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A comparison between conventional and holistic exercise interventions on physiological function in the elderly

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A Comparison Between Conventional and Holistic Exercise Interventions on Physiological Function in the Elderly

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ABSTRACT

Aging is characterised by a decline in physiological function. The rate of this decline can depend on certain lifestyle factors, genetics, and the environment. Although life expectancy is slowly increasing, there is a need to reduce the time spent in debilitated, and non-independent states by elderly individuals. Preventive measures need to be implemented to reduce dependency and improve the quality of life for elderly individuals. One such preventive and remedial measure is the use of exercise and physical activity. Because limited exercise prescription exists for the elderly population, there is a need to determine the effectiveness of exercise interventions that are more desirable for elderly individuals. Hence, the purpose of this pilot study was to implement and compare two types of exercise interventions, a holistic exercise intervention (Range of Motion Dance method or ROM) and a Conventional Exercise intervention commonly performed in the community by aged individuals.

Forty-three elderly individuals over 65-years of age were randomly allocated to the two intervention groups and a control group. The exercise interventions were performed for 10-weeks and included baseline and post-intervention testing. The groups were compared using Analysis of Covariance on the following variables; muscular strength (grip strength, isokinetic knee flexion and extension); postural stability (Berg Balance Scale, and Center of Pressure); and functionality (Timed 'up' and 'go' and Physical Performance Test). T-tests were performed to compare the two intervention groups on attrition and compliance.

The Conventional Exercise and the ROM exercise groups generally showed similar results on all physiological parameters when compared to each other. However, some statistically significant differences were observed between the intervention groups and the control group for isokinetic knee flexor and extensor strength, grip strength and the Physical Performance Test. Mean differences between post-intervention and baseline results for knee extensor and flexor strength measures ranged between 0.97 to 5.78 Newton•meters for the Conventional Exercise group; -6.00 to 5.73 Newton•meters for the ROM group and; 8.74 to 5.36 Newton•meters for the Control group. Both intervention groups showed improvement of approximately 1.5 units for the Physical Performance Test, while the Control group showed no change. No statistically significant differences were found between the groups for any balance measures or for the Timed "Up" and "Go". The two interventions groups showed similar average attendance rates, with 85.4% of sessions performed by the Conventional Exercise group and 88.9% of sessions performed by the ROM group.

The performance of low-intensity exercise intervention, of either a conventional or holistic nature, may provide positive physiological benefits for elderly participants, such as maintaining or improving knee flexor and extensor strength and enhancing functionality. Thus this study provides evidence that low-intensity exercise interventions in the short term can cause physiological change while at the same time maintaining relatively high rates of participation.

DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

(i) *incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;*

(ii) *contain any material previously published or written by another person except where due reference is made in the text; or*

(iii) *contain any defamatory material.*

[redacted]

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CHAPTER 1

1.0 Introduction

1.1 Background

The progressive decline in structure and function of an organism is characteristic of the aging process (Spirduso, 1995; Baker and Martin, 1994). Some of the physiological parameters that decline with age include, reduced range of motion (Hartman et al., 2000), the reduction in skeletal muscle mass and functional strength (Evans, 1999), the decline in cardiorespiratory function (Spirduso, 1995) and reduced postural stability and balance (Woollacott and Shumway-Cook, 1996). The combination of these negative effects may contribute to the decreased ability of the aged individual to perform normal daily activities.

Furthermore, physiological decline can lead to a reduction in productivity and independence in the latter years of life. This physiological decline and disability not only negatively influences the individual's quality of life, but also has socio-economic consequences for health care utilization (Hoffman, Rice, and Sung, 1996). The population aged 65 years and older account for the greatest proportion of chronic disease burden, disability and health care utilization (King, Rejeski, and Buchner, 1998). Exercise may improve active life expectancy by extending independence, preserving bodily functions, and delaying onset of disability due to chronic diseases (Larson, and Bruce, 1987), and hence may reduce healthcare costs.

The economic and social demands by aging populations on society are a cause for great concern in developed countries worldwide. This is due to the precipitated growth in the elderly portion of the overall population. Census data from 2001 suggested that approximately 12.6% (2.4 million) of the total Australian population was aged 65 years and older with a similar proportion (11.1%) observed for the same age category in the Western Australian population (Australian Bureau of Statistics 2002). Between 1995 and 2000, the proportion of individuals aged 85 years and older increased by 31%, in comparison to only a 9% increase in the total state population (Australian Bureau of Statistics, 2001). It is estimated that individuals 65 years and older will account for 25% of the national population by 2051 (Australian Institute of Health and Welfare, 2002). Hence, the aging population and the fact that less than 46% of individuals aged 65 years an older fail to participate in sufficient physical activity to accrue health benefits (Australian Institute of Health and Welfare, 2002), there is cause for concern.

There are a variety of negative side effects of aging, which combined with sedentary lifestyles, encompasses both physiological and psychological parameters. In Australia during 1997 there were over 32,000 reported injuries as a result of falls by elderly persons, with a greater number of falls observed with advancing age (National Injury Prevention Plan Priorities for 2001-2003). The National Ageing Research Institute (1999) reported that one third of individual's aged 65 years and over experience falls, with a greater incidence of falls observed among the elderly in residential aged care facilities than compared to elderly community dwellers. The same report also stated that the cost of managing fall related injuries is over two billion dollars (AUD) annually (National Ageing Institute, 2000). Physiological repercussions and physical injury are not the only issues related to falls. The fear of falling is associated with actual falls and has been shown to cause further reductions in the amount of physical activity performed (Tennstedt et al., 1998; Tinetti, Mendes de Leon, Doucette, and Baker, 1994), thus precipitating some of the factors leading to the fall episode in the first place (i.e., sedentary lifestyle and inactivity).

As well as falls, chronic conditions such as cardiovascular disease, osteoporosis, type II diabetes, osteoarthritis, and hypertension, are all commonly seen in aged individuals (Spirduso, 1995). The prevalence of chronic disease and disability, as well as health care utilisation is highest in older adults aged 65 years and over (King, Rejeski, and Buchner, 1998). Chronic diseases are a major health issue, not only for the aged, but also for the entire population. However, such conditions maybe preventable. Participation in regular exercise and physical activity may be related to better health status in the elderly as well as playing an influential role in determining the likelihood of developing chronic diseases in the later years of life (U.S. Department of Health and Human Services, 1996; Simonsick, Lafferty, and Phillips et al., 1993, Reuben Laliberte, Hiris, and Mor, 1990; Paffenbarger, Hyde, Wing, and Hseih, 1986)

Therefore, from a population point of view, it is necessary to reduce the rate of physiological decline and the occurrence of health complications, particularly those for which a sedentary lifestyle contributes. Medical visits, hospitalisation, and institutionalisation reduce the quality of life experienced by elderly individuals. Current demographic predictions for the next few decades indicate an increase in the elderly age group (Australian Institute of Health and Welfare, 2002), hence this may consequently lead to increased prevalence of certain chronic diseases and episodes of falls. It is necessary that preventative measures, which will lead to increases in physical activity participation by older adults, such as the provision of a wider variety of exercise options, the prescription of individualised exercises, and the implementation of effective exercise interventions need to be implemented.

Physiological function can be maintained and in many cases losses in physical function inhibited, when the individual becomes physically active. Studies using samples of elderly subjects have shown that muscular strength and functional performance can be improved with physical activity and exercise (Fiatarone et al., 1994; Chandler and Hadley, 1996; Taaffe, Duret, Wheeler, and Marcus, 1999; Meuleman, Brechue, Kubilis, and Lowenthal, 2000; Brown et al., 2000; Westhoff, Stemmerik, and Boshuizen, 2000; Schlicht, Camaione, and Owen, 2001; Jones, Rikli, Benedict, and Williams, 1994; Hauer et al., 2001; Brill, Probst, Greenhouse, Schell, and Macera, 1998; Fiatarone et al., 1990). Exercising elderly individuals have generally been shown to experience a variety of physiological benefits including; decreased bodyfat (Takeshima et al., 2002; Sidney, Shepard, and Harrison, 1977) reduced blood pressure (Martel et al., 1999), improved cardiovascular fitness (Buchner et al., 1997) and improved bone mineral density (Rhodes et al., 2000). However, there are many different types of physical activity and exercise prescribed.

Most often exercises involving resistance training or a combination of different modes of physical activity including activities such as walking, balance training, and flexibility training are prescribed for the aged. To supplement these, functional-balance training, mobility and flexibility exercises are sometimes prescribed. In most cases, conventional exercise interventions that include only one or up to several different modes of exercise have been studied. However, studies investigating interventions that are defined as holistic (i.e., Tai Chi, Yoga, Range of Motion Dance) are limited.

Issues that need to be taken into account when prescribing exercise to the elderly are low adherence and high attrition. Such issues reduce the overall effectiveness and purpose of many exercise interventions. Adherence and participation can be effected by physiological and psychological influences. Some psychological factors that may be associated with adherence include attitude toward exercise, exercise sense of control, confusion, and mood state (Jette et al., 1998). Documentation of attrition has shown that a dropout rate of elderly participants of between 6% and 34% occurs before the completion of an exercise intervention (Chandler and Hadley, 1996). It has also been reported that the majority of dropouts leave interventions within the first three months following commencement (Chandler and Hadley, 1996). A higher dropout rate of between 22% and 76% has been observed within one year of commencing an exercise intervention (Sallis, Haskell, Fortmann, and Vranizan, 1986). These findings suggest that it is necessary to develop strategies to enhance exercise participation and reduce attrition. To achieve this, comparisons of attrition and adherence of different types or modes of exercise intervention in the elderly, need to be performed.

Holistic approaches, which integrate mind, body, and spirit (Harlowe and Yu, 1992, pg 8) may be beneficial for elderly individuals both physiologically and psychologically, and may even lead to reductions in attrition. Tai Chi is a common form of holistic exercise intervention. The performance of Tai Chi has been shown to improve physical function through its rationale of graceful body movements, incorporation of mind concentration, breathing control, muscle relaxation and balance shifting of body weight

(Chen and Snyder, 1999). Physiological parameters have also been measured after using Tai Chi as an exercise intervention in the elderly, proving to be influential for improving muscular strength (Jackobson et al., 1997), flexibility, and balance control (Hong, Xian, and Robinson, 2000) and cardiorespiratory function (Lai, Lan, Wong and Teng, 1995).

Psychologically, Tai Chi has been shown to produce feelings of improved wellbeing (Brown et al., 1995) as well as enhancing self-efficacy (Hartman et al., 2000). Tai Chi appears to be practical and effective for performance by elderly participants due to its non-competitive and self-paced method (Yan, 1998). Tai Chi seems an effective alternative exercise intervention however, research on this form of exercise is limited. Although Tai Chi has been shown to provide some positive health benefits, it cannot be said that other holistic interventions that are based on similar principles are equally as effective (i.e., Range of Motion Dance Method or Yoga etc.). Hence there exists a need to determine the efficacy of other exercise interventions that are not commonly used by elderly individuals, but may yet have the potential to provide equal or greater physiological and psychological benefits, as well as showing similar or greater compliance rates, than conventional exercise interventions.

One such exercise intervention known as the "Range of Motion Dance Method" or ROM (Harlowe and Yu, 1992) is a holistic intervention that may prove to be effective for use by elderly individuals. The underlying principles of ROM are based on those adopted by Tai Chi (Harlowe and Yu, 1992), where all movements are performed in a slow and controlled manner. The program involves the development of body awareness, self-imagery, postural alignment, and relaxation, in addition to performing various movements. The ROM intervention presents 42 different movements, where 29 are performed while sitting and standing, and 13 are performed at a table or desk. ROM was originally developed as a gentle movement therapy for individuals with rheumatoid arthritis, but may be an appropriate daily exercise routine for the general senior citizen population. The ROM intervention has been shown to provide physiological and psychological benefits (e.g., improved upper extremity range of motion and increased enjoyment), as well as showing low rates of attrition (Harlowe and Yu, 1992; Van Deusen and Harlowe, 1987a; Van Deusen and Harlowe, 1987b). Whether the ROM intervention can improve physiological parameters such as balance, strength, and functionality remains to be determined. A more detailed description of this intervention can be obtained from the ROM dance method manual (Harlowe and Yu, 1992).

Therefore the objective of this study is to compare the physiological effects of a conventional exercise program against a holistic exercise approach, aimed at improving physical parameters in the aged population. The physiological parameters of strength, balance and functionality will be examined. In addition, attrition and compliance will also be assessed. Activities such as walking, a combination of bodyweight and light dumbbell exercises, and relaxation will be incorporated into the Conventional Exercise program. Participants in the Range of Motion dance program will be exposed to the holistic approach which involves performance of physical activity characterised by, slow continuous, full-ranged movements, and incorporates mind focus and relaxation techniques.

1.2 Research Questions

This study proposes two purposes. The first purpose of this study is to determine whether the Range of Motion dance (a holistic approach) as an exercise intervention, is more effective for improving the following physiological parameters in elderly community-dwelling adults: muscular strength (i.e., knee flexor and extensor strength, and grip strength), balance (i.e., postural sway, and clinically assessed balance), and functionality (i.e., Physical Performance Tests and the Timed "Up" and "Go") in comparison to a low-intensity, self-paced conventional exercise intervention.

The second purpose of this study is to compare participant adherence and attrition between the Range of Motion dance method (ROM) and the Conventional Exercise intervention. The specific research questions relating to this study are:

1. Is a 10-week low-intensity, conventional exercise intervention more effective for improving knee flexor and extensor strength, grip strength, balance and functionality in aged individuals when compared to a 10-week holistic exercise intervention?

2. Will rates of participant adherence and attrition be influenced by whether individuals participate in the holistic intervention group or the conventional exercise group?

1.3 Significance of the Study

It is known that exercise improves physiological parameters such as strength, balance and functionality in the aged. However, a major issue is presented with regards to adherence and attrition. The ability of an exercise intervention to maintain an individual's interest is important particularly if health scientists and professionals want to reduce sedentary behaviour and increase habitual physical activity. It is also necessary to determine the effectiveness of exercise interventions that are not commonly prescribed, but may offer potential benefits to aged individuals. Thus, if relatively unknown interventions provide physiological benefits they can be marketed as an alternative to the variety of exercise interventions that already exist. Therefore the provisions of additional exercise options for the aging population may increase the physical activity levels of current non-volunteering older adult, who dislike or cannot (i.e., due to health problems, immobility etc.) perform the exercise interventions currently being offered.

The following study will allow:

a) Comparison of adherence between the Conventional Exercise intervention and the Range of Motion dance method;

b) Determination of the efficacy of the Range of Motion dance method as an effective exercise intervention for elderly individuals who are independent or require minimal living assistance;

c) Comparison of the measured physiological parameters between the Conventional Exercise intervention and the Range of Motion dance method and;

d) Determination of the effectiveness of instruments to measure physiological function to be assessed for future studies.

By determining more desirable methods of exercise intervention for the elderly, attrition rates for physical activities may be reduced, and more appropriate exercise programs can be designed to appeal to this age group. This would hopefully help to reduce the number of sedentary elderly in the population, assisting to reduce health risk factors, falls, immobility and hospitalisation. This is beneficial to the overall health status of the aging population which inturn reduces the cost to the public health care system by decreasing age-related injuries and cases of chronic diseases. More importantly, increased participation in physical activities that can provide physiological benefits, help to improve the quality and length of life for the elderly population.

1.4 Hypothesis

It is hypothesised that the Conventional Exercise intervention, which is based on traditional forms of exercise, which include walking, and resistance training, will be more effective for improving physiological function than the ROM dance method in elderly individuals.

It is also hypothesised that the ROM dance method with its subtle and slow nature will have higher adherence and lower attrition than the Conventional Exercise intervention

CHAPTER 2

2.0 Literature Review

2.1 Overview

Spirduso (1995) defines the process of aging as the "clinical symptoms (the syndrome of aging) and includes the effects of environment and disease". The process of aging is characterized by a progressive decline in physiological function. The factors influencing the rate of this decline are multi-factorial, influenced by genetics, the environment and the lifestyle of the individual. The selected lifestyle of an individual is dependent on beliefs and attitudes developed throughout a lifetime; including physical activity and exercise behaviours. However, these behaviours can be modified. Physical activity and exercise habits that an individual chooses, even in the later stages of life, can consequently effect the status of physiological parameters, which can further determine the quality of life, the likelihood of disease, and in many cases predict mortality (Laukkanen, Heikkinen, and Kauppinen, 1995; Rantanen et al., 2000).

2.2 Muscular Strength in the Elderly

Progressive resistance training performed by elderly individuals has been shown to be beneficial (Hortobagyi, Tunnel, and Moody, Beam, and De Vita, 2001; Lazowski et al., 1999; Rubenstein et al., 2000). This is important, as muscular strength has been determined as one of several independent factors influencing physical functional capacity in healthy older individuals (Greene, Williams, Macera, and Carter, 1993). Therefore the development or maintenance of muscular strength is of increasing priority. In particular, lower limb strength has been shown to be positively correlated with certain functional parameters, such as stride length and preferred gait velocity (Scarborough, Krebs, and Harris, 1999), and mobility and balance (Greene et al. 1993), all of which impact upon activities performed during normal daily living.

Resistance training performed by aged individuals has been specifically reported to have other positive physiological outcomes including, increased lean muscle mass (Evans, 1999), reduced rate of sarcopenia (Evans, 1995), increased performance of static and dynamic balance tasks (Brown, Sinacore, Binder, and Korht, 2000), and enhanced muscular strength and power (Brown et al., 2000; Foldvari et al., 2000; Meuleman, Brechue, Kubilis and Lowenthal, 2000; Taaffe, Duret, Wheeler and Marcus, 1999). Associated reductions in falls by the elderly have also been reported for individuals performing resistance training (Hauer et al., 2001). Hence, providing evidence for the use of this mode of exercise as a preventative activity, which can contribute to positive health outcomes for elderly participants.

It is important that resistance training is performed for the maintenance of health, with advancing age. This is because significant reductions in muscular strength following the ages of thirty-to-forty years can be observed over the remaining decades of life. It has been suggested that a loss of strength due to aging can result at a rate of approximately 1% to 2% per year, with the upper extremities effected at a slower progression than the lower extremities (Aniansson, Sperling, Rundgren, and Lehnberg, 1983). Therefore this influences activities involving mobility or that require lower limb strength (e.g., climbing stairs) to a greater extent than activities performed using the upper limbs. Another study looking at the decline of strength during the aging process reported that between the ages of 50 to 70 years, dynamic muscular strength decreased between 24%

and 36% (Larson, 1991). More specifically Hunter, Thompson and Adams (2000) found maximal voluntary strength reductions of the knee extensors and plantar flexors of approximately 0.93% and 0.74% per year, respectively. These studies provide evidence of an age related decline in muscular strength.

The underlying mechanisms that cause the loss of muscular strength are relatively unknown (Thompson, 1994). The reduction in force production capabilities of skeletal muscle may be influenced by the loss of lean muscle tissue in elderly individuals (Frontera et al., 2000). This loss of muscular tissue associated with advancing age is commonly referred to as sarcopenia (Evans, 1995).

Several studies have attempted to quantify the relationship between sarcopenia and the loss of muscular strength. Frontera et al. (2000) observed a loss in muscle cross-sectional area of 12.5% to 16.1% over a 12-year period, where a decrease of $1 cm^2$ contributed to a strength loss of 2.68 Newton•meters. Klein, Rice and Marsh (2001) observed a strong positive relationship ($r > 0.74$) between muscle cross-sectional area of the upper limb and isometric maximal voluntary contractions of subjects aged 76 to 95 years. Hakkinen et al. (1998) found a similar relationship ($r = 0.64$) between cross-sectional area of the individual muscles of the quadriceps and maximal isometric force, in younger elderly males. Generally, there appears to be a strong relationship between loss of lean muscle tissue and the decline in muscular strength. The performance of resistance training by elderly individuals may reduce muscular strength loss through the maintenance or increase in lean muscle tissue.

