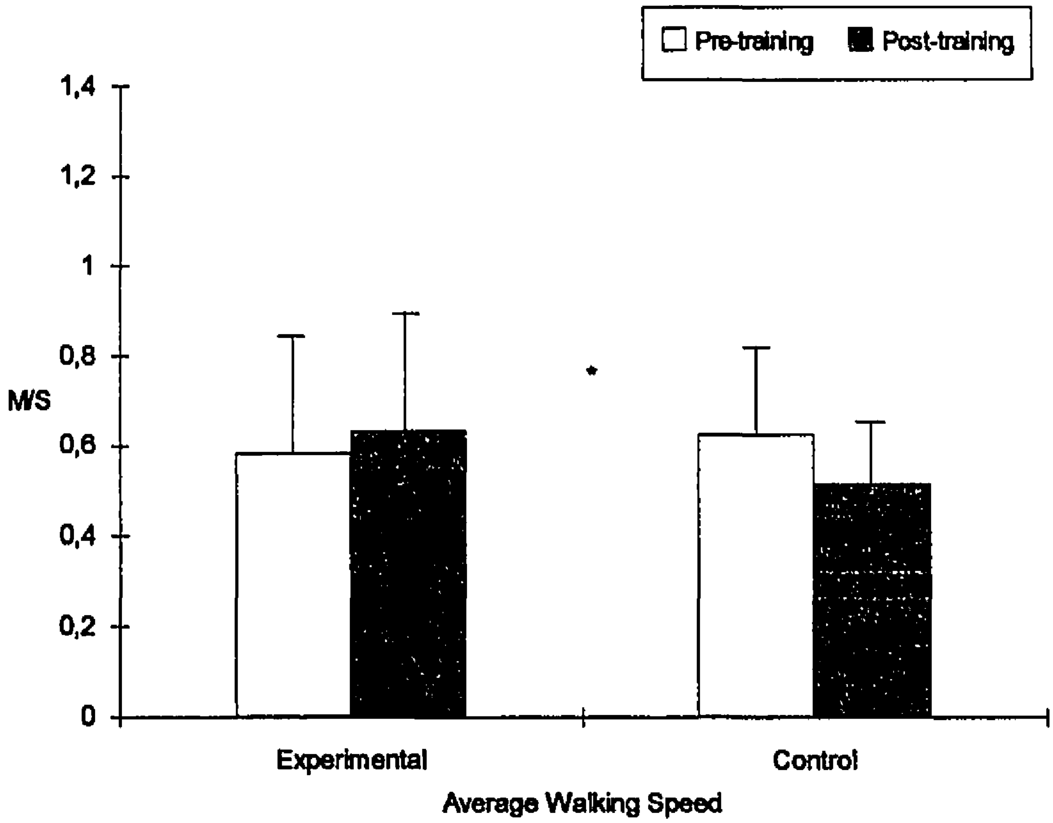

Figure 8. Pre- and post-training comparison of the Average Walking Speed under experimental and control conditions.
Speed measured in meters per second (m/s) over a distance of 30 meters and plotted using means and standard deviations.

* $p < 0.05$

4.5 Correlational Analysis

To determine if there was a relationship between the changes in muscle strength and the changes in mobility functions Pearson's Product-Moment correlation analyses were performed (Table 5). Significant correlations were found between the changes in the TUG scores and the changes in dynamic strength of the right quadriceps (r = -0.68, p = 0.0001), left quadriceps (r = -0.56, p = 0.004) and right shoulder extensors (r= -0.46, p = 0.02). Significant correlations were also found between the changes in the TUG scores and changes in isometric strength of the right quadriceps (r = -0.48, p = .002), left quadriceps (r = -0.51, p = 0.01), right elbow flexors (r = -0.48, p = 0.02) and left elbow flexors (r = 0.43, p = 0.04). In addition, significant correlations were found between the changes in the average walking speed and the changes in dynamic strength in the right quadriceps (r =0.63, p = 0.001) and left quadriceps (r = 0.48, p = 0.02). No other significant correlations were demonstrated.

