Effectiveness of Eccentric, Concentric, and Combined

Resistance Training Programs on Development of Functional Strength

in College Age Females

by

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Abstract

The purpose of this study was to compare the effectiveness of three different lower extremity resistance training programs in developing functional strength in college-age females. The three resistance training programs were differentiated by the contractile modes involved: eccentric, concentric, or combined eccentric and concentric. Ten college-age females were randomly assigned into one of three resistance training groups or a control group. The control group did no resistance training. Participants in the resistance training groups completed two resistance training sessions per week for eight-weeks. During each resistance training session the participants completed three sets of 6-8 repetitions of a standing back squat exercise. Participants in the eccentric group only lowered the weight during each repetition. Participants in the concentric group only lifted the weight during each repetition. Participants in the combined eccentric and concentric group executed a complete squat by lowering and raising the weight during each repetition. A modified stair ascent was used to assess functional strength before and after the 8-week resistance training program. The maximum percentage of body weight that a participant was able to carry up 60 steps was the measure of functional strength. Participants carried the additional weight in a weight vest and ankle weights. The participants in the resistance training groups significantly increased the percentage of body weight carried between the pre- and post-assessment by 13%, $p = 0.003$. The weight carried by the control participant did not change between the pre- and post-assessments. This supports the notion that resistance training programs have a transfer of training effect to functional strength. However, the gain in functional strength was not significantly different between the three resistance training groups.

Preface and Acknowledgements

I would like to start by thanking the students, who gave their time to assist during the pilot studies, and those who served as participants and personal trainers within my study. I would like to acknowledge and thank their instructors who allowed me access to their students. I would like to also thank my thesis committee: Dr. James Hokanson (Chair), Dr. Katherine Polasek, and Dr. Peter McGinnis for their role in making my education at SUNY Cortland enjoyable, challenging, and successful. I would also like to thank Dr. Joy Hendrick who fielded numerous questions and offered me inspirational words of encouragement along the way. A special thanks to Dr. Phil Buckenmeyer for an insightful conversation on the role of a graduate student researcher during challenging times. Finally, I am especially grateful for my wife's never ending love, patience, and support.

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Chapter I

Introduction

Muscular strength is essential for health, functional ability, and enhanced quality of life (Kraemer et al., 2002). Resistance training is the most effective method for developing musculoskeletal strength; it is endorsed by many health organizations (i.e., American College of Sports Medicine, American Heart Association, and the Centers for Disease Control) for improving health and fitness (Brill, Marcera, Davis, Blair, & Gordan, 2000; Garber et al., 2011; Haskell et al., 2007; Kraemer et al., 2002; Kraemer & Ratamess, 2004; Stone, Collins, Plisk, Haff, & Stone, 2000). Resistance training also improves cardiovascular health, lowers the risk of all-cause mortality, benefits endocrine and serum lipid adaptations, increases lean body mass, decreases adipose tissue, increases tissue tensile strength, decreases physiological stress, and increases functional strength (Garber et al., 2011; Kraemer & Ratamess, 2004; Stone, et al., 2000).

Limited research has demonstrated that resistance training leads to significant increases in strength related functional performance (Häkkinen, Alen, Kallinen, Newton, & Kraemer, 2000; Lemmer et al., 2000; Stone et al., 2000) and can produce changes in functional ability and capacity (Stone et al., 2000). Researchers have also concluded that resistance training programs need to include both concentric and eccentric muscle actions (Kraemer et al., 2002; Kraemer & Ratamess, 2004; Stone et al., 2000). This parallels with the human body's natural movement, as it requires both eccentric and concentric actions to successfully navigate the environment on a daily basis (Kraemer et al., 2002). However, research also suggests eccentric-only resistance training programs may be superior because they have the potential for maximum strength gains due to a greater force output, greater energy efficiency, and causing less fatigue (Hortobágyi et al., 1996; Kraemer et al., 2002). However, there is limited research that compares the different modes of resistance training to determine which is most effective and, more importantly, how resistance training contractile modes can be assessed in functional strength ability (Kraemer et al., 2001).

Functional strength is the ability to perform safely, and without excessive fatigue, daily activities needed to maintain independence (Collins, Roomeny, Smalley, & Haven, 2004; Toraman & Ayceman, 2005). Quadriceps strength has been identified as one of the first areas of strength decline due to aging, which can result in the limitation of daily activities (Al-Abdulwahad, 1999; Bean, Kiely, Larose, Alian, & Frontera, 2007; Buchner, 1997; Hurley, Rees, & Newham, 1998; Wolfson, Judge, Whipple, & King, 1995). Tiedemann, Shimada, Sherrington, Murray, and Lord (2008) identified the inability to negotiate stairs as a marker of functional strength decline. Knowing that eccentric and concentric muscle action are involved in stair ascent (DeVita, Helseth, & Hortobágyi, 2007), the present research design utilized a functional strength assessment and lower-extremity resistance training program to match the functional skill that was tested (i.e., ability to negotiate stairs).

Functional strength decline begins in the third decade, ranging from 20-80% decline of leg strength by the eighth decade (Al-Abdulwahad, 1999; Wolfson et al., 1995). In addition, lower muscle mass is associated with lower muscle strength and is thought to also contribute to the development of functional limitations in older age. Women have less muscle mass than men throughout their lifespan; this may put females at a greater risk for falls and fractures that may result in disability later on (Newman et al., 2003).

Within the health education literature, primary prevention is defined as the ability to prevent disease or a negative health outcome before it occurs; it is the most effective approach to preventing disease to the individual as well as the community (Donatelle, 2012). Since functional strength starts to decline well before elderly and resistance training is proven to be an effective prevention method, it is prudent to address functional strength decline within the college-age female population, at a period before it becomes responsible for altering lives.

The outcome of this study may lead to better prescription of lower-extremity resistance training programs based on functional strength goals in a healthy population. The intent was that professionals would be able to utilize a proven resistance training contractile mode (i.e., eccentric-only, concentric-only, and combined eccentric and concentric) in their programs. Finally, this study provided a tested functional strength assessment protocol for a modified stair ascent assessment which can be used to measure lower extremity functional strength.

Statement of Purpose

The purpose of this study was to compare the effectiveness of three different lower extremity resistance training programs in developing functional strength in college-age females. The three resistance training programs were differentiated by the contractile modes involved: eccentric, concentric, or combined eccentric and concentric.

Research Hypothesis

It was hypothesized that participation in an eight-week lower extremity eccentric-only resistance training program would result in greater functional strength outcomes than a lower extremity concentric, combined concentric and eccentric resistance program, or the control group.

Null Hypothesis

There was no significant difference between eccentric, concentric, combined eccentric and concentric resistance training, and the control in functional strength outcomes.

Limitations

The study was limited in that:

1. Self-assessment feedback was dependent on the participant's individual perceptions.
2. Personal trainers were appropriately trained and able to follow the resistance training protocol.
3. Participants were able to successfully complete the standing back squat.

Delimitations

The study was delimited to the following:

1. The participant population was limited to college-age female population.
2. Participants were asked to not be involved in any strenuous exercise or extraneous physical activities outside of the resistance training program.
3. Participants were free from conditions that would limit their participation in a resistance training program.

Assumptions

It was assumed that:

1. Participants demonstrated maximal effort and followed directions during their training sessions and pre- and post-assessments.

2. Student personal trainers were knowledgeable about the resistance training protocols and uniform in their practice.
3. Selection of participants was random and resulted in a normal distribution of college-age females.
4. The functional strength stair ascent assessment was an accurate assessment of strength gain as a result of the resistance training program.

Operational Definitions

1. College-age: individuals between the ages of 18 – 28 years.
2. Elderly: individuals that are over the age of 65 years (Hurly, Rees, & Newham, 1998).
3. Functional strength: the ability to perform safely, and without excessive fatigue, daily activities necessary to maintain independence (Collins et al., 2004; Toraman & Ayceman, 2005). For this study functional strength was assessed by the maximum percentage of body weight that a participant could carry while successfully climbing sixty steps.
4. Resistance training: when skeletal muscle groups undertake short repeated bouts of repetitive contractions under high-loads for the primary goal of increasing muscle hypertrophy and strength (Coffey et al., 2007).
5. Resistance training contractile mode: the type of muscle contraction that is used during a specific resistance training program. For purposes of this study, there are three different resistance training contractile modes: 1) eccentric-only, 2) concentric-only, and 3) combined concentric and eccentric.

a. Concentric muscle contractions occur when muscles shorten while developing tension.

b. Eccentric muscle contractions occur when muscles lengthen while developing tension.

6. "Transfer-of-training effect: the degree of performance adaptation that can result from a training exercise and is strongly related to specificity" (Stone et al., 2000, p.66).

7. Workload tolerance: the level of physical exertion where an individual reaches a state of voluntary exhaustion.

Chapter II

Review of Literature

The purpose of this study was to compare the effectiveness of three different lower extremity resistance training programs in developing functional strength in college-age females. The three resistance training programs were differentiated by the contractile modes involved: eccentric, concentric, or combined eccentric and concentric.

The first portion of this chapter contains a review of literature pertaining to functional strength. The following aspects of functional strength are discussed: a) definition, b) impact of aging on functional strength, and c) modern technologies impact on functional strength.

The second portion of this chapter contains a review of literature pertaining to neuromuscular physiology. The review is broken down into three sections: a) basic neuromuscular physiology, b) comparison of eccentric, concentric and isometric muscle actions, and c) different resistance training modes and methods. At the end of this section, the different principles and best practices are reviewed in terms of resistance training to include: a) intensity, b) volume, c) exercise selection, and d) velocity. As the participants in this study were females, an analysis of the literature as it pertains to females and neuromuscular physiology is provided.

The third portion of this chapter contains information pertaining to functional strength assessments. A brief overview to the history of functional strength assessment is provided, along with how functional strength assessments are currently being used. Finally, this section concludes with a discussion on the various stair assessment tests that exists, their limitations for general use and an inclusion of a weight vest to these assessments.

Functional Strength

Functional strength is the ability to perform safely, and without excessive fatigue, daily activities necessary to maintain independence (Collins et al., 2004; Toraman & Ayceman, 2005). Muscular strength is essential for health, functional ability (i.e., functional strength), and enhanced quality of life (Kraemer et al., 2002). Muscle mass and strength both decline with age (Al-Abdulwahad, 1999; Buchner, 1997; Hunter, McCarthey, & Bamman, 2004; Lemmer et al., 2000; Runge, Rittweger, Russo, Schiessl, & Felsenberg, 2004; Sheapard, 1997; Wolfson et al., 1995). The loss of muscle mass is directly linked to declining strength. The decline in strength is associated with an increased risk of falls, loss of mobility, fractures, loss of bone density, adverse physiological changes, development of sedentary behaviors, and reduction in physical activities. This can lead to functional limitations in activities of daily living and ultimately can compromise one's health status (Collins et al., 2004; Lemmer et al., 2000; Lindle et al., 1997; Runge et al., 2004).

Aging. Aging poses a challenge to preserve skeletal muscular performance (Buchner, 1997). Skeletal muscle strength and associated coordination of the lower extremities declines with aging, which in turn is directly responsible for a decline in mobility. Strength decline is directly associated with a decreased level of daily activity performance as was evident by a high percentage of individuals, over the age of 55 years, that reported difficulty walking 0.4 km or carrying 11kg (Shephard, 1997). Quadriceps strength has been identified as one of the first areas of physical decline, which can lead to a greater chance of falls, thus limiting daily activities (Al-Abdulwahad, 1999; Bean et al., 2007; Buchner, 1997; Hurley et al., 1998; Wolfson et al., 1995). Quadriceps strength is extremely important for daily functional activities such as: proprioception that directly affects postural stability, stair climbing, and standing from a seated position (Buchner, 1997; Buchner, Larson, Wagner, Koepsell, & DeLateur, 1996; Hurley et al., 1998; Wolfson et al., 1995). Tiedemann et al. (2008) identified the inability to negotiate stairs as a marker of functional strength decline.

Functional strength decline begins in the third decade, ranging from 20-80% decline of leg strength by the eighth decade (Al-Abdulwahad, 1999; Wolfson et al., 1995). Fortunately, resistance training leads to significant increases in strength related functional performances (Häkkinen et al., 2000; Lemmer et al., 2000; Stone et al., 2000) and can have a transfer-of-training effect resulting in changes in functional ability and capacity (Stone et al., 2000). A decline in muscle mass is associated with lower-extremity strength loss which is thought to contribute to the development of functional limitations in older age (Newman et al., 2003).