Although there appears to be a definite relationship between both the decline in muscle mass and strength, there is limited knowledge about the changes occurring at the level of the muscle fibre and sarcomere. Hakkinen et al. (1998) reported no differences in the distribution of Type I muscle fibers (motor units with high oxidative/reduced anaerobic capacity recruited during low-intensity activity) at baseline and after training, or between elderly and young subjects after 10-weeks of strength training. O'Neill, Thayer, Taylor, Dzialoszynski and Noble (2000) found similar results with no changes reported for the distribution of Type I fibers, as well as for the distribution of Type II fibers (motor units with high anaerobic/reduced oxidative capacity recruited during high-intensity activity). However, the researchers did find small but significant increases in cross-sectional area of the Type I and IIb muscle fibers, contributing to increases in the peak torque of the knee extensors. Thus, indicating that improvements in muscular strength may be brought about by increases in fiber size rather than through increases in the fibre distributions. Hence for practical purposes it may be beneficial to include resistance training that specifically targets hypertrophy as a means of increasing muscular strength in the elderly (i.e., 3+ sets of 6 to 12 repetitions at 70 to 90% or repetition maximum with exercises performed slowly) (Egger, Champion, and Hurst, 1989)

In a review of the literature Thompson (1994) suggested that muscle containing predominantly Type II muscle fibres showed the greatest loss of muscle tissue with advancing age, showing favoured atrophy when compared to Type I muscle fibers. Therefore, aged individuals may be disadvantaged when performing everyday tasks that involve greater rates of force production (i.e., climbing stairs, moving furniture etc.), and hence require increased innervation of Type II muscle fibers. Exercise interventions that target specifically the Type II muscle fibers, causing either hypertrophy or hyperplasia, may assist older adults to perform tasks (e.g., stair climbing) requiring greater force production.

Improvements at a neuromuscular level may influence strength development. The fact that the exercise interventions for studies by both O'Neill et al. (2000) and Hakkinen et al. (1998) were of a short duration suggest that strength improvements may be partially associated with neuromuscular factors such as reduced antagonist recruitment and improved synchronisation of fibres. After collecting electromyographic data, Hakkinen et al. (1998) showed support for the influence of the neuromuscular system on muscular strength. The investigators observed increases in muscle agonist activation, and reductions in muscle antagonist coactivation in elderly as well as in middle-aged subjects.

Not only are changes in neuromuscular responses to strength training similar between elderly and middle-aged individuals but it has also been reported that elderly subjects are equally as capable as younger subjects of complete maximal voluntary isometric contractions of the dorsi flexors and rapid motor recruitment (Kent-Bruan and NG, 1999). Moreover, the same investigators also found no difference in "specific strength" (i.e., maximal voluntary contraction divided by cross-sectional area) between the two groups hence, observing a linear relationship ($r = 0.81$) between cross-sectional area and muscle strength in the elderly subjects.

Generally, it appears that resistance trained skeletal muscle of elderly individuals adapts in similar ways to that observed in younger individuals. This suggests that the same underlying models for developing exercise prescriptions for younger individuals can be used for elderly individuals. Thus, exercise prescription principles can be applied to elderly individuals. These principles include specificity (specific exercises that target muscle groups), intensity (defined as the amount of weight used, number of repetitions and sets), frequency (how often the exercises are performed either in one session or over an entire duration), recovery (time spent between exercise sessions) and overload (the constant increase in stimulus either by increasing the frequency, intensity, or introduction of different exercises that still focus on the same muscle groups), can still be applied to elderly individuals.

Despite the literature suggesting a strong positive relationship between muscular size and strength, this does not completely account for increases or decreases in strength. The quality of muscle has been mentioned as a possible factor, which could account for some of the variance in strength decrements with age (Hakkinen et al., 1998). The researchers indicate that the ratio of lean muscle to intramuscular fat may decline with age. This would mean that the cross-sectional area between younger and older individuals may appear to be equal, but the lean tissue and hence the functional component of a whole muscle may be reduced in the elderly individual due to a greater non-lean component of the muscle.

Goodpaster, Carlson, Visser, and Kelley (2001) investigated the attenuation (ratio of intramuscular lipid storage and lean muscle) of muscle and its effects on muscular force development. The researchers found that attenuation decreased with age, resulting in an increase of intramuscular lipid storage. The researchers controlled for cross-sectional area in the statistical analysis, identifying a relationship of greater voluntary muscular force, with higher levels of attenuation. Hence the quality of muscle may be an additional factor, which could contribute to strength reductions in aged individuals.

Strength decrements indicated by these studies are significant, and may lead to a reduction in the quality of life. Therefore, it is necessary to implement strategies to reduce the impact of these age associated strength losses. Muscular strength and lean muscle tissue can be increased with the appropriate training, and in some cases, strength impairments in an individual can be partially reversed (Fiatarone et al., 1990). This is especially true where aged individuals have demonstrated muscular adaptations, similar to those of younger individuals (Coggan et al., 1992).

2.3 Strength Training in the Elderly

The benefits of strength training for the elderly population are agreed upon. However, there is no conclusion on the most effective intensity, volume, frequency or recovery that should be prescribed for the elderly population. The American Council on Exercise (Pollock et al., 2000) suggests that for the elderly, resistance training be performed at an intensity of approximately 70% to 80% of 1-repetition maximum with a repetition range from 8 to 15 for one to three sets, performed two to three sessions per week. The American College of Sports Medicine (2000) suggest the performance of at least one-set of 8 to 10 exercises utilizing all major muscle groups, with each set involving 10 to 15 repetitions, performed at least two days per week.

Although these guidelines are similar, there is some discrepancy between the two in the minimum number of sets and repetitions recommended. Both also tend to target the entire elderly population as though it was homogenous. These recommendations are questionable particularly as there is much heterogeneity between individuals aged in the 6th and 9th decade, for which the guidelines are intended. Due to the variability of physiological function in the elderly population an individually tailored approach may be required depending on the physiological and functional make-up of the individual or group. In any case strength improvements have been shown to occur at various intensities and frequencies of resistance training in the aged, which provide the foundation of such recommendations.

The literature indicates that various frequencies, intensities, durations of interventions and modes of exercise for improving muscular strength and physiological functions have been used in the elderly. Taaffe et al. (1999) implemented a high-intensity (80% of 1-repetition maximum) exercise intervention for 24-weeks. Healthy elderly volunteers were recruited from the community and randomly allocated to three groups, bases on the frequency of training. The frequency was characterized by the number of days per week the subjects trained (1-day, 2-days, or 3-days). The researchers observed no significant differences between the groups, but all demonstrated significant improvements in strength (37.0% to 41.9% for all 3 groups) and related increases in lean body mass. Taaffe et al. suggested that participation once or twice weekly in resistance training may allow similar strength gains to that seen in a three day per week regimen.

Schlicht et al. (2001) also studied the effects of a high-intensity strength training intervention on performed 3-days per week for 8 weeks by community-dwelling, elderly subjects. The intervention concentrated on the lower part of the body using 2-sets of 10-repetitions at an estimated intensity of approximately 78% of one-repetition maximum. The researchers reported significant improvements in strength of 20 to 48% and walking speed of the experimental group. Similarly, overall strength gains of 32.8% for isometric and 41.2% for isokinetic have also been observed in elderly nursing home residents after performing moderate intensity exercise interventions (minimum load of 40% of peak concentric torque) (Meuleman et al., 2000). In addition, resistance training at loads of 80% of one-repetition maximum has been reported to improve lower-extremity strength by 61% to 374%, in elderly rehabilitation centre residents, 90 years of age and older (Fiatarone et al., 1990). Thus, signifying that high-intensity resistance training is effective for both the healthy and frail elderly.

The participation by the elderly in high or moderate intensity exercise interventions that involve a strength training component appear to be effective (Taaffe et al., 1999; Schlicht et al., 2001; Meuleman et al., 2000; Fiatarone et al., 1990). However, such interventions may not be well accepted by the majority of elderly individuals for whom access to the type of exercise equipment required to perform high-intensity exercise is not practical. Thus, lower intensity interventions that require less or no sophisticated equipment can be performed at home or in an aged-community setting may be more applicable to individuals within this population.

Low-intensity exercise interventions also appear to be effective for improving muscular strength in elderly individuals. Brown et al. (2000) reported that in a group of elderly physically frail individuals, 3-days per week of low-intensity resistance training over

12-weeks, induced positive effects on physical performance, strength (overall improvement of 9%) and balance. Westhoff, Stemmerik and Boshuizen (2000) also reported strength improvements of approximately 54% in elderly subjects after implementing a low-intensity exercise intervention, 3-sessions per week for 10-weeks. Direct comparisons between these and the high-intensity training studies mentioned are difficult, as the intensity is not specified. This is probably due to the various types of activities performed (i.e., using elastic bands, body-weight resistance) where intensity is difficult to quantify.

Hortobagyi et al. (2001) directly compared of high and low-intensity exercise interventions, with intensities defined by the authors as 80% and 40% of one repetition maximum, respectively. The investigators observed no significant differences for either maximal isometric, eccentric, or concentric strength measures of the quadriceps between the two groups of healthy elderly men after 10-weeks of training. Jones, Rikli, Benedict, and Williams (1994) reported improvements in lower-extremity strength for dorsi and plantar flexion, and non-dominant knee flexion and extension in elderly individuals who participated in a low-intensity (50 to 60% of one-repetition maximum) intervention. The intervention utilised no sophisticated exercise equipment with the authors stating that the intervention was specifically designed to be used in both an aged community and home settings.

The previous studies suggest that for elderly individuals low-intensity exercise interventions provide health benefits (i.e., increase in muscular strength) over short durations in both frail and healthy older adults. This is important, as many elderly individuals cannot access the type of facilities that contain the equipment and expertise to perform high-intensity exercise interventions. There is a need to determine which types of low-intensity exercise interventions are most beneficial for elderly individuals, especially for those who may be functionally unable to perform exercise outside of their own homes or aged care facilities.

The magnitude of change in muscular strength is dependent not only on the effectiveness of the intervention, but also the general functional characteristics and initial fitness level of the elderly individual. This may be part of the reason why low-intensity exercise interventions targeting muscular strength improvement achieve positive results in many elderly individuals. An individual whose physiological capacity is reduced may only require a minimal level of physiological stimulus to induce positive adaptations, particularly when the stimulus is presented frequently enough.

Several studies have investigated the relationship between muscular strength and the prediction of falls, fractures, osteoporosis, and physical function. (Hauer et al., 2001; Rhodes et al., 1999; Humphries et al., 1999; Foldvari et al., 2000; Kerschan-Schindl et al., 2000). Foldvari and colleagues (2000) found that leg power was a promising predictor of self-reported functional status in community-dwelling subjects. The assessment of muscular power instead of strength is based on the idea that both components of power, speed and strength decline with age, theoretically making it a better predictor of physical function in the elderly (Foldvari et al., 2000).

Hauer et al. (2001) found that a 12-week progressive resistant program for the lower extremity at loads of 70% to 90% of one repetition maximum, coupled with functional and balance training, caused improvements in strength and motor performance, as well as contributing to a 25% reduction in falls as compared to a control group. Contrary to findings of this study a 7 to 12 year longitudinal study conducted by Kerschan-Schindl et al. (2000) found that the incidence of falls among a home-based exercise group and a control group were similar. Although this study showed no differences in falls, the limited progressiveness in overload of the exercise protocol may have been a limiting factor. This study may also indicate that regular exercise alone may not prevent falls.

2.4 Grip Strength in the Elderly

Grip strength contributes to the performance of activities of daily living (Laukkanen et al., 1994) and can act as a measure predicting survival (Laukanen, Heikkinen, and Kauppinen, 1995), and mortality (Rantanen et al., 2000). A study by Carmelli and Reed (2000) found that grip strength decreases with advancing age. This study observed grip strength to decline by approximately 0.26% per year. Larger age related declines in grip strength of 0.62% per year have also been reported (Hunter, Thompson, and Adams, 2000). It is unlikely that grip strength has a direct influence on mortality and survival, but it does indicate the current status of an individual's functional capacity, which strongly influences the former. Payne, Gledhill, Katzmarzyk, Jamnik, and Ferguson (2000) determined that in females, grip strength alone could discriminate between the high and low health status, with the authors suggesting that the level of musculoskeletal fitness (including muscular strength) is associated with an individuals level of health.

Despite these relationships, grip strength has not always been reported to improve through the performance of resistance training. Suggesting that some exercise interventions may not lead to grip strength improvements or that grip strength dynamometers are not sensitive enough to detect small changes in muscular strength. A study performed by Rhodes et al. (2000) reported no improvement in grip strength of elderly sedentary female subjects after a year-long resistance-training regimen. However, the researchers did observe significant improvements of 19% to 53% in whole body strength in the same study. Hauer et al. (2001) also observed no significant improvement in grip strength, despite finding other muscular strength improvements, following resistance training. These studies provide evidence that strength development is movement specific, and that general strength training may not necessarily improve grip strength. They also indicate that as muscular strength development is movement specific, muscle groups that most contribute to the performance of normal activities of daily living should be targeted when prescribing exercise interventions.

Payne and colleagues (2000) found that grip strength independently discriminated between high and low health status in females aged between 15 and 69 years. Greene et al. (1993) while identifying dimensions of physical function in the elderly, found that after performing factor analysis, the first factor identified as "strength" included results from grip and back/leg strength measures. Overall the measure of grip strength is useful particularly when determining an individual physiological status, but may not be a suitable indicator for measuring the effectiveness of an exercise intervention. Grip strength dynamometers appear to be sensitive to measuring large strength difference such as that found cross-sectional studies that compare adults across a wide range of ages, and less accurate for measuring changes in specifically aged samples. This is likely to be due to greater differences in grip strength observed between individuals of different ages compared to individuals within the same age group.

2.5 Postural Stability in the Elderly

Postural stability may be defined as "the ability to maintain the center of body mass within limits of stability, determined by the base of support" (Woollacott, and Shumway-Cook, 1996). Postural stability can be divided into two main sub-components. The first comprises static balance, which is characterised by motionless stance with little or no postural changes. Static balance is predominantly measured through the assessment of spontaneous sway and is often observed during quiet standing. Aged individuals show increases in sway, and hence postural instability, which has been associated with the risk of falling (Campbell, Borrie, and Spears, 1989). The second component is dynamic balance, which is usually measured during the event of postural changes where the center of mass is continuously changing direction, whilst maintaining stability.

The advent negative effects of declines in postural stability can be observed by the high numbers of falls that occur within the aged proportion of the population (The National Ageing Research Institute, 1999). Multiple factors are associated with balance impairments in the aged. Faulty mechanisms that influence decrements in balance include, errors in sensory information about joint position (Williams, McClenaghan, and Dickerson, 1997; McChesney and Woollacott, 2000), as well as deficiencies in lower limb strength and tibialis anterior latency (Hughes, Duncan, Rose, Chandler, and Studenski, 1996). Hence, the concept of postural control is complex, involving motor coordination and sensory organization (Ringsberg, Gerham, Johansson, and Obrant, 1999).

Lord, Clark and Webster (1991) found that under static balance conditions, poor balance measurements were associated with reduced tactile sensitivity, joint position sense, vibration sense, reduced ankle dorsiflexion and quadriceps strength in the aged. Poor dynamic balance was found to be associated with increased reaction time reduced tactile sensitivity, decrements in quadriceps strength, and poor vestibular optical stability. The same investigators also reported an increase in sway 1.3 times more during tasks where vision was removed when compared to when vision was available. This study highlighted the dependence on vision by elderly individuals for maintaining postural stability, which may be associated with declines in other kinaesthetic senses and muscular strength.

Strength based exercises are often a dominant component of most exercise interventions prescribed for the elderly, even when improvements in postural stability is the main objective. This could be due to the reductions in falls associated with increasing muscular strength of the lower limbs (Hauer et al., 2001). However, there has been contrary evidence to suggest otherwise. The positive association of lower limb strength and balance has not always been observed in elderly individuals (Schlicht et al., 2001; Ringsberg et al., 1999; Judge, Lindsey, Underwood, and Winsemius, 1993).

Several studies assessing balance as an outcome measure have used various interventions including; strength training supplemented with walking, postural control, and flexibility (Judge et al., 1993; Lazowski et al., 1999); flexibility and postural control exercises, (Judge et al., 1993); strength training alone (Schlicht et al., 2001; Rhodes et al., 2000); and Tai Chi (Hartman et al., 2000; Hain, Fuller, Weil, Kotsias, 1999; Yan, 1998).

Differences in the prescribed exercises and protocols by researchers as well as individual differences, and measurement protocols make it difficult to compare accurately the effectiveness of interventions for improving balance. Province, Hadley, Hornbrook, Lipitz et al. (1995) performed a meta-analysis of several trials known as Frailty and Injury: Cooperative Studies of Intervention Techniques (FICSIT), to determine the effectiveness of short-term (10 to 36 weeks) exercise on falls in the aged. The investigators found that overall the interventions analysed generally reduced, or protected against falls. The same investigators also raised the issue of difficulty when comparing different types of exercises performed in the interventions (Province et al., 1995).

Interventions often use various combinations of differing exercises, in which case it is difficult to determine specifically what attributes contribute most to improvements in balance. Another issue is the heterogeneity of the aged population (Swanson, Tripp-Reimmer, and Buckwater, 2001) and their different rates of adaptation to exercise. Therefore it is necessary to continue measuring balance as an outcome measure of exercise intervention no matter what type of intervention is performed. This will provide further insight into which modes of exercise are beneficial for enhancing postural stability in elderly individuals.

The variability of the Center of Pressure (COP) has been used as an objective measure of balance or postural stability in laboratory settings (Judge et al., 1993; Lord et al., 1991; Brauer, Burns, Galley, 2000; Berg, Maki, Williams, Holliday, and Wood-Dauphinee, 1992; Cho and Kamen, 1998; Hughes et al., 1996; McChesney and

Woollacott, 2000). The variability of the COP is thought to represent postural sway and has been suggested to increase with advancing age (Judge et al., 1993). One particular difficulty occurs when attempting to compare results, as many studies have used different time periods (known as epochs) during which COP data has been collected. Differences in collection time have been shown to influence the COP statistics obtained (Le Clair and Riach, 1996; Carpenter, Frank, Winter and Peysar, 2001), reducing the generalisation of results and increasing difficulty when attempting to compare results between studies.

Balance can also be measured by having individuals perform timed balance tasks or other subjective assessments (Berg et al., 1992; Lazowski et al., 1999; Ringsberg et al., 1999; Harada, Chiu, Damron-Rodriguez, and Fowler et al., 1995; Brauer et al., 2000; Hurvitz, Richardson, Warner, Ruhl, and Dixon, 2000). One such assessment is the Berg Balance Scale (BBS) (Berg, Maki, Williams, Holiday, and Wood-Dauphinee, 1989) which was developed to measure both static and dynamic components of balance in the elderly. Berg and colleagues (1992) found that higher scores on the Berg Balance Scale was associated with higher levels of independence in mobility when comparing scores with those obtained from several mobility tests, which included the Timed "Up" and "Go" test (Podsiadlo and Richardson, 1991). The study also found that the speed and amplitude of the Center of Pressure, accounted for 42% of the variance in the Berg Balance Scale scores, thus indicating the BBS validity. Brauer and colleagues (2000) performed a study assessing the ability of predicting falls in elderly women. They found that with the use of several different instruments, including the BBS, the instruments could not predict fallers. The researchers suggested the BBS might have limited predictive abilities when used to assess elderly community-dwelling adults, due to a ceiling effect for higher functioning persons.

Physical activity and exercise for the elderly is a preventive aid and a therapy for many physiological deficiencies, balance being no exception. Era and colleagues (1997) found a significant positive relationship between physical activity and several balance measures. Heoppner and Rimmer (2000) found that physically active, elderly adults between the ages of 60 and 90 years had better balance than those who were inactive. The researchers also observed that postural sway was significantly associated with timed positional balance tasks and a vestibular stepping task.

Several studies have investigated the effects of structured exercise on physiological parameters including balance. Schlicht and colleagues (2001) investigated the outcomes of an intense strength training intervention performed 3-days per week, for 8-weeks. The exercising elderly subjects showed no significant difference in unipedal stance time compared to the control group however, significant strength increases between 20 to 40% were observed across all resistance exercises performed. The authors concluded that higher body strength alone does not improve static balance.

