THE CHAIR SIT-TO-STAND TEST AS A MEASURE OF

LEG STRENGTH IN SEXAGENARIAN WOMEN

by

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(Under the Direction of Michael Horvat)

ABSTRACT

The purpose of this study was to determine the relationship between isokinetic hip, knee, and ankle joint strength and performance on two chair-sit-to-stand (STS) tests (five- chair STS test and 30-sec. chair STS test) in older adult women. Forty-seven women ages 60-70, performed both chair STS tests on the same day, and bilateral isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength testing (60°/sec.) within seven days after chair STS testing. Regression analyses were performed using the average weight-adjusted isokinetic hip, knee and ankle joint strength scores as the independent variables and five-chair STS test and 30-sec. chair STS test scores as the dependent variables.

Pearson correlation coefficient results indicated a moderate correlation between both STS tests and all symmetrical bilateral leg muscle groups (r = .67-.80, p =.0001), except the ankle dorsiflexors (r = .33, p = .023). Regression analyses including all six leg strength variables explained 48% (p =.0001) of the variance in five-chair STS test scores and 35% (p = .007) of the variance in 30-sec. chair STS scores. Regression results tend to support ankle plantar flexor strength as the leg muscle with the highest predictive value in both chair STS tests, followed by hip flexor and knee extensor strength, indicating the essential role of the ankle plantar flexors, hip flexors, and knee extensors in completing the chair STS maneuver. The R^2 values of the regression models tested suggest that variables other than hip, knee, and ankle joint strength influenced chair STS test performance in the sample studied.

INDEX WORDS: Chair Sit-To-Stand Test, Isokinetic Leg Strength, Physical Function

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CHAPTER I

INTRODUCTION

One of the most common activities of daily living and a precursor to walking, is rising from a seated position to a standing position. The ability to stand up unaided from a chair, bed, toilet, bath tub, or other furniture is important to maintaining physical independence and may be one of the most important measures of physical function and independence for all people (Kelly, Dainis, & Wood, 1976; Rodosky, Andriacchi, & Anderson, 1989). In addition, standing up from a chair is thought to be one of the most biomechanically demanding functional tasks requiring more leg strength and joint ranges of motion than walking or even stair climbing (Hughes & Schenkman, 1996; Riley, Schenkman, Mann, & Hodge, 1991). The gradual loss of leg strength experienced in older adulthood is considered to be a major contributing factor in many physical function problems, including inability to stand up unaided from a chair, difficulty in walking, poor balance, increased reaction time, and an increased risk of falling (Bassey et al., 1992; Bohannon, 1995; Brown, Sinacore, & Host, 1995; Evans, 1995; Fiatarone et al., 1990; and Judge, 1993). In response to losses in leg strength and declines in physical function associated with advancing age, the relationship between leg strength and physical function warrants greater empirical evaluation.

Currently, two chair sit-to-stand (STS) tests (five-chair STS test and 30-sec. chair STS test) that estimate leg strength have been most often used in older adult populations (Guralnik et al., 1994; Rikli & Jones, 1999). Both the five-chair STS test (time needed to complete five chair-stands) (Guralnik et al., 1994), and the 30-sec. chair STS test (number of chair-stands completed in 30-sec.) (Rikli & Jones, 1999), require weight-bearing movements where bilateral strength and coordination of the hips, knees, and ankles are necessary. Several studies indicate that older adults must maintain an adequate level of hip, knee, and ankle joint strength in order to rise successfully from a chair (Brown et al., 1995; Chandler, Duncan, & Studenski, 1997; Judge, Whipple, & Wolfson, 1994; and Schultz, Alexander, & Ashton-Miller, 1992).

Chair STS tests have been accepted on their face validity (Glass & Hopkins, 1996) as proxy instruments to estimate leg strength. For example, Guralnik et al. (1994) utilized the five-chair STS test without the aid of hip, knee, or ankle joint strength measures. In contrast, Jones, Rikli, & Beam (1999) correlated scores on the 30-sec. chair STS test to a weight-adjusted 1-RM (repetition maximum) leg press test before concluding that involvement of the hip, knee, and ankle joints during the leg press exercise were comparable to the involvement of the hip, knee, and ankle joints during the chair STS movement.

At issue in this study is not the validity of the chair STS test as a proxy measure of leg strength, but rather the relationships among and between hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength and five-chair STS test and 30-sec. chair STS test performances. Better knowledge about the contributions of hip, knee, and ankle joint strength on chair STS performance could assist health care practitioners and fitness professionals in designing strength programs for older adults that target the specific leg muscle group(s) known to be important to task-specific physical function.

Although isokinetic knee extensor strength testing is the recognized criterion measure for assessing leg strength in older adults (Aniansson, Rundgren, & Sperling, 1980; Buchner & de Lateur, 1991; Chandler et al., 1997; Cress et al., 1991; Cress et al., 1999; Frontera, Meredith, O'Reilly, Knuttgen, & Evans, 1988; Frontera, Meredith, O'Reilly, & Evans, 1990; Frontera, Hughes, Lutz, & Evans, 1991; and Salem, Wang, Young, Marion, & Greendale, 2000), the use of just one muscle group does not adequately address all the specific movements involved in performing the chair STS task. To illustrate, Schenkman, Berger, Riley, Mann, & Hodge (1990) presented a total-body analysis of the chair STS movement and discussed the four phases of the movement and the importance of hip, knee, and ankle joint strength during each phase (refer to Appendix A). Schultz et al. (1992) used biomechanical analyses to highlight the importance of bilateral hip, knee, and ankle joint strength for older adults to rise from a chair. This rationale suggests that in order to appropriately gage the chair STS test as a proxy measure of leg strength, bilateral hip, knee, and ankle joint strength measures need to be considered conjointly with performance on the STS tasks.

Statement of the Problem

The purpose of this study was to explore the relationships between bilateral isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength measures and performances on two chair STS tests (five-chair STS test and 30-sec. chair STS test) in older adult women.

Hypotheses

Although no definitive information has been reported on the relative contributions hip, knee, and ankle joint strength may have on chair STS test performance in older adults, I hypothesized that there would be no significant differences in the following parameters: (a) bilateral isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength scores (bilateral leg strength symmetry hypothesis); (b) R^2 (R^2_{adj}) values for regression models including all six leg strength scores as independent variables with or without the inclusion of participant height (participant height hypothesis); and, (c) standardized regression coefficients (beta-weights [ß]) for same-leg muscle groups in explaining five-chair STS test and 30-sec. chair STS test scores (beta-weight hypothesis). Consequently, the following hypotheses were tested:

1. There will be no significant differences in bilateral isokinetic mean strength scores of right and left hip extensors, hip flexors, knee extensors, knee flexors, ankle plantar flexors, and ankle dorsiflexors.
2. There will be no significant differences in the R^2 (R^2_{adj}) values for regression models including all six leg strength scores with or without the inclusion of participant height, where average weight-adjusted isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength scores and participant height are the independent variables and five-chair STS test and 30-sec. chair STS test scores are the dependent variables.
3. There will be no significant differences in standardized regression coefficients for same-leg strength scores in explaining five-chair STS test and 30-sec.

chair STS test scores, where average weight-adjusted isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength scores are the independent variables and five-chair STS test and 30-sec. chair STS test scores are the dependent variables.

Significance of the Study

A validated leg strength testing instrument that requires no equipment other than a standard chair and that can be administered in virtually any setting such as the chair STS test, would be beneficial to evaluating strength and physical function efficiency changes over time in older adults.

Limitations of the Study

The generalizability of this study was limited by the following factors:

1. The results of this study may be applicable only to community-residing, sexagenarian women (ages 60-70 years) who are ambulatory and walk without the use of assistive devices, and have no medical, orthopedic, or musculoskeletal conditions that would be contraindicated with testing.
2. Generalization of the results may be reduced by the sample size (N = 47), the isokinetic strength and physical function tests performed, and the specific equipment used in the data collection.
3. Inclusion in the study was dependent on each participant completing a static balance screening test (part of the EPESE Test). All participants successfully passed this balance screening test.

Delimitations of the Study

This study was delimited to forty-seven community-residing, sexagenarian women volunteers (ages 60-70 years) who lived in the Athens, GA area and who were free of any medical, orthopedic, or musculoskeletal conditions that would be contraindicated with testing.

Definition of Terms

The following terms are defined in this investigation based on two categories, conceptual definitions and functional definitions. Conceptual definitions describe concepts that have been defined by recognized authorities. Functional definitions describe concepts as they apply to this investigation.

Conceptual Definitions

Ankle Dorsiflexion. Flexing of the foot in an upward direction where the toes move in a direction toward the tibia (Taber, 1989).

Ankle Plantar Flexion. Extension of the foot in a downward direction, where the sole of the foot is depressed with respect to the position of the ankle (Taber, 1989).

Bilateral. Pertaining to two sides (Taber, 1989). In the case of strength testing, bilateral is associated with testing both limbs (legs or arms) either simultaneously or separately versus testing only one limb (unilateral).

Hip Extension. To increase the angle between the bones that form the hip joint. Any movement that brings the hip joint into or toward a straight condition (Taber, 1989).

Hip Flexion. To decrease the angle between the bones that form the hip joint. Any movement that brings the hip joint into or toward a bent condition (Taber, 1989).

Isokinetics. Isokinetic strength testing is performed using an isokinetic dynamometer and allows individuals to exert as much force and angular movement as they can generate, up to a predetermined velocity (Perrin, 1993).

Knee Extension. To increase the angle between the bones that form the knee joint. Any movement that brings the knee joint into or toward a straight condition (Taber, 1989).

Knee Flexion. To decrease the angle between the bones that form the knee joint. Any movement that brings the knee joint into or toward a bent condition (Taber, 1989).

Peak Torque. Highest isokinetic torque (distance x force) measured in Newton-meters (Nm) seen from all repetitions, at all points in the range-of-motion (Cybex NORM Isokinetics Dynamometer User's Manual, 1998).

Functional Definitions

Sexagenarian. A person between the ages of 60-70 years (cf. Webster's New World Dictionary and Thesaurus, 1996).

Percent Body Fat. That portion of the body made up of adipose tissue. Estimation of percent body fat and body fat distribution in this study was determined using the three-site skinfold technique [triceps, suprailium, and thigh] (cf. Jackson & Pollack, 1985).

Physical Activity. Any bodily movement produced by the skeletal muscles that results in energy expenditure (cf. McArdle, Katch, & Katch, 1996).

Physical Function. Possessing the physiological capacity to perform normal everyday activities safely and independently without undue fatigue (cf. Rikli & Jones, 1997).

Strength. The amount of force produced by the extremities in a movement specific to a physical activity of functional weight-bearing movement (cf. Kovalski & Heitman, 2000).

CHAPTER II

REVIEW OF LITERATURE

This chapter presents a review of the literature related to this study of the chair sit-to-stand (STS) test as a proxy measure of leg strength in sexagenarian women. The literature review is organized as follows: (a) physical function and older adults, (b) review of the chair STS tests, (c) isokinetic strength testing (including sections on isokinetic hip, knee, and ankle strength testing), (d) composite leg strength testing and older adults, and (e) summary of the literature review.

Physical Function and Older Adults

The assessment of physical function and the identification of all the related variables involved in measuring physical function in older adults is a complex task. Physical function is not a homogenous concept. The physical functional abilities of individuals and age groups vary considerably, and no single measure is useful for all circumstances or ages (Hughes, 1994). Rikli & Jones (1997) defined the construct of physical function (within an ability-disability framework) as having the physiological capacity to perform normal everyday activities safely, independently, and without undue fatigue. Within the ability-disability model (refer to Appendix B), an understanding of the progression of physiological variables (e.g., muscular strength, cardiovascular endurance, joint flexibility) that lead to a maintenance or loss of physical function is necessary. The ability-disability model describes the deterioration of physical function in older adults as a process involving both lifestyle factors (e.g., inactivity, smoking, poor diet) and cellular level disturbances (diseases or pathologies), which, over time and if not appropriately addressed, can manifest into physiological impairments (e.g., declines in muscular, cardiovascular, and/or neurological systems), and progress into functional limitations (e.g., restrictions in physical behaviors such as getting up from a chair, walking, climbing stairs, lifting, and balancing) and eventually result in disability (the inability to independently perform activities of daily living such as chair sit-to-standing, walking, shopping, housework, and personal care tasks).

Although there is no "gold standard" for measuring physical function in older adults, several physical function test batteries have been developed to establish normative age range values on key physiologic (e.g., muscular strength, cardiovascular endurance, and joint flexibility) and psychomotor (agility, coordination, reaction time, and balance) variables that support functional mobility and independence (Cress et al., 1996; Guralnik et al., 1994; Osness et al., 1996; Reuben, Siu, & Kimpau, 1992; and Rikli & Jones, 1999). Of these five test batteries, two use a chair STS test protocol (five-chair STS test or 30-sec. chair STS test) as a method of assessing leg strength in older adults (Guralnik et al., 1994; Rikli & Jones, 1999).

Review of the Chair Sit-To-Stand (STS) Tests

Since the mid-1980s, several studies have used a chair STS test as a means of assessing leg strength and physical function in older adults (Csuka & McCarty, 1985; Guralnik et al., 1994; Nevitt, Cummings, Kidd, & Black, 1989; Newcomer, Krug, & Mahowald, 1993; Rikli & Jones, 1999; and Seeman et al., 1994). Chair STS tests were first used in clinical settings to assess functional abilities and rate of disease progression in children and adults with muscular dystrophy (Swinyard, Deaver, & Greenspan, 1957;

Vignos, Spencer, & Archibald, 1963). These early studies utilized a simple chair-rise test (time needed to rise from a seated to standing position) as a method of assessing functional ability and rate of muscular dystrophy progression.

Later studies included single chair-rise times (Nevitt, et al., 1989), time to complete a set number of chair-stands (Csuka & McCarty, 1985, Guralnik et al., 1994; Newcomer et al., 1993; and Seeman et al., 1994), or maximum number of chair-stands that could be completed in a specified time period (Rikli and Jones, 1999). Of interest in this study was the five-chair STS test (Guralnik et al., 1994), and 30-sec. chair STS test (Rikli & Jones, 1999), due to the number of published studies and current data available on both STS tests.

