

EFFECTS OF UPPER BODY RESISTANCE WHILE TREADMILL WALKING IN  
OLDER ADULTS

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OLDER ADULTS

The following faculty members have examined the final copy of this thesis for form and content, and recommend that it be accepted in partial fulfillment of the requirement for the degree of Master of Education with a major in Exercise Science.

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## ABSTRACT

Individuals have been adding hand-weights to walking regimens to increase caloric expenditure and arm strength. This is typically contraindicated due to changes in mechanics caused by weighted swinging arms. To address this safety concern we used a new commercial treadmill with a modified support rail that allowed a resistance to be applied to the upper body without the force of the swinging hand-weights.

**PURPOSE:** The purpose of this study was to assess functional strength, balance and walking speed on older adults, while walking on a modified treadmill that applied intermittent upper-body static presses and see the effects.

**METHODS:** Five older adults (age:  $75 \pm 14$  yrs) males (n= 2) and females (n=3) completed four weeks of exercise trials twice per week. (WALK + RES) were tested on the same days. The WALK + RES trial used a specially designed treadmill equipped with an adjustable weighted sled apparatus. Subjects walked at their desired speed throughout the trial starting at a grade of 0% which was not increased during the ten minutes. The WALK + RES trial incorporated an upper body static press against a weighted sled set at 5% of their body weight as resistance. During the WALK + RES trial, subjects completed ten minutes of 30 second static presses separated by 30 seconds of upper-body relaxation. RPE was recorded at the ten minute trial using the Borg scale, respectively. At the start and finish of the four weeks balance, & strength were retested to see if any gains were made.

**RESULTS:** Strength gains were made on everyone tested and balance gains were also made.

**CONCLUSION:** Adding upper-body resistance to walking significantly increases workload. The modified treadmill allows participants to fix their hands to a rail, similar to pushing a cart addressing the safety concerns of lumbar rotation caused by hand-weights. Adding functional resistance upper-body exercise during walking may be an effective mode of exercise to increase strength, balance and activities of daily living in special populations.

## TABLE OF CONTENTS

Chapter	Page
INTRODUCTION.....	1
1.1 Overview.....	1
1.2 Statement of Problem.....	2
1.3 Significance of Study.....	3
1.4 Hypothesis.....	4
1.5 Limitations.....	4
1.6 Delimitations.....	5
1.7 Assumptions.....	5
1.8 Definitions.....	6
LITERATURE REVIEW.....	8
2.1 Aging Population.....	8
2.2 Increased Number of Falls in Older Adult Population.....	8
2.3 Balance.....	11
2.3.1 Sensory Systems Contributing to Postural Sway.....	12
2.3.2 Postural Stability and Aging.....	13
2.4 Methods of Assessing Balance.....	13
2.5 Declines in Strength and Balance in Older Adults.....	14
2.5.1 Up-and-Go Testing.....	16
2.6 Muscular Strength in Older Adults.....	16
METHODOLOGY.....	22
3.1 Research Questions.....	22
3.2 Site and Participant Selection.....	23
3.2.1 Participants.....	23
3.3 Instruments and Measures.....	24
3.3.1 Thorotread Treadmill.....	24
3.3.2 SWAY Application.....	25
3.4 Procedures.....	25
3.4.1 Balance (SWAY Application).....	26
3.4.2 Thorotread Testing.....	27
3.5 Statistical Analysis.....	27
3.6 Protection of Human Subjects.....	28
3.7 Summary of Methods.....	28

## TABLE OF CONTENTS (continued)

Chapter	Page
RESULTS.....	29
4.1 Research Questions.....	29
4.1.1 Research Question #1.....	29
4.1.2 Research Question #2.....	30
4.2 Effects of ThorotreadTreadmil.....	32
DISCUSSION.....	35
5.1 Overview.....	35
5.2 Limitations.....	37
5.2.1 Limitations with Subjects.....	37
5.2.2 Limitations with Technology.....	37
5.2.3 Limitations with Thorotread.....	37
5.3 Recommendations for Further Research.....	38
5.4 Conclusion.....	39
BIBLIOGRAPHY.....	40

## LIST OF TABLES

Table	Page
2.1 Consequences of Falls in Elderly Males & Females.....	10
5.1 Balance & Strength Assessments Literature Review.....	36

## LIST OF FIGURES

Figures	Page
2.2 Conceptual Model Representing the Systems Contributing to Task Specific Balance & Orientation.....	11
3.7 Summary of Methods.....	28
4.1 RPE Pre and Post Assessments.....	29
4.2 Anterior/Posterior Comparisons.....	31
4.3 Medial/Lateral Comparisons.....	31
4.4 Raw Accelerometry Data from Oldest Subject.....	32
4.5 Raw Accelerometry Data from Youngest Subject .....	33
4.6 Raw Accelerometry Data Baseline.....	34
4.7 Raw Accelerometry Data End Point.....	34

# CHAPTER 1

## INTRODUCTION

### 1.1 Overview

The purposes of balance are to maintain a specific postural alignment, such as sitting or standing, assist in voluntary movement, such as changing posture, and reacting and recovering from an external disturbance that affects stability, such as a trip, slip, or push (Pollock, Durward, Rowe, & Paul, 2000). Balance improvement has been shown to help with recovery, injury prevention, and functional performance in both young and older individuals, but proper assessment is required in order to implement the appropriate protocols for each person. Assessments must be reliable, valid, and reproducible in order to provide the most successful results. Methods have been developed to assess balance, such as the Berg Balance Test, the Postural Assessment Scale for Stroke patients, the Functional Independence Measure, and the Continuous-Scale Physical Function Performance Test, which are functional tests used to measure balance, posture, and equilibrium, typically in the older population (Benaim, Perennou, Villy, Rousseaux, & Pelissier, 1999; Berg, Wooddauphinee, & Williams, 1995; Bohannon & Leary, 1995; Cress et al., 1996). Strength assessments are just as important as balance due to activities of daily living being a main concern for older adults. Falls are a leading cause of morbidity and mortality in older people. One out of every three adults over 65 falls each year, and half of those individuals will fall again within six months (McColgin, Driver, & Goggin, 2009). The older population has become the main growth segment in current society. According to the World Health Organization in 2000, 10%, or approximately 600 million people worldwide, were 60 years old or older, and globally, this number is expected to increase to 1.2 billion by

2025 and 1.9 billion by 2050 (Yu-Kai, Chien-Yu, Feng-Tzu, Chia-Liang, & Chi-Chang, 2012). As a person ages, risks of falling and associated problems are increased. Addressing mobility function and balance impairment are therefore central to fall prevention. In light of research indicating that inability to perform concurrent tasks is a contributing factor to instability and falls in many older adults, it has been suggested that training balance under both single- and dual-task conditions is necessary to optimize functional independence and reduce falls in elderly people (Silsupadol, Siu, Shumway-Cook, & Woollacott, 2006).

## 1.2 Statement of the Problem

Adequate structure and function of the musculoskeletal system is an essential aspect of overall health, functional capacity and mobility during the whole lifespan. With diseases such as sarcopenia, atrophy and osteoporosis as well as normal deterioration, it is important to find ways to maintain a healthy functioning body. The problem is finding a safe and practical way to achieve strength, balance and overall improved function ability without being unattainable for an older individual. Skeletal muscle is the largest organ and protein store of the body and has numerous functions, most important of which is to produce force and generate movement. Muscles generate power during movement and also act to break movement. At the same time, bones serve as levers for the muscles and provide the mechanical integrity for locomotion and protection. Considering the main functions of the musculoskeletal system, it is reasonable that the development of muscle and bone structure and function during growth as well as their maintenance in later life depend on the extent to which mechanical loading and physical activity are applied to them. By training, skeletal muscles can achieve substantial improvements in their capacity to produce force and influence the other components of the locomotor system

(Suominen 2007). Age related reductions in muscle mass and activity levels have significant implications for physical function in older populations. Noticeable reductions in strength, power, gait, balance and increased susceptibility to falls have been proven (Lauretani 2003). Reductions can lead to a loss of functional independence, greatly affecting the quality of life for older adults. Fortunately, resistance training (RT) has been shown to offset many age-related declines in functional performance (Lamoureux 2003). As sarcopenia contributes to decreased muscle function, exercise programs can minimize or combat the loss of muscle mass, strength, and power and can have significant implications on how older adults function (Jansen, 2002).