Table 5

Table of correlations between changes in strength and changes in mobility scores. Post-training. N = 24

Strength	Timed "Up & Go" Score	Average Walking Speed
	r	r
1 RM		
R Quads	-0.68*	0.63*
L Quads	-0.56*	0.48*
R Sh Extensors	-0.46*	0.18
L Sh Extensors	-0.25	0.21
R Elb Flexors	-0.34	-0.08
L Elb Flexors	-0.08	0.25
HHD		
R Quads	-0.48*	0.19
L Quads	-0.51*	0.3
R Sh Extensors	-0.22	0.19
L Sh Extensors	0.03	0.13
R Elb Flexors	-0.48*	0.21
L Elb Flexors	-0.43*	0.25

r = Pearson's Product-Moment correlation
R = right
L = left
Quads = quadriceps
Sh Extensors= shoulder extensors
Elb Flexors = elbow flexors

* $p < .05$

CHAPTER 5

DISCUSSION

5.1 Drop-out and Attendance Rate

One of the primary objectives of this study was to determine the feasibility of a high intensity muscle strengthening program in a functionally impaired group of elderly institutionalized patients. As with any elderly population, drop-out and attendance rate for a program of several months duration was anticipated as a potential problem. The added factors of pre-morbid debility and multiple co-morbidity were also present increasing the likelihood of a higher drop-out rate or poorer attendance. Indeed, this study had a drop-out of 20%, with four subjects dying before the completion of the intervention and one subject sustaining a fall with subsequent hip injury, preventing further participation. However, only one subject withdrew from the exercise protocol and the attendance rate of the remaining subjects was 86%. These rates are similar to those of other training studies for this age group and type of subject (Connelly and Vandervoort, in press; Judge et al, 1993; Nichols et al, 1993), indicating that once the drop-out rate has been considered, active participation in this type of training program can be maintained, even in a frail elderly population. Drop out rate becomes an important factor in the determination of sample size and this rate should perhaps be overestimated for any study of 12 weeks or longer in duration.

5.2 Reliability of the Outcome Measures

Prior to the start of the intervention phase of the study, both interrater and test-retest reliability of all the outcome measures was determined by calculating intraclass correlation co-efficients (ICC 2,1). This type of analysis considers the inter-subject variability as well as the possibility of rater error, making it more robust than the Pearson-Product moment correlation coefficient (Shrout and Fleiss, 1979). With the exception of the timed "Up & Go" (TUG) test (Podsiadlo and Richardson, 1991), reliability data based on the ICC calculation were not found in the literature for an elderly, institutionalized population at the time of pre-testing. Furthermore, the reliability testing for the TUG was done on a community-dwelling geriatric population and not institutionalized subjects. It was, therefore, important to determine the reliability of the outcome measures for this particular population, under these research conditions in order to ensure that any significant results were due to the intervention and not to measurement error.

To take into account the possibility of specificity in the training response, it was felt that both testing and training should be carried out in the same position (Sale and MacDougall, 1981). For example, the quadriceps would be tested and trained in the seated position with the knee flexed to 90°. Although interrater and test-retest reliability results for dynamic strength of the upper and lower extremity and isometric strength of the lower extremity ranged from very good to excellent (ICC = 0.79 - 0.97) there was a pattern of higher test-retest reliability when compared with interrater reliability. A similar observation has been reported for strength measurements in an elderly population (Bohannon et al, 1986) and it may be related to the rater's judgment of "acceptable form" of the testing position or to the strength differences between testers when applying the "break" test.

However, the preliminary reliability calculations for isometric strength in the upper extremity indicated poor reliability, especially between raters (ICC = 0.27- 0.31), for both muscle groups when tested in the seated position. This may have been due, in part, to the substitution of other, perhaps stronger muscle groups especially at the shoulder and/or to the use of trunk movements to augment performance. While efforts were made to control for these two factors, reliability testing for isometric strength continued to produce poor results and the testing position of the upper extremity was ultimately changed to the supine position. This change was felt to reduce the use of muscle substitution and to control for extraneous trunk movement. As a result, excellent test-retest reliability for shoulder extensors (ICC = 0.98) and the elbow flexors (ICC = 0.83) was established. The interrater reliability for the shoulder extensors and the elbow flexors also improved but remained lower than test-retest reliability (ICC = 0.80 and 0.75, respectively).