Modern technology. Modern technology has reduced the need for manual labor and force production during activities of everyday living. Technological advancements are the secondary cause of functional strength decline across all age groups (Haskell et al., 2007); the primary cause is aging (Lemmer, 2000; Sheapard, 1997). Technology encourages a sedentary lifestyle (i.e., elevators have replaced stair climbing, computers with free physical play, and machinery with manual labor) (French, Story, & Jeffrey, 2001; Haskell et al., 2007). Even basic resistance exercises are being replaced with machines that market the message of making exercise easier, which ironically is often less effective (Stone & Borden, 1997). For example, Stone and Borden (1997) demonstrated that individuals using free weights produce superior strength gains, and have a greater cross-training effect to functional activities than stationary weight machines. In addition, free weight exercises biomechanically mimic natural human movements more so than those using resistance machines.

Neuromuscular Physiology

There are 640 skeletal muscles in the human body (Baechle & Earle, 2008; Kraemer, Fleck, & Deschenes, 2012; Stone, Stone & Sands, 2007), which account for 45% of the human body's mass and contain over 250 million muscle fibers (Buchner, 1997). According to Buchner (1997), if all the muscle fibers contracted simultaneously, theoretically they would produce a force of 25 tons. Muscle hypertrophy is a multi-dimensional phenomenon based on motor unit recruitment via external load increase, metabolic, and hormonal adaptations that affect protein translation through mechanical signal pathways (Kraemer & Ratamess, 2004). Wilmore, Costill, and Kenny (2008) classified muscle hypertrophy into two subgroups: transient and chronic. Transient hypertrophy is edema accumulation that occurs immediately after a bout of resistance training; it typically lasts one hour. Chronic hypertrophy is the increase or enlargement of muscles due to structural changes in the individual muscle fibers. This causes fiber hypertrophy resulting from long-term repeated bouts of high intensity anaerobic work or resistance training.

Resistance training is the recognized primary mode to invoke chronic muscle hypertrophy (Baechle & Earle, 2008; Coffey et al., 2007). Two factors contribute to muscular strength gains: neural adaptation and hypertrophy (Staron et al., 1994). Chronic (noticeable) hypertrophy will not occur in the very early phases of strength training; strength gains during this phase are associated with neural adaption (Gabriel, Kamen, & Frost, 2006; Kraemer et al., 2002; Staron et al., 1994). Skeletal muscle hypertrophy cannot transpire without muscle contractions. The overall strength of a given muscle or muscle group is directly proportional to the degree of (chronic) hypertrophy (Coffey et al., 2007; Kraemer et al., 2002; Tan, 1999) which becomes noticeable after 6-8 weeks (Kraemer et al., 2002; Staron et al., 1994).

Chronic muscle hypertrophy is a derivative of force production through muscle contractions, which arise during a sequence of events beginning with a stimulus that increases the workload to the muscle. When stimulated, the long bundles of multinucleated muscle fibers produce force. During force production the myofibrils, which are encompassed by the fasciculus, will increase the contractile proteins actin and myosin (Baechle & Earle, 2008). The actin and myosin filaments combine to form an actomyosin complex. As soon as this reaction occurs, the myosin crossbridge heads pull the actin towards the center of the sarcomere, causing the sarcomere to shorten, which produces force (Baechle & Earle, 2008). Simultaneously as the number of myofibrillar increase, newly formed myofibrils are added to the existing myofibrils. The key outcome is that both events result in an increase of the muscle size (Baechle & Earle, 2008; Bickel, Cross & Bamman, 2011; Kraemer et al., 2012). Even still, the size, number, and density of the preexisting myofibrils are never altered (Kraemer et al., 2012) and it is unclear whether the hypertrophic effect is a result of increase in cellular proteins or myofibrillar proteins or both (Kraemer et al., 2002).

Skeletal muscle is composed of six different muscle fiber types. The muscle fiber types are based on their pH sensitivity (I, IC, IIC, IIA, IIAB, and IIB) (Baechle & Earle, 2008; Staron et al., 1989; Tan, 1999). The number of Type I and Type II fibers, in relationship to each other, are established shortly after birth, but can be influenced by certain activities (Kraemer et al., 2012). In response to muscular contraction events, Type II fiber types must be activated by a habitual and progressive stimulus. This is completed through high-intensity anaerobic work in order to promote the hypertrophic effect of skeletal muscle. During high-intensity anaerobic work, like resistance training, both Type I and Type II muscle fibers are recruited and consequently presented a stimulus for hypertrophic adaptation. Although resistance training typically results in the increase of both Type I and Type II fiber area, the hypertrophic effect does not occur uniformly. Type II fibers exhibit a greater increase in size than Type I fibers (Baechle & Earle, 2008; Bickel et al., 2011; Campos et al., 2002; Kraemer et al., 2004; Staron et al., 1995, 1989; Tan, 1999). Further established by Staron et al. (1989) and then McCall, Byrnes, Dickinson, Pattany, and Fleck (1996) and later by Bickel et al. (2011), resistance training leads to the result of an increase of Type II fiber area at a significantly higher hypertrophic proportion than a Type I fiber area. Even though the potential for muscle hypertrophy resides in the ratio of Type II fibers within a given muscle (Baechle & Earle, 2008; Gardiner, 2011), it is directly related to the increase of workload potential through the development of strength (Farthing & Chilibeck, 2003).

Eccentric, concentric, and isometric muscle actions. There are three basic muscle actions: concentric, eccentric, and isometric. During the concentric action phase, the muscle involved is shortened due to the muscle force exceeding the resistance (Baechle & Earle, 2008; Kraemer et al., 2012; McArdle, 2010). This is accomplished by the actin and myosin filaments increasing their overlapping actions as the muscle shortens (a cross-bridge movement). Because of the overlapping actions during concentric contractions, force output decreases exponentially with increasing contraction velocity (Hortobágyi & Katch, 1990).

During eccentric action, the muscle that is involved lengthens due to resistance exceeding muscle force production. Eccentric action can take place one of two ways; a muscle exerts maximal force, but is unable to exceed the resistance or an individual allows the muscle to increasingly lengthen during force production (Baechle & Earle, 2008; Kraemer et al., 2012; McArdle, 2010). In contrast to concentric actions, during eccentric actions the cross-bridge attachments rip apart as the muscle attempts to resist lengthening. This allows the muscle to produce a much higher force during eccentric actions (Roig et al., 2009; Seger & Thorstensson, 2005; Vikne et al., 2006). The force output in eccentric contractions will progressively increase with the contraction velocity rate (Hortobágyi & Katch, 1990). This is supported by research that states Type II fiber area increases approximately ten times more after eccentric training than concentric training (Hortobágyi et al., 1996).

In addition, eccentric training is much more energy efficient (Hortobágyi et al., 1996; Kraemer et al., 2002; Roig et al., 2009) in comparison to concentric actions which require greater metabolic demand placing the muscles in a hypoxic state (Hortobágyi et al., 1996). Hortobágyi et al. (1996) further contributed that the force potential of concentric training was not achievable due to the fact that concentric training has a higher metabolic cost, which causes participants to fatigue. Therefore, eccentric training is much more energy efficient, thus allowing for maximal force production and causing less fatigue.

Isometric action takes place when the myosin head keeps attaching and detaching at the same active site on the actin filament. There is no visible movement occurring in the muscle as the force is being developed by the muscle attempting to shorten (Baechle & Earle, 2008; Kraemer et al., 2012; McArdle, 2010).

In relationship to concentric and eccentric actions, there is substantial evidence that both neural and muscle fiber adaptations to concentric and eccentric training are different

(Blazevich, Cannaven, Coleman, & Horne, 2007). Historically, resistance training programs have focused solely on two different training methods: concentric muscle contractions (Kraemer et al., 2002) and isometric. While eccentric actions have begun to be emphasized in resistance training programs, only modest research has been conducted to show the true value of eccentric training (Kraemer et al., 2002; Lindstedt, LaStayo, & Reich, 2001). At least three studies have compared the different resistance training contractile modes and these three studies all showed no significant difference in strength outcome (Ben-Sira, Ayalon, & Tavi, 1995; Blazevich et al., 2007; Nickols-Richardson et al., 2007). Reeves et al. (2009) determined that both the combined eccentric and concentric, along with the eccentric-only group increased strength significantly; however, the increase was greater in the eccentric-only group (Reeves et al., 2009). This parallels the results of an earlier study that demonstrated greater quadriceps strength in eccentric compared to concentric following a 6-week leg extension using an isokinetic dynamometer (Hortobágyi et al., 1996).

Researchers have concluded that resistance training programs typically include both concentric and eccentric muscle actions and isometric muscle actions as secondary (Kraemer et al., 2002, 2004; Stone et al., 2000). This parallels with the human body's natural movement, as it requires both eccentric and concentric actions to successfully function (Kraemer et al., 2002). Eccentric muscle actions play a vital role in the normal activities that provide stabilization and deceleration (Lindle et al., 1997). Additionally, there is evidence that demonstrates the potential of eccentric training programs (Reeves et al., 2009).

Resistance training mode and methods. Traditionally resistance training was limited to specific sports such as bodybuilding and weightlifting. Now, it has become so common that when sports do not utilize a resistance training program, it is the exception rather than the norm (Kraemer et al., 2004; Tan, 1999). Resistance training programs have been shown to be the most effective method for developing musculoskeletal strength and are currently prescribed by many major health organizations for improving health and fitness (i.e., American College of Sports Medicine, American Heart Association, and the Centers for Disease Control) (Brill et al., 2000; Garber et al., 2011; Haskell et al., 2007; Kraemer et al., 1999, 2002, 2004; Stone et al., 2000).

The physical changes resulting from resistance training programs produce improved cardiovascular health, a lower risk of all-cause mortality, beneficial endocrine and serum lipid adaptations, increased lean body mass, decreased adipose tissue, increased tissue tensile strength, decreased physiological stress, and increased functional strength (Garber et al., 2011; Kraemer & Ratamess, 2004; Stone et al., 2000). The development of muscular strength is directly linked with improved functional strength (Skelton, Greig, Davies, & Young, 1994). Maintenance of strength throughout the lifespan may reduce the prevalence of functional limitations (Brill et al., 2000; Munn, Herbert, Hancock, & Gandevia, 2005). Even still, very little research has been conducted on resistance training parameters (Munn et al., 2005).

To invoke chronic muscular hypertrophy and directly increase strength, the neuromuscular system needs to be placed in a stressful state. When faced with increasing demands the neuromuscular system adapts by creating an increase in muscular strength (Rhea, Alvar, Ball, & Burkett, 2002). Once the neuromuscular system adapts there no longer remains a demand on the system and the adaptation slows and eventually ceases (Rhea et al., 2002). Resistance training is the recognized primary mode to invoke chronic muscle hypertrophy and strength (Baechle & Earle, 2008; Coffey et al., 2007). Resistance training consists of skeletal muscle groups' under-taking short repeated bouts of repetitive contractions under high-loads for the primary goal of increasing muscle hypertrophy and strength (Coffey et al., 2007). The goal of an optimal resistance training program is the prevention of the neuromuscular systems adaptation by applying the progressive overload principle and manipulation of the training program variables (i.e., volume, intensity, recovery and resistance types) (Baechle & Earle, 2008; Rhea et al., 2002; Tan, 1999).

In order to develop muscular strength, basic principles for a resistance training program need to be followed. Although the literature varies on agreement of components that make an optimal program, it is unanimous on the use of intensity and the overload principle (Rhea et al., 2002). Stone (2000) views overload variation and specificity as the primary principles of resistance training, whereas Kraemer et al. (2004) expanded on that to include eight variables: muscle actions, resistance, volume, exercise selection and workout scheduling, sequence of exercises, rest intervals, velocity, and frequency. Tan (1999) limited the variables to training intensity and volume, stating that all other factors were related to these two variables. Finally the National Strength and Conditioning Association (NSCA) classifies them into seven areas categorized as: needs analysis, exercise selection, training frequency, exercise order, training load and repetitions, volume, and rest periods (Baechle & Earle, 2008). The choices involved in the development of a resistance training program can have considerable consequences to the outcome (Stone & Borden, 1997).

Intensity. Schlumberger, Stec, and Schlumberger (2001) demonstrated that resistance training at high intensity is one important factor to increase muscular strength. Jones, Bishop, Hunter and Fleisig (2001) demonstrated that heavier training loads, defined as a 70-90% of 1-RM resulted in superior outcomes over light training loads, defined as 40-60%

of 1-RM. Tan (1999) demonstrated that strength increases are associated with greater than 80% of 1-RM with concentric contractions and 100-120% of 1-RM with eccentric contractions. Tan concluded that the variation of loads from one set to another is ineffective and thus unnecessary for producing strength gains. Kraemer et al. (2001) determined that greater hypertrophy is associated with high-volume. This is defined as 70-85% of 1-RM for novice and intermediate, and 70-100% for advanced; each completes multiple sets of 8-12 repetitions. Although the literature has revealed the optimal range of intensities for strength development, it is complicated by the interplay between intensity (load) and volume (repetitions) (Tan, 1999). Robinson et al. (1995) demonstrated that longer rest periods lead to greater increases in strength than shorter rest periods. Furthermore, longitudinal resistance training studies show greater strength increases with longer rest periods such as two-three minutes compared to 30-40 seconds (Kraemer et al., 2002).