### 1.3 Significance of the Study

A limited number of studies that assess the use of upper body resistance while treadmill walking are available. This study is significant in that it contributes and expands upon the existing body of literature available to date. The methods used to apply upper body resistance while treadmill walking is unique to this study and outcomes may contribute in the development of improved methods of applying functional strength training while conditioning the cardiovascular system simultaneously. The information obtained from this study will be of benefit to medical professionals, assisted living, and the older adult community due to the potential to report an outcome that would be beneficial to the general public and have a significant contribution to the scientific body of knowledge.

#### 1.4 Hypothesis

1. It is hypothesized that treadmill walking with upper body resistance will improve balance in older adults.
2. It is hypothesized that workload will decrease due to four weeks of specific exercises.

#### 1.5 Limitations of the Study

Mobile devices that are cost-efficient and reliable and can provide accurate, quantitative data on an individual's balance which could revolutionize the way people are assessed, assisted, trained, and diagnosed. This application would provide a convenient, easy way to address issues that can lead to more serious conditions and/or prevent issue from occurring. The first limitation is the subjectstested. The population tested is not as familiar with this type of technology so understanding the use and using the device properly could be problematic. Average age of the participants was 79.1 years old, most of whostruggle with balance so the stances used during the testing might be difficult. Anotherlimitationis relying on the subjects to show up consistently and give their best effort as well maintain proper energy levels and not fatigue easily which could skew results. A third limitation is the Thorotreadwhich is a new treadmill that the older adult population may struggle with due torequired upper and lower body coordination. A final limitation is the cultural or social factors that may influence the knowledge or acceptance of technology and its use in health care. If the participant is unfamiliar or uncomfortable with the technology used for this study (the iPod), it may cause frustration that could potentially affect the results of this study. It is important to note because the success of this study is reliant upon the

acceptance and use of current technology. The device is also the main factor in being able to process the statistics of the study so if the technology malfunctions there can be error in the results.

### 1.6 Delimitations of the Study

Delimitations of the study are as follows:

1. The study is delimited to CPAA members in the Human Performance Studies Department at Wichita State University, Wichita, Kansas.
2. A delimitation of this study is the use of the Apple iPod instead of any other mobile accelerometric device.
3. A delimitation of this study is the use of the Thorotread treadmill instead of a basic treadmill.

### 1.7 Assumptions of the Study

Assumptions for this study are as follows:

1. In order to participate in CPAA which is the population I am using, it is assumed all participants are free of any condition or injury of the skeletal system, nervous system, muscular system or brain that would affect their balance, giving inaccurate results.
2. It is assumed that all participants attempted each trial to the best of their ability, providing accurate results for each trial.

## 1.8 Definition of Terms

Accelerometry: Device consisting of a moveable bar suspended on micro-machined springs that provide resistance against acceleration that measure both static and dynamic acceleration (Culhane, O'Connor, Lyons, & Lyons, 2005).

Aging: Aging is a dynamic and progressive process that results in deterioration of morphological, functional, hemodynamic, and psychological abilities and leads to reduced adaptive ability and quality of life, as well as increased morbidity (Yu-Kai et al., 2012).

Balance: the ability to maintain the center of body mass (COM) within limits of stability determined largely by the base of support, regardless if the base is stationary or moving (Alexander, 1994; Davlin, 2004; Horak, 2006; Tyson & Connell, 2009; Woollacott & ShumwayCook, 1996).

Borg RPE Scale: (RPE) scale to quantify exercise intensity during high-intensity (H), moderate-intensity (M), and low-intensity (L) resistance training (Day, Mcguigan, Brice, & Foster, 2004).

Functional Strength: Functional strength training involves performing work against resistance in such a manner that the improvements in strength directly enhance the performance of movements so that an individual's activities of daily living are easier to perform (Lohne-Seiler, Torstveit, & Anderssen, 2013).

Muscular Endurance: Exercise which may help individuals develop enhanced toleration of physiological environments where high cardiovascular demands and higher lactate concentrations are present (Gotshalk, Berger, & Kraemer, 2004).

Postural Sway: The ability to maintain equilibrium and orientation in a gravitational environment (Tucker, Kavanagh, Morrison, & Barrett, 2010).

Resistance: Resistance-exercise training, also known as resistance exercise, resistance training, or strength training, is a type of exercise that involves the voluntary activation of specific skeletal-muscle groups against external resistance(Yu-Kai et al., 2012).

Timed Up and Go: A test designed to evaluate mobility and function (McGough et al., 2011).

## CHAPTER 2

### REVIEW OF LITERATURE

#### 2.1 Aging Population

Aging is a complex and multidimensional phenomenon subject to a continual redefining of the physical, social, psychological, and cultural self. The collective of these subtleties poses a number of challenges for policy makers, program and community leaders, health professionals, and researchers when trying to enhance quality of life for older adults through physical activity.

The medical and biological conceptualizations of aging have dominated our way of knowing about the aging process, as well as what it means to grow old (Grant & Kluge, 2007). An unprecedented change is occurring in the structure of the population in all regions of the world. In Western countries, those over 65 years currently account for approximately 12% of the population, and this is expected to double by 2050, resulting in approximately 1.9 billion people over 65 years (United Nations, 2002). This will have numerous unprecedented social and economic consequences at the community, national, and global level during the next few decades.

#### 2.2 Increased Number of Falls in the Older Adult Population

Fall-related issues are a major concern for older adults, specifically individuals over 65 years of age (Centers for Disease Control, 2008). Risks of falling and associated problems caused increase as a person ages (National Institute of Health, Senior Health, 2006). Injuries resulting from falls, such as fractures to the hip, pelvis, spine, arm, or ankle result in financial, emotional and physical losses. Financially, the annual cost for treating fall-related injuries in the U.S. is over \$20 billion (Centers for Disease Control, 2008). On an emotional level, fall-related injuries can lead to depression, discouragement, and withdrawal from normal daily activities (McColgin et al.,

2009). The problem of falls in the older population is clearly more than simply a high incidence, because young children and athletes certainly have higher incidences of falls than all but the frailest elderly groups. Rather, it is a combination of a high incidence together with a high susceptibility to injury, because of a high prevalence of clinical diseases (e.g. osteoporosis) and age-related physiological changes (e.g. slowed protective reflexes) that make even a relatively mild fall particularly dangerous. In addition, recovery from fall injury is often delayed in older persons, which in turn increases risk of subsequent falls through deconditioning (Rubenstein, 2006). Medications, specifically psychoactive medications, have also been identified in a number of studies as risk factors for falls. Other specific causes of falls include disorders of the central nervous system, cognitive deficits, poor vision, drug side-effects, alcohol intake, anemia, hypothyroidism, unstable joints, foot problems, severe osteoporosis with spontaneous fracture and acute illness. Most elderly individuals have multiple identifiable risk factors predisposing to falls, the exact cause can often be difficult to determine. A single specific cause for falling often cannot be identified, and because falls are usually multifactorial in origin (Rubenstein, 2006). A study was performed within the Longitudinal Aging Study Amsterdam. In 1998/1999, potential risk factors were assessed during the third data collection. In 1999/2000, 204 community-dwelling persons ( $\geq 65$  years) who reported at least one fall in the year before, were asked about the consequences of their last fall, including physical injury, health service use, treatment and functional decline (Silsupadol et al., 2006). As seen below in Figure 2.1, females experienced a higher incidence of falls with greater injury and greater recovery.

TABLE 2.1

## CONSEQUENCES OF FALLS IN OLDER MALES &amp; FEMALES

Consequences of falls	Total (n=204)		Females (n=112)		Males (n=92)	
	n	%		%		%
Physical consequences						
Any physical injury	139	68.1	8	78.6	1	55.4
Fracture	7	3.4		2.7		4.3
Open Wound	60	29.4	3	29.5	7	29.3
Bruising/extravasation of blood	87	42.6	0	53.6	7	29.3
Sprain	5	2.5		2.7		2.2
Distortion	2	1		0.9		1.1
Brain injury	3	1.5		1.8		1.1
Muscle	7	3.4		3.6		3.3
Pain	10	4.9		5.4		4.3
Health service use						
Any health service use	48	23.5	2	28.6	6	17.4
General practitioner	43	21.2	9	25.9	4	15.2
Hospital	16	7.9	1	9.8		5.4
Rehabilitation	1	0.5		0		1.1
Nursing home	2	1		0.9		1.1
Home for the elderly	1	0.5		0.9		0
Help in household	7	3.7		3.6		3.3
Treatment						
Any treatment	35	17.2	3	20.5	2	13
Medication	21	10.3	5	13.4		6.5
Surgery	3	1.5		1.8		1.1
Physiotherapy	13	6.4		8		4.3
Walking aid	14	6.9		7.1		6.5
Decline in functioning						
Any decline in functioning	76	37.3	4	48.2	2	23.9
Decline in functional status	72	35.3	1	45.6	1	22.8
Decline in social activities	34	16.7	6	23.3		8.7
Decline in physical activities	31	15.2	4	21.4		7.6