5.3 Effect of Training on Muscle Strength

5.3.1 Quadriceps Strength

Following 12 weeks of high intensity exercise, significant differences in dynamic quadriceps strength were observed between the experimental and the control group. The 1 RM of the training group increased by an average of 47%, whereas in the control group, it decreased by an average of 31%. These strength gains are not as dramatic as earlier work, which reported 1 RM increase of 107% to 174% (Fiatarone et al, 1990; Frontera et al, 1988). Yet, they do compare more favourably with the 1 RM increases of 21% to 95% reported in more recent randomized controlled trials using a high intensity approach to training (Buchner et al, 1993; Charette et al, 1991; Judge et al, 1993; Nichols et al, 1993; Pyka et al, 1994). In one particular training study using nine institutionalized subjects with no control group (Fiatarone et al, 1990), the average pre-training 1 RM was lower than the average for subjects in this study, indicating that the population may have been weaker and more frail at the outset of training and perhaps having the most to gain from the training regime. Indeed, the weaker subjects in the present study, demonstrated a similar pattern of strength gains, in the range of 150 - 200%, supporting the hypothesis that those subjects who were weaker to start obtained the most benefit from this training regime.

While study populations differ, based on several factors including age, co-morbidity impacting on physical frailty, sedentary habits and institutionalization versus community-dwelling status, consideration must be given to the variability in the training response among elderly subjects within a study. This variability becomes important in understanding which sub-groups would most likely benefit from a specific program of exercises and also in determining how much supervision is required. For example, two subjects in the experimental group became weaker, despite participation in the strengthening program. Upon review of the post-testing session notes, it was felt that these two subjects may have had difficulty in understanding the testing and training procedures. This raises some doubt as to the suitability of the Mini-Mental State examination (Tombaugh and McIntyre, 1992) as a screening tool for determining sufficient cognitive skills to participate in a training program.

Nevertheless, these two subjects were included in the final analyses of the data and contributed to the variability in the training response. This variability can be expressed as a co-efficient of variation (C.V.), especially for comparison with other studies. The average C.V. (both legs combined) was 160%. Other studies report a C.V ranging from 50% to 300% with the majority of studies clustering around 100% (for review Buchner, 1993). Therefore, it appears that the variability in these subjects' response was relatively high but within the range reported by other studies with elderly subjects. In addition, the variable nature of the training response would indicate that larger sample sizes may increase the likelihood of significant results.

This study further illustrates the importance of a two-way between subjects design to determine the effects of training in an elderly, institutionalized population. Many strength training studies use an uncontrolled design based on the assumption that the control group will remain unchanged and that significant strength gains can be achieved through training. However, because of the variability in training response, this same study without inclusion of a control group would have concluded no training effects, as the pre-and post-training strength comparison ("t" test) demonstrated only a trend toward improvement ($p = 0.09$).

Significant improvement was obtained by comparing the response between the control and experimental groups, thus emphasizing the importance of including a control group in the study. This is especially important in an elderly population where the outcome variables are likely to deteriorate over time.

Indeed, it was interesting to note that while it was not statistically significant, there was a tendency for the control group to become weaker by an average of 31% over the course of the study. The magnitude of this strength loss over a 12 week period was inconsistent with other studies using a randomized control design for the same duration (Brown and Hollowsky, 1991; Buchner et al, 1993; Charrette et al, 1991). Deterioration in a control group has been reported, however, in studies of longer duration (Pyka et al, 1994; Rice et al, 1993). This decline in strength over a relatively short period of time could have been explained by one outlier in the data set, yet even when the data were re-analyzed without this influence, the rate of deterioration still remained above that of the other studies. This loss of strength may typify a very frail, institutionalized population and more importantly, it may indicate that participation in a specialized exercise program may deter the inevitable strength losses associated with aging and inactivity.

In contrast, there was no statistically significant change in isometric strength in either quadriceps, following training. These minimal changes in strength support the theory of specificity in the training response (Frontera et al, 1988; Jones et al, 1989) and agree with one other report using the same measurement protocol (Brown et al, 1990). More recently, however, studies in the upper extremity have demonstrated a training response in both 1 RM and isometric strength using a high resistance, low repetition approach to training (Rice et al, 1993).