Guralnik et al. (1994) developed the Established Populations for the Epidemiological Study of the Elderly Test (EPESE) as a field-based test designed to assess lower extremity strength and function in older adults. The EPESE consists of three functional tests, including items to evaluate leg strength (five-chair STS test), static balance (stand with feet together, semi-tandem, and tandem positions), and walking ability (time to walk four meters). The EPESE can be administered in the home and takes approximately fifteen minutes to complete. The five-chair STS test originated from a fall risk and older adult study published by Nevitt, Cummings, Kidd, & Block (1989), and involves calculating the time needed to complete five consecutive chair-stands (starting from the seated position) without using the arms. A total EPESE score is achieved by adding the scaled results of the five-chair STS test, static balance test, and walking test (all on 1 to 4 scales). The maximum score that can be achieved on the EPESE is 12 (Guralnik et al., 1994). Although the EPESE is a practical and safe test of lower extremity function in older adults, normative performance data exists only for men and women ≥ 71 years old, making data comparisons with the current study difficult (women ages 60-70 years). EPESE normative performance scores were developed over a two year period (1988-1989), on over 5,000 community-residing older adults ≥ 71 years old within two age categories (71-79 and 80+). Regression models utilizing age, gender, and self-reports of disability as the independent variables explained 46% ($p < .001$) of the variance in EPESE scores. Guralnik et al. (1994) reported that the EPESE is sensitive to a wide range of physical function abilities and can provide important information not obtainable from self-reports about disability, including the ability to predict skilled nursing home admission and mortality in older adults. Unfortunately, Guralnik et al. (1994) did not actually measure leg strength and accepted the five-chair STS test on face validity as an instrument to assess functional leg strength.

Rikli and Jones (1999) developed the Senior Fitness Test (SFT) as a field-based test battery designed to assess physical fitness in older adults aged 60-94 years. The SFT consists of six tests, including the 30-sec. chair STS test (leg strength), 30-sec. arm curl test (upper body strength), chair sit-and-reach test (hamstring/low back flexibility), 8-foot up-and-go test (agility/dynamic balance), back scratch test (upper body flexibility), and a 6-minute walk test (aerobic endurance). The SFT can be completed in a community or home setting in approximately thirty minutes. The 30-sec. chair STS test protocol is a modified version of an original chair STS protocol that measured the time it took a participant to perform five repetitions without pushing off with the arms (Guralnik et al., 1994; Nevitt et al., 1989; Seeman et al., 1994). The 30-sec. chair STS test involves counting the number of times a person can stand-up and sit-down in a chair in 30-sec.

(starting from the seated position) without using their arms. SFT normative performance scores were developed from test scores on over 7,000 community-residing older adults (ages 60-90+) from 267 sites in 21 states throughout the United States. Five year sex specific age-group norms for each test were developed. Rikli & Jones (1999) reported that a common problem experienced by many community-residing older adults participating in chair STS protocols involving 5 or 10 chair-stands is difficulty in completing the test. Guralnik et al. (1994) found that as many as 22% of over 5,000 community-residing older adults $\geq$ 71 years old were unable to complete a chair STS test involving five chair-stands. Rikli and Jones (1999) emphasized that by using a 30-sec. chair STS test protocol, rather than the five-chair STS test, the range would increase and variations in leg strength levels could be measured more precisely with scoring ranging from zero (frail to dependent older adults) to a high of $\geq$ 20 (high active older adults). The 30-sec. chair STS test can provide health care practitioners and fitness professionals with a simple testing instrument for assessing leg strength and detecting muscle weakness in generally active, community-residing older adults (Jones, Rikli, & Beam, 1999). SFT normative performance data exists for females in the 60-69 year old age range, making data comparisons with the current study possible.

Jones et al. (1999) validated the 30-sec. chair STS test as a measure of leg strength using a 1-RM (repetition maximum) leg press test (pneumatic Keiser Leg Press) as the criterion strength test on seventy-six community-residing older adults (34 men, 42 women, M age = 70.5). The leg press was used as the validation criteria following Judge (1993). Judge (1993) reported that the leg press is a good criterion measure of leg strength because the leg press is a multiple-joint exercise involving hip extension, knee extension, and ankle plantar flexion, and the movement reflects many common daily activities such as rising from a chair or getting out of a tub or car, or picking up an object from the floor.

Schenkman, Berger, Riley, Mann, and Hodge (1990) and Ikeda, Schenkman, Riley, and Hodge (1991), studied the chair STS movement from a biomechanical perspective and suggested that the STS movement could be divided into four phases: (a) flexion-momentum phase, (b) momentum-transfer phase, (c) extension phase, and (d) stabilization phase (refer to Appendix A). Within each phase, muscular strength of the hip, knee, and/or ankle are needed to complete the maneuver.

The primary reason for incorporating both the five-chair STS test and 30-sec. chair STS test into this study was due to the interest in empirically exploring which of the STS protocols would provide a better means of estimating functional leg strength in a population of sexagenarian women.

Isokinetic Strength Testing

A review of isokinetic leg strength testing is in a sequence (i.e., knee, ankle, and hip joint strength) that reflects the number of published studies for each respective joint site. The reason for testing leg strength with an isokinetic dynamometer was due to the advantage isokinetic strength testing has over other forms of strength testing (e.g., isometrics or isotonics), where the specified muscle groups may be tested at their maximum level throughout the entire joint range of motion (Perrin, 1993).

Isokinetic Knee Strength Testing

Since its appearance into the scientific literature over 30 years ago, isokinetic leg strength testing has focused primarily on strength assessment of the knee extensors and knee flexors of high school and college-aged participants (Perrin, 1993). Biomechanical, kinematic, and electromyography analyses have shown that the knee extensors play a primary role as a dynamic stabilizer during many functional activities, including chair sit-to-standing and walking (Millington, Myklebust, & Shambes, 1992; Pai & Rogers, 1991; and Schenkman, Berger, Riley, Mann, & Hodge, 1990). In older adult populations, adequate knee extensor strength has been shown to be critical in completing the chair STS movement (Rodosky, Andricchi, & Anderson, 1989; Schenkman et al., 1990).

Isokinetic strength assessment of older adults' knee extensors and knee flexors has been done at a variety of angular velocities. The Cybex NORM Isokinetic Dynamometer User's Manual (1998) suggests testing velocities of 30-60°/sec. for slow-speed torque tests of the knee extensors and knee flexors, velocities of 120-180°/sec. for typical participants completing high-speed torque and endurance tests, and velocities of 180-300°/sec. for highly active participants completing high-speed torque and endurance tests. Although the angular velocities for most functional activities are approximately 60-100°/sec. for most joints (Judge, 1993), and isokinetic strength testing at 60°/sec. has clinical support as a velocity to assess hip, knee, and ankle joint strength of older adults, considerable speculation on the inferential value this velocity may have on predicting a participant's functional capabilities remains (Sapega, 1990).

Several studies have documented isokinetic knee extensor and knee flexor strength in older adults and the relationship between their knee strength and physical function (Carmeli, Reznick, Coleman, & Carmeli, 2000; Frontera, Meredith, O'Reilly, Knuttgen, & Evans, 1988; Frontera, Meredith, O'Reilly, & Evans, 1990; Frontera, Hughes, Lutz, & Evans, 1991; Frontera et al., 2000; Murray, Gardner, Mollinger, &

Sepic, 1980; Salem, Wang, Young, Marion, & Greendale, 2000; Sauvage et al., 1992; and Whipple, Wolfson, & Amerson, 1987). Unfortunately, it is difficult to compare the leg strength-to-physical function results of these studies due to differences in angular velocities, testing systems, testing positions, and age group differences (refer to Appendix C for isokinetic leg strength study comparisons). The general conclusion from the knee strength-to-physical function literature is maintenance of functional independence and a decreased risk of falling are possible for older adults only if they maintain an adequate level of knee extensor and knee flexor strength.

Isokinetic Ankle Strength Testing

Similar to isokinetic knee extensor and knee flexor strength testing, isokinetic ankle plantar flexor and ankle dorsiflexor strength testing has focused primarily on high school and college-aged participants (Perrin, 1993). In older adult populations, adequate strength of the ankle plantar flexors and ankle dorsiflexors has been shown to be important in preventing falls and in maintaining proper gait and balance (Buchner & de Lateur, 1991; Morris-Chatta, Buchner, de Lateur, Cress, & Wagner, 1994). The Cybex NORM Isokinetic Dynamometer User's Manual (1998) suggests testing velocities of 30-60°/sec. for slow-speed torque tests of the ankle plantar flexors and ankle dorsiflexors, a velocity of 120°/sec. for typical participants completing high-speed torque and endurance tests, and a velocity of 180°/sec. for highly active participants completing high-speed torque and endurance tests.

Several studies have documented isokinetic ankle strength in older adults and the relationship between ankle strength and physical function (Buchner & de Lateur, 1991; Cunningham, Morrison, Rice, & Cooke, 1987; Fugl-Meyer, Gustafsson, & Burstedt, 1980; Gerdle & Fugl-Meyer, 1985; Morris-Chatta et al., 1994; and Porter, Vandervoort, & Kramer, 1997). Comparing and contrasting these ankle strength-to-physical function studies is difficult due to differences in angular velocities, testing systems, testing positions, and age groups. One general conclusion from this line of research is that maintenance of static/dynamic balance and decreased risk of falling is possible for older adults only if an adequate level of ankle plantar flexor and ankle dorsiflexor strength is maintained.

Isokinetic Hip Strength Testing

Unlike the published studies that have assessed isokinetic knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength, there is a paucity of published data across all ages for isokinetic hip extensor and hip flexor strength (Cahalan, Johnson, Liu, & Chao, 1989). The isokinetic hip extensor and hip flexor strength studies that have been published have focused primarily on younger populations (Markhede & Grimby, 1980; Perrin, 1993; and Tis, Perrin, Snead, & Weltman, 1991). A very limited amount of research exists on isokinetic hip extensor and hip flexor strength in older adult populations. The Cybex NORM Isokinetic Dynamometer User's Manual (1998) suggests testing velocities of 30-60°/sec. for slow-speed torque tests of the hip extensors and hip flexors, a velocity of 120°/sec. for typical participants completing high-speed torque and endurance tests, and a velocity of 150°/sec. for highly active participants completing high-speed torque and endurance tests.

Only three isokinetic hip extensor and hip flexor strength studies were found (Cahalan et al., 1989; Markhede & Grimby, 1980; and Tis et al., 1991). Unfortunately different angular velocities, testing systems, testing positions, and age groups were used across studies making comparisons difficult. Assessing the isokinetic hip strength of older adults could be useful from a clinical and rehabilitative standpoint in quantifying changes before and after various types of surgical procedures (e.g., hip replacement) and therapeutic interventions to determine optimal treatments (Cahalan et al., 1989; Markhede & Grimby, 1980).

Composite Leg Strength Testing and Older Adults

Since the late 1980's, gerontologists have utilized isokinetic or isometric component approaches (e.g., individual absolute or individual weight-adjusted strength scores) or composite approaches (e.g., grouped absolute, grouped weight-adjusted, or grouped standardized strength scores) to regression analyses in assessing the leg strength-to-physical function relationship in older adults. Although both component and composite data analyses were performed in this study, only component analyses were reported due to manuscript space constraints and the interest in exploring the relationship among and between hip, knee, and ankle joint strength and chair STS test performance. It is anticipated that composite data analyses will be published separately in the future.

Applying component regression analysis to independent variables suggests the relative importance each leg muscle group may have in relation to chair STS test scores (Pedhazur, 1997). In applying regression analysis with a composite leg strength score as the independent variable, there is no provision for any differential weighting of the individual components that constitute the composite score (Pedhazur, 1997), meaning the relative importance of each individual muscle group (e.g. standardized regression coefficient and significance value) on chair STS test performance cannot be determined.

Although composite regression results are not reported in this study, it is worth noting that several studies utilizing this approach have added important information on the relationship of leg strength to physical function (e.g., chair sit-to-standing, walking, stair climbing, and static/dynamic balancing) in older adults. Studies have included a combination of knee and ankle (Buchner, Larson, Wagner, Koepsell, & de Lateur, 1996; Chandler, Duncan, & Studenski, 1997; and Schenkman, Hughes, Samsa, & Studenski, 1996), knee and hip (Ferrucci et al., 1997), or hip, knee, and ankle (Brown, Sinacore, & Host, 1995; Buchner et al., 1997; and Judge, Whipple, & Wolfson, 1994) joint strength scores. In each case, leg strength composite scores were created by either summing the absolute joint strength scores for all muscle groups tested and dividing by body weight (Brown et al., 1995; Buchner et al., 1996; Schenkman et al., 1996), summing the absolute joint strength scores and simply dividing by the number of muscle groups tested (Sauvage et al., 1992; Judge et al., 1994), or by converting the absolute joint strength scores into standardized scores (*z*-scores) before summing and dividing by body weight (Chandler et al., 1997).

Chandler et al. (1997) discussed the challenges of combining two or more different muscle groups into a single composite score and emphasized that adding muscle groups together in a linear sum may be problematic because one muscle group (e.g., knee extensors) is more powerful than another (e.g., ankle plantar flexors) and will therefore reduce the functional contribution of the weaker muscle to the task. In addition, Chandler et al. (1997) emphasized that an optimal strategy would be to appropriately weight the muscle groups that are functionally relevant to the task of interest so that the most powerful muscle groups do not automatically contribute the most to the leg strength composite score. This can be accomplished by converting all joint strength scores to standardized scores (*z*-scores = raw score - M / SD). The standardized joint strength scores are then added together into a linear sum, resulting in an equally weighted leg strength composite score (Chandler et al., 1997). The recommendations for converting two or more leg strength scores into a composite score reported by Chandler et al. (1997), were followed in this study and composite data analyses are expected to be published separately at a later date.