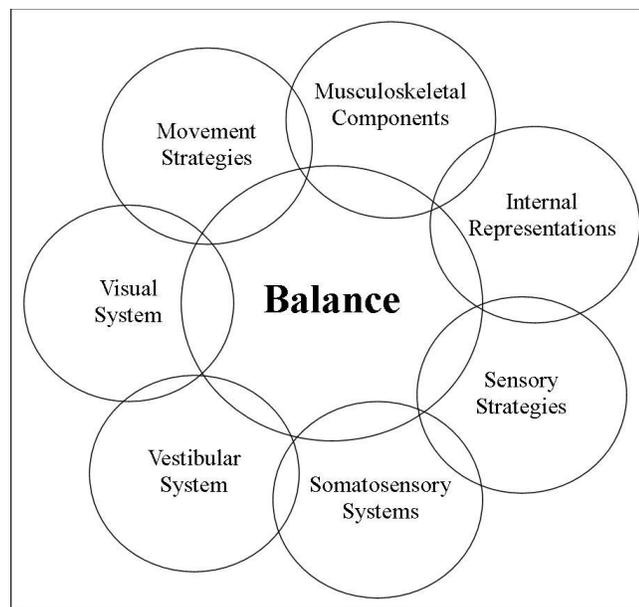
(Silsupadol et al., 2006)

## 2.3 Balance

Balance is a term frequently used by health professionals working in a wide variety of clinical specialties. Balance is a key component of motor skills, ranging from maintaining posture to executing complex sport skills, and is defined as the ability to maintain the center of body mass (COM) within limits of stability determined largely by the base of support, regardless if the base is stationary or moving (Horak, 2006).

### CONCEPTUAL MODEL REPRESENTING THE SYSTEMS

#### CONTRIBUTING TO TASK SPECIFIC BALANCE AND ORIENTATION



(Woollacott & ShumwayCook, 1996)

FIGURE 2.2

Over the past 20 years, a considerable amount of research has been conducted to determine the relationship between balance control and motor or sensory system function in order to understand the causes of falling and to create effective strategies to prevent falls in older people (Silsupadol et al., 2006). Figure 2.2 above shows the relation of balance to other systems.

### 2.3.1 Sensory Systems Contributing to Postural Stability

Postural control is defined as the act of maintaining, achieving or restoring a state of balance during any posture or activity. Postural control strategies may be either predictive or reactive, and may involve either a fixed support or a change in support response. Clinical tests of balance assess different components of balance ability. As one ages, one loses balance function through loss of sensory elements, the ability to integrate information and issue motor commands. Diseases common in aging populations lead to further deterioration in balance function in some people. Treatment of balance dysfunction in aging populations is based on the knowledge of normal aging processes and on an evaluation of the individual's balance loss and remaining balance elements. (Konrad, Girardi, & Helfert, 1999). Falls are one of the major health care concerns for older adults and their impact is a significant public health problem. Annually, about one-third of community dwellers over age 65 fall, and half of those will have a repeat fall. Falls are responsible for two-thirds of all unintentional injury deaths in older adults. Fear of falling affects confidence in performing daily activities, causing self-limitation and a less active lifestyle. This results in muscle atrophy and loss of strength, especially in the lower extremities, which exacerbates the risk for falls. Direct and indirect costs associated with falls total \$75–100 billion in the U.S. annually (Cheryl Hawk & Hall, 2006). Therefore there is a high level of importance to maintain a healthy physical activity level as well as assessing levels of balance and strength regularly.

### 2.3.2 Postural Stability & Aging

The motor system is known to undergo a second significant remodeling during the so called “good aging.” The loss of muscle mass (sarcopenia) and muscle feebleness are the most noticeable results of aging (Meigal, 2011). An individual first begins to feel muscle weakness at about 40 years of age. This process increases after 60 years, and, at the age of 75, the strength and velocity of muscular contraction decreases by 45% compared to a 20 year old individual. The motor system remodeling compensates for these negative changes at the expense of the atrophy of fast twitch muscle fibers (type II) and the dominance of slow twitch fibers (type I), including the mechanism of sprouting (Meigal, 2011). Recent experiments with older persons having a history of falls provide additional evidence for the suggestion that higher integrative levels have a predominant role in postural control (Teasdale & Simoneau, 2001).

## 2.4 Methods of Assessing Balance

As one gets older, balance and posture change, older adults demonstrate increased amounts of postural sway, which may ultimately lead to falls. Mechanisms contributing to age related increases in postural sway and falls in the older adults remain unclear (Laughton et al., 2003). Balance is achieved by the complex integration and coordination of multiple body systems including the vestibular, visual, auditory, motor, and higher level systems (Mancini, 2010). Information from sensory systems is interpreted in the central nervous systems (CNS) based on an internal body schema, an appropriate response is formulated, and the postural muscle synergies are activated to perform the appropriate head, eye, trunk, and limb movements to maintain posture (Mancini, 2010). In an effort to understand age- related changes in posture

control, balance and gait it is important to perform various assessments on levels of balance and strength in the older adult population. Although many of the chronic conditions plaguing older populations are preventable through appropriate lifestyle interventions such as regular physical activity, persons in this age group represent the most sedentary segment of the adult population. The main goal of assessments and testing is to provide interventions to promote physical activity among older adults.

## 2.5 Declines in Strength and Balance in Older Adults

Maintaining adequate physical endurance in later years is important to prevent frailty and loss of independence. Considering the typical decline in aerobic power ( $VO_2$  Peak) of approximately  $5 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  per decade, many inactive older adults will reach or surpass the threshold required for independent living by their late 70's or early 80's unless steps are taken to reduce the rate decline (Rikli & Jones, 1998). A 30% reduction of strength generally occurs between 50 and 70 years of age and even steeper declines after the eighth decade (DiFrancisco-Donoghue, Werner, & Douris, 2007). These declines in strength are associated with marked deficits in functional capacities. Leg power has been shown to be strongly correlated with walking speed in elderly people (DiFrancisco-Donoghue et al., 2007). People over age 65 constitute one of the fastest growing population segments among industrialized nations (Buchner, 1992). They additionally carry by far the greatest proportion of chronic disease burden, disability, and health care utilization, much of it preventable. For example, approximately 88% of those over age 65 have at least one chronic health condition, and large numbers of older adults suffer from impaired functioning and well-being (Buchner et al., 1997). Notably, loss of function can begin to become evident as early as the fifth decade of life, arguing for preventive approaches begun in the middle years, as well as earlier, as a means of

promoting health and limiting disability in the later years of life (Buchner, 1992). Although regular physical activity has been demonstrated to be critical for the promotion of health and function as people age, persons over 50 years of age represent the most sedentary segment of the adult population. Evaluating and managing physical decline during aging are limited by a lack of suitable measurement tools, particular measures that can be administered in labs or nonlaboratory setting to older adults with wide range ability levels.

A landmark study from The University of Chichester in England tested the decline in muscle mass and muscular strength due to the aging process and its associated impairment to functional mobility in older adults (Gault, Clements, & Willems, 2012). Researchers examined the effects of an eccentric endurance exercise program at a self-selected walking speed (SSWS) on functional mobility and eccentric and concentric strength of quadriceps femoris of older adults. Twenty-four older adults ( $67 \pm 4$  years) completed thirty minutes of treadmill walking three times per week for 12 weeks. The subjects were randomized into two groups. Group 1, walked at a level 0% grade while Group 2 walked at declined  $-10\%$  grade and as mentioned previously, all participants chose a self-selected walking speed (SSWS), which was adjusted every four weeks. Participants were assessed for five repetition sit-to-stand (5-RSTS), maximal walking speed (MWS), timed up-and-go (TUG) and dynamic strength. SSWS was similar for both groups with increases. Improvements in 5-RSTS, MWS and TUG were substantial and similar for both groups and TUG improved by 22% for both groups (Gault et al., 2012). Results showed that both regular level (0% grade) and downhill ( $-10\%$  grade) treadmill walking at a SSWS in older adults resulted in substantial improvements in functional mobility, with no statistical differences between the two groups. Interestingly, these outcomes suggest that when prescribing treadmill walking the theorized excess eccentric stress of walking at decline does not show any

further benefits compared to walking at a zero percent grade (Gault et al., 2012). This is an important finding for individuals prescribing exercise for older adults interested in the best outcomes, but concerned about the safety and comfort of participants.