Balance was measured in a study by Lazowski et al. (1999) who investigated the effects of exercise on the frail elderly. The study included two combined training groups, and an additional group that performed range of motion and flexibility exercises. The Berg Balance Scale and the Timed 'Up' and 'Go' test were used to assess functionality, with both measures showing improvement for the combined training groups following the intervention. Strength was also noted to improve, and may have been a contributing factor underlying the improvement in balance found in the resistance trained groups.

Judge and colleagues (1993) investigated the outcomes of a combined exercise intervention. The exercise focussed on the lower limbs, and included walking, flexibility, strength, and balance exercises. Simplified Tai Chi movements were used as part of the balance component. Unipedal stance time increased by 18% for the exercise group however, double stance displacement measured from a force platform, did not show any change for the control or the exercise groups. No correlation existed between the measures for double stance and single stance from the force platform, indicating different underlying factors controlling the two postural stances. The investigators also found no significant correlation between leg strength and balance, which is in agreement with the study by Schlicht et al. (2001).

A study by Hauer et al. (2001) found that using an intervention combining resistance training and functional-balance training, subjects improved walking speed, balance, functional mobility (measured by the Timed 'Up' and 'Go' Test) and increased muscular strength. The authors found a correlative relationship between balance and strength. The study did not investigate the difference between the two areas of focus, namely functional-balance training and strength training, which may have given more insight into what part of the interventions had more influence on balance and the other measured outcomes. A simple light-intensity intervention utilising dumbbells and ankle cuff weights, has been shown to improve functionality, with improvements in the timed chair stand, 6-meter walk, stair climb, and balance (Brill et al., 1998). This indicates that a simple, low cost intervention, implemented in an aged care setting can provide positive results for elderly individuals. However, it is unknown to what degree improvements in lower limb strength had on functionality, as this data was not collected.

Grahm Kronhed, Moller, Olsson, Moller (2001) studied the effects of a specific balance training program in the elderly. The program included exercises to alleviate vertigo, ocular movements, and presented activities of normal daily living. The study found that subjects in the balance group improved their single-legged stance time when their eyes were closed, and while rotating the head. In addition subjects also decreased the time required to walk 30 meters. The researchers believed that improvements were brought about by adaptations in coordination, rather than muscle strength. Interventions that specifically target balance may provide better improvements in postural stability than those, which do not focus on balance.

From the literature reviewed it appears that exercise, particularly exercise that combines different types of activities is beneficial for improving postural stability in the elderly, particularly for individuals who are frail or have balance impairments. Strength training although influential, probably is not alone sufficient to the improve balance, especially in the elderly who are highly functional and have unimpaired (although reduced due to the aging process) postural stability. Results vary greatly between studies and this is partly due to the heterogeneity of the elderly samples used, and in addition to no criterion method for measuring balance being agreed upon.

2.6 Alternative Exercise Interventions: The Holistic Approach

Alternative forms of exercise interventions for both fitness and rehabilitation for the elderly are becoming widely used. Holistic exercise interventions involve not only physical activity, but also a psychological component often consisting of mind concentration and relaxation exercises. Several studies have investigated a type of holistic approach known as Tài Chi, and its potential benefits in the elderly (Xu and Fan, 1988; Yan, 1988; Hain et al., 1999; Hartman et al., 2000). Xu and Fan (1988) stated that because of the moderate intensity, steady rhythm and low physical and mental tension, Tai Chi is appropriate for the elderly and patients with chronic diseases. Tai Chi seems to be particularly easy for the elderly to be involved in because of the activity diversity, ability to be done any place, without necessary equipment, and at a time that best suits the individual. Thus, Tai Chi is an exercise intervention that accommodates the lifestyle of elderly individuals.

Holistic interventions may be effective for improving chronic conditions such as rheumatoid arthritis (Harlowe and Yu, 1984). It has been suggested that holistic interventions such as Tai Chi can be used in conjunction with medical management as an effective therapy for osteoarthritis (Hartman et al., 2000). Although holistic interventions provide promise as alternative forms of exercise to be used in the elderly, unfortunately the scope of research on holistic interventions, particularly on physiological function is limited. Hence there is a need to identify the benefits of performing holistic exercise from a physiological and functional viewpoint.

Hartman and colleagues (2000) measured the benefits of Tai Chi in older adults with osteoarthritis. The investigators measured several physical functions including, balance and walking speed. For this study Tai Chi was formally presented two-sessions per week for a period of twelve weeks. Lower extremity function was based on composite achievement from balance and walking speed, in addition to the time required to rise from a chair over a designated number of repetitions. The researchers found no significant change in lower extremity function, but did however, find small to moderate improvements in one-leg balance time and gait speed for the Tai Chi group. In addition, Hartman et al. also found that individuals in the Tai Chi group had improved self-efficacy, experienced reduced pain, and reported improved satisfaction with their general health status. Improvements in self-efficacy, brought about by increases in movement confidence and well-being has been related to the maintenance and uptake of exercise interventions (Feltz and Chase, 1998).

Hain and colleagues (1999) measured the effects of Tai Chi on balance, in an intervention lasting eight weeks, with one formal session per week presented. The subjects recruited for this study reported self-perceived balance disorders. Peak sway with eyes open and closed was measured, with the intervention group showing highly significant improvements in balance. The balance improvements observed in this study compared to Hartman et al's (2000) study may have been due to subjects having impaired balance at baseline, therefore more likely of showing an improvement. Other investigators have also suggested that Tai Chi may be useful as a modality of rehabilitation for balance (Hain et al., 1999).

Yan (1998) studied the effects of Tai Chi on nursing home residents. The study compared a locomotor intervention group to a Tai Chi intervention group. Using a stabilometer to measure dynamic postural control, Yan (1998) found that the Tai Chi intervention group had greater improvements in balance than those of the locomotor group. The study also found that movement jerk for arm actions was significantly reduced for the Tai Chi group. This may have implications for the performance of normal daily activities that require coordinated and controlled muscular actions, for example drinking from a cup or pouring water into a glass.

In contrast to the other studies mentioned, Wolf, Barnhart, Ellison, and Coogler (1997) in a study on sedentary elderly individuals, found that individuals who participated in a balance training intervention improved postural stability greater than those in a Tai Chi group. This may be because the balance training is specific for improving a single physiological parameter (i.e., balance). The study did however, find that the Tai Chi group had a reduced fear of falling after the intervention, which in itself may lead to further participation in physical activity (Tinetti et al., 1994). The findings of Wolf et al. (1997) indicate that the psychological benefits of holistic exercise may be as important as the physiological outcomes.

A control study by Van Deusen and Harlowe (1987a) examined the effects of an intervention known as ROM dance (Harlowe and Yu, 1984), incorporating a Range of Motion Exercise and Relaxation Program, on subjects with rheumatoid arthritis. The program involved flowing dance like movements, mind concentration and relaxation like that used in Tai Chi Ch'uan. The ROM intervention also promotes the development in awareness of postural alignment and controlled breathing. Van Deusen and Harlowe

(1987a) found that participants, after 4-months of the intervention, showed significant increases in the range of motion of the upper extremity. Subjects also reported increased feelings of enjoyment, hence indicating the interventions ability to provide psychological benefits. Another study by the same authors compared the ROM dance program with a traditional home exercise intervention for rheumatoid arthritic subjects (Van Deusen and Harlowe, 1987b). No differences between the two home-based groups were found for measures of range of motion, but the ROM dance program reported higher participation rates. Participants in this project suffered from rheumatoid arthritis making it difficult to extrapolate these results to the entire elderly population. However, some of the characteristics of this disease and its limiting effects on mobility and daily function can be generalised to some conditions experienced by the elderly individuals.

Like the number of studies performed on the benefits of Tai Chi, there is also limited research of the effects on physiological parameters by the Range of Motion dance method. Measures of strength and balance have yet to be performed on individuals performing the Range of Motion intervention, with its effects on health status unknown. Much of the research performed on this exercise method is qualitative, and therefore requires a more empirical evaluation.

2.7 Adherence to Physical Activity in the Elderly

The risk of disease increases, and functional capacity declines with a sedentary lifestyle (Blair, Kohl, Gordon, and Paffenbarger, 1992). A major barrier to increasing physical activity levels among older adults has been identified as the poor adherence to exercise programs (Jette et al., 1998), although this is not entirely an issue related only to the elderly population. In 2000, the percentage of older Australians, 60 years and older participating in sufficient physical activity to accrue health benefits was estimated at 54.4% (Bauman, Ford, and Armstrong, 2001). The proportion of the entire Australian adult population participating in sufficient physical activity during the same year was found to be 56.8% (Bauman, Ford, and Armstrong, 2001).

A study by Schmidt and colleagues (2000) identified several reasons for dropouts from two exercise interventions performed by the elderly. The study revealed that 36% of individuals dropped out entirely from the 18-month program. Out of those individuals who dropped out, 55% left the interventions within the first 3-months of commencing. The reasons for attrition identified were health problems, followed by the refusal to continue. Early dropouts were observed to be distinguishable by their poorer health and reduced physical performance. Schmidt et al. (2000) also reported that subjects aged 80-years or older were 25-times more likely to drop out.

Adherence or compliance can be measured by several methods. Indirect methods include self-report (e.g., diary of exercise performed), mechanical or electronic procedures (e.g., accelerometers), and direct methods such as recording attendance (e.g., to exercise classes)(Perkins and Epstein, 1988). Essentially, adherence represents the rate or measure of participation in an intervention by a group of subjects.

Jette et al. (1998) measured adherence of a home-based resistance training intervention. The results were comparable to those of Schmidt et al. (2000), where subjects showing higher physical performance also showed higher participation rates. In addition, subjects with fewer new medical problems were less likely to dropout. Jette and colleagues (1998) reported that psychological and demographic factors had no significant influence on predicting participation rates however, adherence to the intervention was related to psychological factors. Individuals with positive attitudes toward exercise were also likely to remain in the intervention.

A study by Tennstedt et al. (1998) used a diverse group orientated intervention, with two-sessions performed per week for four-weeks. The investigators observed that 63.4% of subjects attended 5 to 8 sessions. Schmidt et al. (2000) also showed an attendance rate of approximately 64% but over an 18-month period. In Tennstedt et al.'s (1998) study 16.2% of individuals did not attend any sessions. Reasons for non-attendance included illness and appointments. It was found that subjects with generally lower physical activity levels were less likely to attend the sessions.

Wolinsky, Stump, and Clark (1995) reported that individuals with a greater number physical limitation were less likely to engage in physical activity. A lower number of physical limitations were also a major factor influencing physical activity participation in the study by Jette et al. (1998). Wolinsky et al. (1995) found that subjects who felt that they had a sense of control over their health were more likely to engage in physical activity, further supporting the psychological influence on compliance and participation. Although, health and injury are reported as common barriers to participation in exercise and physical activity by the elderly, other administrative type reasons (as opposed to physical/health, psychological, and knowledge reasons) have also been cited including: inconvenience of class times; difficulty of transportation; expense; and unappealing activities (O'Neill and Reid, 1991).

Overall, studies indicate that both psychological and physiological factors can be attributed to engagement, adherence, and compliance of exercise interventions. Holistic approaches may be beneficial for addressing these factors. The study by Hartman et al. (2000) found that with a Tai Chi intervention only one subject dropped out and 14 out of 18 subjects attended 87% of classes. The study attributes the good adherence of Tai Chi to its slow and gentle movements and because of its mind-body-orientated approach. A pilot study by Harlowe and Yu (1992) found that 85% of individuals performed the ROM dance intervention three or more times per week. However, the exercises were carried out in the home environment, which may have elevated adherence to the intervention. Although, it appears holistic interventions seem well accepted by the elderly, further research is required to determine if holistic interventions are as effective for reducing the number of dropouts and increasing adherence compared to other commonly performed conventional exercise interventions.

2.8 Conclusion

Physiological parameters decline with advancing age. The rate of decline can be reduced and sometimes reversed. However, for this to occur preventive and therapeutic interventions incorporating physical activity and exercise is required. In general physical activity interventions, including holistic exercise provide both psychological and physiological benefits. What is not known is whether holistic interventions are as effective as conventional approaches, which incorporate resistance training for improving physiological parameters such as muscular strength, postural stability, and functionality. These parameters are important for improvements in the quality of life and the maintenance of independence. Hence, it is essential to determine which types of exercise interventions are most beneficial, and which are best accepted as a form of exercise by elderly individuals. In particular, there is a need to directly compare the benefits of performing a low-intensity conventional exercise intervention and a holistic exercise intervention by elderly individuals.

Although Tai Chi appears to be the most common form of holistic exercise interventions reported in sport and exercise science literature, little is known about the effectiveness of the Range of Motion dance method as an intervention for elderly individuals. The potential physiological benefits of this activity need to be compared to a conventional exercise intervention, thus adding a novel aspect to this study.

CHAPTER 3

3.0 Methodology

3.1 Subjects

A total of seventy-eight individuals, aged 65-years and older volunteered to participate in the study. Subjects were recruited into the study by two methods. Subjects were recruited from a database held by Silver Chain Nursing Association, an organization that provides homecare services to both rural and metropolitan regions of Western Australia. Subjects located in the database, who resided in suburbs within a five-kilometre radius of where the interventions were to be operated, were mailed letters inviting them to participate in the study. A total of 902 invitation letters were mailed. In addition subjects were also recruited through community advertising via information brochures, placed in three age hostels in the surrounding area.

All brochures and letters encouraged subjects to bring friends and family. Interested subjects telephoned to receive further information about the study and were invited to an information seminar where additional details were provided. At the seminar subjects that were interested were given written information about the content of the study, a consent form and a health history questionnaire (appendix A). The developed health history questionnaire included questions covering inclusion and exclusion criteria specific to this study. Subjects (n = 78) who completed the questionnaire were required to meet several inclusion and exclusion criteria before they were considered to be part of the study. The inclusion criteria included:

- Subjects were to be aged 65 years and over.

- Subjects were to be living independently within the community or in aged hostels, requiring only limited assistance (one day per week of home care assistance).
- Subjects who could walk or stand unassisted.
- Subjects who were willing to attend two sessions per week over the period of the interventions.

The criteria for exclusion included:

- If subjects reported uncontrolled hypertension or high blood pressure.
- If subjects reported a history of a heart attack.
- If subjects reported feeling chest pain during rest or physical exertion.
- If subjects reported feeling breathless after low or mild exertion.
- If subjects reported feeling unusual or irregular heartbeats during rest.
- If subjects reported a history of fracture to the hip or spine.
- If subjects reported falling more than two-times in the past three-months.
- If subjects, who reported heart or circulatory conditions were not being treated.
- If subjects were currently receiving rehabilitation for any injury that restricts movement.
- If subjects reported belonging to a formal exercise group.

After analysing the health screen questionnaires subjects who were considered borderline for inclusion in the study were telephoned to discuss certain health issues, and to clarify whether it would be safe for them to perform the exercises. Subjects were asked to obtain physicians approval to participate, if there was still uncertainty about the safety of their involvement in the exercise interventions.

3.2 Design

This investigation was a 10-week randomised controlled pilot study consisting of a 3 x 2 group design, which included two intervention blocks, "A" and "B". The interventions were performed in two blocks of 10-weeks to allow smaller group numbers (approximately n = 10) and to facilitate the teaching of the interventions. Names of subject's who met the inclusion criteria were placed in alphabetical order and a random computer-generated number was then determined for each subject. Based on the last digit of the number, subjects were assigned to one of four groups:

1) Conventional intervention;
2) ROM intervention;
3) Control; and
4) Block "B" group.

Subjects in the first three groups underwent baseline testing before the start of the block "A" intervention period. Following the intervention period the Conventional group, ROM group and Control group underwent post-intervention testing, while subjects in the block "B" group performed baseline testing. The Control group and block "B" group were amalgamated and randomly assigned to either the Conventional intervention or the ROM intervention (i.e., block "B" interventions groups) by the method previously stated. Characteristics and format of the testing and exercise interventions were exactly the same between block "A" and block "B". Two sets of data were collected from the control group (i.e., control data in block "A" and intervention data in block "B"). See figure 1 for schema of this process.

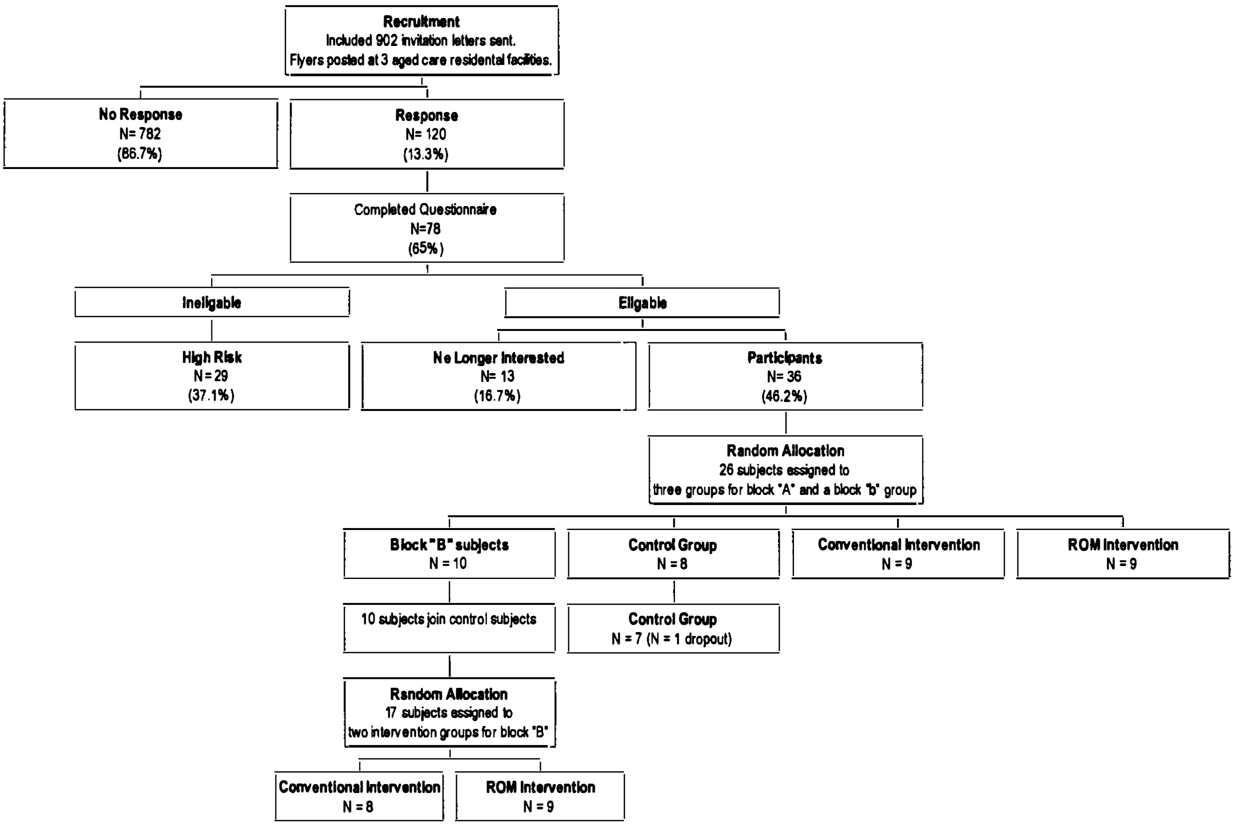

Figure 1. The recruitment process and subject assignment to groups

3.3 Procedures

3.3.1 Testing Procedures

Subjects underwent baseline and post-intervention testing immediately before the start and end of the interventions (with three to four days). At baseline testing, subjects were required to attend a three to four hour testing session at Edith Cowan University, for which all transport to and from the testing venue was provided. During the test sessions the time was divided between physiological and psychological assessments (psychological results not presented in this manuscript), with adequate rest periods provided. The same procedures were adopted during the post-intervention testing period.

A physiological test battery measuring several parameters including muscular strength, postural stability, and functionality was developed to assess the effectiveness of the exercise interventions. Subjects performed the tests at baseline in random order, with the exception for assessment of isokinetic and isometric knee flexor and extensor strength. It was decided that leg strength measures would be assessed following the completion of all other assessments. This was to avoid any fatigue and hence reduce the influence that this fatigue may have on other physiological assessments including the Timed "Up" and "Go", force platform assessment of postural stability, and the Berg Balance Scale. The tests undertaken post-intervention were performed in the same order as the baseline tests for each subject.