Volume. It has been proven that multiple-set resistance training resulted in greater strength increase whereas single-set resulted in strength decrease (Kemmler, Lauber, Engelke, & Weineck, 2004). Schlumberger et al. (2001), Rhea et al. (2002), Stone et al. (1998) and Starkey et al. (1996) further demonstrated that superior strength gains occurred following a 3-set training versus a single-set training regimen. Munn et al. (2005) calculated that three sets of exercises produced double the strength gain of one set.

Exercise selection. The sequencing of exercises significantly affects the acute manifestation of muscular strength (Kraemer et al., 2002). Multi-joint exercises have been shown to increase muscular strength and maximize functional performance, which are essential for optimal strength gain. A multi-joint exercise can affect as many as four to six muscle groups, thus being more metabolic and effective than a single-joint exercise (Stone & Borden, 1997).

Free weights can add a strong mechanical specificity to a number of functional tasks as compared to machines (Stone et al., 1997; 2000). Free weights produce superior strength gains because free weights allow for unlimited variation. Free weights also require balance and permit movement in multiple planes that are typical of functional movements. Free weights automatically confer neuromuscular, intermuscular coordination, and skill acquisition benefits not shown with machine use (Kraemer et al., 2002).

Velocity. There is conflicting evidence regarding the velocity needed for the optimal resistance training program to increase strength. Munn et al. (2005) discovered that a fast repetition rate of 140° per second resulted in 11% greater strength increase compared with a slower repetition speed of 50° per second. Keeler, Finkelstein, Miller, and Fernhall (2001) demonstrated that a resistance training program using a concentric speed of two seconds per repetition and an eccentric speed of four seconds per repetition had significantly greater increase in strength (39%) compared to a resistance training program using ten seconds per repetition for the concentric action and five seconds per repetition for the eccentric action (15%). However, Poliquin (1988) hypothesized that training at slow repetition speeds would be advantageous compared to high speeds in developing muscular mass and strength. Researchers demonstrated that ten seconds per one concentric and one eccentric contraction was superior compared to six seconds per one concentric and one eccentric contraction. This illustrates that a slower repetition speed raises the force curve and augments both duration of stimulus and the levels of tension on the muscle while eliminating momentum.

Blazevich, Cannavan, Coleman, and Horne (2008) contend that, if a resistance training program goal is to increase functional performance, both fast and slow repetition speeds need to be employed. This is because the time available for force production in functional activities is limited to 50-250 milliseconds (ms), which is less than the time needed for maximum force production (300 ms). Functional activities are performed for extended periods of slow-speed action (concentric and eccentric) with intermittence of rapid postural adjustments designed to preserve balance, occurring well before maximum muscle force production.

Resistance training and females. Historically females have avoided resistance training due to social stigmatism and misconceptions (Baechle & Earle, 2008). This is unfortunate considering that regular resistance training reduces the risk of osteoporosis, enhances functional performance, and improves overall health (Baechle & Earle, 2008; Durstine, Moore, Painter, & Roberts, 2009; Ehrman, Gordon, Visich, & Keteyian, 2009). Chronic muscular hypertrophy and strength can be achieved in females, but despite the growing number of females participating in resistance training, existing data is limited (Kraemer et al., 2004; Staron et al., 1998).

Research has demonstrated that in terms of absolute strength, females are able to achieve two-thirds of upper body and comparably equal lower body strength to males. This is in term of strength to hypertrophy ratios, which implies that there is no significant difference between the sexes. This indicates that muscle quality is not sex specific (Abe, DeHoyos, Pollock, & Garzarella, 2000; Baechle & Earle, 2008; Kraemer et al., 2000; Staron et al., 1989). Further research has demonstrated that heavy resistance training was effective in producing both upper and lower body strength, hypertrophy, and power in untrained females (Abe et al., 2000; Kraemer et al., 2001, 2004; Staron et al., 1989; Stone & Coutler, 1994).

Adaptability to resistance training is similar in females and males, however females plateau earlier in their response. Researchers indicate that initial strength gains are neural adaptations. Even still, there are intermuscular changes that occur exclusively in female muscles, which researchers believe to be a precursor for hypertrophy (Hortobágyi et al., 1996). Significant hypertrophy in the muscle Type II fibers have been found in women after six weeks of intense resistance training (Staron et al., 1994).

Functional Strength Assessments

Maintenance of strength throughout the lifespan may reduce the prevalence of functional limitations (Brill et al., 2000). Successful performance in one's daily tasks often requires several physical components, and these components can be difficult to assess and quantify functionally (Reiman & Manske, 2009). Typically, lower-extremity functional strength in healthy populations is measured by the one repetition maximum (1-RM) test. The assumption inherent with the 1-RM test is that there will be a significant cross-over effect, where demonstration of maximum strength can be converted into an accurate measurement of functional strength (Baechle & Earle, 2008). However, in reality all that is truly measured is maximum strength (Reiman & Manske, 2009).

The relationship between laboratory measurements of physical performance and how it relates to functional performance is not well understood. Additionally, assessments also result in a questionable relationship between the score measurement and functional strength (Skelton et al., 1994). Furthermore, Reiman and Manske (2009) demonstrated that physical performance testing assesses attributes (i.e., strength, proprioception) in a clinical setting.

Finally, physical attributes are a part of functional performance, but are not a functional test and do not correlate or have a cross-over effect to functional performance. The ultimate functional test is performance of the functional task. Assessments that measure occupational performance focus on mimicking the actual job tasks. Data obtained from this type of research has resulted in resistance training interventions being designed so that individuals increase their ability to perform physically demanding jobs (Kraemer et al., 2001; Plat, Frings-Dresen, & Sluiter, 2010; Williams-Bell, Villar, Sharratt, & Hughson, 2009; Yanovich et al., 2008).

Studies on functional strength performance assessments primarily look at mobility in the elderly. Because mobility is directly related to the risk of falls, the emphasis of assessments has been not on functional strength, but whether or not a judgment can be placed on an individual's independent living status. These assessments attempt to mimic daily functional activities and are used as predictors of falls (Buchner, 1997; Buchner, Larson, Wagner, Koepsell, & DeLateur, 1996; Collins et al., 2004; Enright, 2003; Hurley et al., 1998; Lindsay, James, & Kippen, 2004; Tiedmann et al., 2008; Wolfson et al., 1995).

There are several tests that are used to assess functional strength in elderly. The Sit to Stand assesses the ability to stand from a seated position and includes repeated bouts of rising from a seated position in a chair to standing and then back again (Bean et al., 2007; Collins et al., 2004; Guralnik et al., 1995; Hurley et al., 1998; Tiedemann et al., 2008). The elderly also have many walk test assessments, which measure the ability to walk a certain distance in a predetermined amount of time (Enright, 2003; Guralnik et al., 1995; Hurley et al., 1998; Tiedemann et al., 2008). There is a Timed Up and Go test, which is a modified walk test starting and ending from a seated position on a chair (Collins et al., 2004; Hurley et al., 1998; Lindsay et al., 2004). Finally, there is a stair ascent and descent test, which assesses the ability of the elderly to walk up and down stairs (Hurley et al., 1998; Tiedemann et al., 2008). A major limitation to the above named tests is that that they lack external load carrying or lifting during the assessments. As Shephard (1997) demonstrated, a factor of falls in the elderly is balance loss due to postural sway because of the inability of the antagonist and agonist muscle to correct the sway when lifting or carrying an unaccustomed weight or performing an unpracticed skill.

As stated previously, Tiedemann et al. (2008) identified the ability to negotiate stairs as a marker of functional strength decline. Enright (2003) states that surgeons often determine a patients' survivability of surgery based on their ability to walk-up two to three flights of stairs afterwards. In addition, self-reported fitness questionnaires often include the question, "how many stairs can you climb?" Even still, the majority of functional assessments involving stairs have focused on cardiorespiratory fitness with little or no concern for functional strength (Boreham, Wallace, & Nevill, 2000; Eves & Masters, 2006; Meyer, Kayser, & Mach, 2009; Teh & Aziz, 2000).

A major limitation of stair assessments is the lack of uniformity in goals and extensive modifications of protocols making it difficult to assess and quantify the functional strength stair assessment. For example, the goal of the Margaria-Kalamen is to assess high-speed strength by having individuals (primarily athletes) run three steps at a time (third step to sixth step to the ninth step) for nine steps total. This is primarily an attribute assessment for explosive power and there is no correlation to functional strength (Hetzler et al., 2010). Stair ascent and decent assessments are also used to determine leg strength utilizing a vast number of steps ranging anywhere from 3 to 148 steps (Al-Abdulwahad, 1999; Hurley et al., 1998; Loy et al., 1994; Tiedemann et al., 2008). In addition, the stair ascent and descent assessment is also used to determine cardiorespiratory fitness including a protocol of 199 to 2280 steps (Boreham et al., 2000; Meyer et al., 2009; Teh & Aziz, 2000). Finally, the stair ascent and descent assessment has been used to measure functional strength, but in relationship to occupational needs (i.e., energetic peak load); steps used in these assessments number 60, 108, and 117 (Plat, 2010; Williams-Bell et al., 2009). There is a biological basis for consideration with the goals of the stair ascent and descent assessment. If the assessment outcome is a measurement of anaerobic capacity (i.e., functional strength) then the assessment cannot exceed 90 seconds. When 90 seconds is exceeded, maximal muscular power output is no longer assessed and the assessment then measures aerobic capacity (Baechle & Earle, 2008).

In addition, there is also variability in the use of external loads with weight vest in conducting stair ascent and descent test. Loy et al. (1994) researched the effects of a stair climbing exercise program with and without an external load on aerobic capacity and muscle strength. While not a part of the assessment, participants used a weight vest that was 8% of the participant's body mass during the star climbing exercise program. When conducting the firefighter candidate physical ability test, Williams-Bell et al. (2009) required the candidates wear 75 pounds (34.1 kg) of external load (weight vest or turn-out gear) and then determined the physiological demands placed on the candidates. Plat et al. (2010) was a continuation of Williams-Bell et al. research with the goal to evaluate the reproducibility and validity of the firefighter candidate physical ability test; this required participants to wear 90 pounds (40.9 kg).

Summary and Rationale

A significant void exists in each of the three research areas: 1) functional strength within college-age females, 2) what contractile mode of resistance training will have the greatest outcome in functional strength within college-age females, and 3) the development of an assessment tool for functional strength in college-age females. This study is intended to fill this void. Because there are few studies that make a direct comparison of different resistance training contractile modes to the adaptation of functional abilities (Kraemer et al., 2001), the purpose of this study was to determine which resistance training contractile mode when using a lower-extremity resistance training program will have the greatest impact on functional strength outcomes in college-age females. Because the literature suggests that eccentric contractile modes have potential for the greatest gains due to having a greater force output, being more energy efficient, and causing less fatigue (Hortobágyi et al., 1996; Kreamer et al., 2002), resistance training contractile mode is of most interest. The secondary purpose of this study is to contribute to the literature about functional strength assessments in the college-age female population.

Chapter III

Methods

The purpose of this study was to compare the effectiveness of three different lower extremity resistance training programs in developing functional strength in college-age females. The three resistance training programs were differentiated by the contractile modes involved: eccentric, concentric, or combined eccentric and concentric. It was hypothesized that participants who completed an eight-week lower extremity eccentric-only resistance training program would gain in functional strength outcomes significantly more than a lower extremity concentric-only or combined concentric and eccentric resistance program.

This chapter outlines the methods for the study. The following aspects of the methods are discussed: a) Participants, b) Groups and Random Assignment, c) Lower-Extremity Resistance Training Program, d) Resistance Training Contractile Modes, e) Functional Strength Assessment, f) Pilot Study Results, g) Application of Percentage of Body Weight, h) Instrumentation for Functional Strength Assessments, i) Stair Ascent Functional Assessment Protocol, and j) Data Analysis.

Participants

Following IRB approval (see Appendix A), college-age females who had no self-disclosed physical limitations that would prevent them from engaging in a lower-extremity resistance training program or stair ascent assessment were recruited as volunteers. Participants were asked to refrain from strenuous exercise and physical activities outside of the study. Participants were recruited from undergraduate classes within the Department of Kinesiology at SUNY Cortland. After thirty-two college-age females were identified, the researcher met with each participant to outline expectations for participation. The researcher highlighted the study's purpose, testing protocol, commitment to participation, and proper dress. At this session, participants also completed the Informed Consent Form (see Appendix B) and the Physical Activity Readiness Questionnaire (PAR-Q) / Modified Health / Medical Questionnaire (see Appendix C) to ensure that they were healthy to participate. In addition, body mass was measured for each participant to identify the initial load of the weight vest and ankle weights for the stair ascent assessment. The researcher indicated that forms would be kept confidential and would be destroyed after three years.