### 2.5.1 Up-and-Go Testing.

Another type of assessment done regarding the older adult population is a Sit-to- Stand or an Up-and-Go test. Sit-to-stand (STS) performance is often used as a measure of lower-limb strength in older people and those with significant weakness. However, the findings of recent studies suggest that performance in this test is also influenced by factors associated with balance and mobility. A study was conducted to determine whether sensorimotor, balance, and psychological factors in addition to lower-limb strength predict sit-to-stand performance in older people. (Stephen R. Lord, 2002). During the study, six hundred and sixty nine community-dwelling men and women aged 75–93 years (mean age 78.9,  $SD = 4.1$ ) underwent quantitative tests of strength, vision, peripheral sensation, reaction time, balance, health status, and sit-to-stand performance. The study found that with this type of assessment community-dwelling older people, STS performance is influenced by multiple physiological and psychological processes and represents a particular transfer skill, rather than an alternative measure of lower limb strength (Stephen R. Lord, 2002).

## 2.6 Muscular Strength in Older Adults

The primary goal for this age group is to maintain function and independence, with secondary objectives of extending life, decreasing the risk of chronic disease, and compressing the period of disability (Paterson, Jones, & Rice, 2007). In order to maintain functional independence both

aerobic and strength conditioning are vital. According to The Journal of Medicine and Science in Sports and Exercise, older adults need moderate-intensity aerobic physical activity for a minimum of 30 min on five days each week or vigorous intensity aerobic activity for a minimum of 20 min on three days each week. Moderate-intensity aerobic activity involves a moderate level of effort relative to an individual's aerobic fitness. On a 10-point scale, where sitting is 0 and all-out effort is 10, moderate-intensity activity is a 5 or 6 and produces noticeable increases in heart rate and breathing. On the same scale, vigorous-intensity activity is a 7 or 8 and produces large increases in heart rate and breathing (Nelson et al., 2007). As for strength training, older adults will benefit from performing activities that maintain or increase muscular strength and endurance for a minimum of two days each week. The Journal of Medicine and Science in Sports and Exercise also recommended that 8–10 exercises be performed on two or more nonconsecutive days per week using the major muscle groups. To maximize strength development, a resistance (weight) should be used that allows 10–15 repetitions for each exercise. The level of effort for muscle strengthening activities should be moderate to high. On a 10-point scale, where no movement is 0, and maximal effort of a muscle group is 10, moderate-intensity effort is a 5 or 6 and high-intensity effort is a 7 or 8 (Nelson et al., 2007). Strength training for older adults, has been shown to have positive effects on improving bone density, energy metabolism, insulin action and functional status (DiFrancisco-Donoghue et al., 2007). Throughout the aging process, people demonstrate an overall decline in muscle mass, with specific atrophy of type II muscle fibers. This generalized loss of skeletal muscle has been termed “sarcopenia” and is considered a major factor leading to the development of impairments in muscle strength and power for older adults. Muscle strength is defined as the ability of a muscle or muscle group to exert maximal force or torque at a specific velocity during a contraction. Muscle power is characterized by the

product of force production and the velocity at which the force is produced. Muscle strength and muscle power both have been shown to decline during the aging process, with power declining at a greater rate than strength (Puthoff, 2013). Muscle size and strength decrease with aging, and the resultant muscle weakness has been implicated in increased risk of falls in older adults.

In a study conducted on thirty older adult's slower-extremity strength, peak power, power at a low relative intensity, and power at a high relative intensity were measured with a pneumatic resistance leg press. Functional limitations and disability were assessed with the Short Physical Performance Battery (SPPB), the Six-Minute Walk Test (SMWT), and the Late Life Function and Disability Instrument (LLFDI). The results showed all measures of strength and power were related to functional limitations. Peak power demonstrated the strongest relationships with SMWT, the SPPB gait speed, and the LLFDI functional limitation component. Power at a high relative intensity demonstrated the strongest relationships to the SPPB total score and the SPPB sit-to-stand subscale score. All measures of strength and power were indirectly related to the LLFDI disability component (Puthoff, 2013).

In a study done, older adults were assessed and then given a workout program to see if the exercise would improve all the areas in which they were assessed. Results showed significant improvement was made by the exercise group on primary indicator of frailty, a physical performance test (PPT) ( $29 \pm 64$  vs  $316 \pm 4$  out of a possible 36 points), as well as many of the risk factors previously identified as contributors to frailty, reductions in flexibility, strength, gait speed, and poor balance (Brown, 2000). Although the home exercise control group showed increases in range of motion, the improvements in flexibility did not translate into improvements in physical performance capacity as assessed by the physical performance test.

An exercise program is extremely vital and important and should be implemented into the life of older adults even if it is just a walking program. Treadmill training has numerous advantages compared to standard walking, treadmill training can be done in small area, a larger volume of steps can be achieved, and walking speed can be well controlled (Lee & Hidler, 2008). Also with treadmill walking one has the ability to immediately change the speed, incline and easily monitor their heart rate.

Researchers at the University of Georgia reported that a daily walking program can be vital to maintaining a functional level of ADLs. The purpose of the study was to assess the effectiveness of a resident-led walking program at an assisted living facility (ALF). Seventeen women (mean age 80, range 62-99) agreed to participate in a "walking club." Pre and post measurements included the Tinetti Performance-Oriented Assessment of Mobility Problems in Elderly Patients, the Functional Reach Test, and the Barthel Index to measure independence in activities of daily living (ADLs). Participants set their own goals for walking distance and frequency, with the assistance of the lead researcher if requested. Distances ranged from 75 ft to over 1 mile. At the end of the 9-week intervention, there was a significant increase in all of the pre-test measurements. In addition, post-test assessment included individual interviews with participants about their experiences with the physical activity program. Four positive themes about the walking program emerged: (a) as a pleasurable activity, (b) as a way to manage current health problems, (c) as a way to continue life-long activity, and (d) because of perceived physical and psychological benefits from the activity. The participants planned to continue the walking program. The results of this pilot study suggest that a walking program can be instituted in an assisted living facility with minimal staff effort and significant benefit to residents (Taylor, 2003).

Functional upper body strength as well as lower body mobility is the main goal for many older adults. The obvious importance of being able to improve balance has resulted in a number of balance intervention studies, which initially focused on task-specific exercises and every day activities such as getting in and out of a chair, or stepping up and down from one level to another. These studies demonstrated that balance could be improved greatly, especially in rehabilitation and nursing home environments. Researchers then began to examine the effects of task-specific exercises in combination with strength training. Researchers found that not only did the combination of the two exercises improve balance, but strength training alone also improved balance (Clary, Barnes, Bembem, Knehans, & Bembem, 2006). A study was done to evaluate the effects of a 9-week supervised multicomponent exercise program on functional fitness and body composition in independent older adults. Forty-two adults age 60-86 years were randomly assigned to an exercise or a control group and were evaluated before and after training. The training program consisted of 3 sessions of walking, strengthening, and flexibility exercises per week. The multicomponent training program resulted in significant improvements on the chair stand, arm curl, 6-min walk, and up-and-go tests. The findings of this study indicate that a 9-week training program increased upper and lower body strength, aerobic endurance, and agility/dynamic balance in older adults. The most affected components of functional fitness were lower body strength and aerobic endurance. There was no effect of the 9-week training on body composition (Toraman, Erman, & Agyar, 2004). The results of this study demonstrated that a 9-week, multicomponent training program resulted in improved performance on the chair-stand, arm-curl, 6-min-walk, and 8-ft-up-and-go tests, which were components of functional fitness.

A study testing regular physical activity and the effects on older adults was conducted by Oxford University. The purpose of this randomized, controlled study was to determine if an 8-

week, 3-day per week intense ( $77.8 \pm 3.4\%$  of 1-repetition maximum [1RM]) strength training program could improve functional ability related to the risk of falling in subjects aged 61—87 years (mean 72, *SD* 6.3). Twelve strength-training subjects performed two sets of 10 repetitions for six lower body exercises while 12 subjects served as nonintervention controls. Subjects were tested pre-, mid-, and postintervention for strength gain and on three tests of functional ability. Results showed postintervention strength was significantly better ( $p < .017$ ) in all training subjects across all exercises, and no injuries were reported as a result of either training or 1RM testing (Schlichta, 2001). The results from the study suggest that strength training alone does not appear to enhance standing balance or sit-to-stand performance in active, community dwelling older adults but that it may improve maximal walking speed. Therefore a combination of both balance and strength should be done.