The test battery incorporated several assessments including; isometric and isokinetic knee extension and flexion; dominant and non-dominant grip strength and; static and dynamic balance assessed by the force platform and the Berg Balance Scale. Functional ability was also measured using the Timed "Up" and "Go" and the Physical Performance Test. The test battery was adopted to provide a variety of clinical and laboratory tests, to be examined for possible future use in elderly subjects. As well as being selected for their validity and reliability, the inclusion of these assessments will provide insight into any practical issues that may need to be overcome for future investigation that is to follow-on from this formative study. The same observers/testers and method of application were used for all assessments both at baseline and at post-intervention testing. The following sections present the methodology used for each of the tests used.

3.3.2 Physical Performance Test

The functional ability of subjects was assessed using the Physical Performance Test (Reuben and Siu, 1990). This instrument measures the ability of the subject to perform activities that are conducted during normal daily living (e.g., writing speed, shelving a book etc.) and hence an assessment of their functionality.

The Physical Performance Test can be used as both a nine and seven-item test battery. For this study the 7-task protocol was used. All items except one (i.e., perform a 360 degree turn), measured the time to complete the given task. Scores given to subjects for individual items are based on their timed performance of that task. A maximum score of four and a minimum score of zero could be obtained for each item. All items on the instrument are then summated to give an overall physical performance score. Once the tester demonstrated the task to be performed, subjects were permitted to perform only one trial of that particular task.

The Physical Performance Test has been shown to have acceptable internal consistency (Cronbach's alpha = 0.79) and inter-rater reliability (r = 0.93) for the seven-item version of the instrument (Reuben and Siu, 1990). The same authors also reported moderate validity for the Physical Performance Test when compared with the Katz Activities of Daily Living (r = 0.50), the hierarchical scale of instrumental and basic activities of daily living (r = 0.56), and the Tinetti gait score (r = 0.69), for the seven-item scale.

3.3.3 Berg Balance Scale

The Berg Balance Scale was used to measure dynamic and static balance incorporated as part of mobility. The instrument developed by Berg and colleagues in 1989 (Berg et al., 1989) includes fourteen items that are based on movements considered to be movements of normal daily activities that require either static or dynamic balance. The items are scored by an observer, who rates the performance of the subjects according to a set of 5 categories. A zero score signifies an inability to perform the required task. Summing all the individual task scores attains a composite score, which can range from 56 to 0. A chair without arm rests, an object such as a slipper or shoe, and a stopwatch is required for this testing procedure.

The Berg Balance scale has been tested and shown to be valid when compared to other clinical instruments of balance and mobility, including the Barthel Mobility Subscale ($r = .67$), the Timed "Up" and "Go ($r = -0.76$) and the Tinetti Subscale ($r = 0.91$) (Berg et al., 1992). The Berg Balance scale has also been shown to have high inter-rater reliability for individual items (ICC = 0.71 to 0.99), internal consistency (Cronbach's alpha = 0.90), and intra-rater reliability (ICC = 0.90) (Berg et al., 1989).

3.3.4 Static Balance

Static balance was measured using the Kistler Force Platform (Kistler 9287B). The force platform measures the Center of Pressure (COP), which is the location of the net force on a support surface. The variability of COP was analysed using the standard deviation of the COP measured as the dependent variable. An assumption for interpreting the COP data is that the variability of the COP is proportional to the unsteadiness or instability of the subject. In this analysis the standard deviation of the COP was used to quantify stability of the subjects across several postural positions. The COP data was collected using the BIOWARE software package a rate of 500Hz and filtered using to reduce erroneous vibration. The duration of the collection was for 10-seconds. Data collected for both the anterio-posterior (Ax) and medio-lateral (Ay) planes were analysed separately, providing information on the stability in a front to back, and the side-to-side directions.

As part of the assessment subjects were asked to perform three different stance positions, which were of advancing difficulty. They included:

1. Double leg / eyes open
2. Double leg / eyes closed
3. Single leg / eyes open

The stances were performed in the order as shown as above, each being measured twice. Each postural stance was performed once before the second trial took place. The subject stated which was their dominant leg prior to any data collection, which was used to stand on by the subject during the single leg stance position. Subjects performed all trials barefooted. For each stance the subject was asked fixate their eyes on an "x" marked figure on a blackboard 5-meters directly in front of them at eye level. Subjects were guided as to where their feet should be placed on the force platform however, the subject ultimately had control over the width of their feet during the collection. For all double postural stances the subject was required to stand with the midline of their body inline with the center of the force platform. For the single-leg stance, subjects were asked to position their preferred foot centrally on the force platform. Subjects were required to keep their hands by their sides throughout the data collection period.

For the single-leg trials, data collection occurred as soon as the non-preferred foot was lifted from the ground, and the subject was observed to be in relative control of their stability. An additional trial attempt was given to individuals who failed to remain standing for the entire ten-second-collection period. If subjects failed on their second attempt then no further trials of that particular stance was given, and the trial was marked as incomplete. Trials could also be deemed as invalid if subjects performed any of the following during the collection; taking a step, talking, touching the force platform with the non-preferred foot during single-leg stance, or became too unstable to the point where falling was imminent. In the case of the latter point a research assistant was on hand to avoid a fall from taking place. The average of the standard deviations collected over two trials for each stance position was determined and used in the analysis. Subjects who failed attempts on trials were excluded from the analysis of that stance position.

The measure of the standard deviation of the COP in the antero-posterior and the medio-lateral planes has been shown to have acceptable reliability ($r = 0.81$ and $r = 0.86$), respectively (Le Clair and Riach, 1996). Goldie, Bach, and Evans (1989) reported moderate reliability (both $r = 0.53$) for the standard deviation of the COP in the anterior-posterior and medio-lateral planes. Although, the measurement of COP representing postural stability shows face validity, due to no criterion measure of balance being agreed upon, there is limited validity data available on force platform measures. Consequently, several COP summary scores (e.g., sway velocity, COP position, COP standard deviation etc.) have been compared against field or clinical based measures with mixed results (Berg et al., 1992; Karlsson and Fryberg, 2000).

3.3.5 Performance Test-Timed "Up" and "Go"

The Performance Test-Timed "Up" and "Go" (TUG) was used to test mobility and functionality of the subjects. Podsiadlo and Richardson (1991) developed the TUG for the assessment of basic mobility skills in elderly individuals, and therefore their functionality. This tool is a single performance measure assessing the time to perform several whole body manoeuvres, including sitting and standing from a chair, walking 3-metres, and performing a turn. The equipment required for this test includes a stopwatch, standard chair with seat height of 45 cm and an arm height of 63 cm.

The subjects were tested wearing their normal footwear. The subjects began with their back resting against the backrest of the chair and arms resting on the arms of the chair. On the instruction of “go” the subject stood up from the chair, walked at a fast but comfortable and safe speed to a marked position 3-meters away. Upon reaching this point the subject performed a 180-degree turn, after which they returned to the chair and sat down again. The tester started the timer on the cue “go” and stopped the timer as soon as the subject’s entire back was against the backrest. The subjects were shown demonstration and were instructed to use the armrest of the chair for both standing from and sitting down onto the chair. Two trials were given with the subject required to use the armrests on both trials. The time was measured in seconds and was recorded to one-tenth of a second, with the fastest time used for the analysis.

The Timed "Up" and "Go" has been reported to have acceptable inter-rater (ICC = 0.99) and intra-rater (ICC = 0.99) reliability, using elderly subjects (Podsiadlo and Richardson, 1991). Rockwood, Awalt, Carver, and MacKnight (2000) found the reliability between two administrations to be modest (ICC = 0.56) in elderly subjects. The TUG has also shown moderate to high correlations between the Berg Balance Scale (r = -0.72), gait speed (r = -0.55), and the Barthel Index of Activities of Daily Living (r = -0.51) (Podsiadlo and Richardson, 1991), indicating moderate to high validity for measuring functional capacity in the elderly.

3.3.6 Leg Strength Dynamometry

The assessment of leg strength involved both isometric and isokinetic testing of the knee extensor (quadriceps) and flexor (hamstrings) muscle groups. Measures were performed using the Cybex isokinetic dynamometer (Cybex 6000). The Cybex 6000 was calibrated regularly as specified by the manufacture. The subject sat affixed to the Cybex at the shoulder, torso, above the right knee and ankle, to reduce any extraneous movement and hence measurement error. The right leg was used for all leg strength measures. The axis of the dynamometer lever arm was positioned in line with the axis of the subject's lateral femoral epicondyle. Before the testing began, a zero point for both knee extension and flexion were determined, and gravity correction performed.

The isometric tests preceded the concentric isokinetic strength tests. The isometric strength protocol included the performance of 3-sets separated by a 20-second recovery period. One-repetition was performed in each set, with 1-repetition including a maximal voluntary isometric contraction of the knee extensors followed immediately by a maximal voluntary contraction of the knee flexors. Each contraction was performed for five-seconds. Maximal voluntary isometric contractions were performed at a knee angle positioned at 45-degrees from a straightened knee position.

The isokinetic strength assessment was measured across three velocities including; 60-degrees per second; 90-degrees per second; and 120-degrees per second. Three sets were performed, one set for each velocity. Three consecutive repetitions per set were performed, with a repetition characterised as a maximal concentric isokinetic contraction of the knee extensors, followed directly by a maximal concentric isokinetic contraction of the knee flexors. A 30-second recovery period separated the each set. Subjects were given verbal encouragement during all contractions. The outcome measures were stored, and the peak torque measurements used for the analysis.

The Cybex isokinetic dynamometer is presented as providing reliable results for knee extension and flexion (Pearson's and ICC's of between 0.66 to 0.99) across velocities between 60 and 240-degree per second for a variety of individuals of different ages and gender (Perrin, 1993, pg 168-172). Although strength is being measured, it is only specific to the knee flexors and extensors. Hence a measure of grip strength was also chosen to evaluate upper limb strength, which with the measure of lower limb strength will provide a better indication of overall strength improvement.

<u>3.3.7 Grip Strength Dynamometry</u>

The grip strength of each subject was measured by a grip dynamometer (Smedley's grip-strength dynamometer). Each subject performed two trials with the highest strength measurement for each hand used in the analysis, with the dynamometer adjusted to fit the size of the subject's hand as recommended (Gore and Edwards, 1992, pg 17). The subject was asked to sit (arm-less chair) and to hold the dynamometer to the side with a straight arm (i.e., no bend in the elbow joint). Subjects were instructed to squeeze in a smooth continuous motion and to keep the dynamometer pointing towards the ground. Measures obtain from the method of using a fully extended elbow has been shown to be the same as those obtained with 90-degree elbow flexion (Ferraz et al., 1992). The measurement was recorded and the dynamometer was then re-adjusted to the zero point and the same procedure performed on the opposite hand. Once the subject had performed one-trial on each hand, the second trial was administered. A one-minute rest-recovery period was taken by the subject between trials for the same hand.

Generally, the Smedley grip strength dynamometer has been found to be an accurate instrument for measuring grip strength (ICC = 0.999) and has been reported to have acceptable test-retest reliability (Stratford, Norman, and McIntosh, 1989).

3.4 Exercise Interventions

3.4.1 Overview

Subjects were randomly assigned to three groups, two of which incorporated exercise interventions. Both the Conventional and holistic exercise interventions were performed for 10 weeks, with the subjects required to attend two sessions per week, held on Monday and Thursday mornings. At least two sessions per week of resistance training has been recommended for the elderly (ACSM, 2000) however, no specific recommendations have been provided for holistic interventions such as ROM. Hence the two sessions per week of each intervention prescribed in this study was deemed appropriate. The interventions began one week following the baseline testing. For the two exercise interventions, the holistic group performed an intervention known as the Range of Motion dance program, and a second group performed a Conventional Exercise program. A final group, known as the control group included subjects who did not perform any exercises or attended any intervention. Both interventions were held at an aged hostel operated by Uniting Church for the entire study. Descriptions of the intervention protocols are outlined in the following section.

3.4.2 Range of Motion Dance Intervention

The Range of Motion dance (ROM) incorporates a holistic approach, utilising mind, spirit, and body. The program involves both a movement phase and a relaxation phase. Movements are performed in slow and controlled manner, like that, which is characteristic to Tai Chi Chuan. The intervention is performed while listening to a verse that is either spoken by the instructor or presented by an audiotape. The intervention requires its participants to focus on several key principles including;

1. Attention to the present
2. Diaphragmatic breathing
3. Postural alignment
4. Awareness of movement
5. Slow movement
6. Relaxed movement
7. Imagination

The program incorporates 29-movements utilising all the major joints and muscle groups within the body, through activities involving both standing and sitting. A further 13-movements are performed at a table involving various hand and wrist movements. The entire 42-movement sequence is performed continuously, with each individual movement flowing into the next. Examples of the type of movements involved in the intervention included; flexion and extension of the torso; hip flexion, extension, adduction and abduction; dorsi and plantar flexion; cervical extension and flexion; scapular elevation, protraction and retraction; shoulder horizontal and frontal flexion, and abduction; wrist pronation, supination, flexion, and extension and; hand flexion and extension.

The ROM intervention is self-paced however, additional repetitions of the movements can be performed, and was encouraged an instructor. The instructor had a background in sport science and had extensive experience teaching exercise classes to the elderly. As part of the program, the subjects were also encouraged to perform daily practice in their own time in addition to the two group sessions per week performed with the guidance of the instructor however, compliance of this was not monitored.

It was the duty of the instructor to supervise the entire exercise session and to assist in the development and refinement of the movements performed by the subjects. The duration of each session was kept to approximately 30 to 40 minutes. The intervention did not include the use of any external equipment to induce muscular resistance, nor did the intervention involve activities such as walking. Additional information on the specific movements and principles of the ROM dance method can be found in the instruction manual (The ROM Dance. A Range of Motion Exercise and Relaxation Program 2nd edition, by Harlowe and Yu, 1992).

3.4.3 Conventional Exercise Intervention

The Conventional Exercise intervention was designed to be of low-intensity, and able to be presented in a community setting (i.e., no sophisticated equipment etc.). Each session was approximately 30 to 40 minutes in duration and included a warm-up, stretching, weight/range of motion circuit, and a cool down/relaxation phase. The warm-up phase included walking type activities (i.e., marching) and chair based flexibility exercises. The circuit phase was the major component of all the sessions and included five stations.

Subjects were partnered in pairs, each performing one of two activities for each station. The time spent on each station was for 2.5-minutes, with subjects changing between the two activities on each station during the work period. Dumbbells were made available and subjects were encouraged to increase the resistance as they improved strength and confidence. The specific exercises used in the circuit phase are presented in Appendix B. The cool-down and relaxation phase involved light stretching and relaxation and was used to end each session. The exercises and activities remained the same for 6 to 7 sessions, before all new activities were introduced. Although different exercises were incorporated, the focus of the new exercises was still on the same muscle groups and joints. Music was also included at all sessions.

3.4.4 Control Group

The control group was encouraged to go about their normal daily activities, and instructed to not join any physical activity programs for the duration of the study. The subjects were invited to attend sessions of the Range of Motion or the Conventional Exercise intervention after the completion of the post-intervention testing.

3.5 Attendances and Attrition

Attendance for each subject was recorded. Attendance checks were taken at the beginning of each exercise session of both of the interventions. Where subjects had missed a session(s) the reason for absenteeism was recorded. Subjects who missed 4-sessions in a row were telephoned to determine the reason for absence or if the subject had dropped out from the intervention. The number and reason of dropouts for each group, including for the control group was recorded.

3.6 Data Analysis

To determine if any significant differences occurred between the outcome measures of the groups following the 10-week study, parametric statistics were used. Descriptive statistics including means, standard deviations and confidence intervals were determined for all of the groups for each variable.

Data for all variables from all three groups were screened using Shapiro-Wilk's assessment of normality. The equality of variances was assessed using the Levene's

Test of Equality of Error Variances, with homogeneity of the regression slopes assessed using simple scatter plots. All of the measured variables met the required assumptions for Analysis of Covariance except for three of the measured outcome variables (i.e., isokinetic extension at 60-degrees per second, isometric 45-degrees extension and flexion, and the Center of Pressure variability with eyes open). For these three variables the assumption of normality failed in at least one of the groups.

The data (baseline and post) from these non-normally distributed variables (i.e., isokinetic extension at 60-degrees per second, isometric 45-degrees extension and flexion, and the Center of Pressure variability with eyes open transformed) using log base 10 transformations. Transformation of both baseline and post-intervention data was required, as baseline measures of the variables was to act as the covariate, and a linear relationship between the covariate and dependent variable is required for the use of the Analysis of Covariance.

Analysis of Variance was performed for weight, and age between the groups at baseline. Analysis of Covariance was used to compare post-intervention measures of each of the physiological variables between the groups with the baseline measures of the variables acting as the covariates. This statistical procedure controlled for any differences between the groups at baseline whilst at the same time detecting differences between the groups for the measured post-intervention variables. Statistically significant differences were determined using an alpha level at $p < 0.05$. Significant findings from Analysis of Covariance underwent post hoc analysis, performed by pair-wise comparisons using Least Significant Differences to identify between which of the three groups the significant differences were located. Least Significant Difference comparisons were used, as adjustments for multiple comparisons for this post hoc test was not made. As this investigation was a prospective pilot study, use of the LSD statistical procedure was thought to be appropriate. Comparisons made between the two intervention groups for average attendance were analysed using independent t-tests at an alpha level of 0.05.

The adjusted post-intervention means will be presented in table form. All statistically significant Analysis of Covariance results will be graphed, presenting the raw score mean differences of the significant variables, obtained for each group. However, the mean differences will not be tested for significance, and are presented to indicate the direction of change in the dependent variables.

3.7 Ethics

The Edith Cowan Human Research Ethics Committee granted ethics approval on the 6th of September 2002.

CHAPTER 4

4.0 Results

4.1 Subject Health Characteristics

Overall the sample from which subjects were recruited for this study showed similar morbidities characteristic of this population. Thus, indicating that the quality of life for some of the subjects in this study were somewhat compromised by their status of health. As seen in figure 1 (page 44) only 36 from the 78 subjects completing health history questionnaires were eligible to participate in the study. The questionnaires from these individuals were analyzed and the percentage of individuals answering positively to each of the questions was determined.

The following characteristics were found from the sample (n = 36); 8.3% of subjects had a history of a heart attack, 38.9% reported having hypertension or high blood pressure, 47.1% were currently being treated for a heart and/or circulatory condition, and 13.9% reported being diabetic. On the health history questionnaire it was also found that 5.7% of the sample reported falling in the last 3-months, 5.6% reported a history of fracture to the wrist or spine, 19.4% required ambulatory assistance, and finally 8.3% were receiving treatment for an injury that restricts movement.

Individuals from the 78-subject sample were deemed as being either eligible or non-eligible to participate in the study dependent on answers given on the health history questionnaire. Potential participants also received telephone calls to further discuss health issues indicated on the questionnaire as a final assessment of their eligibility into the study. Twenty-two individuals were excluded either due to multiple health issues (i.e., where participation in the exercise programs may have compromised the individuals health), the inability to stand independently, or because the individual already belong to a formal exercise group. A further 13-subjects chose not to participate due to becoming disinterested or because of the commitment of time and the travel required to participate in the study. Finally, 46.2% (n = 36) of the original sample was classified as being eligible to participate.

No significant differences between same groups of block "A" and "B" were found using independent t-tests, hence data from same groups for block's "A" and "B" have been combined. All results from his point on will refer to the data as coming from single same groups rather than from blocks "A" or "B". Since the control group subjects became intervention group subjects in block "B", they have been added to the subject numbers of the two intervention groups.

4.2 Compliance and Attrition

Nine-subjects renounced from the study either prior to the start of the exercise sessions (n = 3), during the intervention (n = 4) or just prior to the commencement of post-intervention testing (n = 2). Individuals who exited from the study during these periods were defined as "dropouts" and any data collected from them was excluded from the data analysis. Hence, 34-subjects provided both baseline and post-intervention data for this study.

A comparison of the number of dropouts across groups was similar. Dropouts recorded for each group are as follows; The Conventional Exercise group (n = 3) with approximately 82.4% of the individuals completing the study, the ROM group had a slightly higher number of dropouts (n = 5) with approximately 72.2% of the initial 18-subjects completing the study, and the Control group only had one individual dropout with 85.7 % completing the study. Several reasons for subjects exiting from the study were given including; illness (n = 5), illness of a spouse (n = 2), and subjects going on vacations (n = 2). Dropouts attended on averaged 5.5 (SD ± 6.4) exercise sessions before leaving the study.