Summary of the Literature Review

Five main points are discernible from the extant literature. First, physical function in older adults is a multi-dimensional construct. Accurate measurement of physical function will therefore require a multidimensional rather than a unidimensional assessment. Second, the two chair STS protocols (five-chair STS test and 30-sec. chair STS test), though scored unidimensionally, tap multidimensional skills and therefore have the potential to become important physical function tests that can provide a low-cost, easy to administer assessment of functional leg strength in older adults. Third, maintenance of physical function and independence in older adults is possible only if an adequate level of hip, knee, and ankle joint strength is maintained. Fourth, few researchers have studied the relationship between hip, knee, and ankle joint strength and physical function in older adults. And fifth, the isokinetic velocity of 60°/sec. is the most often cited velocity used in assessing knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength of older adults. More research is warranted on verifying the best tolerated isokinetic velocity for hip extensor and hip flexor strength assessment in older adults. For consistency purposes, this study used the same isokinetic velocity (60°/sec.) across all muscle groups.

CHAPTER III

METHODS

Introduction

This chapter contains information organized in the following sections: (a) participant population included in this study, (b) laboratory procedures that were followed, including isokinetic leg strength testing (hip, knee, and ankle joints and the reasons for targeting these muscle groups) and chair sit-to-stand (STS) testing (five-chair STS test and 30-sec. chair STS), and (c) section explaining the statistical analyses.

Participants

A convenience sample of forty-seven community-residing sexagenarian women (age range 60-70 years; 46 Caucasian, 1 African-American) from the Athens, GA area participated in this study. An examination of the employment and education histories of the participants revealed that a high percentage were retired teachers (81%, 38 of 47) who had completed either undergraduate (18 participants held bachelor's degrees) or graduate training (13 participants held master's degrees, and 7 participants held doctoral degrees). All participants were cleared by a physician to participate (refer to Appendix D), were not currently taking any medications that would be contraindicated with physical activity, and exhibited no physical, musculoskeletal, or cognitive impairments that would limit their participation. Participants were recruited from the Athens

Women's Club, Athens Learning In Retirement (LIR) Association, Athens YWCO, St. Mary's Wellness Center, and from Athens area churches.

Procedures

Following approval from the University of Georgia Institutional Review Board, each participant was required to provide (prior to participation), a signed physician's clearance form, a signed informed consent form, a Physical Activity Readiness Questionnaire (PAR-Q), and health and exercise history forms (refer to Appendices D-H, respectively). This information was necessary in constructing a health and fitness profile of each participant. For example, based on exercise history information, a high percentage of participants (87%, 41 of 47 participants) were physically active ≥ 2 days a week, with the most prevalent activities being walking, gardening, tennis, water aerobics, bowling, stretching, and weight training.

This study required two separate days of testing for each participant, with approximately three to seven days separating Test Day #1 from Test Day #2. All testing was completed in the Movement Studies Laboratory at the University of Georgia by the primary investigator. Test Day #1 took approximately one hour of a participants' time and involved a University of Georgia Movement Studies Laboratory orientation session, collection of descriptive characteristics (e.g., age, height (cm.), weight (kg.), leg dominance, percent body fat using the 3-site skinfold method (Jackson & Pollack, 1985), completion of two chair STS test protocols (five-chair STS test and 30-sec. chair STS test) completed in a randomized order, and completion of a Cybex Isokinetic Dynamometer (CID) demonstration. The CID demonstration was completed to determine if each participant could safely manipulate their body without discomfort into the three different positions required for isokinetic hip, knee, and ankle joint strength testing.

Test Day #2 involved bilateral isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength testing using a Cybex NORM Isokinetic Dynamometer (CID) (Henley Health Inc., Sugar Land, TX). Isokinetic strength testing took approximately 90 minutes of a participants' time to complete. Both legs were individually tested due to the possibility of hip, knee, or ankle joint strength asymmetry or a unilateral symptomatic joint in either the right or left leg (Judge, 1993; Lundin, Grabiner, & Jahnigen, 1995). Although the appropriate rest interval necessary to minimize muscular fatigue is not clearly documented in the literature, a five-minute rest period was given to each participant between each of their isokinetic hip, knee, and ankle joint strength tests (greater than five-minutes depending on machine set-up time). All participants were given clear instructions on how to perform each test and standardized verbal encouragement was used across tests and participants.

Prior to isokinetic strength testing, all participants completed a five-minute stationary bicycle warm-up at an unloaded work level followed by approximately five-minutes of leg and low back stretching. Participants were then seated and stabilized appropriately on the CID (based on the muscle group to be tested) in a manner designed to isolate the target muscle groups and eliminate (as much as possible) contribution from accessory muscle groups. Once secured on the CID, participants completed strength tests for the hip, knee, and ankle joints on both the right and left legs. To ensure proper organization and to minimize isokinetic strength machine set-up time, the sequence of strength tests were completed in the following order: right knee extensor/flexors, left knee extensor/flexors, left hip extensor/flexors, right hip extensor/flexors, right ankle plantar/dorsiflexors, and left ankle plantar/dorsiflexors.

Leg dominance was determined by asking each participant hypothetically, "if a tennis ball were placed on the floor in front of you, what leg would you use to kick it." The dominant leg was considered to be the leg the participant reported they would use to kick the tennis ball. Forty-five of the forty-seven participants in this study considered their right leg/foot to be their dominant leg/foot. Gabbard & Hart (1996) posed the question of whether or not the dominant leg/foot is the leg/foot used to stabilize the body, or the leg/foot that is mobilized (to lead out or manipulate). This issue remains unclear in the literature on which leg/foot is considered an individual's dominant leg/foot. In the past, researchers have either not reported leg dominance, used the tennis ball test (Arnold & Perrin, 1995), or used participant self-reports to determine leg dominance (Frontera, Hughes, Lutz, & Evans, 1991).

There are two reasons why bilateral isokinetic hip, knee, and ankle joint strength was tested in this study. First, adequate bilateral hip, knee, and ankle joint strength has been shown to be critical in carrying out everyday functional activities such as getting up from a chair, walking, climbing stairs, or balancing (Brown, Sinacore, & Host, 1995; Judge, Whipple, & Wolfson, 1994; Morris-Chatta, Buchner, de Lateur, Cress, & Wagner, 1994; Schultz, Alexander, & Ashton-Miller, 1992; Whipple, Wolfson, & Amerman, 1987; and Wretenberg & Arborelius, 1994). Second, by assessing both right and left hip, knee, and ankle joint strength, the assumption of bilateral strength symmetry could be assessed.

Peak torque values for all isokinetic strength tests were recorded in Newton-meters (Nm) and hip and knee joint strength were corrected for the effect of gravity using the CID gravity correction protocol (Cybex NORM Isokinetic Dynamometer User Manual, 1998). Gravity correction procedures account for the weight of the dynamometer's lever arm and the limb being tested (Perrin, 1993).

Isokinetic Strength Testing

Isokinetic strength testing on the CID involves generating a maximum effort of muscular force through a predetermined range-of-motion and angular velocity over a set number of repetitions. Although a variety of different angular velocities have been reported for assessing isokinetic hip, knee, and ankle joint strength (range of 20°/sec to 300°/sec), for consistency purposes, this study used the most widely published knee extensor/flexor angular velocity (60°/sec) across all muscle groups. To become familiar with the procedures, prior to isokinetic strength testing, each participant completed three sub-maximal warm-up repetitions at a specified angular velocity (Dvir, 1995). The warm-up repetitions were followed by actual isokinetic strength testing (1 set of 5 repetitions at 60°/sec.) for hip extensors and hip flexors (following Judge et al., 1994), 1 set of 5 repetitions at 60°/sec. for knee extensors and knee flexors (following Buchner & de Lateur, 1991; Carmeli, Reznick, Coleman, & Carmeli, 2000; Chandler, Duncan, Studenski, 1997; Cress, Conley, Balding, Hansen-Smith, & Konczak, 1996; Frontera et al., 2000; Salem, Wang, Young, Marion, & Greendale, 2000; and Whipple et al., 1987), and 1 set of 5 repetitions at 60°/sec. for ankle plantar flexors and ankle dorsiflexors (following Gerdle & Fugl-Meyer, 1985; Judge et al., 1994; Morris-Chatta et al., 1994; and Whipple et al., 1987).

Each isokinetic strength test started with the command “Ready, Begin”, and finished after five repetitions had been completed. Immediately following the completion of each test, participants were unstrapped and assisted off the CID. For each isokinetic strength test, participants were instructed to push and pull as hard and fast as possible and were provided strong verbal encouragement (e.g. “push as hard and fast as you can” and “pull as hard and fast as you can”) until test completion. The repetition in each set of movements determined to be that of peak torque (highest recorded value) for each muscle group was adjusted for body weight and then used in the analyses reported herein.

Isokinetic Hip, Knee, and Ankle Strength Testing

Before beginning isokinetic hip extensor and hip flexor strength testing, each participant was placed in a supine position on the CID with the testing side knee placed at an upright flexed 90° angle and a trunk-to-thigh angle of 90° (refer to Appendix I). Before beginning isokinetic knee extensor and knee flexor strength testing, each participant was placed in a seated upright position on the CID with the testing side knee joint placed at a 90° angle (refer to Appendix J). Before beginning isokinetic ankle plantar flexor and ankle dorsiflexor strength testing, each participant was placed in a supine position on the CID with the testing side knee placed at a flexed 90° angle and the testing side foot placed on a small metal plate with a heel-cup and stabilizing straps across the top of the foot (refer to Appendix K). For each isokinetic strength test, participants placed their arms across their chest to minimize accessory upper body muscular involvement and had their testing-side leg stabilized appropriately with one or more straps.

Chair Sit-To-Stand (STS) Testing Procedures

Both the five-chair STS test and 30-sec. chair STS test were completed using a padded chair without arms that was positioned against a wall to prevent chair movement during testing. A 17" chair-seat height was used (following Weiner, Long, Hughes, Chandler, & Studenski, 1993).

Participants followed identical sit-to-stand techniques for both chair STS tests. The sit-to-stand technique involved starting from the seated position and standing all the way up (legs straight at the knee joint), and sitting all the way down (knee joint $\leq 90°$ angle), with arms crossed and held against the chest. Participants were instructed to place their full body weight in the chair following each chair-rise. One practice chair STS repetition was completed followed by two actual test trials for each STS test (Guralnik et al., 1994; Rikli & Jones, 1999). For safety purposes, the primary investigator was positioned approximately three feet to the right side of the participant to assist if needed during chair STS testing.

Although the appropriate rest interval necessary to minimize muscular fatigue is not clearly documented in the literature, a five-minute rest period was provided between each chair STS test trial. The average score of the two trials for each chair STS test was used in the reported analyses.

Five-Chair Sit-To-Stand (STS) Test

The five-chair STS test involves calculating the number of seconds (timed with a stopwatch) needed for a participant to complete five repeated chair-stands without using their arms. On the signal "Ready, Begin", the five- chair STS test started and each participant rose from the seated position to a full stand and then returned to a fully seated position five times in succession. All participants were timed from their initial sitting position to a final sitting position following the fifth stand (following, Nevitt et al., 1989). The time needed to complete the five-chair STS test is graded on a scale of 1 to 4 (< 11.1 sec. = 4; 11.2-13.6 sec. = 3; 13.7-16.6 sec. = 2; and > 16.7 sec. = 1). All participants were able to complete the five-chair STS test and each received a scaled score.

30-sec. Chair Sit-To-Stand (STS) Test

On the signal "Ready, Begin", the 30-sec. chair STS test started and each participant rose to a full stand and then returned to a fully seated position as many times as possible in 30-sec. If a participant was close to the standing position (e.g., completed more than half the distance towards the standing position) at the end of the 30-sec. time period, it counted as a full stand (following, Jones et al., 1999).

Research Design

The purpose of this study was to determine the relationships between isokinetic hip, knee, and ankle joint strength measures and performances on two chair STS tests (five-chair STS test and 30-sec. chair STS test) in older adult women. To accomplish this purpose, a correlational research design was employed, utilizing five-chair STS test and 30-sec. chair STS test scores as the dependent variables and isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength scores and participant height as the independent variables (Borg & Gall, 1983).

Sample size was determined as part of a pilot study conducted by the primary investigator on the relationship between 30-sec. chair STS scores and isokinetic knee extensor strength scores in Spring 2000 on 12 older adult women (ages 64-84 years). A power analysis using SAS® version 6.12 software indicated that a sample size of N = 35-40 would generate a power ≥ .80 at an alpha level of .05.

Statistical Analyses

This study was designed as a correlational study utilizing both simple and multiple regression analyses (Pedhazur, 1997) as a means of exploring the relationships between performance on two chair STS test protocols (five-chair STS test and 30-sec. chair STS test) and the average weight-adjusted isokinetic leg strength scores of six muscle groups (hip extensors, hip flexors, knee extensors, knee flexors, ankle plantar flexors, and ankle dorsiflexors) and participant height. Test-retest reliability indices of the five-chair STS test and 30-sec. chair STS test scores were computed using Pearson correlation (Glass & Hopkins, 1996). Correlations for STS tests and bilateral isokinetic hip extensor/flexor, knee extensor/flexor, and ankle plantar/dorsiflexor strength scores were computed using Pearson correlation coefficients. Statistical regression was used to investigate the following: (a) What proportion of variance in the dependent variables (five-chair STS test and 30-sec. chair STS test scores) could be explained by the independent variables (average weight-adjusted isokinetic hip, knee, and ankle joint strength, and participant height), and (b) which leg muscle group(s) may have the highest predictive value
(e.g., highest standardized regression coefficients and lowest significance levels) in estimating five-chair STS test and 30-sec. chair STS test performance.

Although both component (individual leg strength scores) and composite (grouped leg strength scores consolidated into one score) approaches to regression analyses were performed in this study, only component results are reported herein.

Applying component regression analysis to independent variables suggests the relative importance each leg muscle group may have in relation to chair STS test scores (Pedhazur, 1997). This information is evident in the standardized regression coefficients and significance levels of each leg strength variable. In applying regression analysis with a composite leg strength score as the independent variable, there is no provision for any differential weighting of the individual components that constitute the composite score (Pedhazer, 1997).