Communication was done primarily via email to participants to arrange for the pre-assessment. In addition, participants were asked about time availability to be assigned a personal trainer for the resistance training portion of the program. The importance of keeping personal training appointments was stressed throughout the program. The researcher worked with the personal trainers during the first four weeks of the study to ensure consistency with proper technique. After the resistance training period ended, the researcher contacted each participant via email to schedule the post-assessment.

Groups and Random Assignment

Initially, all thirty-two participants were randomly assigned into one of three resistance training programs (concentric, eccentric, and combined concentric and eccentric) or the control group. Each participant was asked to complete an eight-week standing back squat resistance training program. The resistance training programs were purposely designed to emphasize the different contractile modes that would later be analyzed. The control group participant was asked to journal any additional physical activity in addition to completing the pre- and post-assessment.

Lower-Extremity Resistance Training Program

The exercise that was used in the study was the standing back squat. The training protocol was established using the recognized criteria for strength and hypertrophy and the progressive overload principle (Baechle & Earle, 2008). The three treatment groups participated in a twice weekly lower-extremity resistance training program over an eight week period. The American College of Sports Medicine Position Stand recommends that the resistance training frequency be two-three times a week for novice or intermediate trainers, as defined by not being an elite training athlete (Kraemer et al., 2002). To avoid overtraining, the frequency used was twice weekly (Earle & Baechle, 2004). Regardless of the resistance training group the participants were assigned, the following protocol was followed:

1. Participants warmed-up on a cycle ergometer for 3-5 minutes at their own preferred intensity.
2. The weights were at the standing squat station. The personal trainer adjusted the weight appropriately throughout the training session.
3. In addition to the personal trainer, other participants that were available and not completing the lift were asked to help spot. If other participants were not available, the gym monitor assisted the personal trainer to spot.
4. The 1-RM was estimated in order to determine the weight to be used in the standing backsquat. 85% of the 1 RM was used as the starting weight in the first training session for the concentric and combined concentric and eccentric training group. 130% of the 1-RM was used for the eccentric only training group. Participants used

the National Strength and Conditioning Association protocol for determining the estimated 1-RM (Baechle & Earle, 2008), see Appendix D.

5. Each participant completed 6 to 8 repetitions followed by 90 seconds rest/recovery period between each set for 3 sets per training session.
6. In order to conservatively progress the participant's training load throughout the study, the 2-for-2 rule was employed (Baechle & Earle, 2008). If a participant completed two more reps than the repetition goal in the final set of an exercise for two consecutive training sessions, then the load in all of the sets of that exercise were increased by five pounds (2.27 kg) (Baechle & Earle, 2008).

Personal trainers (student volunteers) administered the training sessions. Each participant was assigned to a personal trainer. Each of the personal trainers were informed of and trained in using the proper protocol; they were required to keep a training log of each session with each participant that they worked with (see Appendix E). The researcher attended each personal training session for the first four weeks to ensure that each participant used proper and safe lifting technique and that each participant was adhering to their assigned weight and lifting protocol.

Resistance Training Contractile Modes

The purpose of this study was to analyze different resistance training contractile modes. The protocols for the squat exercise for each group are described below.

1. Eccentric – To eliminate the concentric phase of the standing back squat, the movement was initiated at the erect and standing position. The participant lowered the barbell until thighs were parallel to the floor, at a five second count that was measured with a metronome. The personal trainer/researcher/other participants/gym

monitor lifted the barbell back to the starting position where the participant would resume repeating the movement. To ensure that the total weight lifted by the eccentric resistance training was similar to the concentric resistance training, a load of 45% of the participant's 1-RM was added for a total of 130% (Hortobagyi, Devita, Money, & Barrier, 2001). This was determined important in previous research because the eccentric phase is substantially underloaded (Hortobagyi et al., 2001).

2. Concentric – To eliminate the eccentric phase of the standing back squat, the movement was initiated with thighs parallel to the floor, by adjusting the height of the barbell with the power rack. The participant pressed the barbell, driving their body into an erect and standing position at a five second count that was measured with a metronome. The personal trainer/researcher/other participants/gym monitor served as spotters to ensure safety during the lift. The participant paused when their knees were placid, unlocked, and slightly bent for an additional 2-3 seconds, at which time the personal trainer/researcher/other participants/gym monitors lowered the barbell back to its starting position and the participant repeated the movement (Hortobágyi & Katch,1990).
3. Combined eccentric and concentric – The combined eccentric and concentric resistance training protocol was a combination of the two aforementioned protocols. Participants lowered and raised the weighted barbell during the standing back squat using eccentric and concentric phases of movement in a smooth transition at a five second count during the eccentric phase (down) until thighs were parallel to the floor and a five second count during the concentric phase (up). Cadence was measured with a metronome.

4. Control group - The control group participants were asked to record in a journal any lower-body exercises and extraneous stair-climbing aside from activities of daily living during the training phase. This was to ensure that all activities were accounted for and to ensure their activities during the research program did not interfere with study results. Participants in the control group completed the pre- and post-assessment.

Functional Strength Assessment

Functional strength was measured using a weight vest and ankle weights while participants completed a modified stair ascent test. Several existing stair climb tests were modified to assess functional strength (Hurley et al., 1998; Plat et al., 2010; Teh & Aziz, 2000). All participants performed this assessment prior to (week 0) and following the eight-week (week 9) progressive resistance training program. Data were recorded on a Functional Strength Assessment Record (see Appendix F). For the assessment, 60 steps in a stairwell in the Corey Union on the SUNY Cortland campus were used. Steps were 7.5 inches tall with a depth of 10.5 inches. Participants traveled a total of 37.5 feet. Please see "Stair Ascent Functional Assessment Protocol" below for more details.

Pilot Study Results

A pilot study with the faculty advisor, undergraduate volunteers, and the researcher was conducted prior to this study commencing. The results of the pilot study determined the numbers of stairs to climb, the starting weight to be used with the weight vest and ankle cuffs, along with the cadence of the metronome that would be used. The goal of the pilot study was to confirm a reasonable protocol to be used for the pre- and post-assessment. For further details on the pilot study results see Appendix G.

Application of Percentage of Body Weight

The concept of adding body mass to each of the participants was based on previous research (Loy et al., 1994; Plat et al., 2010; Williams-Bell et al., 2009). Based on the pilot test results, it was determined that all participants would begin the pre-assessment stair ascent with an additional 60% of their body mass. The additional weight that a participant could ascend the stairs was divided between the vest and ankle weights. This was the result of several pilot studies that demonstrated that using only a weight vest to create a resistance of 60% of each participant's body weight was causing too much strain and discomfort in the shoulder area without increasing the level of fatigue in the participant's legs to the appropriate level. Ankle weights were then added and the percent of each participant's body weight was distributed between the weight vest and the ankle weights. The initial resistance of the Rehab Cuff Ankle Weights was 40 pounds (18.14 kg), (20 pounds (9.07 kg) per each leg) and the remaining percentage was added to the weight vest to equal 60% of the participant's body mass. Appendix H demonstrated the amount of weight to be distributed for each participant, based on body weight.

Instrumentation for Functional Strength Assessments

An 84 pound (38.18 kg) max Xvest®-The Firemen Model X8484 (© 2004-2007 Xtreme Worldwide Athletic Equipment, Houston, TX) and Rehab Cuff Ankle Weights (performbetter.com) and a stairwell with 60 stairs were used to measure the functional strength of each participant (see Figure 1). The Xvest is made of nylon and is adjustable by two shoulder straps and two lateral straps, both with Velcro® closers, to ensure a proper fit. The unloaded vest weighs 1.5 pounds (0.68 kg) and the fully loaded vest weighs 84 pounds (38.18 kg). One pound (0.45 kg) weight cylinders are securely placed in two anterior and two posterior pockets that are superior and inferior to one another. Each pocket is secured with Velcro® closers and holds up to 21 pounds (9.55 kg). The weight with the vest can be adjusted by 0.45 kg increments, which allows a wide load range during the functional strength testing. The Xvest has been used in three other known studies (DeWitt, Hagan, & Cromwell, 2008; Faigenbaum et al., 2006; Clark, Stearne, Walts, & Miller, 2010) and four additional studies used a similar model weight vest (Loy et al., 1994; Kraemer et al., 2001; Plat et al., 2010; Williams-Bell et al., 2009). In addition, Rehab Cuff Ankle Weights (performbetter.com) were used: four 10 pounds (4.5 kg), two 5 pounds (2.26 kg), and two 2.5 pounds (1.13 kg). Each secured with Velcro® straps. To keep cadence consistent, a Matrix MR 500 Metronome was used in the study.

Figure 1. Various Functional Strength Assessment Instruments (weight vest, left; ankle weights, center; and metronome, right)

Stair Ascent Functional Assessment Protocol

All participants were asked to complete a stair ascent pre- and post-assessment with their maximum percentage of body weight that they could walk up the stairs at a pace of 88 steps per minute (set by a metronome). The goal was to measure functional strength workload tolerance pre- and post- resistance training program. The specific protocol followed was:

1. The initial load for each participant was calculated at 60% of their body mass. Each participant had their body mass measured prior to the assessment and was asked to wear the weight vest and ankle weights with the weight added (see Appendix H).
2. Participants were required to ascend the 60 steps at a constant step rate, which was indicated by a metronome at 88 steps per minute. The average time to complete the stair ascent was 51 seconds.
3. Participants were instructed to take one step at a time and to touch each step with only one foot.
4. In order to complete one cycle of the test, participants needed to completely ascend the steps without stopping. If the participant did not maintain the 88 steps per minute rate, the test was terminated.
5. The researcher ascended with each participant throughout the test to ensure safety and monitor the testing protocol.
6. After completion of the initial ascent, each participant was asked to identify his or her level of exertion using the BORG scale (see Appendix I). If the participant indicated that they could not tolerate an increase in workload (defined as 16-20 (hard – maximal exertion) on the BORG scale), the test was terminated and their completed workload weight was recorded as the maximum load.
7. If the participant felt that they could tolerate an increase in workload (defined as 6-15 (nothing - hard) on the BORG scale), they would be instructed to recover for 2 minutes with no activity. After this rest period, an additional 2.5 pounds (1.13 kg) was added per

leg and the remaining percentage was added to the weight vest. The protocol was repeated until the participant could not complete the stairs ascent assessment or indication that the participant reached their workload tolerance, defined as 16-20 on the BORG scale).

8. During the pre-assessment, participants had a maximum of three ascents determine maximum voluntary workload before the participant would have to retake the assessment after a 24 hour recovery period.
9. Participants completed the post-assessment 3-5 days following completion of the resistance training program. During the post-assessment, participants began the test with the maximum workload from the pre-assessment. Again, each participant had a maximum of three ascents to determine maximum voluntary workload before the participant would have to retake the assessment after a 24 hour recovery period.
10. At any time when the participant could not complete the stair ascend or they reached their volitional maximum tolerance, the previous weight was recorded as their workload maximum.

Data Analysis

This study utilized a pre-post-test control group design. The researcher recorded the maximum percentage of body weight that each participant completed the pre- and post-assessments (as determined through the BORG scale, or the inability to complete one stair ascend). Participants were assigned to one of four groups (eccentric, concentric, combined eccentric and combined, or the control group). Means and standard deviations of the percent of body weight carried were determined for each of the four groups.

The researcher determined if the level of strength increase was statistically significant among all groups using a 2 (test) x 3 (group) mixed ANOVA test with repeated measures on the second factor. Statistical tests were conducted at the conventional level of significance (p <0.05). Repeated measures are used in situations in which the measurements are repeated on the same participant. In this study, all participants were assessed pre- and post the resistance training programs. The data were analyzed using ANCOVA to determine if there was a significant difference between the four groups and the pre- and post-assessments. The statistical analyses were completed using SPSS for Windows version 19.

Chapter IV

Results and Discussion

The results section of this chapter begins by briefly discussing the characteristics of the participants. The main findings are then discussed in terms of strength gains and differences between the resistance training groups. Additional descriptive data about the pre- and post-assessment BORG ratings and the resistance training starting and ending training weight is provided.

The discussion section of this chapter reviews the purpose, methods, and results. The following aspects are included in the discussion, as these items could have impacted the results: a) Resistance Training Protocols, b) Resistance Training Contractile Modes, and c) Functional Assessments. The summary statement provides an overview to what the results were and, more important, what this may mean.