5.3.2 Upper Extremity Strength

In the upper extremity, one significant group difference was demonstrated and that was for isometric strength in the right shoulder extensors, whereas for all other upper extremity muscles, strength changes only showed a tendency toward improvement (5% - 32%). Other studies involving the upper extremity have demonstrated significant improvement in either dynamic strength (Brown et al, 1990; Nichols et al, 1993; Pyka et al, 1994) or both dynamic and isometric strength (Rice et al, 1993) when compared with a control group. These studies used custom-made training equipment and all were conducted in a laboratory setting, whereas this was a clinical environment, with a simple wall pulley device with 1 kg weight increments. In addition, in one particular study the focus was entirely on upper extremity training (Rice et al, 1993). The main focus in this study was the effect of training on the lower extremity and its relationship to functional performance. While all exercises were supervised, perhaps more emphasis was placed on quadriceps training and as a result upper extremity training may have been influenced by muscle substitutions or poorer performance of the exercises, problems similar to those encountered during reliability testing.

5.4 Effect of Training on Mobility Functions

Significant improvement in the two objectively measured functional activities, the timed "Up & Go" (TUG) and average walking speed was demonstrated. A 39% reduction in the TUG and a 17% improvement in average walking speed occurred following 12 weeks of high intensity exercise. Consistent with the two strength parameters, both performance-oriented measures tended to deteriorate in the control group.

The TUG is an outcome measure that evaluates independent function in a clinically relevant way. By reducing the TUG by 39% in the present study, the average score decreased from 35.4 seconds to 21.5 seconds. In the development of the TUG test (Podsiadlo and Richardson, 1991), three time groups were arbitrarily described and found to be correlated to balance, gait speed and overall functional status as measured by the Barthel Index (Mahoney and Barthel, 1965). Those subjects who took 30 s or longer to perform the test tended to be more dependent in ADL, were unable to climb stairs without assistance and had an average walking speed of less than 0.5 m/s. When a subject scored less than 20 s, it indicated more independence in basic ADL, the ability to climb stairs independently, an ability to get in and out of a chair independently and an average walking speed of greater than 0.5 m/s. The training group, by virtue of their pre-intervention score of 35.4 seconds fell into the first category. However, following 12 weeks of high intensity exercise, this group almost reached the "less than 20 second" category (21.5 seconds), indicating a significant improvement in their level of functional performance. Only one other study reported using the TUG to objectively measure functional mobility (Connelly and Vandervoort, in press). In that study, a non-significant 23% reduction in the TUG was observed following 8 weeks of moderate intensity exercise in a small group of elderly women. However, the pre-testing average for the TUG for this group was 21.65 seconds or the middle time group, indicating relatively mobile subjects at the outset of their study with a smaller margin of expected clinical meaningful change. While the TUG is a quick and practical method of testing basic mobility manoeuvres in an elderly population and is used frequently in the clinical setting, however, some of the psychometric properties such as responsiveness, construct validity and predictive validity have yet to be determined. Future research in these areas may enhance its utility as a useful research tool.

Average walking speed was measured at the subject's usual or self-selected velocity and the baseline average speed was found to be 0.58 m/s. This was below many studies found in the geriatric literature (Aniansson et al, 1980b; Hoxie and Rubenstein, 1994; Judge et al, 1993; Murray et al, 1969; Rantanen et al, 1994; Robinett and Vondran, 1988), however, it must be emphasized that these studies used groups of healthy, older subjects, living in the community and free of any serious mobility impairment. Studies involving older, institutionalized subjects with mobility problems remain scant. The results from two recent studies of nursing home residents, indicated that for those subjects who required a walking aid, the average walking speed was found to be in the range of 0.41 - 0.64 m/s (Bassey et al, 1992; Thapa et al, 1994).