Regression analyses were performed for two reasons: (a) To determine the best model to use in explaining variation in chair STS test scores (considering the number of independent variables and the resulting R^2 values), and (b) to determine the relative importance of each leg strength score (standardized regression coefficients and significance levels) in estimating chair STS test scores. Standardized regression coefficients can be interpreted as indicating the expected change in the dependent variable (e.g. chair STS test scores) associated with a standard deviation change in the independent variable (e.g. leg strength scores) while holding any remaining independent variable(s) constant (Pedhazur, 1997).

Descriptive statistics (e.g., means, standard deviations, and correlation coefficients) were calculated for isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar, and ankle dorsiflexor strength (peak torque measured in Newton-Meters), and for five-chair STS test and 30-sec. chair STS test scores. Regression analyses were conducted using five-chair STS test and 30-sec. chair STS test scores as the dependent variables and average weight-adjusted isokinetic hip extensor, hip flexor, knee extensor, knee flexor, ankle plantar flexor, and ankle dorsiflexor strength scores, and participant height as the independent variables respectively. All analyses were conducted using SPSS® version 10.0 software. An alpha level of .05 was used for all analyses.

CHAPTER IV

RESULTS

This chapter presents details on the statistical analyses of this study in the following sections: (a) descriptive analysis of the sample, (b) chair sit-to-stand (STS) test results, (c) bilateral isokinetic leg strength results, (d) five-chair STS test regression results, and (e) 30-sec. chair STS test regression results.

Descriptive Analysis of the Sample

A convenience sample of forty-seven community-residing sexagenarian women participated in this study. Results are reported in the format ($M \pm SD$). Physical characteristics included: (a) age (64.51 $\pm$ 3.08 years), (b) height (163.03 $\pm$ 4.34 cm.), (c) weight (67.73 $\pm$ 10.08 kg.) , and (d) percent body fat (30.24 $\pm$ 5.00%).

Chair Sit-To-Stand (STS) Results

The five-chair STS test and the 30-sec. chair STS test were each performed twice on the same day in a randomized order, and the average score of the two trials for each chair STS test were used in the data analyses. Included in Table 1 are sample mean and standard deviation chair STS test scores and frequencies for the sample aggregated into percentile rankings and score ranges that match the normative data published for the five-chair STS test (Established Populations for Epidemiological Studies of the Elderly Test [EPESE]) (Guralnik, et al., 1994), and the 30-sec. chair STS test (Senior Fitness Test [SFT]) (Rikli & Jones, 1999).

Based on Pearson test-retest correlation coefficient analyses, both the five-chair STS test (*r* = .95, *p* = .0001) and 30-sec. chair STS test (*r* = .93, *p* = .0001) demonstrated high degrees of stability when performed on the same day. In addition, performance scores on the five-chair STS test and 30-sec. chair STS test were highly correlated ($r = -.83$, $p \leq .01$).

<u>Bilateral Isokinetic Leg Strength Results</u>

Included in Table 2 are bilateral isokinetic leg strength scores reported in Newton-meters (Nm), in the format (<u>M</u> ± SD). Although maximum, minimum, and average isokinetic strength scores were calculated, only average isokinetic strength scores were included in the regression analyses due to the high correlation between average and maximum strength scores (*r* = .84 -.98, *p* = .0001) and average and minimum strength scores (*r* = .85 -.98, *p* = .0001). Average isokinetic leg strength scores included: (a) hip extensors (123.55 ± 23.20 Nm), (b) hip flexors (40.89 ± 12.26 Nm), (c) knee extensors (91.13 ± 13.80 Nm), (d) knee flexors (51.72 ± 10.87 Nm), (e) ankle plantar flexors (33.20 ± 8.44 Nm), and; (f) ankle dorsiflexors (9.16 ± 1.99 Nm). To account for individual differences in body weight, all isokinetic strength scores were adjusted by dividing the average strength score (Newton-meters) by body weight (kg.) (following, Chandler, Duncan, & Studenski, 1997).

Based on Pearson correlation coefficient analyses for bilateral (right vs. left) isokinetic hip, knee, and ankle joint strength, a moderately high correlation was indicated for bilateral hip extensor strength (*r* = .79, *p* = .0001), hip flexor strength (*r* = .80, *p* = .0001), knee extensor strength (*r* = .71, *p* = .0001), knee flexor strength (*r* = .67, *p* = .0001), and ankle plantar flexor strength (*r* = .72, *p* = .0001), indicating a reasonable level of bilateral strength symmetry in these muscle groups. Borges (1989) suggested that if there are no known joint impairments and bilateral hip, knee, and/or ankle joint strength correlation coefficients are $r \geq .80$, then bilateral strength symmetry can be assumed. Bilateral isokinetic ankle dorsiflexor strength demonstrated a low correlation (*r* = .33, *p* = .023), indicating the presence of bilateral strength asymmetry in this muscle group (refer to Table 3). Paired sample *t*-tests revealed significant symmetrical differences in right and left ankle dorsiflexor strength (*t* = - 6.309, *p* = .0001). In contrast, no significant differences were apparent in other muscle groups ($p > .05$) (refer to Table 4).

Pearson correlation coefficient results for average isokinetic leg strength scores and five-chair STS test and 30-sec. chair STS test scores are the identical values represented by the standardized regression coefficients associated with each leg strength score in simple regression analyses (refer to Table 5). Other variables that were significantly correlated to five-chair STS test performance were participant height (cm.) (*r* = 0.34, *p* = .02), and body weight (kg.) (*r* = 0.34, *p* = .02). Variables that were non-significant included age (*r* = 0.02, *p* = .92) and percent body fat (*r* = 0.23, *p* = .12). Similarly, participant height (cm.) (*r* = - 0.37, *p* = .01), and body weight (kg.) (*r* = - 0.33, *p* = .02) were significantly correlated to 30-sec. chair STS test performance, and age (*r* = - 0.01, *p* = .97) and percent body fat (*r* = - 0.25, *p* = .09) were non-significant.

Five-Chair STS Test Regression Results

Included in Table 5 are results of simple regression (single muscle group) using average weight-adjusted isokinetic leg strength scores as the independent variable and five-chair STS test scores as the dependent variable. In order of highest R^2 value and lowest *p*-value, hip flexor (R^2 = .34, p = .0001), ankle plantar flexor (R^2 = .33, p = .0001), knee extensor (R^2 = .21, p = .001), knee flexor (R^2 = .12, p = .018), and hip extensor (R^2 = .09, p = .047) strength scores explained the highest proportion of variance in five-chair STS test scores and each variable was significant at alpha level $\leq$ .05. These results indicate the proportion of variation in the dependent variable (five-chair STS test scores) that can be explained by the independent variable (hip extensor, hip flexor, knee extensor, knee flexor, and ankle plantar flexor strength scores) when each leg muscle was individually entered into the simple regression model. To illustrate using one of the significant leg strength variables, if average isokinetic hip flexor strength were increased by one standard deviation (e.g., 12.26 Nm), it would be expected that five-chair STS test performance time would decrease by -.582 standard deviation units (where one standard deviation unit = 2.44 sec., and -.582 is the standardized regression coefficient associated with hip flexor strength with respect to five-chair STS test performance) (refer to Table 5). In contrast, ankle dorsiflexor strength (R^2 = .02, p = .347) explained the lowest proportion of variance in five-chair STS test scores and was non-significant at alpha level $\leq$ .05. This result indicates ankle dorsiflexor strength explained a low proportion of variance in five-chair STS test scores and was a weak predictor of five-chair STS test performance when individually entered in simple regression.

Further analysis of reciprocal muscle groups (e.g., hip extensor/flexors, knee extensor/flexors, and ankle plantar/dorsiflexors) as the independent variables (multiple regression) and five-chair STS test scores as the dependent variable, indicated that hip flexor strength (ß = -.562, p = .0001) had a higher standardized regression coefficient and lower significance level when paired with hip extensor strength (ß = -.045, *p* = .742), knee extensor strength (ß = -.395, *p* = .019) had a higher standardized regression coefficient and lower significance level when paired with knee flexor strength (ß = -.118, *p* = .473), and ankle plantar flexor strength (ß = -.601, *p* = .0001) had a higher standardized regression coefficient and lower significance level when paired with ankle dorsiflexor strength (ß = .068, *p* = .607) (refer to Table 7). These results emphasize the relative importance of hip flexor, knee extensor, and ankle plantar flexor strength in explaining a proportion of five-chair STS test score variance when hip flexor, knee extensor, and ankle plantar flexor strength scores were paired with their respective reciprocal muscle groups (e.g., hip extensors, knee flexors, and ankle dorsiflexors) as independent variables in multiple regression. To illustrate using one of the significant leg strength variables, if average isokinetic knee extensor strength were increased by one standard deviation (e.g., 13.80 Nm), it would be expected that five-chair STS test performance time would decrease by -.395 standard deviation units (where one standard deviation unit = 2.44 sec., and -.395 is the standardized regression coefficient associated with knee extensor strength with respect to five-chair STS test performance) (refer to Table 6). In contrast, the same reciprocal muscle group regression results cannot be made for knee flexor strength scores (also hip extensor and ankle dorsiflexor strength scores) due to their non-significance in explaining five-chair STS test scores when paired with their respective reciprocal muscle groups as independent variables in multiple regression.

Multiple regression analyses using five-chair STS test scores as the dependent variable and all leg strength scores as the independent variables is contained in Table 7.

Regression results using all six leg strength variables explained 48% (*p* = .0001) of the variance in five-chair STS test performance, suggesting that it is reasonable to conclude that independent variables other than hip, knee, and ankle joint strength influenced five-chair STS test performance. The inclusion of participant height to the regression model with all leg strength variables provided a negligible incremental change in R^2 value (R^2 = .53 with height, R^2 = .48 without height) in five-chair STS test performance, suggesting the low level of relative importance participant height had in explaining five-chair STS test performance (*p* = .078).

Within the multiple regression model, ankle plantar flexor (ß = -.450, *p* = .014), hip flexor (ß = -.337, *p* = .045), and knee extensor (ß= -.301, *p* = .053) strength scores demonstrated the highest standardized regression coefficients and each variable was significant in five-chair STS test performance at an alpha level $\leq$ .05. In contrast, hip extensor (ß = .158, *p* = .331), knee flexor (ß= .146, *p* = .398), and ankle dorsiflexor (ß = .158, *p* = .244) strength scores demonstrated the lowest standardized regression coefficients and each variable was non-significant in explaining five-chair STS test performance at an alpha level $\leq$ .05. To illustrate using one of the significant leg strength variables, if average isokinetic ankle plantar flexor strength were increased by one standard deviation (e.g., 8.44 Nm), it would be expected that five-chair STS test performance time would decrease by -.450 standard deviation units (where one standard deviation unit = 2.44 sec., and -.450 is the standardized regression coefficient associated with ankle plantar flexor strength) (refer to Table 7). In contrast, the same multiple regression results cannot be made for ankle dorsiflexor strength scores (also hip extensor and knee flexor strength scores) due to their non-significance in explaining five-chair

STS test scores when entered as independent variables into the multiple regression model.

30-sec. Chair STS Test Regression Results

It should be noted that comments on 30-sec. chair STS test regression results are similar to five-chair STS test regression results. Included in Table 5 are results of simple regression (single muscle group) using average weight-adjusted isokinetic leg strength scores as the independent variable and 30-sec. chair STS test performance as the dependent variable. In order of highest R^2 value and lowest significance level, ankle plantar flexor (R^2 = .27, p = .0001), hip flexor (R^2 = .23, p = .001), knee extensor (R^2 = .19, p = .002), knee flexor (R^2 = .11, p = .023), and hip extensor (R^2 = .11, p = .026) strength scores explained the highest proportion of variance in 30-sec. chair STS test scores and each variable was significant at alpha level $\leq$ .05. These results indicate the proportion of variation in the dependent variable (30-sec. chair STS test scores) that can be explained by the independent variable (hip extensor, hip flexor, knee extensor, knee flexor, and ankle plantar flexor strength) when each leg muscle was individually entered into the simple regression model. To illustrate using one of the significant leg strength variables, if average isokinetic hip flexor strength were increased by one standard deviation (e.g., 12.26 Nm), it would be expected that 30-sec. chair STS test performance would increase by .474 standard deviation units (where one standard deviation unit = 3.07 stands, and .474 is the standardized regression coefficient associated with hip flexor strength with respect to 30-sec. chair STS test performance) (refer to Table 5). In contrast, ankle dorsiflexor strength (R^2 = .04, p = .158) explained the lowest proportion of variance in 30-sec. chair STS test scores, and was non-significant at alpha level $\leq$ .05.

This result indicates ankle dorsiflexor strength explained a low proportion of variance in 30-sec. chair STS test scores and was a weak predictor of 30-sec. chair STS test performance when individually entered in simple regression.

Further analysis of reciprocal muscle groups (e.g. hip extensor/flexors, knee extensor/flexors, or ankle plantar/dorsiflexors) as the independent variables (multiple regression) and 30-sec. chair STS test scores as the dependent variable, indicated that hip flexor strength (ß = .411, p = .007) had a higher standardized regression coefficient and lower significance level when paired with hip extensor strength (ß = .145, p = .325), knee extensor strength (ß = .369, p = .030) had a higher standardized regression coefficient and lower significance level when paired with knee flexor strength (ß = .118, p = .477), and ankle plantar flexor (ß = .511, p = .001) had a higher standardized regression coefficient and lower significance level when paired with ankle dorsiflexor strength (ß = .032, p = .815) (refer to Table 7). These results emphasize the relative importance of hip flexor, knee extensor, and ankle plantar flexor strength in explaining a proportion of 30-sec. chair STS test score variance when hip flexor, knee extensor, and ankle plantar flexor strength scores were paired with their respective reciprocal muscle groups (e.g., hip extensors, knee flexors, and ankle dorsiflexors) as independent variables in multiple regression. To illustrate using using one of the significant leg strength variables, if average isokinetic knee extensor strength were increased by one standard deviation (e.g., 13.80 Nm), it would be expected that 30-sec. chair STS test performance would increase by .369 standard deviation units (where one standard deviation unit = 3.07 stands, and .369 is the standardized regression coefficient associated with knee extensor strength with respect to 30-sec. chair STS test performance) (refer to Table 6). In contrast, the same reciprocal muscle group regression results cannot be made for the knee flexor strength scores (also hip extensor and ankle dorsiflexor strength scores) due to their non-significance in explaining 30-sec. chair STS test scores when paired with their respective reciprocal muscle groups as independent variables in multiple regression.