Participants Characteristics

Female volunteer participants were recruited from various classes at the State University of New York College at Cortland. Of an initial 32 participants that indicated interest by signing up to participate in the study, 13 completed the pre-assessment (initial drop-out rate was 68.75%). Of the 13 that completed the pre-assessment and actively participated in their assigned resistance training group/control, 10 participants completed the post-assessment (attrition rate was 23.07%). The reasons for three students not completing the study were personal in nature. The breakout of participants appears in Table 1. These ten final participants weight range was 90 – 196 pounds (40.9 kg – 89 kg) (M = 125, SD = 28.5). In completion of the PAR-Q and Modified Medical Questionnaire (See Appendix C), seven out of the 10 participants (70%) were free from any present or past medical issues. Three participants reported the following medical conditions; injury to back/knee injury, exercise induced asthma, and scoliosis. One-half of the participants stated that they currently participate in a regular exercise program. In addition, one-half of the participants reported having previously participated in a resistance training program.

Table 1. Participants

Group	Number of Participants completing Pre-Assessment	Number of Participants completing Pre-and Post-Assessment
Eccentric	4	4
Concentric	2	2
Combined Eccentric and Concentric	4	3
Control	3	1
Total	**13**	**10**

Significant Strength Gains

Using a 2 (test) x 3 (group) mixed ANOVA on the pre- and post-assessment maximum amount of weight participants carried during the stair ascent, it was determined that the main effect of assessment was significant: $F(1, 6) = 23.58$, $p = 0.003$, partial $\eta^2 = .797$ (large effect size). In sum, during the pre-assessment, the mean percentage of body weight that all three resistance training group participants carried was 69%. After the 8-week resistance training program, the mean percentage of body weight that was carried in the post-assessment was 82%; an increase of 13%. Figure 2 demonstrates the significant difference between the pre- and post-assessment. The percent of body weight carried by the lone control subject did not change between the pre- and post-assessments.

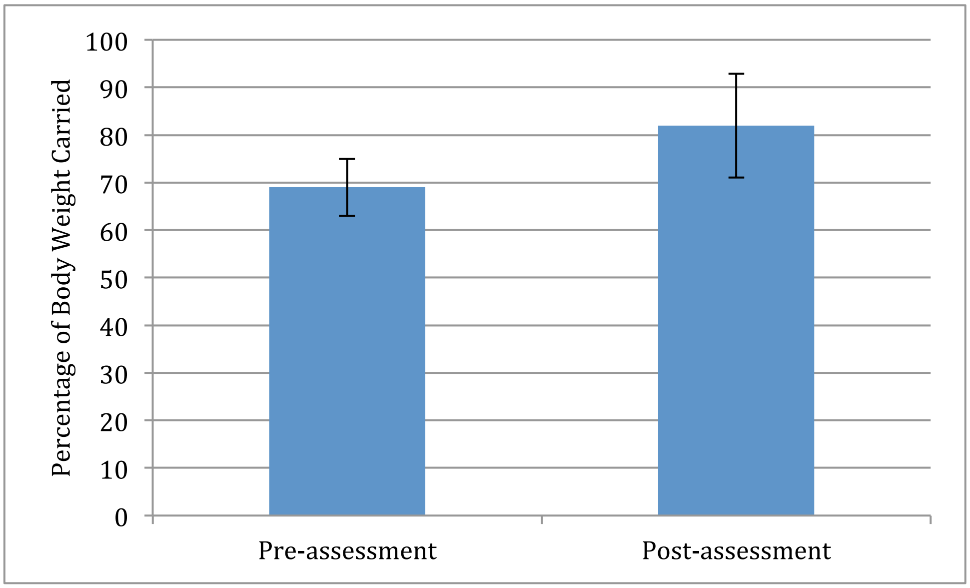

Figure 2 – Mean (±SD) Percentage of Body Weight Carried at Pre-Assessment and Post-Assessment by Participants in all Resistance Training Groups. A significant difference was determined between the pre- and post-assessment using 2 (test) x 3 (group) mixed ANOVA (p = 0.003).

In addition, descriptive statistics of each resistance training group are demonstrated in Table 2. However, the interaction among the groups between the assessments was determined not to be significant: $F(3, 6) = .86$, $p = 0.511$, partial $\eta^2 = .301$. The observed power was weak at .148.

Table 2. Percentage of Body Weight Carried – Mean and Standard Deviation for Pre- and Post-Assessment

Group	Number of Participants	% Body Wt. Carried Pre-Assessment (Mean)	% Body Wt. Carried Pre-Assessment (SD)	% Body Wt. Carried Post-Assessment (Mean)	% Body Wt. Carried Post-Assessment (SD)
Eccentric	4	65.0	5.8	77.5	9.6
Concentric	2	70.0	0	85.0	7.1
Combined Eccentric and Concentric	3	73.3	5.8	86.7	15.3
Total (resistance training groups)	9	68.9	6	82.2	10.9
Control	1	70.0	-	70.0	-
Total (all groups)	**10**	**69.0**	**5.7**	**81.0**	**11.0**

Strength Gains Between Groups

In employing ANCOVA to the data set, it was determined that the assumption of homogeneity had not been violated (p = 0.733). Levene's Test of Equality of Error Variances demonstrated that the data did not violate the assumption of equality of error variance (p = 0.263). In addition, the covariate (pre-assessment percentage of body weight) was significantly related to the dependent variable (post-assessment percentage of body weight) at p = 0.039, with a partial η^2 of .608 (moderate effect size). After adjusting for pre-test percentage of body weight, there was not a significant effect of the between subjects factors, $F(3,5)$ = 1.077, p = 0.438, partial η^2 = .393. The observed power was weak at .162.

The differences in the percentage of body weight during the post-assessment compared to the pre-assessment are noted in Table 3.

Table 3. Difference in percentage of body weight during the post-assessment compared to the pre-assessment

Resistance Training Group	Number of Participants	Difference in % Body Wt. Carried Post-Assessment to Pre-Assessment (unadjusted means)
Eccentric	4	12.5
Concentric	2	15.0
Combined Eccentric and Concentric	3	13.4
Control	1	0

BORG Scale

Throughout both the pre- and post-assessments, either the BORG scale was used to terminate the assessment or participants voluntarily choose not to complete the assessment. During the pre-assessment, there were 19 trials conducted over 10 participants. This averages to each participant completing only 1.9 trials. In addition, only the control did not reach the limit on the BORG scale, but choose to not continue in the assessment. All other participants reached the BORG maximum. The average BORG ratings during the pre-assessment per trial are provided in Figure 3.

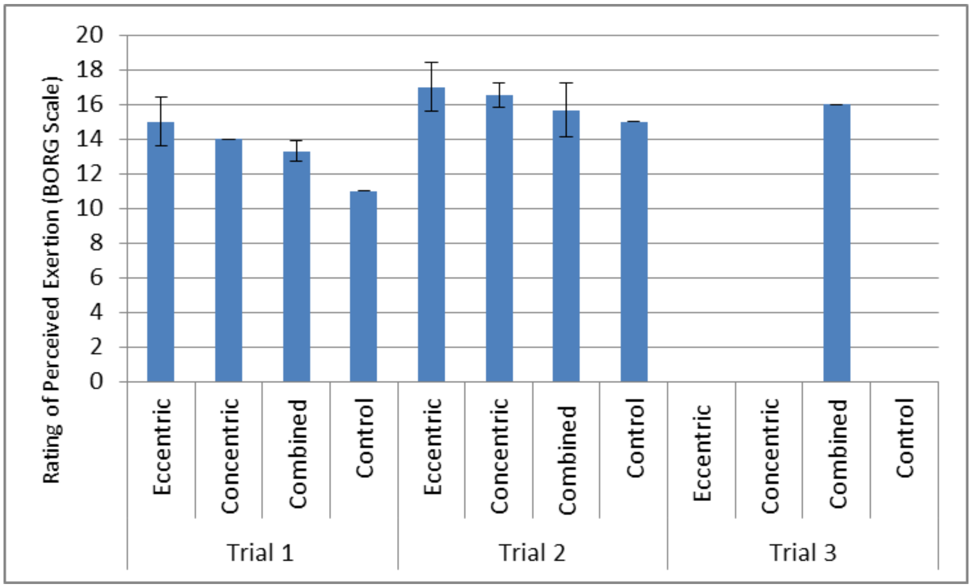

Figure 3 – Mean (±SD) BORG ratings of participants during the pre-assessment per different resistance training groups in each of the trials. The test was terminated either through volition or RPE rating equal or greater than 16.

During the post-assessment, there were 21 trials conducted over 10 participants. This averages to each participant completing 2.1 trials. In addition, two participants did not reach the limit on the BORG scale, but choose to not continue in the assessment. All other participants reached the BORG maximum. The average BORG ratings during the post-assessments per trial are provided in Figure 4.

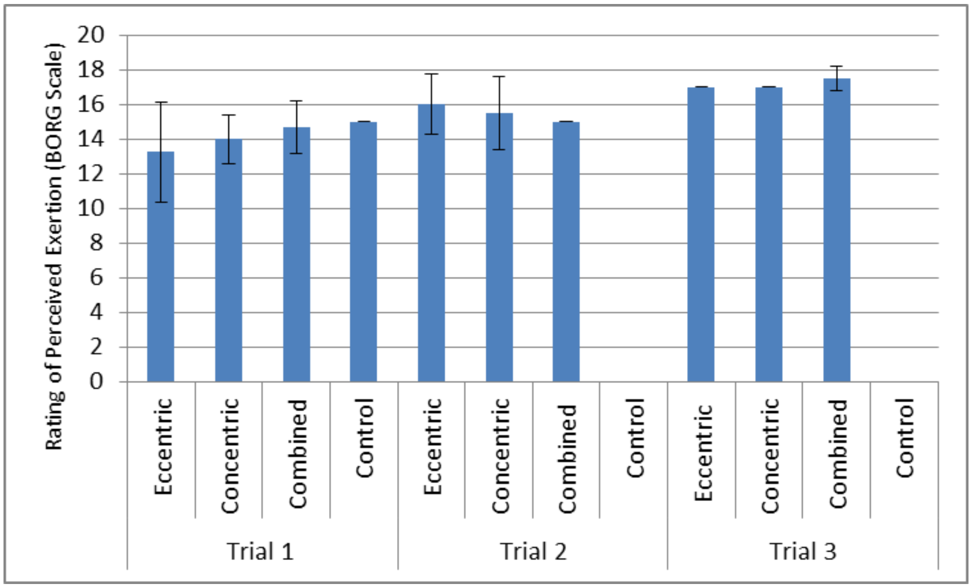

Figure 4 – Mean (±SD) BORG ratings of participants during the post-assessment per different resistance training groups in each of the trials. The test was terminated either through volition or RPE rating equal or greater than 16.

During each trial, the average BORG rating during the pre-assessment was 14.83. During the post-assessment, participants carried the maximum weight lifted during the pre-assessment and the average BORG rating during the post-assessment was 15.50. As evident in Figures 3 and 4, participants during the pre-assessment completed fewer trials (average of 1.9) and went to a 16 or higher BORG rating quickly. After the resistance training program was completed, participants then were asked to carry the maximum weight determined at the pre-assessment to start the post-assessment. Results demonstrated that during the post-assessment participants completed multiple trials (average of 2.1 trials) to reach 16 or higher BORG rating.

Resistance Training Weight

The amount of weight that a participant was able to lift over the 8-week resistance training program varied greatly. Using a 2 (test) x 4 (group) mixed ANOVA on the start and end weight of the participants, it was determined that the main effect of end weight was significant: $F(1,6) = 7.20$, $p = 0.036$, partial $\eta^2 = 546$. There was no significant difference between the start and end weight between the difference resistance training groups. The start and end weight for each participant is noted in Table 4. In addition, Figure 5, shows the mean difference in weight between each of the three resistance training groups.

Table 4 – Start and End Weight of Resistance Training Program Per Participant

Participant No.	**Resistance Training Group**	**Start Weight (kg)**	**End Weight (kg)**
1	Eccentric	20.4	29.5
2	Eccentric	65.8	70.3
3	Eccentric	52.2	56.7
4	Eccentric	38.6	70.3
5	Concentric	65.8	74.8
6	Concentric	20.4	29.5
7	Combined Eccentric and Concentric	34.0	62.5
8	Combined Eccentric and Concentric	77.1	81.6
9	Combined Eccentric and Concentric	58.9	63.5

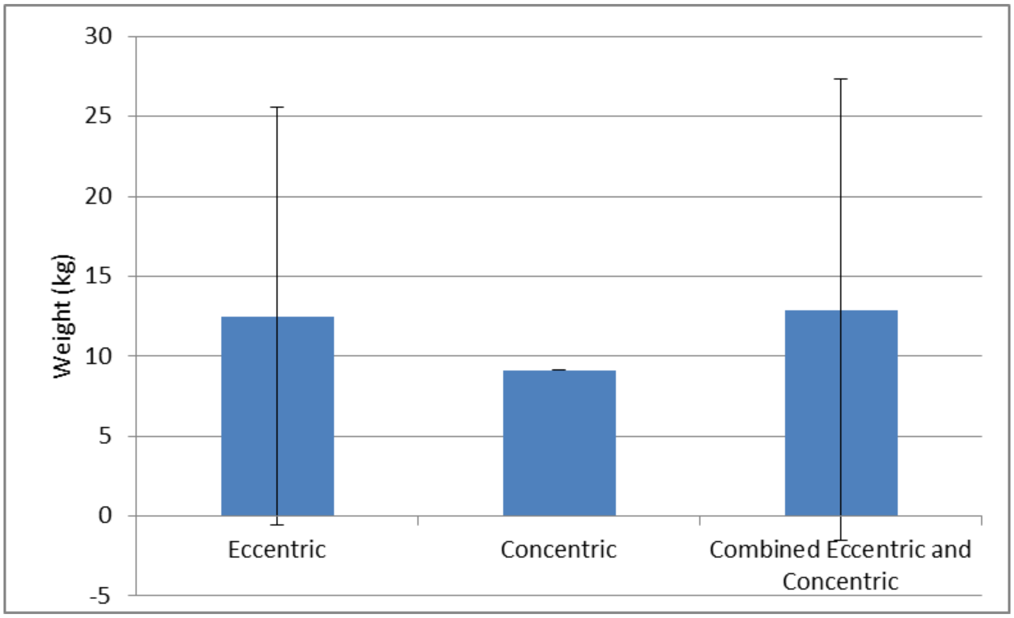

Figure 5 – Mean (±SD) of the different starting weight and ending weight lifted in the resistance training program separated by contractile mode group. There was significant difference between participants start and end weight (p = 0.036).