Although research suggest that the contribution of upper body strengthening and lower body endurance through walking could be of physiologically beneficial, the biomechanics present potential harm. A study done by researchers McGill, Marshall and Anderson investigated the consequences of carrying load in hand while walking and found carrying a load in one hand (30 kg) resulted in more spine load (McGill, Marshall, & Andersen, 2013).

Walking while using hand weights has been shown to increase upper body strength and aerobic capacity. But due to the loading to the lumbar spine and the swinging of the arms this makes the activity contraindicated. The methods used to apply upper body resistance while treadmill walking is unique and may contribute in the development of improved methods of applying functional strength training.

## CHAPTER 3

### METHODOLOGY

This chapter describes the methods and data used to address the research questions presented in this study. Discussion in this chapter includes: (1) restatement of the research questions answered by the study, (2) description of the study, (3) explanation of the importance of the study and measures used for data collection, (4) discussion of the study procedures, (5) description of data analysis used, and (6) assurances regarding the protection of human subjects.

#### 3.1 Research Questions

Studies have shown that assessing balance as well as ones level of functional strength can contribute to the improvement and implementation of programs that can prevent and help in identifying injury and various diseases. Assessments can also help in finding the causes of neuromuscular effects which can assist in finding ways to decrease the risk of falling in the aging, provide rehabilitation, determine neurological disorders, enhance functional or athletic performance, and provide a better understanding of the physiological systems contributing to postural movement and stability (Allum, Bloem, Carpenter, Hulliger, & Hadders-Algra, 1998; Allum & Honegger, 1998; Bell, Guskiewicz, Clark, & Padua, 2011; Berg, Maki, Williams, Holliday, & Wooddauphinee, 1992; Davis, Sanborn, Nichols, Bazett-Jones, & Dugan, 2010; Dietz, Horstmann, & Berger, 1989).

The study looks to address the following questions:

1. How does treadmill walking effect muscular endurance and balance?
4. What limitations exist for this type of testing?

### 3.2 Site and Participation Selection

This study was conducted at Wichita State University (WSU) in Wichita, Kansas.

Baseline measures were assessed in the Heskett Center and testing was conducted in the Human Performance Laboratory. The selection of this site for the study was chosen for three main reasons: (1) access to necessary equipment for study procedures, (2) time and availability of subjects, and (3) convenience of the location for participant use. Since the study utilized Center for Physical Activity and Aging (CPAA) in the Department of Human Performance Studies, the site selected for conducting each trial had to be in a location that was accessible to the CPAA. The location for the study had to be a familiar, convenient location for all participants in order to prevent location from being a limiting factor.

#### 3.2.1 Participants

The participants of this study were members of the CPAA at WSU. 18 participants (7 female, 11 male), age ranging from 64 to 94 years (median=78.5). Each participant gave written and verbal consent before participating in the study.

### 3.3 Instruments and Measures

Discussion of the instruments and measures used during this study include (1) the Thorotread Treadmill, and (2) the Balance Manager Smartphone Application. All device configurations, settings, and usage were in accordance with each device's manufacturer instructions for proper set up, use, and care of the equipment.

#### 3.3.1 Thorotread Treadmill

The Thorotread is a multi-function exercise apparatus that combines strength training with a traditional treadmill function. The exercises are created by engaging an upper body resistance system that is connected to the slideable control console. The resistance is adjustable from 5 to 45 pounds in 1 pound increments to accommodate users of all ability levels. The user can vary their gripping positions and engage in either static pushing exercises or reciprocating presses for a variety of exercises. Combining the walking or running speed with the pushing exercises at inclines from 0 to 25 degrees offers total body engagement of strength and cardio training. The main argument for using the Thorotread is that walking underlies many activities of daily living, and walking ability (eg, gait speed) can be used to predict future mobility and physical disability (VanSwearingen, Perera, Brach, Wert, & Studenski 2011). Multicomponent exercise programs, including strength, balance, walking, and endurance, are intended to reduce impairments and improve physiological capacity for walking in older adults (Brown & Holloszy 1991).

### 3.3.2 SWAY by Capacity Sports Smartphone Application

The SWAY Smartphone Application was developed by Capacity Sports (Tulsa, OK) and is designed as a tool to measure balance. It can be used in clinical, athletic, or typical everyday settings, with the goal of providing accurate, quantitative information about the user, to help assess and verify balance and/or determine conditions preventing proper balance, such as traumatic brain injuries like concussions. The application takes advantage of the accelerometers found in mobile devices, like Apple iPods or iPhones. Accelerometers measure both static and dynamic acceleration, consisting of a moveable bar suspended on micro-machined springs that provide resistance against acceleration (Culhane et al., 2005). Deflection of this bar is then converted into an acceleration reading (Culhane et al., 2005). Three accelerometers can be incorporated into a single device providing information on three-dimensional movement (tri-axial accelerometer) (Culhane et al., 2005). The information measured is the anterior/posterior and medial/lateral stability, which is the displacement in degrees from level. .

### 3.4 Procedures

Upon enrollment into the study, participants completed the Informed Consent form detailing the outline of the study's trials. Following the completion of the Informed Consent, participants' age, gender, and dominant foot were recorded as well. Once all personal data was collected, familiarization with the technology and each participant was instructed on proper technique for each trial that would be conducted.

### 3.4.1 SWAY Application

Participants completed three balance assessments two times each, using the iPod, SWAY Application by Capacity Sports. Participants were first familiarized with the assessment. The SWAY performs three, ten second tests before collecting data. Once the “Begin Test” button is pressed, the participant has three seconds to assume the proper position before the test begins. The application has an audible count-down tone to inform the participant when the test begins and ends. Once the test ends, the participant hands the mobile device to the test administrator, and the test administrator advances to the second test. Once the participant has the mobile device and presses “Begin Test”, the participant again has three seconds to assume the proper position, and then the ten second test begins. Regardless of position, for every test, the right foot was pre-determined to be the “dominant” foot. All single-leg tests were performed on the right foot, and the right foot was in front during tandem stances. Proper posture was required for every test, which included standing in an upright position, shoulders back position, with both hands on the mobile device, with the device pressed up against the center of the chest. The assessments began with feet together and eyes closed. This was used as the “baseline” measure. After the baseline, the following assessments were 1) feet together with eyes open on ground, 2) tandem stance on the ground with eyes open, 3) single-leg on the ground with eyes open, all three would be repeated twice. Once the participant completed the total of six assessments, anterior/posterior and medial/lateral stability was recorded and was termed Actual Stability Score.

### 3.4.2 Throtread Testing

Once Pre assessments were complete, the participant stepped onto the Thorotread treadmill identified a comfortable hand position and resistance was set to 5 percent of their body weight. The treadmill gradually began and the participant was assisted with their balance to prevent falls. Walking speed was adjusted according to their rate of perceived exertion (RPE) corresponding to a score of 12-14 (Easy to Moderate) on the Borg RPE Scale. To assess the test-retest reliability (repeatability) of Borg's 6-20 rating of perceived exertion (RPE) scale using a more appropriate statistical technique than has been employed in previous investigations. The RPE scale is used widely in exercise science and sports medicine to monitor and/or prescribe levels of exercise intensity (Lamb, Eston, & Corns, 1999). A static hold of 5 percent of the body weight was held for 30 seconds and then rest for 30 seconds. This protocol was repeated throughout the full 10 minutes of the study. Treadmill sessions were completed twotimes a week for 4 weeks and took place during their normal exercise sessions with the CPAA. Workouts with CPAA are located in the Heskett Center Gymnasium which is conveniently located within 100 feet of the Human Performance Laboratory.

### 3.5 Statistical Analysis

Statistical analyses for this study were completed with the use of Statistical Packages for the Social Sciences (SPSS) version 17.0. Descriptive statistics were computed on all data, repeated measures general linear models were computed and compared against the p value of 0.05.

### 3.6 Protection of Human Subjects

Approval from the Wichita State University Institutional Review Board (IRB) for Research involving Human Subjects was obtained for the study design and consent form prior to the initiation of participation recruitment and data collection. Informed consent was explained verbally and in writing for all study participants. Informed consent was obtained from all study participants and assurances were provided by the researcher that their responses or data would be reported as a group, or a representative or group data, and not identified by, or identifiable as pertaining to, a specific individual.