Multiple regression analyses using 30-sec. chair STS test scores as the dependent variable and all leg strength scores as the independent variables is contained in Table 7. Regression results using all six leg strength variables explained 35% (p = .0001) of the variance in 30-sec. chair STS test performance, suggesting that it is reasonable to conclude that independent variables other than hip, knee, and ankle joint strength influenced 30-sec. chair STS test performance. Although the inclusion of participant height in the regression model with all leg strength variables was significant (p = .030), the results suggest that due to the negligible incremental change in R^2 (R^2 = .39 with height, R^2 = .35 without height) in explaining 30-sec. chair STS test performance, and the number of independent variables in the regression model (seven), participant height provided a low level of relative importance in explaining 30-sec. chair STS test. Further study on the effect participant height may have on 30-sec. chair STS test performance may be warranted based on the significance of adding participant height (p = .030) to the regression model, and the results of Part Correlation analysis, where 8% of the variance in 30-sec. chair STS scores could be attributed to participant height (p = .029).

Within the multiple regression model, ankle plantar flexor (ß= .358, p = .074) strength had the highest standardized regression coefficient and was the only leg strength variable approaching significance in explaining 30-sec. chair STS test scores at alpha level ≤ .05. In contrast, hip extensor (ß= -.004, *p* = .984), hip flexor (ß= .204, *p* = .270), knee extensor (ß= .257, *p* = .135), knee flexor (ß= -.136, *p* = .481), and ankle dorsiflexor (ß= -.017, *p* = .908) strength scores all demonstrated low standardized regression coefficients and were non-significant in 30-sec. chair STS test scores at alpha level ≤ .05. Because all leg strength variables within the multiple regression model were non-significant in explaining 30-sec. chair STS test performance, no definitive results can be illustrated with respect to standard deviation unit changes in hip, knee, or ankle joint strength scores and the resulting standard deviation unit changes that would be expected in 30-sec. chair STS test performance.

Statistical procedures for comparing same muscle group standardized regression coefficients (beta-weights [ß]) for the five-chair STS test and 30-sec. chair STS test were completed (refer to Table 7 for standardized regression coefficient values). Although the movements are both sit-to-stand assessments, significant differences were indicated for ankle plantar flexor, hip flexor, and knee extensor strength scores, indicating the inherent differences in administering and scoring the tests (e.g., time to complete five-stands vs. number of chair-stands completed in 30-sec.), affected the weighting (positive or negative) of each respective leg strength standardized regression coefficient. These results illustrate the inverse relationship between hip flexor, knee extensor, and ankle plantar flexor strength scores (hip extensor, knee flexor, and ankle dorsiflexor strength scores were non-significant) and five-chair STS test performance, where it would be expected that *stronger* hip flexors, knee extensors, and ankle plantar flexors would correspond to a *lower* amount of time necessary to complete five successive chair-stands. In addition, the results illustrate the positive relationship between hip flexor, knee extensor, and ankle plantar flexor strength scores (hip extensor, knee flexor, and ankle dorsiflexor strength scores were non-significant) and 30-sec. chair STS test performance, where it would be expected that *stronger* hip flexors, knee extensors, and ankle plantar flexors would correspond to a *higher* number of chair-stands completed in 30-sec.

Table 1

Chair STS Test Results for Sexagenarian Women (N = 47), With Comparisons to Five-Chair STS Test and 30-sec. Chair STS Test Normative Performance Scores

		EPESE Normative Performance Scores [a]			
Test	Sample *M* (±SD)	# Subjects/ Category	Sample % Ranking	Score Range	Percentile Ranking
Five-Chair STS Test	11.34 sec. (2.44 sec.)	23	50% (23/47)	≤ 6.8 - 11.0 sec.	≥ 90th percentile
		18	38% (18/47)	11.1 - 13.6 sec.	75th percentile
		3	6% (3/47)	13.7 - 16.5 sec.	50th percentile
		3	6% (3/47)	16.6 - 20.0 sec.	25th percentile
		SFT Normative Performance Scores [b]			
Test	Sample *M* (±SD)	# Subjects/ Category	Sample % Ranking	Score Range	Percentile Ranking
30-sec. Chair STS Test	13.97 stands (3.07 stands)	7	15% (7/47)	18 - 20 + stands	≥ 90th percentile
		8	17% (8/47)	16 - 17 stands	75th percentile
		16	34% (16/47)	13 - 15 stands	50th percentile
		12	26% (12/47)	10 - 12 stands	25th percentile
		4	8% (4/47)	≤ 9 stands	10th percentile

Note. Five-chair STS test score = time to complete five chair-stands (sec.). 30-sec. chair STS test score = maximum number of chair-stands completed in 30-sec. Comparing chair STS test results to normative data provides a means of estimating physical function (e.g. low active, average active, or high active).

[a]Guralnik et al. (1994)

[b]Rikli & Jones (1999)

Table 2

Isokinetic Leg Strength Results (60°/sec.) for Sexagenarian Women (N = 47),

With Comparative Results from Other Studies

Variable	*M*	*SD*	Range	Isokinetic Leg Strength Comparisons at 60°/sec.
Hip Extensors				
Right	124.91	21.87	80.00-177.64	
Left	122.18	27.08	74.58-187.13	
Average	123.55	23.20	82.72-182.39	88.00 [a]
Hip Flexors				
Right	40.69	15.25	13.56-88.82	
Left	41.09	10.56	18.98-65.09	
Average	40.89	12.26	17.63-70.63	44.00 [a]
Knee Extensors				
Right	89.52	16.13	46.10-127.46	
Left	92.73	13.72	55.60-126.11	
Average	91.13	13.80	50.85-124.76	84.00 [b]
Knee Flexors				
Right	52.21	10.79	24.41-71.19	
Left	51.22	12.99	27.12-81.36	
Average	51.72	10.87	33.90-71.53	48.00 [b]
Ankle Plantar Flexors				
Right	33.28	9.02	17.63-52.88	
Left	32.12	9.19	17.63-54.24	
Average	33.20	8.44	20.34-52.21	35.00 [c]
Ankle Dorsiflexors				
Right	7.86	2.43	2.71-12.20	
Left	10.46	2.45	6.10-16.27	
Average	9.16	1.99	5.76-13.56	12.00 [c]

Note. All isokinetic strength scores are in Newton-Meters. Hip Extensor strength was the only leg strength score different from previous results.

[a]Judge, Whipple, & Wolfson. (1994).

[b]Average results from seven studies (refer to Appendix C)

[c]Judge, Whipple, & Wolfson (1994) and Morris-Chatta, Buchner, de Lateur, Cress, & Wagner (1994)

Table 3

Pearson Correlation Coefficients for Bilateral Isokinetic Leg Strength (Newton-Meters) for Women Age 60-70 (N = 47)

Left Leg	Right Leg HE	HF	KE	KF	AP	AD
HE	0.79**	--	--	--	--	--
HF	--	0.80**	--	--	--	--
KE	--	--	0.71**	--	--	--
KF	--	--	--	0.67**	--	--
AP	--	--	--	--	0.72**	--
AD						0.33*

Note. HE = Hip Extensors; HF = Hip Flexors; KE = Knee Extensors; KF = Knee Flexors; AP = Ankle Plantar Flexors; AD = Ankle Dorsiflexors

* $p < .05$

** $p < .0001$

Table 4

Paired Sample *t*-tests for Bilateral Isokinetic Strength

(Newton-Meters) for Women Age 60-70 (N = 47)

Bilateral Muscle Group	*t*-statistic	*p*-value
HE	1.134	.263
HF	-.289	.774
KE	- 1.891	.065
KF	.682	.499
AP	.161	.873
AD	- 6.309	.0001

Note: Ankle dorsiflexor strength was the only bilateral paired muscle group to show significant strength asymmetry.

HE = Hip Extensors   HF = Hip Flexors
KE = Knee Extensors   KF = Knee Flexors
AP = Ankle Plantar Flexors   AD = Ankle Dorsiflexors

Table 5

Simple Regression Analyses Using Five-Chair STS Test and 30-sec. Chair STS Test Scores as the Dependent Variables and Average Weight-Adjusted Isokinetic Leg Strength Scores (Newton-Meters) as the Independent Variables

Independent Variables	R^2 (R^2_{adj})	*p*-value	Standardized Regression Coefficient
Five-Chair STS			
HE	.09 (.06)	.047	-.291
HF	.34 (.32)	.0001	-.582
KE	.21 (.20)	.001	-.463
KF	.12 (.10)	.018	-.345
AP	.33 (.32)	.0001	-.578
AD	.02 (-.01)	.347	-.140
30-sec. Chair STS			
HE	.11 (.09)	.026	.325
HF	.23 (.21)	.001	.474
KE	.19 (.17)	.002	.437
KF	.11 (.09)	.023	.330
AP	.27 (.26)	.0001	.523
AD	.04 (.02)	.158	.209

Note. Standardized Regression Coefficients are negative for leg muscle groups associated with Five-Chair STS test scores, due to the inverse relationship between leg strength and time to complete five chair-stands. To account for individual differences in body weight, all isokinetic strength scores were adjusted by dividing the average strength score by body weight (kg.)

HE = Hip Extensors   HF = Hip Flexors
KE = Knee Extensors   KF = Knee Flexors
AP = Ankle Plantar Flexors   AD = Ankle Dorsiflexors

Table 6

Regression Analyses Using Five-Chair STS Test and 30-sec. Chair STS Test Scores as the Dependent Variables and Average Weight-Adjusted Isokinetic Reciprocal Muscle Groups (Newton-Meters) as the Independent Variables

Class of Independent Variables	R^2 (R^2_{adj})	Model Significance (*p*-value)	Standardized Regression Coefficient	Individual Significance (*p*-value)
Five-Chair STS				
HE & HF	.34 (.31)	.0001	HE = -.045 HF = -.562	.742 .0001
KE & KF	.22 (.19)	.004	KE = -.395 KF = -.118	.019 .473
AP & AD	.34 (.31)	.0001	AP = -.601 AD = .068	.0001 .607
30-sec. Chair STS				
HE & HF	.24 (.21)	.002	HE = .145 HF = .411	.325 .007
KE & KF	.20 (.16)	.007	KE = .369 KF = .118	.030 .477
AP & AD	.27 (.24)	.001	AP = .511 AD =.032	.001 .815

Note. To account for individual differences in body weight, all isokinetic strength scores were adjusted by dividing the average strength score by body weight (kg.)

HE = Hip Extensors   HF = Hip Flexors
KE = Knee Extensors   KF = Knee Flexors
AP = Ankle Plantar Flexors   AD = Ankle Dorsiflexors

Table 7

Regression Analyses Using Five-Chair STS Test and 30-sec. Chair STS Test Scores as the Dependent Variables and All Six Isokinetic Leg Strength Scores (Newton-Meters) as the Independent Variables

Class of Independent Variables	R^2 (R^2_{adj})	Model Significance (*p*-value)	Standardized Regression Coefficient	Standard Error	Individual Significance (*p*-value)
Five-Chair STS					
Average Isokinetic Leg Strength	.48 (.40)	.0001	HE = .158	.161	.331
			HF = -.337	.163	.045*
			KE = -.301	.151	.053
			KF = .146	.171	.398
			AP = -.450	.175	.014*
			AD = .158	.134	.244
Average Isokinetic Leg Strength and Height	.53 (.44)	.0001	HE = .188	.137	.179
			HF = -.343	.138	.016*
			KE = -.250	.128	.059
			KF = -.006	.133	.964
			AP = -.350	.133	.027*
			AD = .188	.121	.129
			HT = .225	.125	.078
30-sec. Chair STS					
Average Isokinetic Leg Strength	.35 (.25)	.007	HE = -.004	.020	.984
			HF = .204	.182	.270
			KE = .257	.169	.135
			KF = -.136	.191	.481
			AP = .358	.195	.074
			AD = -.017	.147	.908
Average Isokinetic Leg Strength and Height	.39 (.29)	.004	HE = -.081	.155	.010*
			HF = .229	.155	.147
			KE = .194	.145	.605
			KF = .047	.157	.766
			AP = .274	.172	.120
			AD = -.071	.138	.609
			HT = -.316	.141	.030*

Note. HE = Hip Extensors; HF = Hip Flexors; KE = Knee Extensors; KF = Knee Flexors; AP = Ankle Plantar Flexors; AD = Ankle Dorsiflexors

* = $p < .05$

CHAPTER V

DISCUSSION

The ability to rise unaided from a chair is important to maintaining physical independence and may be one of the best predictive measures of physical function for all people (Kelly, Dainis, & Wood, 1976; Rodosky, Andriacchi, & Anderson, 1989). The chair sit-to-stand (STS) movement is a common activity of daily living and requires a sufficient level of hip, knee, and ankle joint strength to successfully rise from a chair and complete the task (Schultz, Alexander, & Ashton-Miller, 1992; Judge, Whipple, & Wolfson, 1994; Brown, Sinacore, & Host, 1995; Chandler, Duncan, & Studenski, 1997). Chair STS tests have been accepted on face validity (Glass & Hopkins, 1996) as instruments to estimate leg strength due to the functional nature of the STS movement in everyday life (Csuka & McCarty, 1985; Guralnik et al., 1994; Newcomer, Krug, & Mahowald, 1993; and Rikli & Jones, 1999), and the fact that the STS test requires no equipment other than a standard chair and can be administered in virtually any setting.