Discussion

This study was designed to determine which lower-extremity resistance training contractile mode would significantly increase functional strength using a modified weighted stair ascent assessment among college-age females. Ten participants were randomly assigned into one of four groups to which three groups completed an 8-week lower-extremity resistance training program to focus on the following contractile modes: eccentric, concentric, and combined eccentric and concentric. Each participant worked with the researcher or a student personal trainer while completing a standing back-squat exercise. The fourth group was the control, which were asked to complete the pre- and post-assessment.

Participants were tested prior to the start and at the conclusion of the 8-week resistance training program to determine the level of functional strength among participants.

Specifically, participants were asked to complete a 60-step stair ascent while wearing a percentage of their body weight (via weight vest and ankle weights). The maximum percentage of body weight that participants were able to carry during the stair ascent was recorded during the pre- and post-assessment and analyzed. Participants were able to carry a significantly larger percent of their body weight during the post-assessment when compared to the pre-assessment. However, the hypothesis that participation in an eight-week lower extremity eccentric-only resistance training program would result in greater functional strength outcomes than a lower extremity concentric-only or combined concentric and eccentric resistance program was not supported.

Resistance Training Protocols

The literature supports the following principles of resistance training programs; intensity, volume, exercise selection, and velocity (Baechle & Earle, 2008). This study determined the initial weight load in the resistance training programs using the estimated 1-RM (Baechle & Earle, 2008). It is possible that participants did not start with the correct maximum amount of weight to use in their resistance training programs, and therefore, misjudged the intensity level throughout the program.

The sequencing of exercises can also impact muscular strength (Kraemer et al., 2002). It could be possible that the resistance training program should have included additional exercises, such as a back squat and a walking lunge, as one exercise can limit the scope of the results (Stone & Borden, 1997). Regardless, exercises need to be reviewed carefully to determine which have both a concentric and eccentric contractile mode so that the resistance training programs are developed appropriately. Velocity of concentric/eccentric muscular rate was noted to have variability in the literature (Keeler et al., 2001; Munn et al., 2005; Poliquin, 1988). This study used the rate of 5 seconds per movement, which was on the slower spectrum of velocity, and perhaps could have been too slow for muscular change and also a more difficult rate for participants to be uphold, especially novice lifters.

Resistance Training Contractile Modes

The literature is limited, but mixed with regards to the expected outcomes of strength gains that each resistance training contractile mode group should experience. As there was no significant difference between the four groups in the present study, this is consistent with three other studies in the literature that compared the different resistance training contractile modes and noted no significant difference in strength outcomes (Ben-Sira et al., 1995; Blazevich et al., 2007; Nickols-Richardson et al., 2006). It should be noted that these studies measured strength outcome, not functional strength. Researchers did find a significant strength increase in the eccentric group compared to the concentric and eccentric group while completing a leg press and knee extension (Reeves et al., 2009). While Reeves' et al. (2009) participants were elderly, this result was consistent with another study that demonstrated eccentric has greater strength outcome than concentric (Hortobágyi et al., 1996).

While there was no significant finding to determine which resistance training program was most effective with the functional strength assessment in this study, there may be neuromuscular reasons at the basis of demonstrating no difference between the three different resistance training contractile mode groups. First, it may be possible that the motor unit recruitment via the external load was not being met or increased during the resistance training phase (Kraemer et al., 2004). Given the novice status of the participants and the student personal trainers, this could have impacted the results. Research has also demonstrated that once the neuromuscular system adapts that there no longer remains the demand on the system and then adaptation slows and eventually ceases (Rhea et al., 2002). It is possible that the participants became complacent and plateaued very early during the resistance training programs. In addition, some research suggests that the strength gains for females are only at the level of neural adaptation and therefore, may not have experienced hypertrophy (Hortobágyi et al., 1996). Because this is a group of female participants, it supports that female participants may not have experienced an adaptation to the resistance training program. Finally, hormonal adaptations and metabolic rates could have influenced the results the study (Kraemer et al., 2004).

Functional Assessment

It is important to note that this particular functional assessment has not been validated in the literature; however, the researcher used different examples to support the concept in this study (Al-Abdulwahab, 1999; Loy et al., 1994; Plat et al., 2010; Williams-Bell et al., 2009). Results might not have been different between the resistance training groups because it is possible that one particular contractile mode may not have a transfer of training effect to the stair ascent. In addition, the protocol for the study may have been not specific enough to test or identify a significant difference between the different groups.

In this study, the functional assessment was initially designed to include both a stair ascent and descent protocol. However, during the pilot studies, the researcher determined that the participants felt less fatigue (defined by a low RPE rating) in their quadriceps when they descended and then ascended the stairs instead of just completing a stair ascent. Because of this, the protocol was changed to be a stair ascent, as the eccentric movement of going down the stairs was not allowing the participants to reach their maximum and participants reported that their quadriceps were recovered. Nowhere in the literature was this phenomenon described or researched. In addition, completing the stair ascent could have limited the findings because the assessment was now only testing concentric contractile modes and limited eccentric contractile modes, which did not necessarily match the different resistance training groups.

Summary

Participants significantly increased the percentage of body weight that they carried during the stair ascent between the pre- and post-assessment by 13%, $p = 0.003$. This supports the fact that resistance training programs can have a transfer of training effect with functional strength. However, the hypothesis of the study was shown to not be true. There was no significant difference between the resistance training contractile modes/control to determine which (eccentric, concentric, combined eccentric and concentric or control) would result in the greatest increase in functional strength. The most prominent difference between this study and other research was that a functional assessment was used to determine the outcome of a resistance training program. In addition, the different resistance training contractile modes were analyzed to determine which was most effective to increase in functional strength. Perhaps there was no significant difference observed between the different resistance training contractile modes or there were other reasons for no difference being identified. These reasons might include a having a neuromuscular basis, the resistance training protocol not being appropriate, or short-comings in the functional strength assessment.

Chapter 5

Summary, Conclusions, and Recommendation

Summary

The purpose of this study was to compare the effectiveness of three different lower extremity resistance training programs in developing functional strength in college-age females. The three resistance training programs were differentiated by the contractile modes involved: eccentric, concentric, or combined eccentric and concentric. Past research has concluded that resistance training programs need to include both concentric and eccentric muscle actions (Kraemer et al., 2002, 2004; Stone et al., 2000). This parallels with the human body's natural movement, as it requires both eccentric and concentric actions to successfully navigate on a daily basis (Kraemer et al., 2002). There is also literature that suggests eccentric-only resistance training programs could be superior based on having the potential for maximum gains due to having a greater force output, being more energy efficient and causing less fatigue (Hortobágyi et al., 1996; Kraemer et al., 2002). However, there are few studies that compare the different modes of resistance training to determine which is most effective and, more importantly, how resistance training contractile modes can be assessed in functional strength ability (Kraemer et al., 2001). The present study sought to explore this.

Ten college-age female students were recruited as participants. They were randomly divided into three resistance training groups (concentric, eccentric, combined concentric and eccentric) or a control. The resistance training group participants were asked to complete an eight-week standing back squat resistance training program. The resistance training programs were purposely designed to emphasize the different contractile modes that would later be analyzed. All participants completed a pre- and post-assessment at the start and end of the eight-week resistance training program to measure functional strength. Participants were asked to complete a modified stair ascend test using a percentage of body weight with a weight vest and ankle weights to be measured during pre- and post-assessment.

The maximum percentage of body weight that was used in the pre- and post-assessment was analyzed using a mixed ANOVA design. It was determined that the main effect of assessment was significant, meaning that participants increased the percentage of body weight during the post-assessment compared to the pre-assessment. This finding was predicted since previous research has shown that resistance training programs increase strength (Brill et al., 2000; Garber et al., 2011; Haskell et al., 2007; Kraemer et al., 2002, 2004; Stone et al., 2000). However, the present study used ANCOVA to test the hypothesis. It was determined that there was no significant result between the different groups, meaning that there was no difference between the resistance training groups (eccentric, concentric, concentric and eccentric) as it pertains to pre- and post-assessment. This finding is consistent with other work that showed no difference between the different contractile modes (Ben-Sira et al., 1995; Blazevich et al., 2007; Nickols-Richardson et al., 2007). This is a different outcome which demonstrated significant strength gains (although not defined in a functional assessment context) with the eccentric-only contractile mode groups (Hortobágyi et al., 1996; Reeves et al., 2009).

Findings

The present study resulted in the following findings:

1. The hypothesis that participation in an eight-week lower extremity eccentric-only resistance training program would result in greater functional strength outcomes than a

lower extremity concentric-only or combined concentric and eccentric resistance program was not supported.

2. There was a significant increase in the percentage of body weight that participants recorded between the stair ascent pre- and post-assessment after an 8 week lower-extremity resistance training program.

Conclusions

The present study resulted in the following conclusions:

1. Contractile mode specific resistance training programs does not necessarily increase the amount of percentage of body weight that would be recorded on the functional strength stair ascent pre- and post-assessment.
2. Completing an 8-week lower-extremity resistance training program significantly increases participants' performance on a functional stair ascent assessment. Because of transfer of training effect, this may suggest that resistance training programs can impact functional strength.

Recommendations

Based on the findings of the present study, future research should include the following:

Number of Participants

The original goal was to have 32 participants in the study (which was accomplished initially). Based on previous work that compared different contractile modes of resistance training, this number was considered appropriate (Blazevich et al., 2007, Staron et al., 1998). However, there are a few studies that have compared the different contractile modes with lower number of participants. More importantly, these studies were able to yield significant results (i.e., Aagaard et al., 2000 used 15 participants; Hortobágyi & Katch, 1990 used 18 participants; Seger & Thorstensson, 2005 used 10 participants).

The initial drop-out rate of 68.75% for participants in this study was high. While reasons for this initial drop-out from this study are thought to be primarily participants personal reasons, future studies need to focus on methods to ensure participant adherence. In computing the ANCOVA to analyze the hypothesis directly, it was determined that there was not a significant effect between subjects factors. This analysis concluded that there was no difference between the resistance training groups while the observed power was .162 and considered weak. As a result, the null hypothesis may be true or perhaps the present study had insufficient statistical power.

Skill Level of Participants

The novice skill level of participants in the resistance training group could have influenced the resistance training sessions and ultimately the results. While not a requirement for participation, as evident in the Modified Health Medical Questionnaire, only 50% of the participants had reported ever participating in a resistance training program. Though anecdotal, some that participated in resistance training programs had not specifically ever performed the back squat exercise. As noted in the National Strength and Conditioning Association Guidelines for Hypertrophy and Strength, participants were instructed to complete the standing back squat at 85% of their maximum lift (Baechle & Earle, 2008). However, given the subjects' lack of experience and the learning curve required for a back squat, this could cause some variance in the results. In addition, it was noted that participants in the eccentric group had concerns with the amount of weight there were required to use in the training sessions as it was an additional 45% of their 1-RM. Participants were reserved to the weight load being asked of them to lift and none of the eccentric group participants were able to achieve the 130% 1-RM lift during their resistance training program.

Skill Level of Student Personal Trainers

While the original intent was to have the researcher conduct each personal training session for each participant, this was expanded to include undergraduate student personal trainers from an Exercise Science class as part of a course requirement. Initially, each student personal trainer was assigned one participant, however; drop-out of the personal trainers was also high and the result was four student personal trainers working with the ten final participants. In response to having student personal trainers, the researcher worked directly with them during the first four-weeks and until they felt confident to ensure they understood the appropriate protocols to be employed. While the entire participant group significantly increased in the percentage of body weight carried in the post-assessment compared to the pre-assessment, there were concerns about the skill level of the student personal trainers which could have impacted the outcome of the quality of training that each designated resistance training group received and hence, the results.