Attendance over the course of the 10-week intervention was determined for subjects who completed the Range of Motion (ROM) and Conventional Exercise interventions only. The maximum number of sessions an individual could attend was 20 (i.e., 2-sessions per week for 10-weeks). Only 5-subjects attended all 20-sessions (n = 2 from ROM and n = 3 from the Conventional Exercise group). The mean and standard deviations for the number of sessions attended by individuals for each of the groups are as follows; Conventional Exercise group (n = 14, mean = 17.07, SD ± 2.73) and the ROM group (n = 13, mean = 17.77, SD ± 2.17). Analysis using an independent t-test determined that the difference in the mean attendance between these two groups (85.4% versus 88.8%) ($t = -0.732$, $p > 0.47$) was not significant with an alpha level greater than $p < 0.05$.

The reasons for absenteeism of subjects for both the Conventional Exercise and the ROM groups were combined and arranged into seven categories, which is graphically presented in figure 2. A total of 69 exercise sessions were missed when absenteeism was combined for all subjects excluding the control group or dropouts. The major reason for individuals being absent from exercise sessions was due to illness (days = 18) followed by attendance to non-medical appointments (days = 10). Injury, caused by events occurring outside the exercise interventions accounted for a total of 8-sessions to be missed, whilst medical appointments accounted for 7-days of absence. Individuals going on vacation missed 5-sessions in total, with sessions missed due to family reasons (reunions, sickness in family, funerals etc.) also accounting for 5-days. All other sessions where subjects were absent (days = 16) were categorised as "other" which defines absences where no reason was specified.

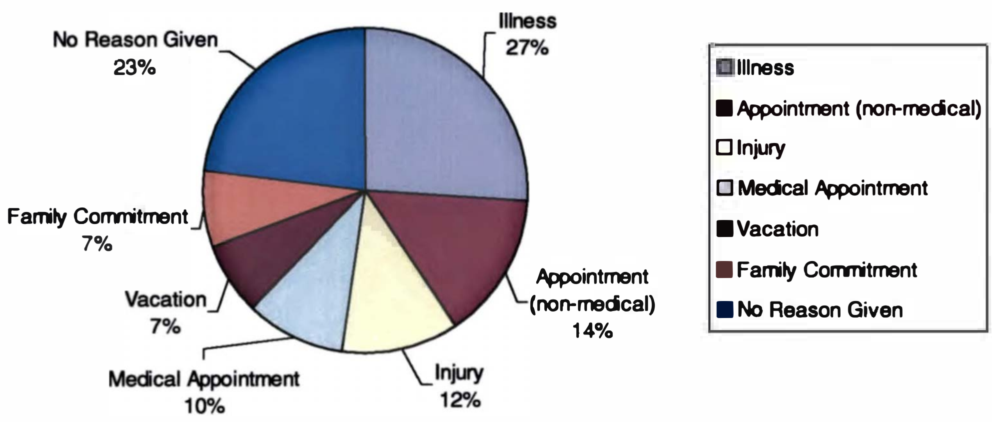

Figure 2. The percentages of sessions missed and the corresponding reasons. The total number of sessions absent was n = 69.

4.3 Baseline Characteristics

One-way Analysis of Variance was used to identify any baseline statistical differences between groups for the characteristics of age, weight and gender. No significant differences were identified between these characteristics at baseline. Results for the one-way ANOVA are presented in table 1.

Table 1. Age, weight, and gender characteristics (mean, standard deviation and range) at baseline.

		Conventional Exercise Group [a]	Range of Motion Exercise Group [a]	Control Group	P value (sig. *)
N (subjects)	Total	14	13	7	
	Female	12	11	7	
	Male	2	2	0	
Age (years)	Mean	77.78	78.69	80.85	0.61
	SD	6.94	7.56	3.13	
	Range	66-85	67-92	77-86	
Weight (Kg)	Mean	69.3	69.46	71.04	0.95
	SD	16.62	8.15	14.95	
	Range	50.1 - 98.2	56.3 - 84.2	52.0 - 94.1	

* Significant at $p < 0.05$
[a] Includes control subjects of block "A"

4.4 Strength Measures

Group means, standard deviations and p-values for baseline and post-intervention strength measures for the three groups can be found in tables 2.

Table 2. Baseline and Post intervention means[1] (and standard error of mean) and 95% confidence intervals for knee extensor, knee flexor, and grip strength variables.

Variable	Conventional		ROM		Control		P value (sig. *)
	Pre	Post	Pre	Post	Pre	Post	
Flexion							
60 deg/sec	29.9 (2.3) *(26.6-37.0)*	31.4 (2.3)[a] *(26.6-36.2)*	28.3 (3.8) *(20.1-36.6)*	32.4 (2.4)[c] *(27.5-37.3)*	23.4 (4.4) *(12.6-34.3)*	19.1 (3.3) *(12.3-25.9)*	.007*
90 deg/sec	30.5 (3.4) *(23.2-37.8)*	34.7 (2.3)[a] *(30.0-39.4)*	31.7 (3.9) *(23.2-40.1)*	28.6 (2.4)[c] *(23.8-33.6)*	23.3(3.8) *(23.2-40.1)*	19.6 (3.4) *(12.8-26.4)*	.003*
120 deg/sec	26.1(3.7) *(18.2-34.1)*	32.1 (2.9)[a] (26.1-38.0)	29.0(3.9) *20.4-37.6)*	27.3 (3.1) *(21.1-33.6)*	24.3 (5.0) *(11.9-36.6)*	18.5 (4.2) *(10.0-27.0)*	.040*
Isometric 45-degrees	43.3(3.5) *(35.7-50.9)*	44.9 (2.0) *(40.8-49.1)*	43.4(5.3) *(31.8-54.9)*	46.6 (2.2) *(42.1-51.1)*	30.1(4.1) *(20.1-40.2)*	42.4 (3.1) *(36.1-48.7)*	.551
Extension							
60 deg/sec	42.6(4.6) *(32.7-52.5)*	29.9 (1.1)[a] *(24.7-36.2)*	45.4(7.5) *(29.1-61.7)*	28.4 (1.1)[c] *(23.2-34.6)*	26.6(5.0) 14.4-38.8)	17.7 (1.2) (13.3-23.7)	.016*
90 deg/sec	37.4 (3.9) *(28.8-45.9)*	39.9 (2.5)[b] *(34.9-44.9)*	43.4 (5.6) *(31.2-55.5)*	31.9 (2.6) *(26.6-37.3)*	23.7(4.6) (12.3-35.1)	31.4 (3.7) (23.8-38.9)	.050*
120 deg/sec	31.4(3.9) *(22.8-39.9)*	37.1 (3.1) *(30.9-43.4)*	37.7(5.5) *(25.7-49.7)*	29.3 (3.2) *(22.7-35.9)*	24.0(4.8) (13.0-35.0)	24.7 (4.4) (15.6-33.8)	.057
Isometric 45-degrees	58.1(4.3) *(48.9-67.3)*	54.0 (3.7) *(46.4-61.6)*	64.1(8.6) *(45.3-82.9)*	62.7 (4.1) *(54.3-71.2)*	37.4(5.7) *(40.2-65.7)*	51.9 (5.7) *(40.2-65.7)*	.124
Grip Strength							
Dominant Hand (kg)	23.6(1.1) *(21.2-26.0)*	20.3 (0.7) *(18.8-21.7)*	23.7(7.9) *(17.3-30.1)*	24.1 (0.7) *(22.6-25.6)*	18.7(1.6) *(14.8-22.7)*	23.6 (1.0)[a] *(21.5-25.7)*	.002*
Non-Dominant Hand (kg)	19.5(1.3) *(16.8-22.2)*	18.9 (0.8) *(17.2-20.6)*	22.9(2.3) *(17.8-28.0)*	19.1 (0.9) *(17.3-20.9)*	16.5(1.7) *(12.3-20.7)*	21.5 (1.2) *(19.0-23.9)*	.203

[1]= Post intervention values represent means that are adjusted by baseline values (i.e., baseline values of all groups act as covariate) for the specified variable. Values determined from the raw scores obtained.
Post means in Newton•metres, except Isometric 45-degrees, which is measured in Newtons.
Italics = 95% Confidence Intervals
[a] = Conventional sig. diff. to Control ($p < 0.05$)
[b] = Conventional sig. diff. to ROM ($p < 0.05$)
[c] = ROM sig. diff. to Control ($p < 0.05$)

Overall the strength results indicate minor differences between the two intervention groups however, both the ROM and Conventional Exercise groups generally showed higher measures of strength compared to the Control group. All strength measures were compared as absolute values (i.e., as Newtons for isometric variables or Newton•meters for isokinetic variables) with no adjustments made for the subjects weight, as no relationship was found between bodyweight and muscular strength. Performing of the

ANCOVA's showed no significant differences in peak strength between the groups for isometric knee flexion at 45-degrees ($p < 0.551$) or for isometric knee extension at 45-degrees ($p < 0.124$). Significant ANCOVA's performed for isokinetic knee flexion at the velocities of 60, 90, and 120-degree/second were observed ($F [2,3] = 5.916$, $p < 0.007$, $F [2,34] = 6.941$, $p < 0.003$, and $F [2,34] = 3.575$, $p < 0.04$), respectively.

A significantly greater strength gain in peak torque for 60 degree/second flexion was found for the ROM group compared to the Control group ($p < 0.016$) with a mean difference between post-intervention scores of the two groups equal to 13.33 Newton•metres. The Conventional Exercise group also showed a significantly greater post peak torque ($p <0.016$) for 60-degree/second of flexion compared to the Control group, with a mean difference between the two groups of 12.29 Newton•metres. For isokinetic knee flexion at 90-degree/second post hoc comparisons found significantly greater post peak torques between the Conventional and the Control groups (mean difference of 15.13 Newton•metres, $p < 0.001$) and between the ROM and the Control group (mean difference of 9.061 Newton•metres, $p < 0.038$). A significant mean difference for post peak torque at 120-degree/second of flexion of 13.56 Newton•metres ($p < 0.012$) was also found between the Conventional and Control groups. No other significant differences between the groups were observed. Figures 3 to 5 present the mean differences baseline and post-intervention testing for knee flexion at various velocities.

The Mean Difference Between Post-Interventions and Baseline for Isokinetic Knee Flexion at 60-Degree/Second

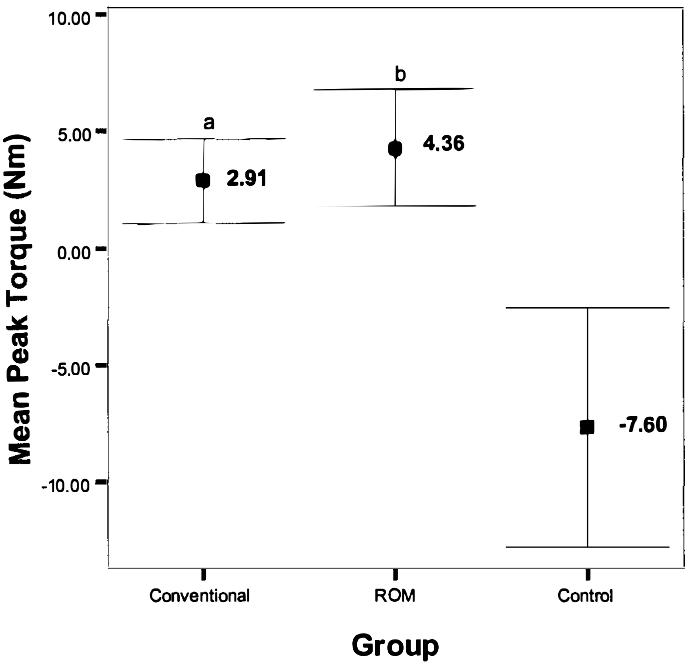

Figure 3. The unadjusted mean difference and standard error of mean between baseline and post-intervention measures of peak torque for isokinetic knee flexion at 60 degree/second. Significances represent ANCOVA (baseline as covariate) results only.
[a] = Conventional group > Control group ($p < 0.05$)
[b] = ROM group > Control group ($p < 0.05$)

The Mean Difference Between Post-Interventions and Baseline for Isokinetic Knee Flexion at 90-Degree/Second

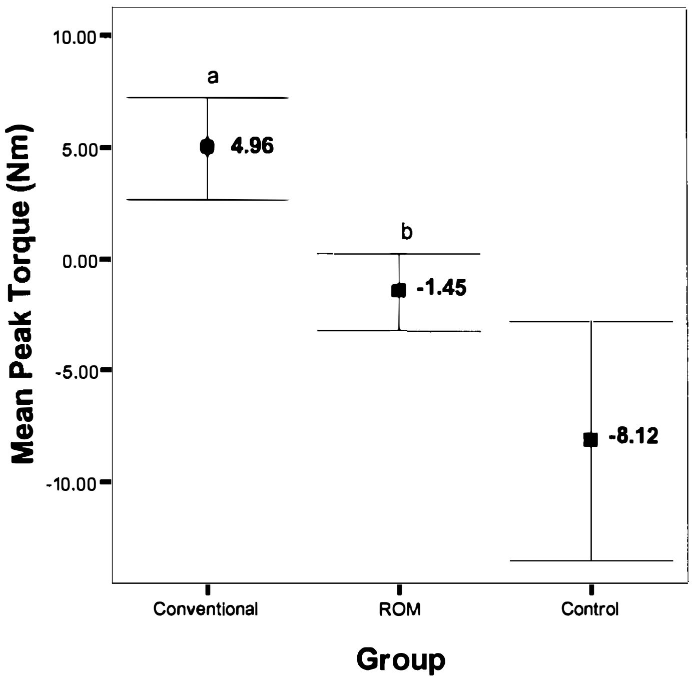

Figure 4. The unadjusted mean difference (standard error of mean) between baseline and post-intervention measures of peak torque for isokinetic knee flexion at 90-degree/second. Significances represent ANCOVA (baseline as covariate) results only.

[a] = Conventional group > Control group ($p < 0.05$)

[b] = ROM group > Control group ($p < 0.05$)

The Mean Difference Between Post-Interventions and Baseline for Isokinetic Knee Flexion at 120-Degree/Second

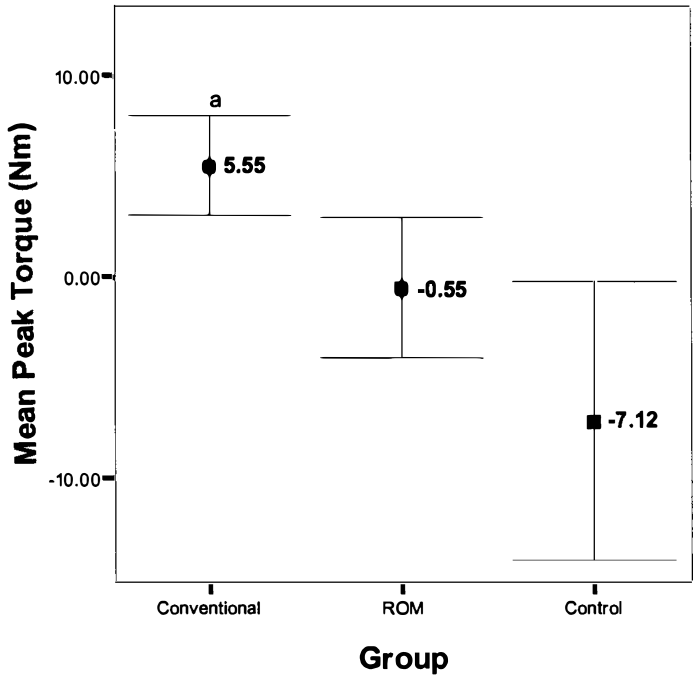

Figure 5. The unadjusted mean difference (standard error of mean) between baseline and post-intervention measures of peak torque for isokinetic knee flexion at 120-degree/second. Significances represent ANCOVA (baseline as covariate) results only.
[a] = Conventional group > Control group ($p < 0.05$)

Post peak torques for both 60 (log transformed) and 90-degree/second of knee extension were found to be significantly different between the groups ($F [2,34] = 4.796$, $p < 0.016$, and $F [2, 34] = 3.310$, $p < 0.05$), respectively. Figures 6 and 7present the change in strength for each of the groups at 60 and 90-degree/second of knee extension, respectively. Although the mean differences were not analysed for significance between the groups, the values do indicate the direction of change.

Post hoc comparisons revealed significant differences between the Conventional and Control groups (mean difference of 0.524 [log] Newton•metres, $p < 0.005$) and the ROM and Control groups (mean difference of 0.471[log] Newton•metres, $p < 0.012$) for isokinetic extension at 60-degree/second. Differences between the Conventional and ROM groups was found for isokinetic extension at 90-degree/second (mean difference of 7.985 Newton•metres, $p < 0.033$), with the difference between the Conventional and Control groups for the same velocity approaching significance (mean difference of 8.609 Newton•metres, $p < 0.062$). Differences between the groups for post peak torque for knee extension at 120-degree/second approached significance ($p < 0.057$) for the ANCOVA.

The Mean Difference Between Post-Interventions and Baseline for Isokinetic Knee Extension at 60-Degree/Second

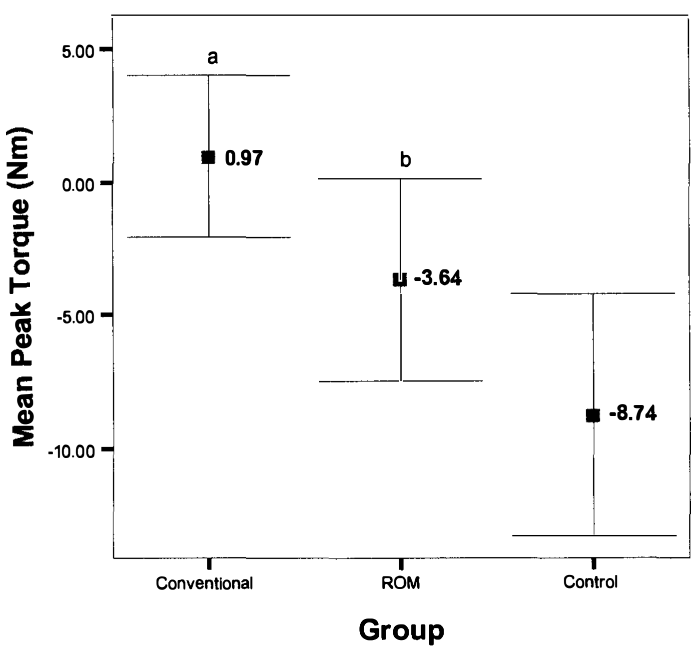

Figure 6. The unadjusted mean difference (standard error of mean) between baseline and post-intervention measures of peak torque for isokinetic knee extension at 60-degree/second. Significances represent ANCOVA (baseline as covariate) results only.
[a] = Conventional group > Control group ($p < 0.05$)
[b] = ROM group > Control group ($p < 0.05$)

The Mean Difference Between Post-Interventions and Baseline for Isokinetic Knee Extension at 90-Degree/Second

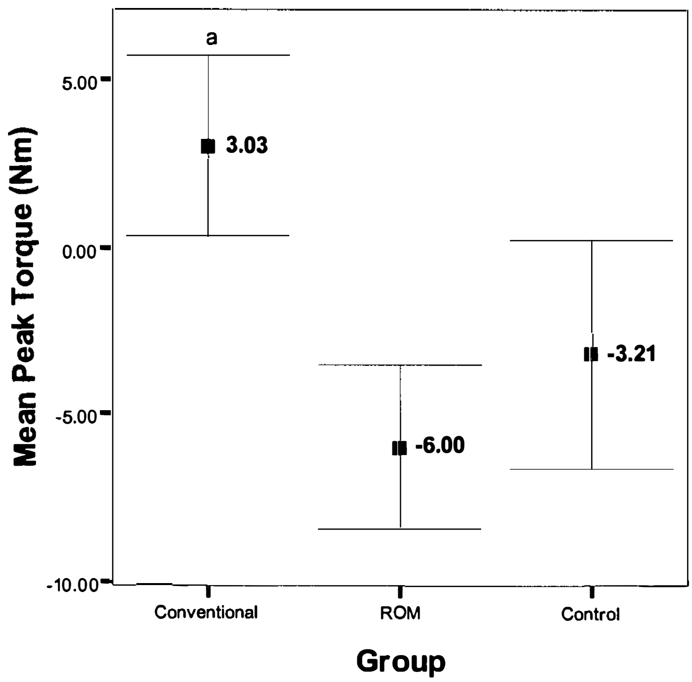

Figure 7. The unadjusted mean difference (standard error of mean) between baseline and
post-intervention measures of peak torque for isokinetic knee extension at 90-degree/second. Significances represent ANCOVA (baseline as covariate) results only.
[a] = Conventional group > ROM group ($p < 0.05$)

For the measurement of grip strength, 29-subjects were identified as having right-hand dominance and 5-subjects as left-hand dominant. The ANCOVA was found to be highly significant between post-intervention measures of dominant-hand grip strength between the groups ($F_{[2,30]} = 7.828$, $p < 0.002$) when controlling for dominant-hand grip strength at baseline. Figure 8 presents the mean differences between baseline and post-intervention grip strength of the dominant hand, indicating that a decrease in grip strength by the Conventional group is partly responsible for the significant findings. The post-intervention mean differences between the ROM and Conventional Exercise groups (mean difference of 3.79 kg) were found to be highly significant ($p < 0.001$).