In using chair STS tests to document the relationship between leg strength and physical function, it is essential to compare testing methodology, protocol, and instrumentation before making generalizations about the efficacy of a physical function test. Commonly, researchers have used the chair STS movement as an instrument to assess functional leg strength in older adults (Csuka & McCarty, 1985; Nevitt, Cummings, Kidd, & Black, 1989; Newcomer et al., 1993; Guralnik et al., 1994; Seeman et al., 1994; and Rikli & Jones, 1999). In addition, a biomechanical analyses of the chair STS movement utilizing hip, knee, and ankle joint kinematic parameters has proved useful in studying the leg strength-to-physical function relationship in older adults. For example, one kinematic study of the chair STS movement by Schenkman, Berger, Riley, Mann, & Hodge (1990), suggests that the STS movement can be divided into four phases (flexion-momentum, momentum-transfer, extension, and stabilization phases). Within each phase of the STS movement, the following leg strength contributions have been suggested: (a) A sufficient level of hip flexor and ankle dorsiflexor strength is essential during the flexion-momentum phase (phase I), when the body weight is shifted from the buttocks to the feet, (b) knee extensor strength is essential during the momentum transfer phase (phase II), when the body weight is moved off the chair and over the feet, (c) both knee extensor and hip extensor strength are essential during the extension phase (phase III), when maximum knee and hip extensor velocities are achieved, and (d) ankle plantar flexor strength is essential during the stabilization phase (phase IV), after the STS movement has been completed and maintenance of postural stability and balance are important. Although the importance of knee flexor strength during the ascent portion of the STS movement is unclear based on the four phases of the STS movement, it has been suggested that knee flexor strength is important in stabilizing the body during the descent portion of the STS movement (Schenkman et al., 1990). Because the chair STS test involves repeated chair rising and sitting, future research on the contributions of hip, knee, and ankle joint strength during the descent portion of the STS movement may be useful in assembling a complete leg strength profile associated with the STS movement.

Based on the data analysis, a number of findings were evident in the relationships between isokinetic hip, knee, and ankle joint strength and chair STS test performances in sexagenarian women. Using R^2 values, standardized regression coefficients (beta-weights [ß]), and significance levels calculated through both simple (e.g., one leg strength variable) and multiple regression (e.g., reciprocal leg strength variables and all leg strength variables), it was apparent that only a low to moderate proportion of variance in chair STS performance could be explained (see R^2 values in Tables 5, 6, and 7), using hip, knee, and/or ankle joint strength scores (and participant height in Table 7) as independent variables. It has been suggested by Saries & Stronkhorst (1984), that if $R^2 < .90$, it is likely that important variables have been omitted.

Researchers have established that adequate hip, knee, and ankle joint strength are physiologically essential to completing the STS movement (Brown et al., 1995; Chandler et al., 1997; Judge et al., 1994; Schenkman et al., 1990; and Schultz et al., 1992). In addition, knee extensor strength has been found to surpass all other major lower extremity muscle groups during the STS movement (Chandler, Duncan, & Kochersberg, 1998; Hughes, Myers, & Schenkman, 1995; and Schenkman, Hughes, Samsa & Studenski, 1996). When hip, knee, and ankle joint strength scores were measured, results of the current study suggest that in addition to knee extensor strength, ankle plantar flexor and hip flexor strength are also specific to the STS movement. In addition, the low to moderate R^2 values (refer to Tables 5, 6, or 7) suggest that the STS movement is a multidimensional task requiring a multidimensional assessment (e.g., physiological, psychological, and demographic variables) rather than a unidimensional assessment (e.g., leg strength variables alone). This conclusion is supported by Corrigan & Bohannon (2001), who reported that causes of decreased STS capacity in older adults are most likely multifactorial, and may include both objective and subjective measures. In addition, research by Sharma et al. (1999) on the relationship between knee joint laxity and osteoarthritis, emphasized that leg strength can account for only a limited amount of physical functional decline in patients with osteoarthritis and suggested that additional variables such as age, gender, ethnicity, genetics, injury history, and age-related soft-tissue changes can all contribute to joint laxity, osteoarthritis, and physical functional decline.

Because the current study included only a unidimensional assessment of the STS test (e.g., leg strength measures), it is not surprising that low to moderate R^2 values were realized in regression analyses. In retrospect, although leg strength variables (especially knee extensor strength) have been shown to be important in relation to the STS movement, additional independent variables that address the multidimensional nature of the STS movement (following, Sharma et al., 1999), may provide additional evidence into what specific combination of independent variables explain the variance in chair STS test performance.

In examining simple regression results contained in Table 5, it was evident that all leg strength variables (e.g., hip extensors, hip flexors, knee extensors, knee flexors, and ankle plantar flexors) except ankle dorsiflexor strength were significant in explaining five-chair STS test and 30-sec. chair STS test performance. Although ankle dorsiflexor strength scores displayed low R^2 values and were non-significant in explaining STS test performance, adequate ankle dorsiflexor strength has been shown to be physiologically essential during the flexion-momentum phase of the STS movement (Schenkman et al., 1990). The fact that ankle dorsiflexor strength scores were not connected to statistically significant regression results, only means that the participant's variation in ankle dorsiflexor strength did not cross a statistically significant threshold (e.g., alpha = .05), which would imply a statistically meaningful relationship between ankle dorsiflexor strength and chair STS test scores. Because a majority of the research on the relationship between ankle joint strength and physical function has focused primarily on ankle plantar flexor strength (Buchner & de Lateur, 1991; Cunningham, Morrison, Rice, & Cooke, 1987; Fugl-Meyer, Gustafsson, & Burstedt, 1980; Gerdle & Fugl-Meyer, 1985; Morris-Chatta, Buchner, de Lateur, Cress, & Wagner, 1994; and Porter, Vandervoort, & Kramer, 1997), more research is warranted on the relationship bilateral ankle dorsiflexor strength may have on STS performance and other functional tasks importance to independence in older adults, including walking, stair climbing, and balancing.

Reciprocal regression results contained in Table 6 demonstrated that when paired with their respective reciprocal muscle groups, hip flexor, knee extensor, and ankle plantar flexor strength scores explained more variance in five-chair STS test and 30-sec. chair STS test scores. These results suggest the importance of maintaining adequate hip flexor, knee extensor, and ankle plantar flexor strength in order to rise from a chair successfully (once or repeatedly). Although hip extensor, knee flexor, and ankle dorsiflexor strength scores were non-significant in explaining STS test performance, adequate strength in each of these muscle groups has been shown to be physiologically essential during the ascent portion (e.g., hip extensors and ankle dorsiflexors) and descent portion (e.g., knee flexors) of the STS movement (Schenkman et al., 1990). The fact that hip extensor, knee flexor, and ankle dorsiflexor strength scores were not connected to statistically significant regression results, simply means that the participant’s strength variation in each of these muscle groups did not cross a statistically significant threshold (e.g., alpha = .05), which would imply a meaningful relationship between hip extensor, knee flexor, and/or ankle dorsiflexor strength scores (when paired with their respective reciprocal muscle groups) and chair STS test scores. Although the role knee joint strength (especially knee extensor strength) and ankle joint strength (especially ankle plantar flexor strength) have on physical function has been established (Buchner & de Lateur, 1991; Chandler et al., 1998; Hughes et al., 1995; Morris-Chatta et al., 1994; and Schenkman et al., 1996), more research is warranted on the reciprocal role hip extensor and hip flexor strength have on STS performance, and other functional tasks important to independence, including walking, stair climbing, and balancing.

Multiple regression results contained in Table 7 demonstrated that ankle plantar flexor (ß = -.450, p = .014), hip flexor (ß = -.337, p = .045), and knee extensor (ß = -.301, p = .053) strength scores had the highest standardized regression coefficients and were significant with respect to five-chair STS test scores. In contrast, ankle plantar flexor strength scores were the only leg strength score approaching significance (ß = .358, p = .074) with respect to the 30-sec. chair STS test scores. The fact that specific hip, knee, and ankle joint strength scores were not connected to statistically significant regression results with respect to five-chair STS test (e.g., ankle dorsiflexors, hip extensors, and knee flexors) and 30-sec. chair STS test performance (all leg strength scores except ankle plantar flexor strength), only means that the participant's variation in strength in these muscle groups did not surpass a statistically significant threshold within the regression model (e.g., alpha level = .05), which would imply a statistically meaningful relationship between those leg strength variables found to be non-significant, and chair STS test scores.

When regression results of the current study are compared to the work of Schenkman et al. (1990) on the four biomechanical phases of the chair STS movement, it is evident that an adequate level of hip flexor strength is essential during the flexion-momentum phase; an adequate level of knee extensor strength is essential during the momentum-transfer and extension phases; and an adequate level of ankle plantar flexor strength is essential during the stabilization phase of the chair STS movement. The results of this study suggest that in the sample of sexagenarian women studied, sustaining an adequate level of bilateral hip flexor, knee extensor, and ankle plantar flexor strength is critical to completing the STS movement, and thus has an essential role in maintaining physical independence. Biomechanical results on the essential physiological role the hip, knee, and ankle joints have during the STS movement reported by Schenkman et al. (1990), have been supported by other researchers (Brown et al., 1995; Chandler et al., 1998; Chandler et al., 1997; Hughes et al., 1995; Judge et al., 1994; Schenkman et al., 1990; Schenkman et al., 1996; and Schultz et al., 1992).

Although previous research on the five-chair STS test has not included leg strength validation results (Guralnik et al., 1994), the 30-sec. chair STS test has been validated with a 1-RM (repetition-maximum) leg press test by Jones, Rikli & Beam (1999). These authors indicated that the coordinated involvement of the hip extensors, knee extensors, and ankle plantar flexors during the leg press exercise were indicative of overall leg strength during the chair STS maneuver. Based on the low to moderate R^2 values obtained in the current study through simple and multiple regression analyses, the results of Jones et al., (1999) cannot be confirmed. In addition, other researchers have tested the relationship between bilateral knee strength and chair STS performance and reported correlation coefficients for knee extensor strength ($r = 0.49$, $p < .05$) (Salem, Wang, Young, Marion, & Greendale, 2000), and regression values ($R^2 = .48$, $p = .0001$) for knee extensor strength (Chandler et al., 1997). In each study, although knee extensor strength was significant, it is evident from our regression results and the biomechanical results reported by Schenkman et al. (1990), that ankle plantar flexor and hip flexor strength are also specific to chair STS performance. In theory, these results suggest that if an individual were to increase the strength of their hip flexors, knee extensors, and ankle plantar flexors, a corresponding improvement in their ability to stand up from a seated position would be expected. These results may be useful to health care professionals and physical and occupational therapists working with older adults on task specific functional improvement.

In examining all muscle groups, it appears that ankle plantar flexor strength had the highest relative predictive value in both chair STS tests, followed by hip flexor and knee extensor strength. These results are in contrast to results reported by Chandler et al., (1998), Hughes et al., (1995), and Schenkman et al., (1996), where knee extensor strength was found to be the most important muscle group with respect to the STS movement. However, the results of the current study are supported by the findings of Brunt, Greenberg, Wankadia, Trimble, & Shechtman (2002), who reported the importance of ankle joint strength and foot placement during the STS movement in patients with hemiplegia.

From our results, ankle plantar flexor, hip flexor, and knee extensor strength could all be seen as good indicators for estimating STS performance and functional leg strength in the sample of sexagenarian women studied. Of the three muscle groups determined to be significant in estimating chair STS test performance (e.g., hip flexors, knee extensors, and ankle plantar flexors), it would seem the ankle plantar flexors would have an inferior role in estimating chair STS test performance. Intuitively, this result would seem reasonable given the vast differences in muscle mass and strength between the hip and ankle joints, and knee and ankle joints. However, given the fact that each chair STS test involves repeated sitting and standing, where each successive STS repetition requires an adequate level of static balance, the essential role the ankle plantar flexors play in stabilizing the body in the upright standing position following each chair-rise becomes apparent. Future research is warranted on investigating whether an ankle plantar flexor strength threshold exists in older adults, where strength above this theoretical threshold would correspond to functional independence and strength below this theoretical threshold would correspond to non-functional dependency.

Previous research on the relationship between hip, knee, and/or ankle joint strength and STS performance have included large age range variations and populations (Brunt et al., 2002; Chandler et al., 1998; Hughes et al., 1996; Wheeler, Woodward, Ucovich, Perry, & Walker, 1985; and Wretenberg & Arborelius, 1994). In contrast, all the participants in this study were community-dwellers within the 60-70 year age range, without any medical, orthopedic, or musculoskeletal conditions. Because of the demographics of the women included in the current study, it was expected that they would display an average to high level of physical function. Physical function level was verified by comparing five-chair STS test and 30-sec. chair STS test performance results to normative chair STS test performance data (Guralnik et al., 1994; Rikli & Jones, 1999) (refer to Table 1). Chair STS test results (N = 47) were compared to normative five-chair

STS test or 30-sec. chair STS test percentile ranking categories to estimate physical function level of the sexagenarian women in the sample. Functional ability categories (e.g., low active, average active, and high active) have been established for both chair STS tests (Guralnik et al., 1994; Rikli & Jones, 1999). Results demonstrated that 44 of 47 participants scored ≥ 50th percentile for five-chair STS test performance, and 31 of 47 participants scored ≥ 50th percentile for 30-sec. chair STS test performance, indicating that 94% (44 of 47) of five-chair STS test participants and 66% (31 of 47) of 30-sec. chair STS test participants would be classified with average to high physical function when compared to normative performance data. Normative performance scores for the five-chair STS test were developed from data on 2033 females ages 71-79 (Guralnik et al., 1994), whereas normative performance scores for the 30-sec. chair STS test were developed from data on 1622 females ages 60-69 (Rikli & Jones, 1999).