The 17% improvement in average walking speed following 12 weeks of training reflected a post-training average speed of 0.69 m/s. Again, comparison with other studies remains difficult because of the paucity of published results, although one study did use a high intensity protocol for 12 weeks and found an 8% improvement in speed (Judge et al, 1993). While the average age was similar (81.6 years), the sample was drawn from "life care" communities, with 94% of subjects fully independent in ADL. The pre-training average speed was found to be 1.04 m/s. Clearly, this was a more mobile and independent population. The authors did note that there was substantial variability among subjects, with the most improvement occurring in subjects with the least strength and slowest speed at baseline. However, there were also increases in average speed for those subjects who had excellent strength at the outset. In fact, this phenomenon occurred in the present study.

5.5 Correlations Between Strength Gains and Mobility Performance

The goal of this study was to determine whether high intensity strength training would have an impact on mobility function in a group of mobility-impaired individuals. The results showed that both dynamic strength and mobility were improved following training. However, this training included not only high intensity strengthening exercises but also exercises that simulate daily tasks such as repeated sit-to-stand maneouvers and stair-climbing. This made it difficult to ascertain what aspect of the program was effective in producing the changes in functional outcome. In order to determine the impact of strength gains on mobility, correlational analyses were performed between the changes in strength and the changes in performance outcome measures. A significant correlation was found between the changes in dynamic strength of the quadriceps and the changes in average walking speed, indicating that 40% of the variance of the changes in average walking speed could be explained by changes in dynamic strength. Similar correlations were observed between changes in the TUG and dynamic strength, however, the changes in the TUG were also found to be correlated to changes in isometric quadriceps strength, even though isometric strength was unaltered by training. Therefore, the link between dynamic strength gains and mobility, as measured by the TUG improvement became less obvious. However, in a prior study of 12 subjects, TUG and walking speed were unaltered by a 12 week program of exercises simulating daily tasks, suggesting that without a high-intensity training component, mobility would not have improved (personal observations, unpublished data).

5.6 Limitations

This results of this study demonstrated a training effect with significant differences in dynamic strength of the lower extremity and both mobility functions in a small group of elderly men. Female subjects were not included in the sample because less than 5% of the patient population of Ste Anne's Hospital is female. This type of intervention should be replicated with women in order to determine the training response in elderly women.

Subjects were included in this study because of difficulty with mobility functions and so this training approach would be considered an appropriate treatment approach for institutionalized, patients with mobility problems. It is uncertain whether subjects with less mobility impairment would have improved as significantly as those in the present study and therefore the preventative aspects of this training protocol need to be examined in more detail.

The screening protocol focussed on TUG scores of greater than 20 s. and on average walking speeds of less than 0.9 m/s. Whereas this may have been a quick and easy way of screening, it may not have identified those subjects with mobility problems associated with poor lower extremity strength. While the TUG score reflected a clinical picture of impaired mobility, there was an unclear relationship between lower extremity strength and this particular mobility function. In addition, the construct validity of the TUG has not been established. It has been hypothesized that the TUG tests basic mobility manouevers that require lower extremity strength, balance and ambulatory potential. In one study of concurrent validity of the TUG (Podsiadlo and Richardson, 1991), forty geriatric clients were tested on the TUG, a laboratory measure of balance (sway path) and gait speed.

Correlations with sway path were poor (r = 0.5) and with gait speed were moderate (r = .75). Twenty-two patients were also tested using other clinical measures of balance and function. A curvilinear relationship was found between the TUG and the Berg Balance Scale (r = -0.72), gait speed (r = 0.55) and the Barthel Index (r = -0.51). More research is needed to establish more definitely, the constructs or concepts that are represented by this very useful clinical test.

Despite a significant difference in dynamic quadriceps strength between the experimental and control groups, there was variability between subjects within both groups as determined by the co-efficient of variation. In order to minimize the variability and to demonstrate a pre-/post- training effect within the same group, a larger sample size would be required.

This study relied on testing equipment readily available in any clinical setting thus permitting the methodology to be conducted by all clinicians. However, as a result of the simplicity of the evaluation procedures, the evaluations may have lacked the sophistication and technical advances that are available in a laboratory environment. This could have influenced the preciseness of the measurements, especially in evaluating lower extremity strength in terms of specificity of the training response.