### 3.7 Summary of Methods

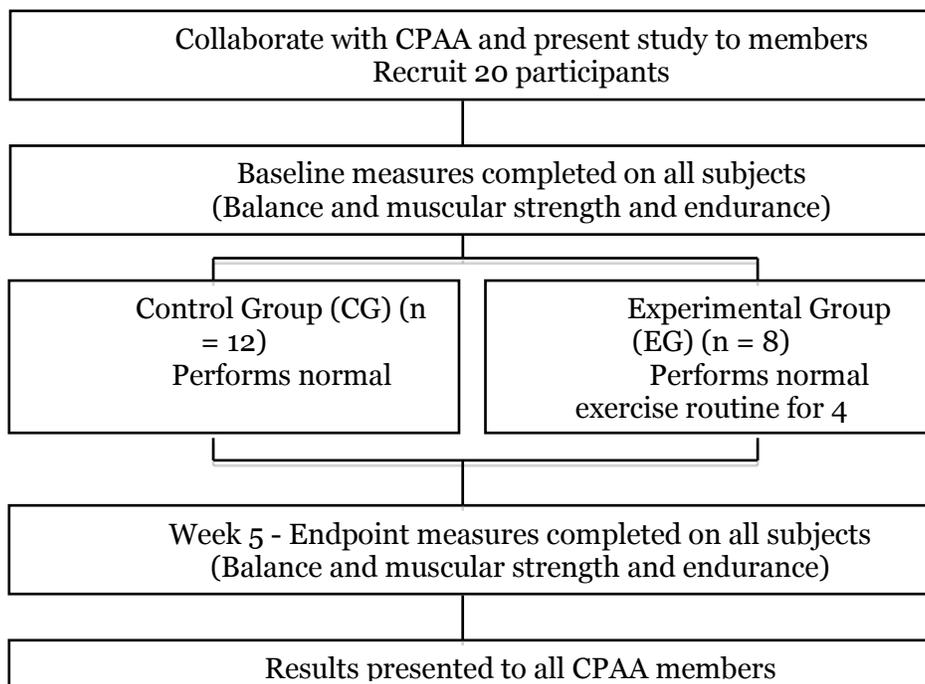


FIGURE 3.7  
SUMMARY OF METHODS

## CHAPTER 4

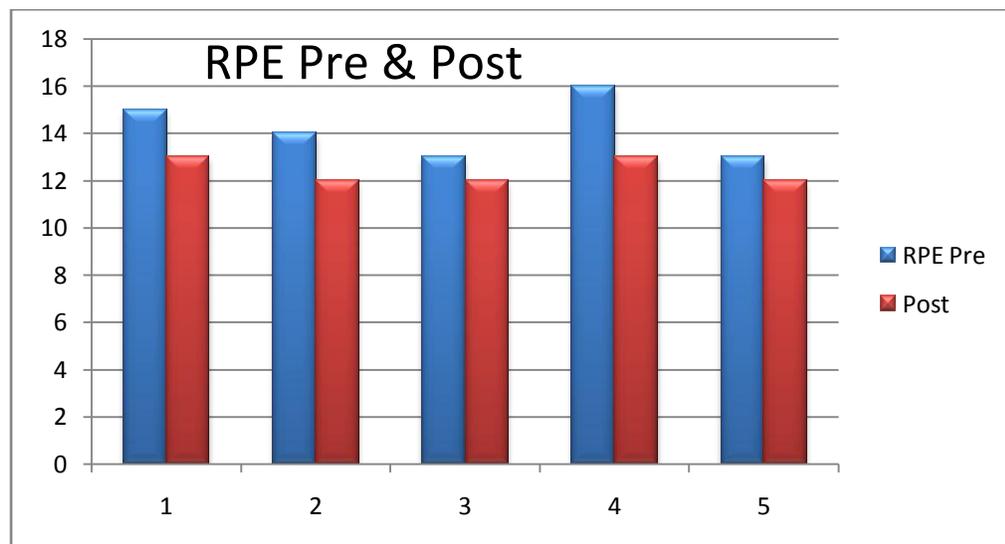
### RESULTS

#### 4.1 RESEARCH QUESTION

##### 4.1.2 Workload will decrease due to four weeks of specific exercises.

###### Hypothesis 1:

It is hypothesized that workload will decrease due to four weeks of specific exercises. For those who performed the four weeks of treadmill walking, a 30 second upper body strength test was performed. This test consisted of taking five percent of the subjects body weight and having them do repetitive pushing and pulling of the sled on the treadmill. At the end of the 30 seconds the subject was asked to rate their exertion by using the Borg RPE Scale. The upper body functional strength test was performed both before and after the four week treadmill test. Baseline RPE scores were significantly lower when compared end point testing, suggesting a decrease in the perception of work being completed. Figure 4.1 shows the decrease in RPE following the four weeks of treadmill exercise.



Borg RPE Scale is based on a scale from 5-20 (Dunbar et al., 1992).

FIGURE 4.1

#### 4.1.3 Thorotread Treadmill may be another useful assessment tool.

##### Hypothesis 2:

It is hypothesized that there Thorotread Treadmill can be another useful assessment tool to identify noticeable areas within the subject's balance that can improve due to upper body resistance while walking. An Independent Samples Test was used to determine the correlation between Anterior/Posterior and Medial/Lateral movement. Figure 4.2 analyzes Anterior/Posterior while Figure 4.3 analyzes Medial Lateral movement which shows there is a correlation between both movements. If an individual has poor Medial Lateral movement, it is 87% more likely that they will also have poor Anterior Posterior movement. An improvement that can be made based off of these results is making sure that that multiple tasks are being integrated into their exercise regimen. This allows for equipment like the Thorotread which integrates the dual task of walking and resistance training to be heavily utilized and help decrease poor balance. Research has shown balance training designed to improve intersensory interaction could effectively improve balance performance in healthy older adults (Hu & Woollacott, 1994). Older adults are be able to improve their balance under dual-task conditions following specific types of balance training (Silsupadol et al., 2006).