The Control group was found to have a significantly greater post-measure of dominant hand-grip strength compared to the Conventional Exercise group (mean difference of 3.26 kg, $p < 0.014$), However, no significant difference was found between the ROM and Control groups ($p < 0.682$).

The Mean Difference Between Post-Interventions and Baseline for Dominant Grip Strength

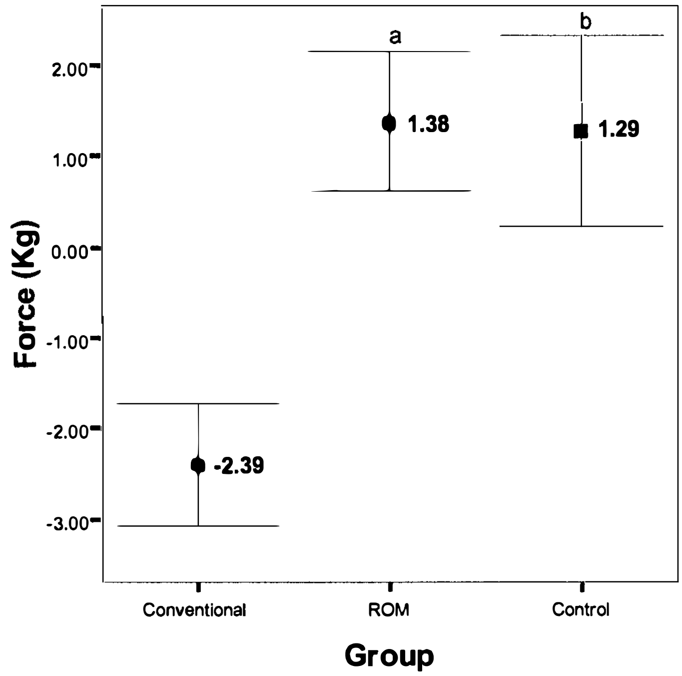

Figure 8. The unadjusted mean difference (standard error of mean) between baseline and post-intervention measures of grip strength (dominant hand). Significances represent ANCOVA (baseline as covariate) results only.
[a] = ROM group > Conventional group ($p < 0.05$)
[b] = Control group > Conventional group ($p < 0.05$)

Observation of the non-dominant grip strength results appeared as expected. No significant differences were found between the groups for non-dominant-hand grip strength ($p < 0.203$) when baseline measures of non-dominant-hand grip strength were controlled for in the analysis. Results from the ANCOVA for the grip strength measures are shown in table 2.

4.5 Balance Measures

Post intervention means (from ANCOVA) for the force platform and Berg Balance Scale variables are presented in table 3.

Table 3. Baseline and Post intervention means[1] (and standard error of mean) and 95% confidence intervals for medio-lateral Center of Pressure, and the Berg Balance Scale.

Variable	Conventional		ROM		Control		P value (sig. *)
	Pre	Post	Pre	Post	Pre	Post	
COP							
Eyes open (mm)	3.3(0.5) *(2.1-4.8)*	2.32 (1.15) *(1.8 - 3.1)*	3.4 (0.4) *(2.4-4.4)*	1.88 (1.15) *(1.4- 2.5)*	3.6(0.5) *(2.4-4.9)*	2.21 (1.21) *(1.5-3.3)*	.564
Eyes closed (mm)	7.3 (3.8) *(0.8-15.0)*	2.16 (1.1) *(1.7-2.7)*	2.7(0.3) *(2.1-3.3)*	2.17 (1.1) *(1.7-2.8)*	5.0 (1.3) *(1.9-8.1)*	2.21 (1.1) *(1.6 - 3.1)*	.992
Berg Balance Scale	49.9(0.9) *(47.9-51.9)*	50.5 (1.04) *(48.4-52.6)*	47.7(1.5) *(44.5-50.9)*	47.6 (1.07) *(45.4-49.8)*	48.0(1.3) *(44.7-51.3)*	48.1 (1.44) *(45.2 -51.0)*	.152

[1] = Post intervention values represent means that are adjusted by baseline values (i.e., baseline values of all groups act as covariate) for the specified variable. Values determined from the raw scores obtained.
Italics = 95% Confidence Intervals
[a] = Conventional sig. diff. to Control ($p < 0.05$)
[b] = Conventional sig. diff. to ROM ($p < 0.05$)
[c] = ROM sig. diff. to Control ($p < 0.05$)

The standard deviation was used to measure the variability of the Center of Pressure (COP), representing the subject's postural stability. Only data for the measurement of stability in the medio-lateral direction were used, as the anterior-posterior data for the COP from several subjects were lost due to a computer fault. Values collected from the force platform were analysed in their original format as raw scores. All groups showed general improvements in stability for the double foot stances with eyes-open and eyes-closed from baseline to post-measures however, no significant differences between post- measures of the groups were found when baseline balance was controlled for with alpha values of $p < 0.564$ for eyes open, and $p < 0.992$ for eyes closed observed.

Stability measures for the single foot eyes-open stance were collected however, due to the high number of subjects unable to stand for durations longer than 10-seconds on one leg (i.e., n = 6 at baseline and n = 4 at post-testing were able to stand for the required time) no statistical analysis was performed for this variable.

Similar to the laboratory measure of postural stability, clinical assessment using the Berg Balance Scale also showed no significant differences between the groups after the intervention with a calculated alpha value of $p < 0.153$ for ANCOVA.

4.6 Functionality

Post intervention results from ANCOVA for variables of functionality are presented in table 4.

Table 4. Baseline and Post intervention means[1] (and standard error of mean) and 95% confidence intervals for the Physical Performance Test and the Timed "Up" and "Go".

Variable	Conventional		ROM		Control		P value (sig. *)
	Pre	Post	Pre	Post	Pre	Post	
COP							
Physical Performance Test	21.2 (0.9) *(21.5-23.3)*	22.4 (0.43)[a] *(21.5 -23.3)*	20.1 (1.1) *(17.7-22.5)*	21.6 (0.45) *(20.7 -22.6)*	20.0 (1.8) *(15.6-24.4)*	20.3 (0.61) *(18.9 -21.5)*	.025*
Timed "Up" and "Go"	9.7(0.6) *(8.5-10.9)*	9.6 (0.42) *(8.7 -10.4)*	11.6 (0.9) *(9.7-13.6)*	10.4 (0.42) *(9.6 -11.3)*	12.3 (0.6) *(8.3-10.6)*	9.4 (0.57) *(8.3-10.6)*	.246

[1] = Post intervention values represent means that are adjusted by baseline values (i.e., baseline values of all groups act as covariate) for the specified variable. Values determined from the raw scores obtained.
Italics = 95% Confidence Intervals
[a] = Conventional sig. diff. to Control ($p < 0.05$)
[b] = Conventional sig. diff. to ROM ($p < 0.05$)
[c] = ROM sig. diff. to Control ($p < 0.05$)

The results found for the assessment of functionality were mixed. Observation of the data from baseline to post-intervention seemed to show improvements from baseline to post- testing for the Timed 'up' and 'go' (TUG) for all groups (although this was not tested for significance) however, ANCOVA failed to show any significant differences in post-test TUG times between the groups after the intervention ($p < 0.246$).

The Physical Performance Test (PPT) was found to be significantly different between the groups ($F [3,30] = 4.17$, $p < 0.025$) after controlling for baseline PPT scores. Mean differences between baseline and post-testing for the PPT is presented in figure 9. A significantly greater post-intervention score was found for the Conventional Exercise group when compared to the Control group (difference of 2.18, $p < 0.007$) indication an improvement in functionality in the Conventional Exercise group.

No other significant differences were observed between the groups although the difference between the ROM and the Control group approached significance (difference of 1.43, $p < 0.07$).

**The Difference Between
Post-Intervention and Baseline for
The Physical Performance Test**

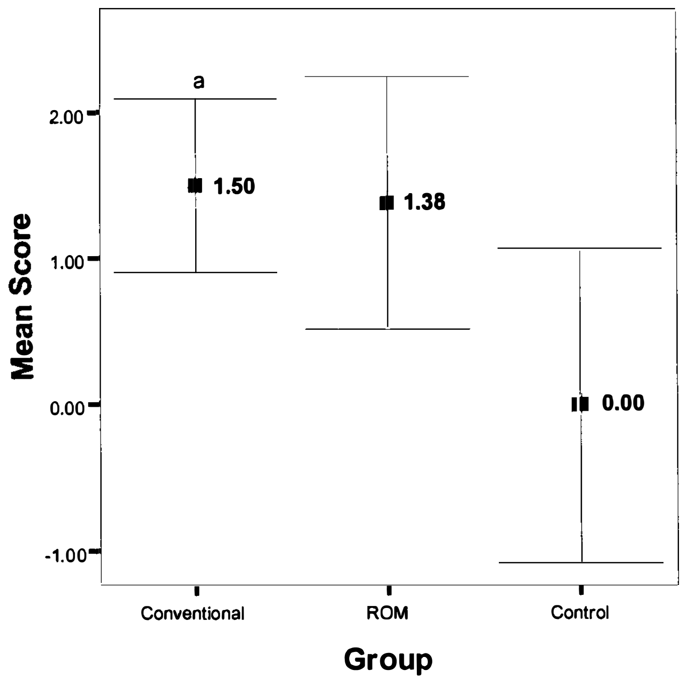

Figure 9. The unadjusted mean difference (standard error of mean) between baseline and post-intervention measures of peak torque for the Physical Performance Test. Significances represent ANCOVA (baseline as covariate) results only.
[a] = Conventional group > Control group ($p < 0.05$)

CHAPTER 5

5.0 Discussion

5.1 Overview

The purpose of this study was to determine if a holistic exercise intervention (ROM) is an effective exercise intervention compared to a conventional exercise intervention for elderly individuals aged over 65-years. Overall, the results of this study indicate limited differences in effectiveness between the two interventions, for both physiological parameters and for compliance and attrition. However, the two intervention groups did show improvement in general physiological function in comparison to the control group.

The results of this study tend to show that the exercise interventions used, provided maintenance of physiological parameters in the elderly subjects rather than increasing their functional capacity. This was observed as the Control group generally showed declines in the measured physiological variables, while the interventions groups showed either no change or small improvements.

5.2 Compliance and Attrition

Both exercise intervention groups showed modest rates of participant attendance. The ROM group subjects on average attended approximately 85% and the Conventional Exercise group subjects 88% of the prescribed sessions. Attendance between the two intervention groups was not found to be statistically significant suggesting that both were equally appealing and well accepted by this sample.

Attendance rates for the interventions of this study are comparable to that found by other studies reviewed. Attendance rates for the ROM group in the present study are similar to a pilot study performed by the authors of the ROM intervention, where the average attendance was approximately 84% over an eight-week period (Harlowe and Yu, 1992). Other studies that have used holistic methods such as Tai Chi have also reported high rates of attendance (greater than 75%) (Hartman et al., 2000). Similarly, conventional exercise interventions (8 to 26 weeks in length) such as those which have been performed by elderly subjects at home (Jette et al., 1998), in aged rehabilitation units (Hauer et al., 2001), in community settings (Westhoff et al., 2000) or in multilevel aged care facilities (Brill et al., 1998) have also shown high rates of attendance (85 to 93%).

Although all of the studies previously mentioned, including the present study show acceptable attendance rates, all are characteristic of presenting interventions over a relatively short duration (up to 6-months). It is likely that for interventions of greater length, adherence rates may actually decrease, possibly due to a greater window of opportunity being presented for influential events such as medical conditions, death, funerals, holidays to occur. Moreover, had the interventions been performed for a longer period it is predicted that the rate of attrition would be higher and attendance lower. Other investigations support this, in particular where exercise interventions have been tracked for three years and have shown lower attendance rates (mean attendance 68%, minimum = 58%, and maximum = 82%), suggesting that the length of the intervention is influential (Ecclestone, Myers, and Paterson, 1998). Within the mentioned study it was also reported that the holistic intervention (i.e., Tai Chi) showed the greatest rate of attendance (82 %) and had a lower dropout rate of 34 % compared to other types of exercise interventions.

Lan, Lai, Chen, and Wong (2000) found that the average attendance over a 6-month intervention of Tai Chi was approximately 54% of sessions for males and slightly higher for females. However, this outcome is based on the opportunity for subjects to attend Tai Chi practice seven days per week, which on an absolute scale equates to three to four days per week. If considered as a moderate intensity exercise then the frequency of weekly participation in physical activity classes is sufficient for elderly individuals under current physical activity guidelines recommended by the American College of Sport Medicine (Balady et al., 2000) and the 1996 Surgeon General's Report (U.S. Department of Health and Human Service, 1996). This frequency would also be appropriate under the National physical activity guidelines in Australia, which recommends the accumulation of moderate intensity physical activity (30 minutes daily) on most, preferably all days, and for extra health benefits, vigorous physical activity three to four days per week (30 minutes or more each time) (Egger et al., 2001). However, specific guidelines for the frequency and duration of holistic interventions including Tai Chi have not been developed.

Although no specific guidelines have been implemented for the duration or frequency of holistic approaches such as Tai Chi, it is likely that this type of exercise would be defined as an activity of moderate intensity. This is based on Tai Chi's energy cost of 4 MET's (or Metabolic Equivalents), which is similar to that found for walking (i.e., at 3.5 mph, on a level firm surface) (Ainsworth et al., 1993). Hence, according to the current physical activity guidelines (Egger et al. 2001, US Department of Health and

Human Services, 1996), holistic approaches (i.e., which would include ROM) should be performed most days of the week, accumulating 30-minutes of exercise per day. A definitive description of what modes of activities (i.e., cardiovascular, strength or flexibility) contribute to holistic approaches needs to be determined so that specific exercise guidelines, outlining frequency, duration and intensity can be developed.

The results of this study showed no significant difference between intervention dropouts for Conventional Exercise and ROM groups (i.e., 18% versus 28%). Illness was found to be the most cited reason for subjects dropping out of the study. This finding is relevant to other research findings, indicating that subjects who demonstrate fewer new medical conditions were less likely to dropout (Schmidt et al., 2000). Illness in Schmidt et al's study accounted for 20% of dropouts. Likewise the current study cited the most reported reasons for subjects being absent from exercise sessions were illness, followed by appointments. This observation supports findings by Tennstedt et al. (1998) who also reported that illness and appointments were the major reasons for non-attendance. Hence, it would be expected that dropout rates and non-attendance in exercise interventions with elderly participants would be elevated above what would be expected in the entire population due to the high number of medical conditions and susceptibility to illness, characteristic of the elderly population.

It may be that the number of dropouts for this study is somewhat high. Ecclestone et al. (1998) found a dropout rate of 34% for Tai Chi over a three-year period. In this study the Conventional Exercise group reported almost half as many dropouts (18%) and the ROM group a greater percentage (28%) in only a 10-week period. However, it has been found that approximately 50% of subject's dropped out within the first three months of beginning an exercise intervention (Schimidt et al., 2000). Similar dropout rates have also been reported in the first six to twelve months of exercising adults (Dishman, 1988; Sallis, Haskell, Fortmann, Vranizan, 1986). Estimation of subject or participant numbers allows researchers, exercise physiologist, and organisers of community exercise classes to take both the expected number of dropouts and the average attendance into account when planning, designing and implementing exercise interventions.

Overall, both the ROM and the Conventional Exercise interventions showed good acceptability by their participants over the course of 10-weeks indicated by the low number of dropouts and the high attendance. Although the equivalent may not have been found had the interventions been performed for a longer period. The low number of physical limitations reported by this sample could have contributed to the high compliance and low number of dropouts, which is supported by Schmidt et al. (2000).

Strategies need to be devised to reduce the number of early dropouts and to encourage participation and enrolment for exercise interventions. Although from the findings of this study and others, illness is major reason for non-attendance and attrition, several other more controllable barriers to participation may exist. The cost, transportation, access and lack of time a just a few barriers to physical activity participation reported by the elderly population (O'Neill and Reid, 1991). Such factors could be overcome, through effective planning. For example organization of community bus or car-pooling could be adopted to transport participants to and from the facility. Other factors not isolated to elderly individuals, may also influence participation, including inconvenience of time, lack of spousal support, lack of positive feedback, fear of injury, and lack of exercise variety (Franklin, 1998). Therefore the low-intensity interventions presented in this study, performed in a group setting, with positive feedback given, presented in a community setting at various times to suit participants, may help reduce the number of barriers that cause high attrition, high absenteeism, and non-volunteering.

5.3 Muscular Strength

5.3.1 Knee Flexor and Extensor Muscular Strength

Sufficient levels of muscular strength in the elderly are required to enable activities including, but not limited to, walking, standing from a chair, standing from the ground, climbing stairs, carrying groceries etcetera to be undertaken. The Conventional and ROM exercise interventions in most cases were observed to be equally effective for improving muscular strength. However, after close examination of the results, it is likely that the exercise interventions, particularly the ROM group, only maintained knee flexor and extensor muscular strength rather than causing improvements. This assumption is made on the basis of significant differences found between the ROM and Control groups for leg strength, which were a result of a decline in the Control group and not an improvement in the ROM group. Specific findings will be discussed in the following sections.

Isometric knee extensor and flexor strength was not significantly different between the three groups following the intervention. Due to the low-intensity nature of both the Conventional and ROM interventions it is unlikely that isometric contractions requiring maximal effort would have been performed during actual exercise sessions. An increase in intensity or inclusion of exercises that replicate the testing action of isometric knee flexor and extensor strength may have resulted strength improvements. However, the purpose of the study was to measure the effects of low-intensity exercise interventions, which could be applied in aged settings, rather than prescribing high-intensity exercise which for most of the aged population is unrealistic.

Non-significant findings of isometric knee flexor and extensor strength are similar to other studies using low-intensity exercise interventions with the elderly (Brown et al., 2000; Wolf et al., 1996). However, isometric knee extensor strength has been shown to improve in an 8-week low-intensity, conventional exercise intervention in elderly subjects (Westhoff et al., 2000). However, in this study subjects who presented maximum peak torques exceeding 87.5 Newton•meters were excluded. The homogenous sample of subjects all showed low knee-extensor strength at baseline and hence were probably more likely to improve under the conditions of the study (Westhoff et al., 2000).

The sample used in the present study, overall showed greater heterogeneity. Differences in the functional abilities of the subjects would have contributed to varying rates of individual improvement. Although baseline differences between groups and individual differences were controlled for by the statistical procedures adopted, the rates at which individuals responded to the intervention cannot be statistically controlled. The fact that isometric leg strength did not change was not surprising. It is possible that had all or most subjects shown lower functional capacity at baseline, the intensity of the interventions was such that sufficient stimuli were presented to induce adaptation or the exercises performed were similar to the tests conducted, then improvements in isometric leg strength may have been observed. Higher intensity or more specific exercise may need to be prescribed to high functioning older adults to provide sufficient stimulus or overload. It may be more beneficial to observe exercise effects on stratified groups of elderly individuals, determined by their functional ability in order to determine the influence of exercise interventions of differing overload on particular subgroups. It may also be necessary to provide individualised exercise prescriptions for individuals to take into account their functional disparities.