The physical function level of the participants was further supported by hip flexor (40.89 Nm.), knee extensor (91.13 Nm.), knee flexor (51.72 Nm.), ankle plantar flexor (33.20 Nm.), and ankle dorsiflexor strength (9.16 Nm.) results (refer to Appendix C), which were comparable to the mean strength results of previous studies on isokinetic knee extensor (84 Nm.) and knee flexor strength (48 Nm.) (Buchner & de Lateur, 1991; Buchner, Larson, Wagner, Koepsell, & de Lateur, 1996; Buchner et al., 1997; Carmeli, Reznick, Coleman, & Carmeli, 2000; Frontera, Hughes, Lutz, & Evans, 1991; Judge et al., 1994; and Salem et al., 2000), ankle plantar flexor (35 Nm) and ankle dorsiflexor strength (12 Nm.) (Judge et al., 1994; Morris-Chatta et al., 1994), and hip flexor strength (44 Nm.) (Judge et al., 1994). In contrast, hip extensor strength scores (124 Nm.) were higher than those reported in the Judge et al. (1994) investigation (88 Nm.), possibly due to age group differences (refer to Appendix C). Finally, on the issue of isokinetic leg strength symmetry, it is unclear why the participants in this study displayed bilateral ankle dorsiflexor strength asymmetry, and the effect this asymmetry may have had on chair STS test performance. Brunt et al., (2002) reported that asymmetrical leg strength and foot placement in patients with hemiplegia affected STS performance especially during the momentum-transfer phase (following, Schenkman et al., 1990). The results suggest that population-specific research pertaining to the STS movement may be warranted (Corrigan & Bohannon, 2001).

Although several researchers have reported leg strength-to-physical function results incorporating regression analysis with either one (simple regression) or more (multiple regression) leg strength variables (Brown et al., 1995; Buchner et al., 1996; Buchner et al., 1997; Chandler et al., 1997; Ferrucci et al., 1997; Judge et al., 1994; and Schenkman et al., 1996), differences in isokinetic strength testing velocities (e.g., range from 0°/sec. to 300°/sec.), testing positions (e.g., seated, standing, supine, prone), protocols (e.g., number of sets, repetitions, and lever arm range-of-motion), equipment (e.g., Cybex, Kin-Com, Biodex, and Lido), and age group and ability differences (e.g., children, college students, athletes, individuals with disabilities, and older adults), make comparisons to the current study difficult.

Conclusions and Recommendations

Although there is no "gold standard" test for measuring physical function in older adults, the chair STS test may be one of the most important measures of physical function and independence (Kelly et al., 1976; Rodosky et al., 1989). From our results, it appears that in order to complete the chair STS movement (once or repeatedly), one must maintain an adequate level of bilateral ankle plantar flexor, hip flexor, and knee extensor strength. Although previous research has reported the importance of knee extensor strength during the STS movement (Chandler et al., 1998; Hughes et al., 1995; and Schenkman et al., 1996), our data suggests that of the six muscle groups tested, ankle plantar flexor strength had the highest predictive value in estimating five-chair STS test and 30-sec. chair STS test scores, followed by hip flexor and knee extensor strength. Information on the relative importance hip, knee, and ankle joint strength have in relation to the STS movement, could be useful to health care professionals and fitness specialists working with older adults on designing strength training regimens with the goal of targeting specific leg muscles to improve task specific physical function and level of independence.

Although the results of this study suggest that both chair STS tests may be used as proxy measures of estimating functional leg strength in older adults, more research is needed in a diverse sampling of older adults to determine the fundamental assessment differences between the five-chair STS test (e.g., more of a test of leg strength and/or leg power), and the 30-sec. chair STS test (e.g. more of a test of leg endurance). Based on the amount of time needed to complete five successive chair-stands (sample M = 11.34 sec. ± 2.44 sec.), the five-chair STS test may be a more appropriate functional leg strength and/or leg power assessment instrument for older adults categorized with lower physical functional abilities (e.g., assisted living and nursing home residents, and individuals with joint replacement or hip, knee, or ankle joint arthritis). In contrast, the 30-sec. chair STS test may be a more appropriate functional leg endurance assessment instrument for older adults categorized with higher physical functional abilities (e.g., community-residing individuals who are fully independent, physically active on a daily basis, and experiencing no hip, knee, or ankle joint involvement). In addition, future research on the chair STS test should investigate the effect participant height may have on STS test performance (especially the 30-sec. chair STS test), the effect high or low seat heights may have on STS test performance (following, Alexander, Schultz, Ashton-Miller, Gross, & Giordani, 1997; and Corrigan & Bohannon, 2001), and the effects bilateral hip, knee, and/or ankle joint strength asymmetries may have on STS test performance.

Finally, due to the large number of individuals living beyond their 80’s in the United States, continued research on the relationship hip, knee, and ankle joint strength have on performance of various activities of daily living (e.g., standing up unaided from a chair, bed, or toilet, walking, stair climbing, and balancing), has merit not only for gerontologists and health care professionals, but also for individuals experiencing declines in function and independence associated with the phenomenon of aging, and family members who are in a caregiving role.

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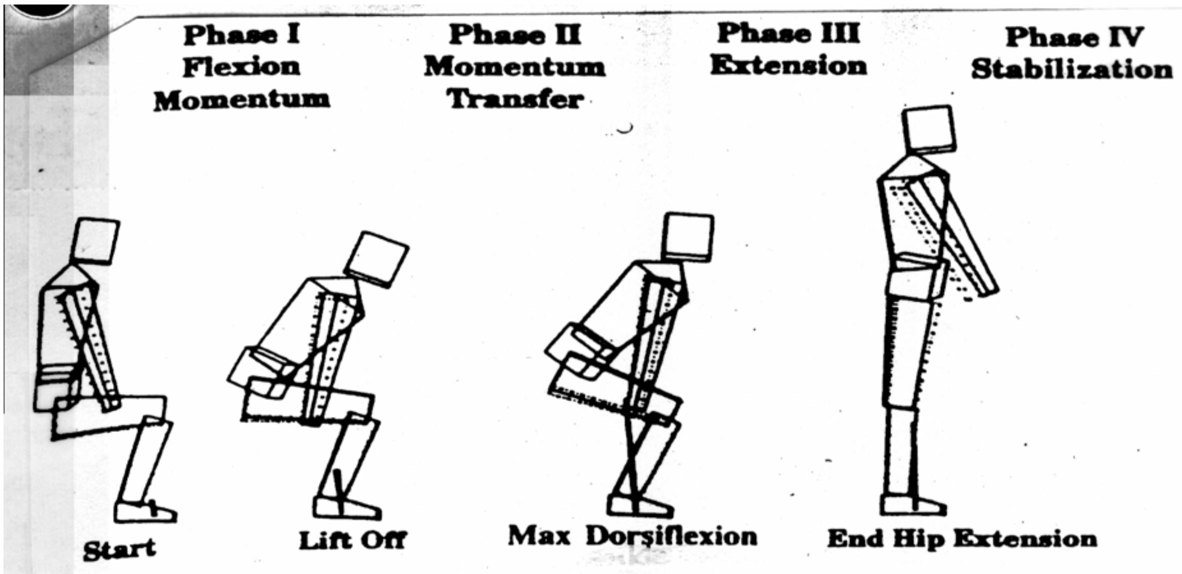
APPENDIX A

Four Phases of the Chair Sit-To-Stand Movement

Four Phases of the Chair Sit-To-Stand Movement.



Flexion-Momentum Phase (Phase I)
Begins with the initiation of the chair rise movement and ends just before the gluteus maximus is lifted from the seat of the chair (lift-off).

Momentum Transfer Phase (Phase II)
Begins as the gluteus maximus is lifted from the seat of the chair and ends when maximum ankle dorsiflexion is achieved.

Extension Phase (Phase III)
Initiated just after maximal ankle dorsiflexion and completed when the hips and knees decelerate and come to full extension (velocity reaches 0°/sec).

Stabilization Phase (Phase IV)
Begins just after hip-extension velocity reaches 0°/sec. and continued until all motion associated with stabilization from rising is complete.

Reference:

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APPENDIX B

Ability / Disability Model

(Rikli & Jones, 1997)

Ability/Disability Model (Rikli & Jones, 1997)

Disease/Pathology → Impairment → Functional Limitation → Disability
Inactivity/Lifestyle

Functional Ability Framework (Rikli & Jones, 1997)

Physical Parameters	Functions	Activity Goals
Muscular Strength/ Endurance	Walking	Personal care
Aerobic Capacity	Stair climbing	Shopping/errands
Flexibility	Standing up from a chair	Housework
Motor Ability power	Lifting/reaching	Gardening
speed/agility balance	Bending/kneeling	Recreational sports
reaction time	Jogging/running	Traveling
Body composition		

Physical Impairment → Functional Limitation → Reduced Ability/Disability

APPENDIX C

Isokinetic Leg Strength Study Comparisons

Isokinetic Leg Strength Comparisons

Author (reference)	N	M age or age range	HE	HF	KE	KF	AP	AD
			Isokinetic Strength at 60°/sec.					
Present Study	47F	65 (60-70)	124	41	91	52	33	9
Buchner et al. (1997)	53F	68-85	-	-	87	45	-	-
Buchner et al. (1996)	102	60-69	-	-	89	55	-	-
Buchner et al. (1991)	122F	60-74	-	-	86	-	-	-
Carmeli et al. (2000)	10F	80	-	-	90	49	-	-
Frontera et al. (1991)	34F	65-78	-	-	89	49	-	-
Judge et al. (1994)	110M/F	80	88	44	89	49	35	11
Morris-Chatta et al.(1994)	24F	75	-	-	-	-	34	13
Salem et al. (2000)	46F	74	-	-	56	40	-	-

Note. All isokinetic strength scores are in Newton-Meters (Nm).

HE = Hip Extensors HF = Hip Flexors
KE = Knee Extensors KF = Knee Flexors
AP = Ankle Plantar Flexors AD = Ankle Dorsiflexors
M = Males F = Females

APPENDIX D

Physician's Clearance Form

Physician's Clearance Form for the Dissertation Study Entitled "The Chair Sit-To-Stand Test as a Measure of Leg Strength in Older Adult Women"

Name:___________________________________ Date:_____________
Please Print

The above mentioned individual has expressed an interest in participating in the dissertation research study entitled "The Chair Sit-To-Stand Test as a Measure of Leg Strength in Older Adult Women", being conducted by Erick McCarthy (Ph.D. candidate in Physical Education at the University of Georgia). The purpose of the study is to validate the chair sit-to-stand test as a measure of leg strength in older adult women using isokinetic hip, knee, and ankle joint strength as the criterion. A secondary purpose is to determine the relationship leg strength has on performance of other physical functional tests (e.g. 8 foot Up-and-Go, stair-climb, and balance tests).

The purpose of this letter is to provide an outline of the study procedures for the physician, so a decision can be made as to whether or not the above mentioned individual can participate in the study without any contraindications related to their current health condition. In order to participate in this study, each participant will be required to provide a signed physician's clearance form, and complete a Physical Activity Readiness Questionnaire (PAR-Q) (see below), a Medical History form, and an Exercise History form. If a question is marked YES on the PAR-Q, a physician's advice will be needed to determine if the physical activity required for this study is inappropriate based on the medical history or current medical condition of the participant.

<u>Physical Activity Readiness Questionnaire (PAR-Q)</u>

YES	NO	
___	___	Has a doctor ever said that you have a heart condition and recommended only medically supervised activity?
___	___	Do you have chest pain brought on by physical activity?
___	___	Have you developed chest pain in the past month?
___	___	Do you tend to lose consciousness or fall over as a result of dizziness?
___	___	Do you have a bone or joint problem that could be aggravated by the proposed physical activity?
___	___	Has a doctor ever recommended medication for your high blood pressure or heart condition?
___	___	Are you aware through your own experience, or a doctor's advice, of any other physical reason against your exercising without medical supervision?

Procedures

This study will involve two days of testing, with approximately five to seven days separating each session. Test Day #1 will last approximately 60 min. and include a University of Georgia Movement Studies Laboratory familiarization session, completion of two chair sit-to-stand tests (30 sec. chair sit-to-stand test and five-chair stand test), an 8 foot Up-and-Go test, a stair climb test, and a balance test. Test Day #2 will last approximately 90 min. and involve testing the isokinetic strength of the hips, knees, and ankles on both legs using a Cybex Strength Machine. All testing will be completed in the Movement Studies Laboratory at the University of Georgia under the supervision of Erick McCarthy.

Prior to isokinetic strength testing, all participants will complete a five minute stationary bicycle warm-up at an unloaded work level followed by about 5-min. of stretching for the legs led by Erick McCarthy. Following warm-up and stretching, participants will be seated on the Cybex Strength Machine and complete three sub-maximal warm-up repetitions to become familiar with the procedures followed by actual isokinetic strength testing (1 set of 5 repetitions at 60 degrees/sec. for the hip extensor/flexors, knee extensor/flexors, and ankle plantar/dorsiflexors). The best repetition (highest peak torque value) will be used in the analysis.

Physical function tests in this study will include a 30-sec. chair sit-to-stand test, a five chair-stand test, an 8 foot Up-and-Go test, a stair climb test, and a one-legged balance test. A 17 in. chair without arms will be used for both chair sit-to-stand tests and the 8- foot Up-and-Go test. The 30 sec. chair sit-to-stand test involves counting the number of times a person can stand-up and sit-down in a chair in 30 sec. without using their arms. The five chair-stand test involves calculating the amount of time needed to complete five chair-stands without using the arms. The 8 foot Up-and-Go test involves calculating the amount of time needed to stand up from a chair, walk forward 8-feet and return to the seated position. The stair-climb test involves calculating the amount of time to climb 12 steps. The one-legged balance test involves calculating the amount of time one can balance on either their left or right leg (10 sec. maximum). Adequate practice time will be given to each participant before actual testing for each functional test. Two trials will be completed for each functional test and a mean score will be used in the analysis.

The discomforts a participant may face during this study may include a small risk for muscle strain or muscle fatigue during isokinetic strength testing. The warm-up and stretching sessions will assist in minimizing any muscular discomfort, while strict supervision of each testing session will ensure that each participant is performing each movement safely and correctly. All laboratory testing will be supervised by Erick McCarthy who is CPR certified, holds an M.S. in Exercise Physiology and has 11 years experience as a physical activity leader for younger and older adults. Any discomfort or pain associated with testing will result in an immediate cessation of the movement. Should you have any questions regarding this research, please contact Erick McCarthy at 542-3389 (Lab), 543-1849 (Home), e-mail: erickmccarthy@hotmail.com, or Dr. Michael Horvat at 542-4455 (Office).

______________________________________ _______________

Physician's Signature Date

If there is a reason(s) why the above mentioned individual should not participate in this study, please explain.