CHAPTER 6

CONCLUSION

6.1 Research Conclusions

Exercise programs are among the therapeutic interventions advocated to address the functional mobility problems encountered by an aging population. Most studies recruit healthy older volunteers and few published studies have targeted physically unfit or institutionalized subjects. The major finding of this study demonstrated that a high intensity exercise program was feasible in strengthening the quadriceps in a group of elderly, institutionalized men up to 97 years of age, despite the presence of multiple chronic diseases, sedentary habits and functional limitations. Resisted exercises incorporated into a task specific routine provided an effective treatment for the muscle weakness and mobility impairment which were observed in these elderly, institutionalized patients. These findings indicate that the muscle weakness that often accompanies old age can be modified with the use of specific exercises and that this high intensity approach to training should be advocated as a safe and appropriate rehabilitation strategy for an elderly, institutionalized population.

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APPENDICES

APPENDIX A

SCREENING TOOL

Name:____ Age: __________

Floor: ____________________

Attending Physician: ____

Date of Screening: ____

Date of Medical Clearance: ____

Diagnosis____

____

Mini-Mental Score:________________

Mobility Status: Indep: _____ Walker: _____ Cane: _____ W/C: _____

Screening Tests:

Timed "Up & Go": _______________Average Walking Speed: _______________

Accepted:______________________Excluded:__________________________

Signature:____

Date: ____

APPENDIX B

UNIVERSITÉ MC GILL

ÉCOLE DE PHYSIOTHÉRAPIE ET ERGOTHÉRAPIE

Je __________ accepte de participer à cette étude.

a) But et objet de cette étude

Le but de cette étude est de prendre connaissance des effets des exercices de renforcement sur la résistance des muscles et sur la performance lors de déplacements. J'ai été averti qu'il y aura une évaluation deux fois avant le début de l'expérience et par la suite. La durée de ces séances sera d'environ une heure chacune et comprendront des tests sur l'endurance de mes bras et de mes jambes, tel que me lever hors d'une chaise ou marcher sur une courte distance ainsi qu'une marche de plus grande distance, soit quarante mètres (40 m).

Je comprends que je peux être assigné soit au groupe d'exercices expérimentaux ou au groupe d'activités et que le choix du groupe se fait par répartition.Si je fais parti du groupe expérimental, je suis conscient que je serai impliqué dans un programme qui sera réparti sur une période de douze semaines avec trois séances par semaine. Chaque période d'exercices durera environ quarante-cinq minutes et inclura une série d'exercices qui auront pour but de renforcer mes bras et jambes. Si je fais partie du groupe d'activité, je suis conscient que je serai impliqué dans des activités organisées pour une période de douze semaines avec des activités trois fois par semaine.

b) Désavantages lors de la participation à cette étude

Le désavantage majeur sera le temps que j'investirai. Je vais devoir être évalué au moins trois fois et si je fais partie du groupe d'exercices, je vais devoir me présenter en physiothérapie trois fois par semaine pour une période de douze semaines. Je suis conscient qu'il pourra y avoir quelques malaises au début du programme d'exercices.

c) **Avantages lors de la participation à cette étude**

Quoiqu'il n'y ait pas de bénéfices monétaires ou personnels pour les participants de cette étude, les résultats de cette recherche vont contribuer à mieux comprendre les effets de l'exercice face à la performance chez des adultes plus âgés.

d) **Questions concernant cette étude**

Je comprends que les questions que je pourrais avoir vont être répondu par Judi Newnham, au département de physiothérapie, à l'Hôpital Ste-Anne au 487-3440, poste 2210.

e) **Retrait de cette étude**

Ma participation à cette étude est volontaire et je peux me retirer à n'importe quel moment sans préjudice lors de futur traitement au département de physiothérapie.

f) **Permission d'utiliser de l'information**

Je permets à l'enquêteur de garder et d'utiliser l'information résultant de cette étude tout en ne divulgant pas mon identité.

Signé le ________ de ________ 199_.

Signature : ____________________.

Témoin : ____________________.

Moi, Judi Newnham, certifie par la présente que j'ai expliqué au sujet mentionné plus haut, le but de cette étude, les risques connus résultant de la participation à cette étude n d'un retrait en tout temps.

Signature : ____ .