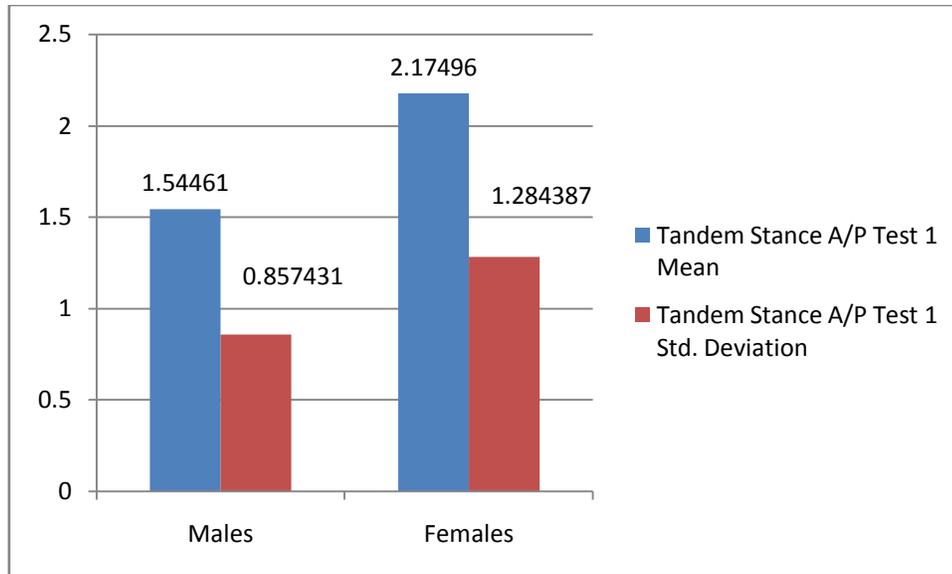


FIGURE 4.2  
ANTERIOR POSTERIOR COMPARISONS

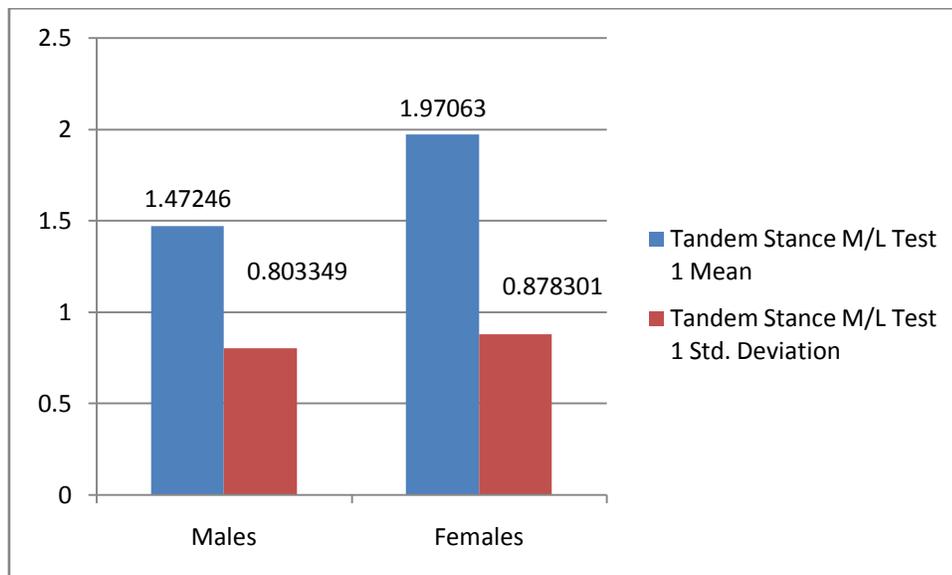
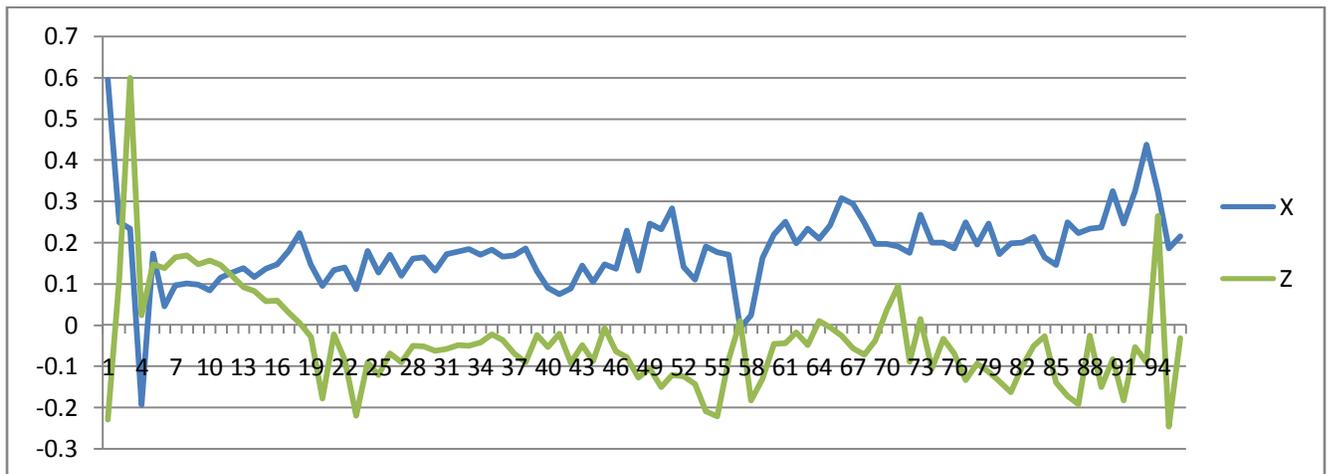


FIGURE 4.3  
MEDIAL LATERAL COMPARISONS

## 4.2 Effects of Thorotread Treadmil

Another finding was the noticeable difference in the oldest and youngest person tested. Figure 4.4 shows the data for the oldest subject (89 yrs old) recorded and Figure 4.5 shows the youngest subject recorded (64 years old). The green line shows the Anterior/Posterior movement over the ten seconds of the test. An upward spike in the line represents posterior movement, meanwhile the downward spike represents anterior movement. The blue line represents Medial/Lateral movement. When the blue line dips down that represents medial movement, while an upward spike represents lateral movement.



(10 second time period)

FIGURE 4.4

RAW ACCELEROMETRY DATA FROM OLDEST SUBJECT

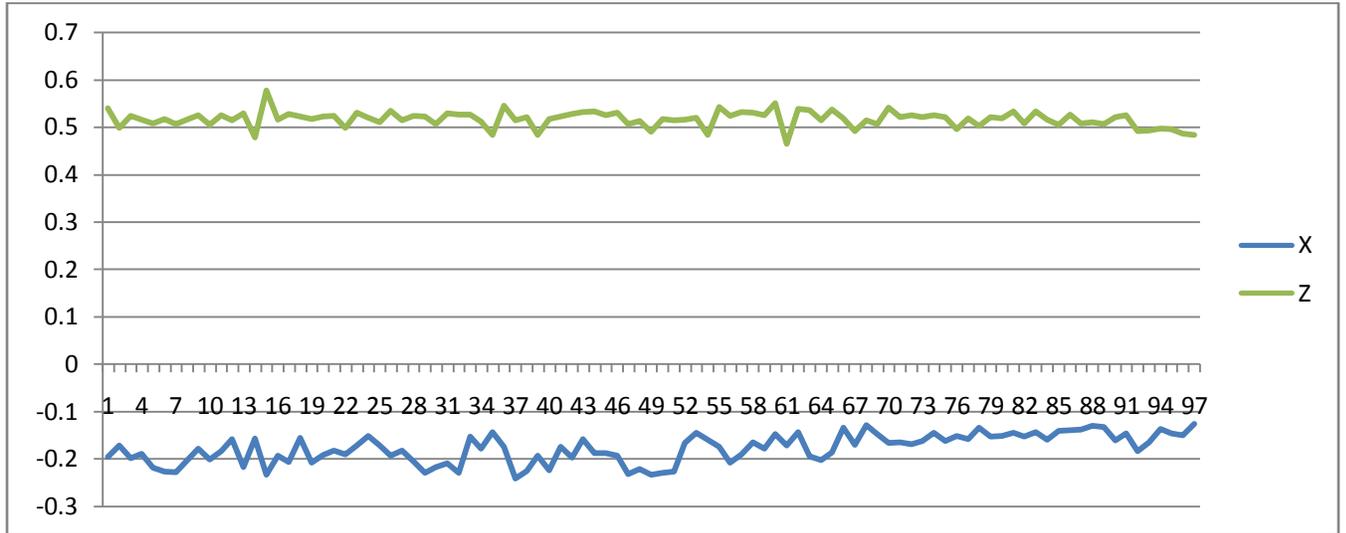


FIGURE 4.5

RAW ACCELEROMETRY DATA FROM YOUNGEST SUBJECT

Another effect noticed was the improvement in overall balance after the four weeks of Thorotread exercise. Figure 4.6 displays the balance result of a subject before the study while Figure 4.7 shows the balance result after the study. As shown the Anterior/Posterior movement has become noticeably more stable as well as the Medial/Lateral movement.