Functional Strength

Researchers interested in functional strength assessment should investigate other protocols designed to assess functional strength. Functional strength assessment research is limited to certain populations (i.e. occupational, elderly and athletics), but should continue to be analyzed as it pertains to a healthy population in primary prevention efforts.

Another possible fruitful area of exploration might include development of standardized exercises to analyze the transfer of training effect on functional ability.

Furthermore, if the goal is to assess functional ability, it would be worthy to study a functional assessment outcome that is based on similar exercise modes.

Resistance Training Programs

Even though the present study's methods was based on the literature, it was more conservative and may have produced different results had the resistance training programs changed in either the length of time, velocity, exercise sequencing or intensity in the resistance training program. Future research examining the different contractile modes by manipulating different principles to be more challenging could impact the outcome and should be reviewed.

Application to Other Populations

The worthiness of researching the different outcomes of resistance training contractile modes is many. Given the hypothesis that eccentric training can produce more strength quickly with less fatigue can dramatically help certain populations where resistance training programs are essential. For example, an individual with Multiple Sclerosis would benefit tremendously from a resistance training program that would require less energy expenditure. Another example would be military personnel where functional strength is essential to the occupation and having a resistance training program that can produce results quickly would improve all aspects of training and combat-readiness. The potential that this hypothesis can assist most all people in maintaining a productive and healthier lifestyle is powerful for the field of exercise physiology and should continue to be explored.

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Appendix A

SUNY Cortland
Institutional Review Board

MEMORANDUM

To:	Timothy A. Lamey
From:	Amy Henderson-Harr, Institutional Review Board (IRB) Compliance Officer Assistant Vice President
Date:	December 21, 2011
RE:	Institutional Review Board Approval

In accordance with SUNY Cortland's procedures for human research participant protections, the protocol referenced below has been approved for a period of one year:

Title of the study:	Comparing Resistance Training Modes in College-age Females on a Functional Strength Stair Assessment	
Level of review:	**Expedited**	**Protocol number: 111208**
Project start date:	December 21, 2011	**Approval expiration date*:** December 21, 2012

* **Note:** *Please include the protocol expiration date to the bottom of your consent form and recruitment materials.* For more information about continuation policies and procedures, visit www.cortland.edu/irb/Applications/continuations.html

The federal Office for Research Protections (OHRP) emphasizes that investigators play a crucial role in protecting the rights and welfare of human subjects and are responsible for carrying out sound ethical research consistent with research plans approved by an IRB. Along with meeting the specific requirements of a particular research study, investigators are responsible for ongoing requirements in the conduct of approved research that include, in summary:

- obtaining and documenting informed consent from the participants and/or from a legally authorized representative prior to the individuals' participation in the research, unless these requirements have been waived by the IRB;
- obtaining prior approval from the IRB for any modifications of (or additions to) the previously approved research; this includes modifications to advertisements and other recruitment materials, changes to the informed consent or child assent, the study design and procedures, addition of research staff or student assistants, etc. (except those alterations necessary to eliminate apparent immediate hazards to subjects, which are then to be reported by email to irb@cortland.edu within three days);
- providing to the IRB prompt reports of any unanticipated problems involving risks to subjects or others;
- following the principles outlined in the Belmont Report, OHRP Policies and Procedures (Title 45, Part 46, Protection of Human Subjects), the SUNY Cortland College Handbook, and SUNY Cortland's IRB Policies and Procedures Manual;
- notifying the IRB of continued research under the approved protocol to keep the records active; and,
- maintaining records as required by the HHS regulations and NYS State law, for at least three years after completion of the study.

Appendix A

In the event that questions or concerns arise about research at SUNY Cortland, please contact the IRB by email irb@cortland.edu or by telephone at (607)753-2511. You may also contact a member of the IRB who possesses expertise in your discipline or methodology, visit http://www.cortland.edu/irb/members.html to obtain a current list of IRB members.

Sincerely,

Amy Henderson-Harr

Attachment: Approved Consent Form

C: J. Hokanson, Faculty Sponsor

INFORMED CONSENT

IRB APPROVED FOR THE PERIOD OF 12/21/11-12/21/12

I hereby consent to voluntarily engage in an exercise program that involves a squat exercise. I also will participate in an exercise test, which is designed to determine my leg strength.

Prior to my involvement in the exercise program and the exercise test, I confirm that I am in good health and am able to participate in an exercise program. I have completed the medical history questionnaire, physical activity readiness questionnaire (PAR-Q), and the health risk analysis questionnaire. I have provided correct and accurate responses to all questions.

The exercise program will consist of 32 people being randomly assigned to one of four groups. All participants will perform three sets of six to eight repetitions of the squat exercise with a weight barbell. The exercise program will last for eight weeks and will meet twice a week. One group will not participate in the exercise program, but will participate in the exercise test.

The exercise test will be performed in a stairway located in Van Hoesen Hall on the SUNY Cortland campus. It will be completed prior to the initiation of the exercise program and after the 8-week program. The exercise test is to go down the stairs and up the stairs while wearing a weighted vest. The weight in the vest will be increased after going down and up the stairs unless I am unable to complete the test physically or voluntarily based on my tolerance level. I will state out loud to the researcher any symptoms such as fatigue, shortness of breath, or chest discomfort. I can stop the test at any point if I feel unusual discomfort, fatigue or by choice. I also understand that as soon as I request the test to stop that my request will be immediately granted.

There may be benefits from participating in the exercise program which include an increase in lower leg strength and fitness level. I understand that the results of completing the exercise test may or may not benefit me. Potential benefits include knowing my exercise and strength abilities.

I further understand that there are risks with exercise programs and completing the exercise test. Such risks include, but are not limited to, muscle soreness, muscle fatigue, and joint discomfort. If there are research-related injuries, voluntary compensation and treatment will not be provided. Despite the fact that a complete accounting of all risks have not been provided to me, I still voluntarily proceed with the exercise program and exercise test. At any time during the study, I am able to quit.

I have been informed that the information obtained in the exercise program and exercise test will be treated as privileged and confidential. Information will not be released or revealed to any person without my express written consent. I do, however, agree to the use of any information for this research and statistical purposes so long as the information does not provide facts that could lead to my identification. Any other information obtained, however, will be used only by the researcher to

IRB, Miller Building, Room 402 • P.O. Box 2000 • Cortland, NY 13045-0900
Phone: (607) 753-2511 • Fax: (607) 753-5590

evaluate my participation status. All information obtained will be used for research through SUNY College at Cortland and is a part of the MS degree requirements of the researcher.

I have been given an opportunity to ask questions about the exercise program and exercise test. At any time during the study, I can contact Mr. Timothy Lamey (tlamey@twcny.rr.com) for questions regarding the actual research. I can also contact Dr. Peter McGinnis (Peter.McGinnis@cortland.edu), or IRB Office (607) 753-2511, or the IRB Chair, Dr. Jena Curtis, at (607) 753-2979 at any time for questions about the rights of the research subjects. Finally, I can contact my professional health care provider for any questions related to research related injuries. I acknowledge that I have read this document in its entirety.

Signature: ____

Date: ____

Signature of witness: ____

Date: ____

Approved by SUNY Cortland's IRB under protocol #111208

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	**1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	**2. Do you feel pain in your chest when you do physical activity?**
☐	☐	**3. In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	**4. Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	**5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	**6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	**7. Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ______________________________

SIGNATURE ______________________________ DATE ______________________

SIGNATURE OF PARENT ______________________________ WITNESS ______________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

Health/Medical Questionnaire

Date: ______________________

Name: ______________________ Date of birth: __________ Soc. Sec. #: ______________

Address: ____
Street City State Zip

Phone (H): ______________ (W): ______________ E-mail address: ______________

In case of emergency, whom may we contact?

Name: ______________________ Relationship: ______________________

Phone (H): ______________________ (W): ______________________

Personal physician

Name: ______________________ Phone: ______________ Fax: ______________

Present/Past History

Have you had OR do you presently have any of the following conditions? (Check if *yes.*)

___ Rheumatic fever
___ Recent operation
___ Edema (swelling of ankles)
___ High blood pressure
___ Injury to back or knees
___ Low blood pressure
___ Seizures
___ Lung disease
___ Heart attack
___ Fainting or dizziness
___ Diabetes
___ High cholesterol
___ Orthopnea (the need to sit up to breathe comfortably) or paroxysmal (sudden, unexpected attack) nocturnal dyspnea (shortness of breath at night)
___ Shortness of breath at rest or with mild exertion
___ Chest pains
___ Palpitations or tachycardia (unusually strong or rapid heartbeat)
___ Intermittent claudication (calf cramping)
___ Pain, discomfort in the chest, neck, jaw, arms, or other areas
___ Known heart murmur
___ Unusual fatigue or shortness of breath with usual activities
___ Temporary loss of visual acuity or speech, or short-term numbness or weakness in one side, arm, or leg of your body
___ Other

Family History

Have any of your first-degree relatives (parent, sibling, or child) experienced the following conditions? (Check if *yes.*) In addition, please identify at what age the condition occurred.

___ Heart attack
___ Heart operation
___ Congenital heart disease
___ High blood pressure
___ High cholesterol

___ Diabetes
___ Other major illness ___________________

Explain checked items: ____

____

____

Activity History

1. How were you referred to this program? (Please be specific.) ___________________

____

____

2. Why are you enrolling in this program? (Please be specific.) ___________________

____

____

3. Are you presently employed? Yes ___ No ___
4. What is your present occupational position? ___________________
5. Name of company: ___________________
6. Have you ever worked with a personal trainer before? Yes ___ No ___
7. Date of your last physical examination performed by a physician: ___________________
8. Do you participate in a regular exercise program at this time? Yes ___ No ___ If yes, briefly describe:

____

____

9. Can you currently walk 4 miles briskly without fatigue? Yes ___ No ___
10. Have you ever performed resistance training exercises in the past? Yes ___ No ___
11. Do you have injuries (bone or muscle disabilities) that may interfere with exercising? Yes ___ No ___ If yes, briefly describe: ___________________

____

12. Do you smoke? Yes ___ No ___ If yes, how much per day and what was your age when you started? Amount per day ______ Age ______
13. What is your body weight now? ____ What was it one year ago? ____ At age 21? ____
14. Do you follow or have you recently followed any specific dietary intake plan, and in general how do you feel about your nutritional habits? ___________________

____

15. List the medications you are presently taking. ___________________

____

____

16. List in order your personal health and fitness objectives.
    a. ____
    b. ____

    ____
    c. ____

    ____

Health Risk Analysis

This form is a learning tool to identify positive and negative aspects of your health behavior. Though many of the effects are based on real findings from large epidemiological investigations, the estimates are generalized and should not be taken too literally. It is impossible to predict with accuracy how long you will live or when you will die.

Plus one (+1) represents a positive effect that could add a year to your life or life to your years, and minus one (-1) indicates a loss in the quantity or quality of life. A zero (0) indicates no shortening or lengthening of your longevity. If none of the categories listed for a factor apply to you, enter 0.