APPENDIX C

MCGILL UNIVERSITY

SCHOOL OF PHYSICAL AND OCCUPATIONAL THERAPY

Consent To Participate in a Research Study on Exercise

I ______________________________consent to participate in this research study

(a) **Purpose and Design of the Study**

The purpose of this study is to investigate the effects of strengthening exercises on muscle strength and on the performance of mobility tasks. I have been told that I will be evaluated twice prior to the start of the experiment and once following it. These sessions will last approximately 1 hour each and will involve the testing of my arm and leg strength as well as my performance in basic mobility functions such as getting up from a chair and walking a short distance, as well as walking a longer distance of 40 meters.
I understand that I may be assigned to either the experimental, exercise group or the control, activity group and that this assignment will occur by chance allocation. If I am assigned to the experimental group, I am aware that I will be involved in an exercise program that will be held 3 x week, for 12 weeks. Each session will last 45 minutes and will involve a series of exercises designed to strengthen my arms and legs. If I am assigned to the control group I am aware that I will be involved in an organized activity 3 x week, for 12 weeks.
Following completion of the experiment, the control group will be offered the same exercise program as the experimental group.

(b) **Disadvantages of Participation in this Study**

The main disadvantage will be the time commitment on my part. I will be required to be evaluated at least 3 times and if I am involved in the exercise program, I will be required to attend Physiotherapy 3 x week for a 12 week period. I am aware that there may be some mild discomfort at the start of the exercise program.

(c) **Advantages of Participation in this Study**

Although there are no monetary or personal benefits to be gained from participating in this study, the results from this research will contribute to the understanding of how exercise affects strength and functional performance in the older adult.

(d) **Enquiries Concerning the Study**

I understand that any enquiries that I may have will be answered by Judi Newnham, Physiotherapy Department, Ste. Anne's Hospital, 457-3440. ext. 2210.

(e) **Withdrawal from the Study**

I understand that my participation in this study is voluntary and that I may withdraw at any time, without prejudice to any further treatment in the Physiotherapy Department.

(f) **Permission to Use Information**

I give the investigator(s) permission to keep and utilize the information from the study as long as my identity is kept confidential.

Dated the ________day of ________, 19____.

Signed: ________________________________

Witness: ________________________________

I, Judi Newnham, hereby certify that I have explained to the above-mentioned subject the nature of the study, the known risks involved in participating in the study and that he has the option of withdrawing from the study at any time.

Signed: ________________________________

APPENDIX D

SUB-SAMPLE PROFILE

CHARACTERISTIC	VALUE
NO. OF SUBJECTS	10
AGE (YRS)	86.1 ± 4.2
AVERAGE WALKING SPEED (M/S)	.61 ± .19
TIMED "UP & GO" (S)	41.89 ± 8.48
MUSCLE STRENGTH (KG)	
DYNAMIC (1 RM)*	7.95 ± 3.88
ISOMETRIC (HHD)**	13 ± 5.23
USE OF WALKING AID	
NONE	5
CANE	2
WALKER	3

All values given in means ± Standard deviations

* 1 RM = one repetition maximum

** HHD = hand held dynamometer

APPENDIX E

EXERCISE PROGRAM

1. Warm-up exercises for the upper and lower extremities.
   - upper extremity pulleys
     - shoulder flexion/extension
     - shoulder abduction
     - horizontal add/abduction with 90 shoulder abduction
   - lower extremity
     - stationary bike with no resistance x 3 minutes

2. Upper extremity strengthening.
   - weighted pulleys 3 sets of 8-10 reps with progression to maintain 80% 1 RM for
     - shoulder extension
     - elbow extension
     - elbow flexion

3. Lower extremity strengthening.
   - knee extension through 90 ROM in sitting
     - 3 sets of 8-10 reps with weighted progression to maintain 80% 1RM
   - sit-stand manoeuvre with progression to 10 reps.

4. Stationary bike with resistance and time progression to maintain the estimated 50% Maximum Heart Rate.

5. Stair-climbing with progression to 3 sets of 4-step flight.

6. Walking around a 200 foot block.

Average time should be 30 minutes of exercise during a 45 minute session

Attendance is 3 x week for 12 weeks