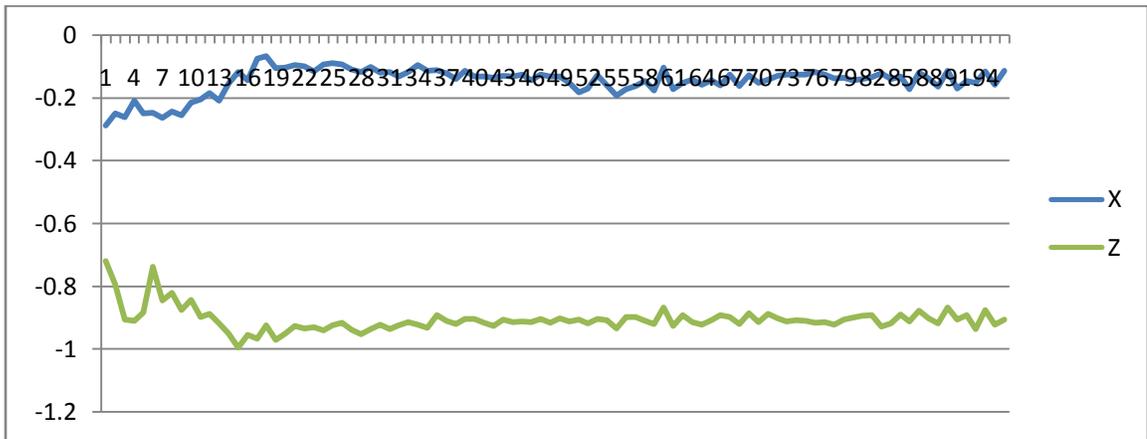


FIGURE 4.6  
RAW ACCELEROMETRY DATA BASELINE

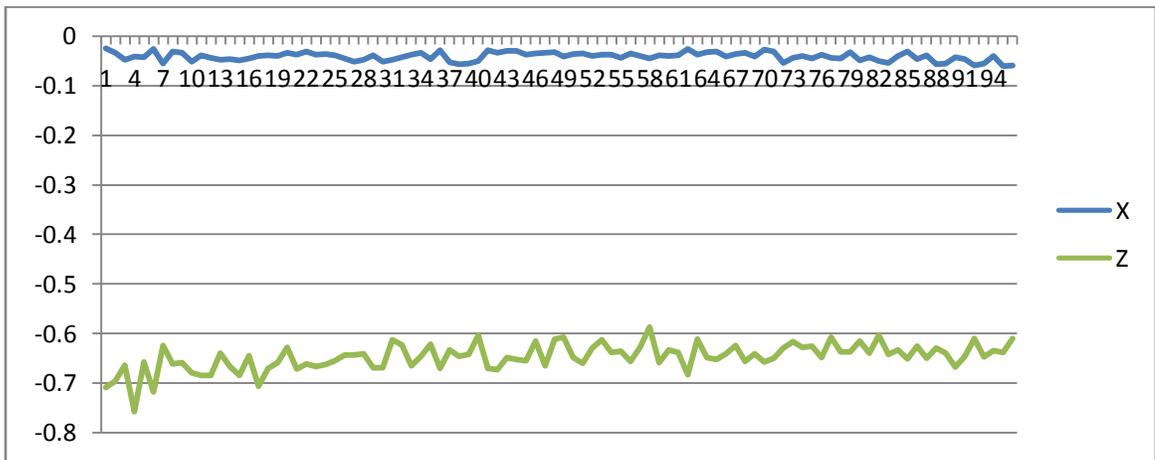


FIGURE 4.7  
RAW ACCELEROMETRY DATA END POINT

## CHAPTER 5

### DISCUSSION

#### 5.1 OVERVIEW

The purpose of this study was to observe the effectiveness of balance and strength assessments, as well as seeing the effects of the Thorotread treadmill. Numerous studies have shown the effects or influences of balance and strength assessments have on older adults. A search through Web of Science showed that there are 130, 734 published studies involving older adults. Of those on this topic, 726 discussed the relevance of balance assessments and 708 discussed the relevance of strength assessments. To the author's knowledge, this is the only study to assess both strength and balance while also using a Thorotread treadmill. Several populations have been studied when assessing balance, especially older adults. When comparing Figure 4.4 to Figure 4.5 you can see a lack of balance and stability in the 89 yr old versus the 64yr old. This shows that there is a decline in balance as age increases.

This discussion will look at the two hypotheses formed: Workload will decrease due to four weeks of specific exercises and the Thorotread Treadmill may be another useful assessment tool. Provided that the aging process will in some form cause declines in sensory, vestibular, and vision systems, there will be an increases risk of falls. Exercise has been shown to improve the quality of life of an older adult as well as the ability to maintain activities of daily living. With increased upper body strength as well as increased lower body strength one has an overall increased balance.

TABLE 5.1

BALANCE & STRENGTH ASSESSMENTS LITERATURE REVIEW

<i>Year</i>	<i>Journal</i>	<i>Author</i>	<i>Population</i>	<i>Measures</i>	<i>Results</i>
1997	The Journals of Gerontology Series A: Biological Sciences and Medical Sciences	Buchner	Older adults ages 65-80	Balance	No effects of exercise on gait, balance, or physical health status.
1998	Journal of Aging & Physical Activity	Jones	Older adults ages 60-87	Balance	6-min walk can be used to obtain reasonably reliable and valid measures of physical endurance in older adults.
2000	American Academy of Physical Medicine and Rehabilitation	Brown	Older adults ages 79-87	Strength	Physical frailty is modifiable with a program of modest activities that can be performed by virtually all older adults.
2001	Journal of Gerontology	Schilichita	Older adults ages 61-87	Strength	There were no significant between-group differences for 1-leg blind balance time or 5-repetition sit-to-stand performance.
2002	The Journals of Gerontology: Series A	Lord	Older adults ages 75-93	Balance	STS performance is influenced by multiple physiological and psychological processes.
2003	Gait & Posture	Laughton	Older adults ages 65-92	Balance	Elderly fallers demonstrated significantly greater amounts of sway in the anterior posterior (AP) direction.
2003	Journal of Community Health Nursing	Taylor	Older adult ages 62-99	Strength	Regular physical activity of the participants increased, as did scores on the tests administered for functional status.
2004	Journal of Aging & Physical Activity	Toraman	Older adults ages 60-86	Strength	A 9-week training program increased upper and lower body strength, aerobic endurance, and agility/dynamic balance in older adults.
2006	Journal of Sports Science Med	Clary	Older adults ages 50-75	Strength	In general, all three training programs improved dynamic balance.
2007	British Journal of Sports Medicine	Difranco	Older adults ages 65-79	Balance	One set of exercises performed once weekly to muscle fatigue improved strength as well as twice a week in the older adult.
2007	Medicine and Science in Sports and Exercise	Nelson	Older adults age 50-64	Strength	Effective interventions to promote physical activity in older adults deserve wide implementation.
2007	Applied Physiology, Nutrition, and Metabolism	Paterson	Older adults ages 65+	Strength	Appropriate recommendation for older adults are moderate to vigorous cardiorespiratory activities & strength maintenance of muscle mass.
2008	Journal of Applied Physiology	Lee	Older adults ages 50-70	Strength	From a therapeutic perspective, this suggests that training individuals with neurological injuries on a treadmill appears to be justified.
2010	European Journal of Physical Rehabilitation Medicine	Horak	Older adults ages 60-90	Balance	Functional clinical balance assessment tools were developed to determine whether or not a patient has a balance problem.
2012	European Journal of Applied Physiology	Willems	Older adults ages 63-71	Balance	Regular level and downhill treadmill walking by older adults, at a SSWS, results in substantial improvements in functional mobility.
2013	The Journal of the American Physical Therapy Association	Puthoff	Older adults ages 70-84	Strength	Older adults should focus on increasing and maintaining lower-extremity strength and power across a range of intensities to decrease functional limitations & disability.

## 5.2. LIMITATIONS

### 5.2.1 Limitations with Subjects

One major factor within the testing was the lack of subjects tested. This was due to the unwillingness for the older adults to participate as well as the inconsistency of attendance on testing days. The older adults also found the Thorotread difficult due to the coordination and intensity required. Another difficulty found was that many of the subjects didn't hold the device properly which altered the balance scores. In addition having medical history was something that was not allowed therefore many of the older adults had injuries, surgeries or health conditions that restricted them from being tested.

### 5.2.2 Limitations with Technology

The SWAY application used during testing had a couple of difficulties, one being the update to the software which resulted in crucial data being lost also syncing over wifi caused a loss in data as well. Another difficulty was that there were times that the application would force close during a test which would result in loss of data as well as having to restart a test.

### 5.2.3 Limitations with Thorotread

Limitations with the treadmill were the lack of studies done using the treadmill as well as the inability for the sled to be more controlled so when the subject lets go it doesn't slide back rapidly. Also having the ability to program the treadmill for intervals that included various levels of speed, grade and resistance it could be programmed to do so. Lastly the handle bars were

confusing at times for the subjects so maybe having the handle bars labeled or colored to be easily identified for the subject

### 5.3 RECCOMENDATIONS FOR FUTURE RESEARCH

Mixed measures provide valuable baseline preliminary data for further studies or intervention strategies to increase the volume of physical activity completed by older adults.

Future research needs to begin by having all CPAA members tested regularly at the beginning and ending of each semester and being familiar with the application and how to use it. Also height, weight and age should be updated regularly as well. Another thing that would be beneficial is a health questionnaire that is updated regularly.

In this study, participants did treadmill testing twice a week, in the future testing should be preformed three times a week for longer than four weeks to produce more accurate results.

This study also took into consideration a walking speed that felt comfortable to them, in the future having a standard speed could be better so the protocol is not changing for every participant.

This study compared balance scores as well as functional strength and a Timed Up& Go test, in the future more strength and functional testing should be added such as bicep curls and sit to stand testing.

Lastly, future research should focus on heart rate as well as improved balance and strength. If heart rate is not being monitored at all times during testing and other exercise situations one doesn't know if the subject isn't able to handle the exercise due to the inability of

the subject or the fact that the subject has other health related issues or physiological adaptations that are limiting them.

#### 5.4 CONCLUSIONS

At the conclusion of this study, the researcher determined that this was a beneficial method of testing and with additional adjustments more valuable information will be obtained. The researcher has also developed the following conclusions:

1. Rate of perceived exertion will decrease of four weeks of specific exercises.
2. Thortread Treadmill will benefit in assessing strength and balance.

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