Generally, both isokinetic knee flexion and extension at the tested velocities were found to be greater for the two intervention groups than that of the Control group. For the most part significantly greater isokinetic values (i.e., peak-torque) between the interventions groups and the Control group was contributed to by a decline in strength of the Control group. For example the ROM group actually showed a decrease in strength for isokinetic knee flexion (90 and 120-degree/second) and extension (60 and 90-degree/second). The Control group likewise was found to decrease in strength, although to a greater extent across the same velocities. Indicating that the ROM intervention may be beneficial for maintaining or reducing the rate at which muscle strength is loss.

Although both the ROM and Control groups showed declines in peak torques, the ROM group showed significantly greater post-intervention strength for isokinetic knee flexion at 60 and 90-degree/second and for knee extension at 60-degree/second. Thus, indicating that the ROM intervention may have slowed the rate of strength loss at slower knee angular velocities (60 and 90-degree/second) when compared to the control group. Wolfson et al. (1996) also found that the performance of Tai Chi following more conventional types of exercise intervention reduced the loss muscular strength. It may therefore be unnecessary to test angular velocities higher than that observed for movements performed during the ROM dance or similar holistic interventions.

Although Tai Chi and the ROM intervention are slightly different, both share common characteristics with regard to the slow and continuous manner in which movements are performed. Therefore adding support to the finding that ROM may slow the rate of strength loss, and could be used to maintain strength, at least over a 10-week period. In situations where the elderly individual is limited in what activities they can perform, possibly due to mobility or health complications, injury or even hospitalisation, a slow gentle exercise intervention such as ROM may be an effective therapy for maintaining or reducing the loss of muscular strength. The use of ROM also has implications where individuals are housebound. The nature of the ROM intervention allows it to be performed in a confined space, with no equipment other than a chair and table required. The actual intervention is also on videocassette, which makes the intervention available to individuals without necessarily requiring an exercise instructor.

Although there are no studies presenting the measurement of muscular strength using the ROM intervention, the authors of ROM dance integrated principles from Tai Chi, for the interventions development. Therefore results from studies presenting Tai Chi interventions will be used to compare with the findings from the ROM group of this study. The ROM intervention was shown to significantly maintain isokinetic knee extension and flexion at 60-degree/second in comparison to the control group. This finding is similar to that found by Lan et al. (2000) who used a Tai Chi intervention. However, subjects in this study showed an increase in strength rather than just maintaining it as was the case in our study. The same study also found isokinetic knee extension at higher velocities to improve (180 and 240-degree/second), which in contrast to our findings, where higher velocity strength measures did not improve.

Several reasons may be attributed to the differences found between the current study and the study performed by Lan et al., (2000). Firstly the intervention was performed for 6-months (compared to 10-weeks for this study), thus providing more stimuli and a greater period over which changes can take place. Secondly, the average age of participants was somewhat lower than the sample of the present study. It is possible that subjects of Lan et al.'s study still participated in other physical activities and had limited physical dysfunction. Finally, although the ROM dance and Tai Chi share common movement characteristics, they are still two different types of intervention. To elaborate this point, it has been stated that due to the movements in Tai Chi being carried out with a lowered center of gravity, and hence constant knee flexion, it is likely that leg strength can be developed or maintained (Wolfson et al., 1996). Greater emphasis is placed on the lower limbs during the performance of Tai Chi as compared to that of the ROM intervention. It may be beneficial that participants of the ROM intervention to performed other exercises, which may assist in the development of knee flexor and extensor strength, such as regular walking.

The Conventional Exercise group, although improving for all post-intervention measures of isokinetic peak torque was only found to be significantly different from the Control group for all knee flexion velocities and for knee extension for the slowest velocity. However, the Conventional Exercise group also showed a significantly greater post-intervention peak-torque for knee extension at 90-degree/second compared to the ROM group. For the most part the Conventional Exercise intervention seems to be effective for improving isokinetic knee flexion across all of the tested velocities. However, the finding that similar strength improvements were not found to be significant across isokinetic knee extension is likely to be contributed to by the within group variability, individual difference in improvement, and a small sample size, thus reducing the statistical power to detect these differences. This is particularly evident as mentioned earlier, with the ROM and the Control group showing general decreases in isokinetic knee torque, while in all cases the Conventional Exercise group was observed to improve. In addition the observed difference (although not tested for significance) between the groups at baseline may have negatively influenced by adjusted post-intervention means computed made by the ANCOVA procedure.

Power calculations were performed *post hoc*, to determine the minimum number of subjects that would be required to detect the difference between the means found by our study for lower limb strength. Although this was performed prior to commencement of this study, sufficient numbers of subjects were not recruited. With this in mind it can't be ruled out that for some variables sufficient power could have been present, but the change or effect size was insufficient to be found significant. Nevertheless calculations were made for all non-significant knee flexor and extensor strength variables between the Conventional and ROM groups, and between the ROM and Control groups. From Table 5 (Appendix C), it is determined that had the samples sizes been two times greater, additional significant differences would have been observed between the groups for several of the two-group (independent groups) comparisons. It is unrealistic to expect or even recruit group sizes of over 200 subjects for relatively short exercise interventions. By recruiting more ideal group sizes, say over 30 to 40 subjects per group (which would have allowed six additional comparisons to be found significant), and by selecting a more homogenous group of subjects, sufficient statistical power would be derived. It must be noted that these sample sizes are based on findings from this study (means and standard deviations) and therefore may not be appropriate where the expected effect size is smaller or measures of the dependent variables show greater variance.

The observed results for isokinetic knee flexion and extension are similar to that found by other studies where intervention groups have been compared to control groups (Jones et al., 1994; Brown et al., 2000; Westhoff et al., 2000; O'Neill et al., 2000). Jones et al. (1994) using a low-intensity, 16-week Conventional exercise intervention found a significantly greater improvement in non-dominant knee flexor and extensor isokinetic strength (i.e., 90-degree/second) when compared to the control group. Brown et al. (2000) found significant improvements for knee extension and flexion at 60-degree/second but not at faster velocities (i.e., 180-degree/second) or isometrically, using a 3-month low-intensity conventional exercise intervention. Improvements at higher velocities of knee extension over an 8-week period in elderly subjects have been observed however, exercises were performed on pin-loaded equipment offering greater resistance than what was presented in the current study (O'Neill et al., 2000). It is possible that after an introductory period of low-intensity exercise, elderly individuals could advance onto more sophisticated exercises, utilising resistance training. This may produce greater strength gains than performing low-intensity exercise interventions, all other factors being equal, but may come at a greater risk of injury or higher attrition.

With some limitation due to the lack of power and the nature of the control group, the findings for leg strength of this study add evidence to other previous studies, which have shown the efficacy of low-intensity exercise interventions for improving leg strength at slower angular velocities in elderly individuals over short period of time.

The fact that this and other studies utilising low-intensity interventions have not found improvements at higher velocities is likely due to the limited number of "explosive" type movements performed.

It has been suggested that concentric strength development is velocity specific especially at slow velocities (Coyle et al., 1981). Hence, the performance of slow velocity movements in the interventions will only produce changes in isokinetic strength at those velocities trained. Resistance training at higher velocities may increase isokinetic strength measured at slower velocities (Perrin, 1993, p. 53), which may explain the improvement in strength, by the Conventional Exercise group across the range of velocities tested. It is possible that movements performed in the Conventional Exercise intervention would have been faster than those measured in the tests. As isokinetic knee peak-torque was measured at a maximum velocity of 120-degree/second, the upper velocity at which strength improvements would be observed cannot be determined. Thus, in future studies a greater spectrum of angular velocities should be tested to allow the limits of strength improvement to be determined, and to provide an estimate of the velocity of movements being performed within the intervention.

The significance of the observed strength improvements on the performance of activities of daily living of elderly individuals is not known. The functional significance of strength changes has also been questioned by other researchers (Brown et al., 2000). It has been suggested that many daily functional activities are performed at velocities of approximately 60 to 100 degree/second (Judge, 1993). Observed findings in isokinetic knee flexor and extensor strength of this study would generally suggest that some improvement in the performance of daily functional activities is possible. However, observed measures of functional ability in this study do not indicate strength improvements as being influential. A greater absolute change in strength may need to occur before positive flow-on effects can be observed in functional ability. Conversely, it may also indicate that muscular strength at these velocities is not a component effecting performance on the functionality tests. This may be brought about by increasing the intensity either by adding the number of repetitions performed or weight lifted, or by increasing the frequency of exercise sessions performed in the interventions.

The long-term effects of low-intensity conventional exercise interventions are less well understood. It is likely that ceiling effect in the development of muscular strength may occur in these types of interventions when implemented over an extended duration. Particularly when the exercises themselves are self-paced and additional overload is not presented, where changes in exercise intensity, type, and frequency are not made to meet the physiological improvement of the individual. It is possible that low-intensity conventional or holistic interventions like those presented in this study could be implicated as introductory exercise for several weeks, before elderly individuals progress onto more advanced (i.e., higher intensity, use of resistance machines etc.) or personalised interventions. It appears therefore that low-intensity exercise interventions lead to isokinetic strength development at slower rather than faster angular velocities. This is important as elderly individuals, particularly with adverse health issues that may exclude them from participating in more intense interventions, can still benefit from low-intensity interventions.

The Conventional Exercise intervention, although using only light resistance was able to provide enough stimuli to induce some strength adaptations. This is promising as the exercises themselves were mainly self-paced, in contrast to the ROM intervention, which is performed at the pace of the instructor. The format used with the Conventional Exercise intervention, whereby the exercises were replaced with a new set every sixth to seventh session, provided a greater variety of movements and may have facilitated strength improvements. This is in contrast to the format used by the ROM intervention, where the movements performed remained unchanged for the entire intervention, with only increments in the number of repetitions performed.

The ROM intervention did not involve a vast quantity of movements for the lower limbs, therefore presenting greater stimulus to the upper body. As this study only concentrated on two strength assessments (i.e., knee flexor/extensor and grip strength) it is possible that strength improvements could have occurred for other muscles of the body which were not tested. Therefore it is necessary to measure muscular strength at other joints to provide better detail of whether the ROM intervention does or does not improve muscular strength in elderly individuals. Particularly as the tests of the current may not have been specific to the movements undertaken in the ROM intervention.

5.3.2 Grip Strength

Grip strength is essential for performing activities, which require a "power grip" such as using a hammer, gripping a handrail, weeding, using a shovel etc. Hence reductions in grip strength can potentially negatively influence performance of many normal daily activities. This study found that dominant grip strength was significantly greater post-intervention for the ROM and the Control group. This was due to a reduction of dominant handgrip strength in the Conventional Exercise group, with accompanying small improvements in both the ROM and Control groups. This finding is questionable, particularly as no difference was found between the groups for non-dominant grip strength. It would be expected that if the interventions were to have a true effect on grip strength that both dominant and non-dominant grip strength measures would show similar changes. A non-significant finding in grip strength with improvements in strength of other muscles has also been observed (Rhodes et al., 2000; Hauer et al., 2001). This indicates that strength improvements may only be identified across joints that are specifically trained.

Reasons for this observation in the current study may include measurement or instrument error however, the method for measuring grip strength and the dynamometer used, remained consistent across all trials. Therefore any variability would have likely been presented in the results of all groups, had it been a major influential factor. Fatigue may have had some influence on grip strength. This may be apparent, as the variability within the Conventional Exercise group is small, suggesting that the group as a whole behaved in a similar way. However, the post- intervention testing was performed within several days following the last exercise session for all groups, which under the circumstances should have been enough time for recovery had muscles of the wrist and hand become fatigued after the exercise sessions. However, subjects within the same group were not necessarily tested on the same day, hence the ability to recover, and the time between the last exercise session and the test session may have been an influencing factor at an individual level.

An observed improvement in grip strength for the Control group may indicate a confounding influence such as the possibility of a learning effect. It is conceivable that members of the Control group could have performed exercises similar to those of the interventions, against the request of the researchers, influencing the results obtained. However, had this taken place it is proposed that associated changes in other physiological parameters similar to the other groups would also have been observed. The Control group in this study was not required to keep a participation record of daily physical activity or exercise. Hence this previous point is only speculation and cannot be proven from this investigation. The major reason for finding a significant difference is due to the decline of dominant-grip strength in the Conventional Exercise group rather than an intervention induced improvement in the ROM group.

However, the positive influence of the ROM intervention on grip strength cannot be ruled out entirely. The ROM intervention was originally designed for sufferers of rheumatoid arthritis, hence, it includes several movements that specifically focus on the development of joint mobility of the hand and wrist. It has been suggested that reduced mobility of the fingers are influenced by a decrease in pinch force (Ranganathan, Siemionow, Sahgal, and Guang, 2001). Therefore, improvements in hand mobility of the ROM group may have consequently caused improvements in grip strength.

Overall, grip strength measured for the non-dominant hand was lower than that of the dominant hand. Non-dominant grip strength showed no difference between post-intervention means of the three groups, which in this study probably provides a better representation of the actual changes that were likely to occur as a cause of the interventions. Hence the effectiveness of measuring grip strength as an indicator of change in upper limb strength in an exercise intervention is questionable.

Several studies have found no change in grip strength, while muscular strength has been observed to improve at other joints within the body (Hauer et al., 2001; Lazowski et al., 1999). Brill et al. (1998) found a significant improvement in left-hand, and not right-hand grip strength in elderly subjects. Wolf et al. (1996) found a decrease in grip strength after a 15-week Tai Chi intervention, but concluded that decreases in the Tai Chi group was less than that found in balance training and education groups, indicating that Tai Chi could slow the decrease in grip strength. A reason for this finding was not provided, given that activities to improve grip strength were not performed during the intervention. The current study, with evidence from the studies reviewed indicates that exercise interventions do not necessarily induce improvements in grip-strength. In addition, improvements in grip strength are often observed to be different between left and right hands.

Although grip strength has been shown to be a predictor of survival and mortality (Laukanen et al., 1995; Rantanen et al., 2000) its use as a measure of the effectiveness of low-intensity interventions in elderly individuals may not provide accurate indicator of the effectiveness of the intervention. If improvements in grip strength are part of the aims of an exercise intervention, then activities themselves should focus upon resistance and mobility exercises of the hand. For measuring the change of muscular strength, other measures such as hand-held dynamometry (i.e., measuring isometric strength in a field setting) or isokinetic dynamometry (i.e., to measure concentric, eccentric and isometric strength in a laboratory setting) should be adopted.

5.4 Balance

Clinical and laboratory based assessments were used to examine balance, representing activities during normal daily living (Berg Balance Scale). Neither the ROM intervention nor the Conventional Exercise intervention improved the balance ability measured by the Center of Pressure (COP) or the Berg Balance Scale (BBS) in the elderly subjects. This may be the result of several factors including; the performance of non-specific balance exercises during the intervention; minor or functional insignificant improvements in lower limb strength; higher level of balance ability at baseline; and possible insensitivity of the instruments used to detect small changes in balance ability.

Several reasons may explain why the interventions of the present study did not improve postural stability. Balance is a multi-component parameter effected by several physiological influences (Lord, Clark, and Webster, 1991). It is possible that the interventions of this study did not provide sufficient stimuli for all systems influencing balance, including Sensory (vision, touch, proprioception, vibration sense, vestibular sense), Motor (muscle strength and neuromuscular control), and Central Nervous (sensory and motor factor integration) systems (Lord et al., 1991). The subjects included in this study also showed high balance ability at baseline (as seen in the Berg Balance Scores). Although partially related, this maybe reflective of the fact that 5.7% of subjects reported falling in the 3-months prior to the study. However, in conflict with this finding, it was observed that the majority of subjects were not able to stand on one-leg for 10 seconds. Low uni-pedal stance time has been shown to reflect physical function, balance ability and the occurrence of falls in the elderly (Vellas et al., 1997; Hurvitz et al., 2000). Had a greater number of subjects been able to balance on one-leg long enough to allow sufficient force platform data to be collected, changes as of a result of the interventions could have been analysed. It may have been more suitable to test a greater array of postural stances including standing on different surface types or even testing reactive balance as a result of external perturbations.

Another factor that may have eventuated to the non-significant observations is the types of instruments used to assess postural stability. The BBS, which measures both static and dynamic postural stability, may not be sensitive enough to detect small changes, particularly in high functioning elderly individuals (i.e., concluded by the findings of fast TUG times and modest BBS scores of the current study). Brauer and colleagues (2000) provide evidence for this after reporting that the BBS was not sensitive enough predict falls in community-dwelling elderly women. However, content of the instrument may not be related to falls. Nevertheless, the BBS may be more suitable for detecting differences between low and high functional elderly individuals and in cross-sectional studies where individuals of different ages are compared, and between group variability is normally greater.

No difference was observed in the variability of COP variables, suggesting that neither of the interventions improved postural stability. Problems encountered during the data collection stage of this study meant that only COP data in the medio-lateral plane was obtained and analysed. It is possible that changes may have occurred in the anterior-posterior plane. Unfortunately at present there is no agreed "gold standard" or criterion measure of postural stability, meaning that some instruments may not be suitable for all elderly individuals.

Activities within the interventions themselves did not focus on developing balance, but rather measured balance as a possible additional benefit of performing the exercise interventions. Multi-dimensional interventions that have not included strength training have shown positive balance outcomes (Grahn Kronhed et al., 2001). This may indicate that strength training alone does not improve balance, but instead may contribute to it. This study shows that muscular strength improvement of the lower limbs does not necessarily lead to increases in postural stability, particularly if the change in strength is small. As activities performed by the subjects were non-specific for improving balance, it is likely that greater increases in lower limb strength are required for there to be improvements in postural stability, particularly in non-frail elderly individuals.

Other studies have found mixed results for balance versus strength following exercise interventions. Rubenstein et al. (2000) found no improvement in balance, with accompanying improvements in isokinetic knee extension and flexion (i.e., 60-degree/second), using the Performance Orientated Mobility Index (POMI). The magnitude of change in strength was slightly higher than that shown by participants in this study. However, supporting findings by this study that small improvements in knee flexor and extensor strength do not result in changes in balance measured by the BBS or postural variability as measured by the standard deviation of the COP. This at least appears to be true for higher functioning elderly individuals.

Significant differences were found for the BBS and other balance indicators in a study by Brown et al. (2000) where subjects were also reported to have improved isokinetic knee extensor and flexor strength tested at a velocity of 60-degree/second. The magnitude of strength change was not overly different to that measured in this study for the same velocities. Although in contrast with findings of the present study, Brown et al. (2000) used subjects who were defined as a physically frail, determined by low scores they had achieved on the PPT. Hence, the sample overall would likely have had compromised postural stability at baseline and therefore more likely to show improvements with the addition of an exercise intervention. Subjects in this study appeared to be higher functioning than first thought, therefore less likely to show significant improvements.

Postural stability is related to falls in the elderly, which leads to further health implications such as reductions in further physical activity (Tinetti et al., 1994). This is a parameter that should be of focus when designing exercise interventions, particularly due to the high numbers of injuries occurring as result of episodes of postural instability (National Injury Prevention Plan Priorities for 2001-2003). Specific, exercises should be performed to improve balance in addition to others that focus on strength, flexibility, and cardiovascular fitness. Activities that train the visual, vestibular, and somatosensory systems should also be incorporated (Shumway-Cook and Woollacott, 1995).

Several activities that specifically target postural stability should be incorporated, with it being suggested that dynamic (e.g., tandem walking), rather than static (e.g., standing) postural exercises be performed (Gardner, Buchner, Robertson, Campbell, 2001). The types of activities that may be performed to improve balance include; sit-to-stand; backward walking; walking and turning around; sideways walking; tandem stance; tandem walk; heel walking and; toe walking (Gardner et al., 2001). These activities can be performed at different levels of difficulty dependent on the balance ability of the individual or group (i.e., using support, increased number of repetitions etc.). Additional specific activities for improving or retraining balance should be included with interventions such as those used for this study.

Post hoc sample size calculations were performed to determine the "n" required to find significant differences between the conventional and ROM group and the ROM and control groups for variables of postural stability (Table 6-Appendices C). The sample sizes were calculated using the effect size and variability observed between baseline and post-intervention of this study. Therefore the sample sizes calculated should only be used as a guide.