APPENDIX E

Informed Consent Form

INFORMED CONSENT

I, ______________________________________ give my consent for participation in the research study entitled "The Chair Sit-To-Stand Test as a Measure of Leg Strength in Older Adult Women" which is being conducted by ERICK McCARTHY, phone number 542-3389 (Lab) or 543-1849 (Home), under the direction of DR. MICHAEL HORVAT, phone number 542-4455 (Office), University of Georgia, Department of Physical Education and Sport Studies. I understand that this participation is entirely voluntary. I can withdraw my consent at any time without penalty and have the results of the participation returned to me, removed from the research records, or destroyed.

1. The following points have been explained to me:

a. The purpose of the study is to validate the chair sit-to-stand test as a measure of leg strength in older adult women. A secondary purpose is to determine the relationship between leg strength and performance of other physical function tests (e.g. 8 foot Up-and-Go test, stair-climb test, and one-legged balance test) in older adult women.
b. The potential benefits participants may expect from participating in this study include knowledge of their hip, knee, and ankle strength, and how the strength at each of these joints may relate to their successful performance on physical function tasks such as chair sit-to-standing, standing-up and walking, stair-climbing, and balancing.

2. The procedures are as follows:

All participants will need to provide a signed physician's clearance form and complete a Physical Activity Readiness Questionnaire (PAR-Q), and Health and Exercise History forms before being able to participate. This study will require two separate days of testing, with approximately five to seven days between each test session. Test Day #1 will last about one hour and include a University of Georgia Movement Studies Lab familiarization session, collection of height, weight, percent body fat, and completion of two chair sit-to-stand tests (30 sec. chair sit-to-stand test and the five-chair stand test), an 8 foot Up-and-Go test (time to stand up from a chair walk 8 feet and return to the seated position), a stair climb test (time needed to climb 10 steps), and a one-legged balance test (ability to stand on one leg, 10-sec. maximum). Test Day #2 will last about two hours and involve testing the isokinetic strength of the hips, knees, and ankles on both the right and left legs using a Cybex Isokinetic Strength Machine. All testing will be conducted in the Movement Studies Laboratory at the University of Georgia.

Before strength testing, each participant will complete a five-minute stationary bicycle warm-up at an unloaded work level followed by about five min. of stretching led by Erick McCarthy. Each participant will then be seated on the Cybex Isokinetic Strength Machine and complete strength testing for their hips, knees, and ankles on both the right and left legs.

Isokinetic strength testing of the hips, knees, and ankles involves producing a maximum effort of muscular force through a full range-of-motion for five repetitions. Before actual testing, each participant will complete 3-5 sub-maximal warm-up repetitions to become familiar with the procedures. The warm-up set will be followed by actual strength testing (1 set of 5 repetitions at 60 degrees/sec. for the hips, knees, and ankles). For each strength test, you will be instructed to "push and pull as hard and fast as you can" until test completion. If you experience any pain or discomfort during strength testing, the testing will immediately be terminated.

The physical function tests that will completed in this study include a 30-sec. chair sit-to-stand test, a five chair-stand test, an 8 foot Up-and-Go test, a stair-climb test, and a one-legged balance test. A 17-in. chair without arms will be used for both chair sit-to-stand test protocols and the 8- foot Up-and-Go test. The 30 sec. chair sit-to-stand test involves counting the number of times you can stand-up and sit-down in a chair in 30 sec. without using your arms. The five chair-stand test involves calculating the amount of time needed for you to complete five chair-stands without using your arms. The 8 foot Up-and-Go test involves calculating the amount of time needed for you to stand up from a chair, walk forward 8-feet and return to the chair and sit. The stair-climb test involves calculating the amount of time it takes you to climb 10 steps. The one-legged balance test involves calculating the amount of time you can balance on either your right or left leg (10 sec. maximum). After a demonstration by Erick McCarthy, adequate practice time will be given before actual testing of each physical function test. Two trials of each test will be completed and the mean score will be used in the analysis.

3. The discomforts that you may experience during this study may include a small risk for muscle strain or muscle fatigue during strength testing. There is a very minimal risk of heart attack associated with any vigorous muscular activity. The warm-up and stretching sessions will assist in minimizing any muscular discomfort, while strict supervision of each testing session will ensure that you are performing each movement safely and correctly. All laboratory testing will be supervised by Erick McCarthy. Any discomfort will result in immediate cessation of activity. I am CPR certified, hold a M.S. in Exercise Physiology and have 11 years experience as a physical activity leader for younger and older adults. Emergency plans are in place in the Movement Studies Laboratory if they are needed.

4. The results of this study will be confidential and will not be released in any individually identifiable form without my prior consent, unless otherwise required by law. Code numbers will be used to conceal participant identities. The code list identifying names will be kept exclusive and secured.

5. Both my major professor (Dr. Michael Horvat) and I will answer any questions about this research now or during the course of the project. You can reach me by phone at 542-3389 (Movement Studies Laboratory), 543-1849 (Home),or e-mail: erickmccarthy@hotmail.com, or 542-4455 (Dr. Michael Horvat, Office).

Researcher	Date	Participant	Date

Research at the University of Georgia which involves human participants is overseen by the Institutional Review Board. Questions or problems regarding your rights as a participant should be addressed to Ms. Julia Alexander, M.A., Institutional Review Board, Office of V.P. for Research, The University of Georgia, 606A Graduate Studies Research Center, Athens, GA 30602-7411, Phone (706) 542-6514.

APPENDIX F

Physical Activity Readiness Questionnaire (PAR-Q)

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

A SELF-ADMINISTERED QUESTIONNAIRE FOR ADULTS

Name ____ Date _______________________

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and the completion of the PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

For most people, physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be in appropriate or those who should have medical advice concerning the type of activity most suitable to them.

Common sense is your best guide in answering these questions. Please read then carefully and check YES or NO opposite the question as it applies to you.

YES	**NO**	
___	___	Has a doctor ever said that you have a heart condition and recommended only medically supervised activity?
___	___	Do you have chest pain brought on by physical activity?
___	___	Have you developed chest pain in the past month?
___	___	Do you tend to lose consciousness or fall over as a result of dizziness?
___	___	Do you have a bone or joint problem that could be aggravated by the proposed physical activity?
___	___	Has a doctor ever recommended medication for your high blood pressure or heart condition?
___	___	Are you aware through your own experience, or a doctor’s advice, of any other physical reason against your exercising without medical supervision?

If you answered YES to any of the above questions, please consult with your physician to determine whether or not the physical activity required for this study is inappropriate based on your medical history or current medical condition.

APPENDIX G

Medical History Form

MEDICAL HISTORY FORM

Name ________________________________ Age __________
Date of Birth ___________

1. List Hospitalization History

Age of Hospitalization	Reason for Hospitalization	Duration of Stay

2. List All Medications Currently Taking

Medication	Dose	Purpose

3. Family History of Heart Disease or Stroke (please indicate immediate family members…parents, siblings, aunts, uncles…who have been diagnosed with heart disease or stroke, or who have died from heart disease or stroke). Please list relationship, type of disease, age of diagnosis, and age at death if necessary.

____
____
____
____
____

4. Do you currently or have you ever experienced any cardiovascular problems, musculoskeletal problems, orthopedic problems, hip, knee, or ankle joint problems, low-back problems, diabetes, arthritis, or any other medical/health condition that might prevent you from participating in this research study?

____
____
____
____

APPENDIX H

Exercise History Form

EXERCISE HISTORY FORM

1. Over the course of your life, what physical activities have you participated in for extended periods of time?

____
____
____
____
____

2. Over the past two years, what physical activities have you participated in regularly (weekly)? Please be specific with the type of activity, duration, frequency/week, and intensity.

____
____
____
____
____

3. Have any physical activities listed above given you discomfort or pain (e.g. hip, knee, or ankle pain, extreme fatigue, dizziness, etc.). Please be specific.

____
____
____
____
____

4. Please list any medical or physical conditions that may inhibit your participation in the physical activities described in the consent form.

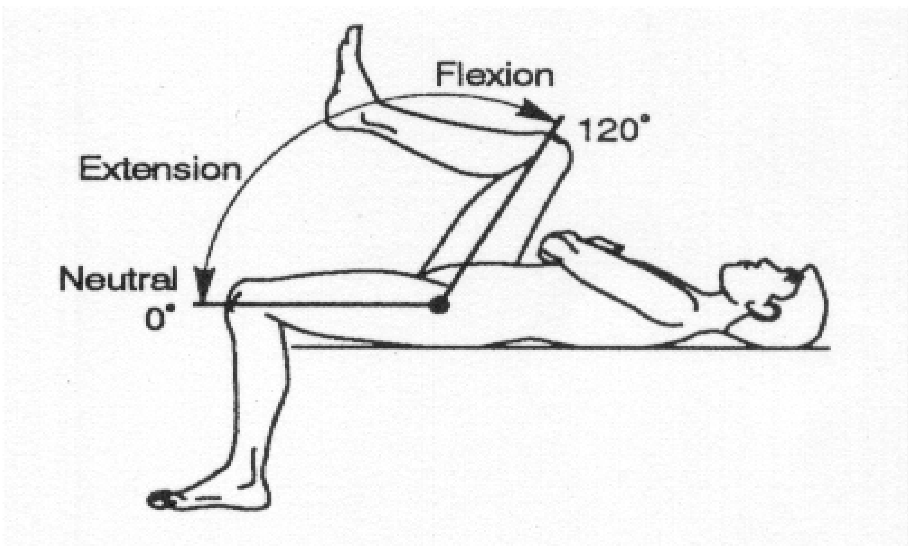
____
____
____
____
____

5. Please provide a short autobiography (e.g. education, career, family, hobbies, etc.).

____
____
____

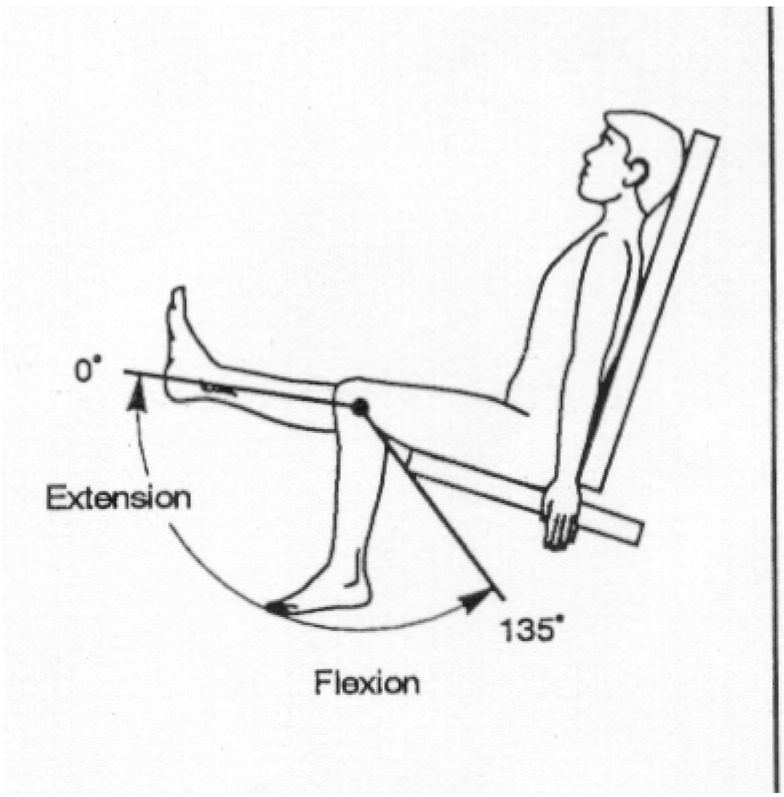
APPENDIX I

Isokinetic Hip Extensor/Flexor Strength Testing Position


Flexion
120°
Extension
Neutral
0°

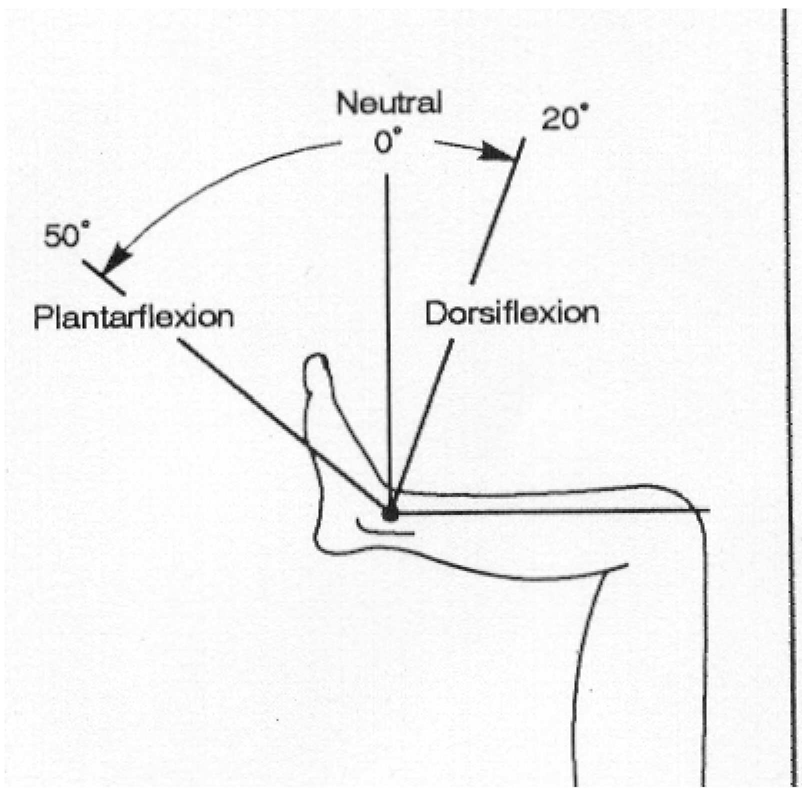
APPENDIX J

Isokinetic Knee Extensor/Flexor Strength Testing Position


0°
Extension
135°
Flexion

APPENDIX K

Isokinetic Ankle Plantar/Dorsiflexor Strength Testing Position


Neutral
0°
20°
50°
Plantarflexion
Dorsiflexion