The sample sizes were based on unequal variances, the means observed by this study, with an alpha of 0.05 and power of 0.80, 23 subjects per group would have been required to find a statistical significant difference between the Conventional Exercise and the ROM groups for the BBS. Thirty-three subjects would be needed in each group to find a statistically significant difference between the ROM and Control groups for the BBS. The number of subjects required to detect statistically significant differences for COP and especially for COP with eyes closed is large and would be considered unrealistic for future study. This provides additional evidence that the sample sizes for this study limited the number of statistically significant differences observed, at least with regard to the strength variables and the BBS.

5. 5 Functionality

Results from the Timed "Up" and "Go" (TUG) indicate that functional ability and mobility did not change as of a result of the exercise interventions. This is possibly due to the specificity of the activities performed within the interventions or due to the low

TUG times measured at baseline. Hence, the TUG may not be sensitive enough to detect changes in higher functioning elderly individuals.

The ROM intervention included no walking, and only minimal translational movement from a sitting to a standing position. The improvement in knee flexor strength at 60 degree/second did not influence the performance of the TUG by the ROM intervention group. This is could due to velocities of movements performed during the TUG are at faster velocities, than those which were tested for strength in this study.

The Conventional intervention included some walking activities, the core of the exercises performed were strength based. Only small changes in leg strength were observed and it is unlikely that the Conventional Exercise intervention would have had a significant impact on the TUG outcomes. This is also seen in the Control group where lower measures of leg strength did not equate into slower TUG times. Although, the Conventional Exercise group did show some indication of leg strength improvement at higher angular velocities it is still likely that these velocities were slower than those, which would be required for movements performed during the TUG.

Another factor influencing the non-significant finding between groups for the TUG following the intervention could be because of the fast times recorded at baseline. Timed "Up" and "Go" times recorded by elderly individuals from other studies have varied with baseline times from 8 to 33 seconds (Steffen, Hacker, and Mollinger, 2002; Lazowski et al., 1999). The baseline results recorded by subjects of the present study (baseline average of 11.2 seconds) indicate that this sample was generally at a competent level of functional ability.

Changes of approximately 16% in TUG times have been found in elderly individuals showing high baseline times (Lazowski et al., 1999), with smaller changes observed when baseline times have been less (Westhoff et al., 2000). This range in scores across studies highlights the heterogeneity in functional capacity of elderly subjects, as well as suggesting that changes in functional capacity are more likely to be observed in samples, which show deficiency in functional ability. Thus, partly explaining why no changes in the TUG times were observed for either intervention in this study.

The Physical Performance Test (PPT) was also included in this study to assess functional ability however, testing a greater diversity of movements compared to the TUG. The PPT scores were found to be greater in the Conventional Exercise group compared to the ROM and the Control groups however, only significantly different to the Control group. The difference between the Conventional Exercise group and the ROM and Control groups for the PPT post-intervention scores were 3.5% and 9.4 %, respectively.

Several factors may have contributed to the PPT scores obtained by the groups. Firstly there appears to be little or no learning effect, as the Control group showed no change in the mean PPT score. The Conventional Exercise intervention group showed a significantly greater post-intervention PPT mean, which could be attributed to the greater diversity of movements performed, and the inclusion of activities involving the use of light resistance. For example the used of light resistance for both bicep curls and front raises could assist with tasks such as lifting a book from waist level and placing it on a shelf at head high. Mobility exercises for the shoulder joint could assist with the ability to put on a coat or jacket. Hence the use of the PPT as an assessment tool may be more specific to the types of activity performed in the Conventional exercise intervention (i.e., similar movements are performed for both the intervention and the test).

The Conventional Exercise intervention is more effective for improving functional ability, although not significantly more so than the ROM intervention. An approximate 10% greater post-intervention score for the Conventional Exercise group compared to the Control group indicated the effectiveness of the former for improving functional abilities found on the PPT. However, the impact of this degree of improvement in the daily functioning of elderly individuals cannot be estimated from this study. It has been found that subjects with poor performance on the PPT (i.e., 8-item version) have been shown to improve the greatest following a low-intensity exercise intervention (King, Judge, Whipple, and Wolfson, 2000). However, this cannot be assumed as post-interventions scores were adjusted for baseline differences. This study suggests is that the Conventional Exercise intervention induces positive changes in functionality (at least for those activities measured on the PPT) compared to participating in no exercise intervention. The performance of exercise should be seen as a necessity of maintaining functionality and potentially independence in the later stages of life.

5.6 Limitations

This study presents several possible limitations. Firstly, an effort was made to recruit subjects who were characteristic of elderly individuals within the population (i.e., living independently, receiving living assistance etc.). However, when recruiting volunteers, it is possible that the subjects recruited are those who are in less need of the exercise interventions as individuals who choose not to volunteer. It has been suggested that volunteers somewhat differ from those who do not (Elwood, 1998, pg 62). This effects the external validity, as results of this study can only be generalised to those elderly individuals who are likely to be volunteers for studies such as this one.

The selection criteria used for this study may have biased the recruitment, as less functional individuals (due to self-reporting multiple health issues) may have been excluded due to the exclusion criteria. Although an important issue, it is difficult to overcome this bias as many ethical considerations influence the criteria used to include or exclude subjects. This is particularly true when components of the study may put an individual at risk of injury or health complications.

Baseline results of this study suggest that subjects who volunteered and subsequently were included in the study overall showed moderate to high functional characteristics, at least for some of the tests (e.g., Timed "Up" and "Go", and Berg Balance Scale). Thus, influencing the extent to which the results observed could be generalised to the entire aged population. The results therefore, more accurately represent elderly individuals who are more functionally capable rather than the stereotypical elderly individual. This is an important, as a less functional group of subjects would show a different response to the same exercise intervention than a higher functioning group.

Secondly, the results of this study can only be generalised within the contexts of the study design. It is difficult to determine or even assume whether the pattern of physiological improvement would occur over a longer study period (i.e., 6-months to a year). Hence the results of this study can only represent what may occur over the short-term (10-weeks) exercise intervention and no longer. The same constraint also applies to attrition and compliance observed within this study. Therefore as this study is limited in its ability to forecast physiological and attrition/compliance outcomes over a long-duration it may be necessary to design future studies to overcome this issue.

Finally, statistical power for most measures was insufficient to detect the small real-effects brought about by the interventions. The response of the subjects recruited may have had a bearing on this. It was expected that the individuals recruited for this study would have been of lower functional ability, and more likely to show greater adaptations as a result of the interventions however, as mentioned this was not the situation. Higher functioning individuals are more likely to show less change than lower functioning individuals given the design of the interventions used. This caused smaller intervention effects to be observed, and requiring more statistical power to be detected. Insufficient power was evident when groups showed overall changes of outcome measures in opposing directions (i.e., increase versus decreases) yet were still not found to be significantly different. In addition the unexpected results obtained from the Control group (i.e., loss in leg strength over only 10-weeks), highlights how irregular outcomes may be obtained if sample sizes are two small and/or how mean scores can be biased by inconstant changes (with rest of the group) in only a couple of subjects. Therefore, recruitment of a larger sample, hence decreasing within group variability would have improved statistical power.

5.7 Recommendations

Given the limitations of this study, the findings of this study should be interpreted with caution. Several recommendations can be made, of which can then be used for future study designs investigating similar issues. The following recommendations may also be useful should the interventions of this study be implemented in community situation.

Study Design. For future study designs it is recommended that exercise interventions of longer duration be implemented, with repeated measures of physiological variables and attrition and compliance performed. This will allow the long-term effects of both the conventional and holistic exercise interventions to be determined. Repeated measures will make it possible to determine when the interventions are most effective for inducing physiological changes or if these changes are continuous with the increasing length of the intervention. A longer intervention period will also allow attrition and compliance over the short and long terms to be investigated. This is important as underlying influences may differ depending on the length of the intervention.

Sampling. Based on issues of sampling and recruitment of this study it is recommended that a larger sample size be used and a more representive sample be recruited. This study showed that even with advertising to over 900 potential subjects, this does not guarantee a sufficient sample size. Other methods other than mailed invitations and information flyers, or recruitment over a longer duration maybe required to attract more elderly volunteers from the community, to participate.

Obtaining a larger sample size, in most cases will provide less variability, and will improve statistical power. In addition it is also suggested that the groups be stratified by functional ability, age, and even Body Mass Index to determine the effects of the same exercise interventions on elderly individuals with different characteristics. Hence the specificity of the exercise interventions can be established in different segments of the aged population. Future studies may also want to determine the characteristics and reasons of elderly individuals who choose not to volunteer in exercise interventions. This type of research design would also require a larger sample to be recruited, but will improve the generalisation of the results.

Moreover, it may also be beneficial to measure baseline physical activity levels through electronic means (accelerometer) or by self-report (questionnaire or interview) to determine how sedentary the sample is. Hence better knowledge of the characteristics of the sample can be obtained and improved inferences can be made.

Interventions. The interventions presented in this study were deliberately designed to be of low-intensity. The exercises of the Conventional Exercise group were designed to represent what elderly individuals in the community or aged settings, may perform. This was necessary as the ROM intervention was also of low-intensity and this study was designed to compare an intervention that is already performed by elderly individuals (i.e., Conventional exercise) to one that could be performed in the future (i.e., ROM dance). Although both are low-intensity, this is not easily quantified through observation. It is therefore recommended that for two different types of interventions to be compared accurately, a method of quantifying the amount of work performed in each, possibly through the use of motion sensors is required. This will assist in reducing the issue commonly defined in layman terms as "comparing apples with oranges".

The interventions promoted in this study were specific to mobility, functionality and muscular strength development, purposely ignoring any cardiovascular component. In addition the activity promoted alone did not meet the minimum level (30 minutes daily most days of the week) of physical activity required to accrue health benefits (Egger et al., 2001; U.S. Department of Health and Human Services, 1996). In community settings, additional physical activity should also be promoted to complement interventions similar to those conducted in this study, to encourage participants to reach sufficient levels of physical activity being promoted within the United States (U.S. Department of Health and Human Services, 1996) and Australia (Egger et al., 2001).

The method of familiarisation of the testing procedures may have been inadequate for the sample of this study. Although, several trials of each test were provided before actual data collection, the subjects may not have become accustomed to the tests undertaken in the trials provided. Hence, learning effects may have been taking place during the actual collection of data. Although the same procedure for testing (e.g., number of trials etc.) was undertaken it might be more accurate to allow a familiarisation session (i.e., on a different day to testing) to take place separate from the collection of data to be used in the study.

Both the Conventional Exercise intervention and the ROM dance could be used in any aged setting. However, due to their low-intensity, it is recommended that the interventions be prescribed for individuals beginning exercise for the first time or after an extended duration of limited physical activity involvement. It is possible that individuals could perform both types of interventions at the same time, in order to add variation and possibly improve compliance and lower attrition. Although it is likely that greater gains in physiological function would be brought about by increased intensities of exercise. The literature tends to indicate that the long-term benefits of exercise interventions of different intensities is relatively understudied in the elderly however, exercise of greater intensity appears to provide larger improvements in physiological function in the short-term. Hence, it may be more productive for the elderly individuals, after performing an introductory period of exercise using the two interventions of this study, to advance onto more physical activity or exercise program with increasing overload to cause continuous adaptation.

5.8 Conclusion

This study found that for the most part the ROM and Conventional interventions are not significantly different in compliance or physiological function when performed for 10-weeks. However, it cannot be said that they are equally effective for improving physiological function particularly leg strength, as on most occasions the ROM group actually showed declines in strength. This study although not finding such differences statistically significant, does indicate that further study is required to establish these differences, thus determine the efficacy of the ROM intervention as an activity that should be used by elderly individuals.

The present study assessed physiological function as the performance of only three different parameters including strength, balance and functionality. However, other parameters such as cardiovascular fitness and flexibility also contribute to physiological function and to the performance of normal daily activities. Therefore changes in other parameters that may have gone unmeasured, may have possibly improved as a result of the interventions. Hence, the results can only be generalised to physiological function defined by the parameters measured by this study. All physiological parameters need to be measured during intervention studies to understand fully the potential health benefits that may be provided as well as establishing which parameters most influence normal daily living and function.

In conclusion, although caution should be taken in interpreting the findings of this investigation, this study has shown that short-term low-intensity exercise interventions are effective for improving some parameters of strength and physical function in elderly individuals. Although for the most part no significant differences existed between the ROM and the Conventional Exercise groups, with the later seeming more beneficial for improving physiological function, while the former to a certain extent is beneficial for maintaining physiological function. However, further investigation is required to determine this. Essentially, this study shows that the performance of exercise whether it is holistic or conventional has some positive outcomes for elderly individuals, compared with performing no exercise. Hence, participation by the elderly in any physical activity regardless of frequency, and intensity, maybe in itself enough to cause improvement in physiological parameters.

The findings of this study do not support the hypotheses which proposed that the Conventional Exercise intervention would be more effective for improving physiological function than the ROM intervention; and that the ROM intervention would show higher adherence and lower rates of attrition compared to the Conventional Exercise group.

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APENDICES

A

Parameters of Effective Exercise Programs in the Elderly: Physical Function, Wellbeing and Independence

Screening Criteria Questionnaire

Please read the following questions carefully and answer them to the best of your ability, as it is a guide for us to select the appropriate participants for this particular study. All questions answered on this sheet will be kept confidential, and only the research team will have access to it. Please cross the following questions: yes or no.

1.	**yes**	**no**	Do I get chest pains while at rest and /or during exertion?
2.	**yes**	**no**	If the answer to question 1 is "yes," is it true that I have not had a physician diagnose these pains?
3.	**yes**	**no**	Have I ever had a heart attack?
4.	**yes**	**no**	If the answer to question 3 is "yes," was my heart attack in the last year?
5.	**yes**	**no**	Do I have high blood pressure?
6.	**yes**	**no**	If you don't know the answer to question 5, answer this: was my last blood pressure reading more than 150/100?
7.	**yes**	**no**	Am I short of breath after extremely mild exertion and sometimes even at rest or at night in bed?

8. **yes** **no** While at rest do I frequently experience fast irregular heartbeats or, at the other extreme, very slow heartbeats?

9. **yes** **no** Am I currently being treated for any heart or circulatory condition, such as vascular disease, stroke, angina, hypertension, congestive heart failure, valvular heart disease, blood clots or pulmonary disease? If so what condition?...

10. **yes** **no** As an adult have I ever had a fracture of the hip or spine?

11. **yes** **no** Did I fall more than twice in the past 3-months (no matter what the reason)?

12. **yes** **no** Do I have diabetes?

13. **yes** **no** Do I need assistance to walk (a cane, a walking frame, wheel-chair, personal help etc.)?

14. **yes** **no** Do I exercise more than twice a week?

15. **yes** **no** Am I receiving physiotherapy or some other treatment for an injury that restricts my movement?

16. **yes** **no** Is there any reason why I should not participate in physical activity?

I have read and understood all of the questions, and answered them to the best of my knowledge.

NAME: ______________________ **SIGNITURE:** _________________________

DATE: ________________________

In the case of any problems or emergency that may unexpectedly arise, please fill out the following information.

Contact Person:_____________________ **Telephone N°.:**________________

Thank you for completing this questionnaire.

APPENDICES
B

Conventional Exercise Program

Overview

The Conventional Exercise program is a low-intensity exercise intervention design to be performed by elderly individuals. The program includes the use of light-weights (1 to 3 kilograms) as well as other equipment such as pieces of rope, beanbags, and hoola-hoops. The program is develop to include different activities introduced every 6 to 7 sessions however, still focussing on the same areas of the body. The total time required to complete each session is approximately 30 to 40 minutes. All exercise sessions are performed to music.

Intervention Structure

Number of Exercise Sessions: 20 (2 per week)

Length of the Intervention: 10-weeks

Session Structure

Warm-up Phase

- Includes performing as a group walking and marching, static chair stretches, and range of motion exercises
- Performed for approximately 10-minutes.

Conditioning Phase

- Circuit consisting of 5-stations, including strength and range of motion exercises.

- Each station consists of two activities.
- Each station is performed once in s ingle session for a period of 2.5-minutes.
- Participants work in pairs, alternating on the activities at each station.
- At the end of the 2.5 minutes, pairs of participants move onto the next exercise station.

Cool-Down Phase

- Includes seated static stretches and relaxation techniques.
- Performed for approximately for 10-minutes

Criteria for Stations

- Station 1: Range of Motion (emphasis on shoulder girdle).
- Station 2: Legs Strength, full range of motion.
- Station 3: Arm/Shoulder Strength, full range of motion
- Station 4: Torso/Abdominal Strength
- Station 5: Grip Strength/Range of Motion (wrist and fingers)

Exercises Performed

Participants are instructed to alternate activities on each station continuously for the entire 2.5-minute working period. For example, once a participant had completed the required repetitions of the two activities at the station, they would return to the first activity and continue the pattern.

Sessions 1 to 6

- **Station 1:** Use of rope (skipping rope) doing figure of 8, and circles for each arm. Each movement is done for 8-repetitions on each arm before changing.
- **Station 2:** (seated) flex the thigh and then extend the knee for 8-repetitions each leg, followed by hip/leg external and internal rotations, 8-repetitions of external and of internal rotation for each leg.
- **Station 3:** Bicep curls for 8-repetitions followed by triceps extensions for 8-repetitions, continuing pattern until the 2-minutes is finished.
- **Station 4:** Elbow to knee abdominal contractions (seated) for 8-repetitions for each side, followed-by back extensions for 8-repetitions.
- **Station 5:** Towel roll (wrists) for one minute followed by bounce and catch of a ball.

Sessions 7 to 13

- **Station 1:** Shoulder rotations, with hands on shoulders, through the full range of motion for the shoulder girdle.
- **Station 2:** Leg/thigh side raises for 8-repetitions, followed by thigh/hip extensions 8-repetitions.
- **Station 3:** Forward deltoid/shoulder raises for 8-repetitions followed by upright chest press for 8-repetitions.
- **Station 4:** Step-ups (onto small block) for 8-repetitions each leg followed by assisted squat (chair) for 8-repetitions.
- **Station 5:** Wrist extension/flexion with dumbbell, 8-repetitions each movement and for each hand, followed by 'bean bag catch' and 'drop'.

Sessions 14 to 20

- **Station 1:** Posterior deltoid/shoulder extensions with a rope for 8-repetitions, followed by forward deltoid/shoulder raises with rope for 8-repetitions.
- **Station 2:** Sit and stand from a chair for 8-repetitions, followed by calf raises for 8-repetitions.
- **Station 3:** Lateral raises for 8-repetitions followed by upright rows for 8-repetitions.
- **Station 4:** Pelvic rocks, followed by lumbar roll and release. 8-repetitions each movement.
- **Station 5:** Ball Squeezes for 8-repetitions, followed by finger flexion/extensions, for 8-repetitions.

APPENDICES

C

Table 5. Samples sizes required to determine statistically significant differences between groups for knee extension and flexion based on results from the present study.

Variable	Conventional vs. ROM (n)	ROM vs. Control (n)
Isometric knee flexion	286	46
Isometric knee extension	37	25
Isokinetic knee extension 60 deg/sec	80	Sig.
Isokinetic knee extension 90 deg/sec	Sig.	Sig.
Isokinetic knee extension 120 deg/sec	28	21
Isokinetic knee flexion 60 deg/sec	928	4626
Isokinetic knee flexion 90 deg/sec	27	82
Isokinetic knee flexion 120 deg/sec	67	27

Estimates based on unequal variances and means derived following Analysis of Covariance, with a power of 0.80 and an alpha of 0.05.
"sig." where the current sample size for this study was sufficient.
"n" is the number of subjects per group.

Table 6. Samples sizes required to determine statistically significant differences between groups for Center of Pressure and the Berg Balance Scale for the present study.

Variable	Conventional vs. ROM (n)	ROM vs. Control (n)
Berg Balance Scale	23	33
COP-eyes open	1138	1554
COP-eyes closed	> 2 million	> 90 000

Estimates based on unequal variances and means derived following Analysis of Covariance, with a power of 0.80 and an alpha of 0.05.
"sig." where current sample size for this study was sufficient.
"n" is the number of subjects per group.