I. Coronary Heart Disease (CHD) Risk Factors

Cholesterol, total cholesterol/HDL ratio

Under 160 <3 +2	160-200 3-4 +1	200-220 4-5 –1	220-240 5-6 –2	Over 240 >6 –4	☐

Blood pressure $\left(\frac{systolic}{diastolic}\right)$

110 60-80 +1	110-130 60-80 0	130-150 80-90 –1	150-170 90-100 –2	170 >100 –4	☐

Smoking

Never +1	Quit 0	Smoke cigar or pipe or close family member smokes –1	1 pack cigarettes daily –3	2 or more packs daily –5	☐

Heredity

No family history of CHD +2	1 close relative over 60 with CHD 0	2 close relatives over 60 with CHD –1	1 close relative under 60 with CHD –2	2 or more close relatives under 60 with CHD –4	☐

Body weight (or fat)

5 lb below desirable weight (<10% fat—M; <16% fat—F) +2	5 lb below to 4 lb above desirable weight (10-15% fat—M; 16-22% fat—F) +1	5-20 lb overweight (15-20% fat—M; 22-30% fat—F) 0	20-35 lb overweight (20-25% fat—M; 30-35% fat—F) –2	>35 lb overweight (>25% fat—M; >35% fat—F) –3	☐

Sex

Female under 55 years 0	Female over 55 years –1	Male –1	Stocky male –2	Bald, stocky male –4	☐

Stress

Phlegmatic, unhurried, generally happy +1	Ambitious but generally relaxed 0	Sometimes hard-driving, time-competitive 0	Hard-driving, time-conscious, competitive (Type A) –1	Type A with repressed hostility –3	☐

Physical activity

High-intensity, over 30 minutes daily +2	Intermittent, 20-30 minutes 3-5 times/week +2	Moderate, 10-20 minutes 3-5 times/week +1	Light, 10-20 minutes 1-2 times/week 0	Little or none –2	☐

TOTAL: I. CHD Risk Factors ______

Enter on Scoring Summary

II. Health Habits (related to good health and longevity)

Breakfast

Daily +1	Sometimes 0	None –1	Coffee –2	Coffee and doughnut –3	☐

Regular meals

3 or more +1	2 daily 0	Not regular –1	Fad diets –2	Starve and stuff –3	☐

Sleep

7-8 hr +1	8-9 hr 0	6-7 hr 0	9 hr –1	6 hr –2	☐

Alcohol

None +1	Women 3/wk +1	Men 1-2 daily +1	2-6 daily –2	6 daily –4	☐

TOTAL: II. Health Habits ______

Enter on Scoring Summary

III. Medical Factors

Medical exam and screening tests (blood pressure, diabetes, glaucoma)

Regular tests, see doctor when necessary	Periodic medical exam and selected tests	Periodic medical exam	Sometimes get tests	No tests or medical exams	☐
+1	+1	0	0	−1	

Heart

No history of problems self or family	Some history	Rheumatic fever as child, no murmur now	Rheumatic fever as child, have murmur	Have ECG abnormality and/or angina pectoris	☐
+1	0	−1	−2	−3	

Lung (including pneumonia and tuberculosis)

No problem	Some past problem	Mild asthma or bronchitis	Emphysema, severe asthma, or bronchitis	Severe lung problems	☐
+1	0	−1	−2	−3	

Digestive tract

No problem	Occasional diarrhea, loss of appetite	Frequent diarrhea or stomach upset	Ulcers, colitis, gall bladder, or liver problems	Severe gastrointestinal disorders	☐
+1	0	−1	−2	−3	

Diabetes

No problem or family history	Controlled hypoglycemia (low blood sugar)	Hypoglycemia and family history	Mild diabetes (diet and exercise)	Diabetes (Insulin)	☐
+1	0	−1	−2	−3	

Drugs

Seldom take	Minimal but regular use of aspirin or other drugs	Heavy use of aspirin or other drugs	Regular use of amphetamines, barbiturates, or psychogenic drugs	Heavy use of amphetamines, barbiturates, or psychogenic drugs	☐
+1	0	−1	−2	−3	

TOTAL: III. Medical Factors ______ *Enter on Scoring Summary*

IV. Safety Factors

Driving in car

4,000 mi/year, mostly local	4,000-6,000 mi/year, local and some highway	6,000-8,000 mi/year, local and highway	8,000-10,000 mi/year, highway and some local	10,000 mi/year, mostly highway	☐
+1	0	0	−1	−2	

Using seat belts

Always	Most of time (75%)	On highway only	Seldom (25%)	Never	☐
+1	0	−1	−2	−3	

Risk-taking behavior (motorcycle, skydive, mountain climb, fly small plane, etc.)

Some with careful preparation	Never	Occasional	Often	Try anything for thrills	☐
+1	0	−1	−1	−2	

TOTAL: IV. Safety Factors ______ *Enter on Scoring Summary*

V. Personal Factors

Diet

Low-fat, high-complex carbohydrates	Balanced, moderate fat	Balanced, typical fat	Fad diets	Starve and stuff	☐
+2	+1	0	−1	−2	

Longevity

Grandparents lived past 90, parents past 80	Grandparents lived past 80, parents past 70	Grandparents lived past 70, parents past 60	Few relatives lived past 60	Few relatives lived past 50	☐
+2	+1	0	−1	−3	

Love and marriage

Happily married	Married	Unmarried	Divorced	Extramarital relationship	☐
+2	+1	0	−1	−3	

(continued)

Health Risk Analysis *(continued)*

V. Personal Factors *(continued)*

Education					
Postgraduate or master craftsman +1	College graduate or skilled craftsman +1	Some college or trade school 0	High school graduate –1	Grade school graduate –2	☐
Job satisfaction					
Enjoy job, see results, room for advancement +1	Enjoy job, see some results, able to advance +1	Job OK, no results, nowhere to go 0	Dislike job –1	Hate job –2	☐
Social					
Have some close friends +1	Have some friends 0	Have no good friends –1	Stuck with people I don't enjoy –2	Have no friends at all –3	☐
Race					
White or Asian 0	Black or Hispanic –1	American Indian –2			☐

TOTAL: V. Personal Factors ______ *Enter on Scoring Summary*

VI. Psychological Factors

Outlook					
Feel good about present and future +1	Satisfied 0	Unsure about present or future –1	Unhappy in present, don't look forward to future –2	Miserable, rather not get out of bed –3	☐
Depression					
No family history of depression +1	Some family history—I feel OK 0	Family history and I am mildly depressed –1	Sometimes feel life isn't worth living –2	Thoughts of suicide –3	☐
Anxiety					
Seldom anxious +1	Occasionally anxious 0	Often anxious –1	Always anxious –2	Panic attacks –3	☐
Relaxation					
Relax meditate daily +1	Relax often 0	Seldom relax –1	Usually tense –2	Always tense –3	☐

TOTAL: VI. Psychological Factors ______ *Enter on Scoring Summary*

VII. For Women Only

Health care					
Regular breast and Pap exam +1	Occasional breast and Pap exam 0	Never have exam –1	Treated disorder –2	Untreated cancer –4	☐
Birth control pill					
Never used +1	Quit 5 years ago 0	Still use, under 30 years 0	Use pill and smoke –2	Use pill, smoke, over 35 –3	☐

TOTAL: VII. For Women Only ______ *Enter on Scoring Summary*

SCORING SUMMARY

Category	Score (+/- years)
I. CHD Risk Factors	☐
II. Health Habits	☐
III. Medical Factors	☐
IV. Safety Factors	☐
V. Personal Factors	☐
VI. Psychological Factors	☐
VII. For Women Only	☐

☐ + ☐ = ☐

TOTAL + Your age = Longevity estimate

LIFE EXPECTANCY

Nearest age	Expectancy
30	74
35	74
40	75
45	76
50	76
55	77
60	78
65	80
70	82

Now go back and see how you can add years to your life by improving behaviors and lifestyle. Check each category for possible changes you would like to make in your current lifestyle.

From *NSCA's Essentials of Personal Training* by Roger W. Earle and Thomas R. Baechle, 2004, Champaign, IL: Human Kinetics. Adapted from B.J. Sharkey, 2002. *Fitness and Health, Fifth Edition*, (Champaign, IL): Human Kinetics, 63-67.

1RM TESTING PROTOCOL

1. Instruct the athlete to warm up with a light resistance that easily allows 5 to 10 repetitions.
2. Provide a 1-minute rest period.
3. Estimate a warm-up load that will allow the athlete to complete three to five repetitions by adding
   - 10 to 20 pounds (4-9 kg) or 5% to 10% for upper body exercise or
   - 30 to 40 pounds (14-18 kg) or 10% to 20% for lower body exercise.
4. Provide a 2-minute rest period.
5. Estimate a conservative, near-maximal load that will allow the athlete to complete two to three repetitions by adding
   - 10 to 20 pounds (4-9 kg) or 5% to 10% for upper body exercise or
   - 30 to 40 pounds (14-18 kg) or 10% to 20% for lower body exercise.
6. Provide a 2- to 4-minute rest period.
7. Make a load increase:
   - 10 to 20 pounds (4-9 kg) or 5% to 10% for upper body exercise or
   - 30 to 40 pounds (14-18 kg) or 10% to 20% for lower body exercise.
8. Instruct the athlete to attempt a 1RM.
9. If the athlete was successful, provide a 2- to 4-minute rest period and go back to step 7.

If the athlete failed, provide a 2- to 4-minute rest period, then decrease the load by subtracting

- 5 to 10 pounds (2-4 kg) or 2.5% to 5% for upper body exercise or
- 15 to 20 pounds (7-9 kg) or 5% to 10% for lower body exercise

AND then go back to step 8.

Continue increasing or decreasing the load until the athlete can complete one repetition with proper exercise technique. Ideally, the athlete's 1RM will be measured within three to five testing sets.

Appendix E

Participant Training Log Record

Group		Participant		Trainer		
DAY ONE	Set One		Set Two		Set Three	
Week	Weight	Repetition	Weight	Repetition	Weight	Repetition
One						
Two						
Three						
Four						
Five						
Six						
Seven						
Eight						
DAY TWO	Set One		Set Two		Set Three	
Week	Weight	Repetition	Weight	Repetition	Weight	Repetition
One						
Two						
Three						
Four						
Five						
Six						
Seven						
Eight						

Appendix F

Functional Strength Assessment Record

Participant Pre-Test Weight					Participant Post-Test Weight			
Participant	Trial 1	Trial 2	Trial 3		Participant	Trial 1	Trial 2	Trial 3

Appendix G

Pilot Study Results

Below is a summary of the pilot study results that took place to determine the protocol of the functional strength pre- and post-assessment.

Volunteer #1

In the rear stairwell of Van-Hoesen Hall, the participant descent and then ascent 53 steps, a total of 106 steps in one cycle while wearing a weight vest equal to 20% of his body mass. Twenty percent of body mass was used as initial weight of the vest; this was determined by review of literature.

Trial #1: The participant negotiated the stairs at a cadence of 80 beats per minute that was measured by a metronome.

Results: Participant rated his perceived exertion level as an average of 10.5.

Trial # 2: The weight of the vest was increased to 40% of their body mass and the participant repeated the stair descent and then ascent cycle at the same cadence.

Results: Almost identical to the previous trial with a perceived exertion level average of 12. The participant self-reported that he experienced very minimal fatigue while completing the ascent and felt his legs were recovering slightly while during the stair descent.

Results: The low perceived exertion rating was unacceptable for the study.

Volunteer #2

Location of the functional strength assessment was moved to Cory Union so that a stairwell of 60 steps could be used. The participant only completed the stair ascent while wearing a weight vest to eliminate the descent component of the functional strength assessment thus eliminating the recovery feeling the participant in the first pilot study reported. Due to the outcome of the pervious pilot study, 60% of the body mass was the initial weight of the vest.

Trial #1: The participant negotiated the stairs at a cadence of 80 beats per minute that was measured by a metronome.

Results: Participant rated their perceived exertion level as an average of 13.

Trial #2: The weight of the vest was increased to 70% of her body mass and the participant repeated the stair ascent at the same cadence.

Results: Participant rated their perceived exertion level as an average of 14.5.

Trial #3: The weight of the vest was increased to 80% of her body mass and the participant repeated the stair ascent at the same cadence.

Results: Participant complained of a crushing feeling on her shoulders and indicated that her fatigue level in her legs did not significantly increase with the added weight. The low perceived exertion rating and the high weight of the vest were unacceptable for the study.

Volunteer #3

Using the 60 step stairwell location in Cory Union location the participant from the second pilot study was asked to complete the stair ascent to the cadence of 80 beats per minute that was measured by a metronome while wearing 70 % of the body mass in the vest and 10 pounds ankle weight cuffs on each leg. At the end of the stair ascent cycle, the participant was asked to provide specific feedback on how to increase the fatigue level in her legs. The participant's feedback was that the cadence should be increased and the amount of weight distributed between the legs increased.

Volunteer #4

Trial #1: Using the 60 step stairwell location in Cory Union location, the participant from the second and third pilot study was asked to complete the stair ascent to the cadence of 84 beats per minute that was measured by a metronome while wearing 60% of her body weight in the vest and 20 pounds ankle weight cuffs on each leg.

Results: Participant rated their perceived exertion level as a 15.

Trial #2: Based on the participant's feedback the weight of the vest was increased to 70% of her body mass and the ankles weights where 22.5 pounds per leg. The participant repeated the stair ascent at an increased cadence of 88 beats per minute.

Results: Participant rated their perceived exertion level as a 17.

After the pilot study was complete, the researcher developed the Weight for Stair Ascent Assessment Chart to follow with the pre- and post-assessment (see Appendix H).

Appendix H

Weight for Stair Ascent Assessment

BW (lbs)	60%		70%		80%		90%	
	Ankle Wt.	Vest Wt.	Ankle Wt.	Vest Wt.	Ankle Wt.	Vest Wt.	Ankle Wt.	Vest Wt.
90	40 lbs (20)	14 lbs	45 lbs (22.5)	18 lbs	50 lbs (25)	22 lbs	55 lbs (27.5)	26 lbs
95	40 lbs (20)	17 lbs	45 lbs (22.5)	22 lbs	50 lbs (25)	26 lbs	55 lbs (27.5)	31 lbs
100	40 lbs (20)	20 lbs	45 lbs (22.5)	25 lbs	50 lbs (25)	30 lbs	55 lbs (27.5)	35 lbs
105	40 lbs (20)	23 lbs	45 lbs (22.5)	29 lbs	50 lbs (25)	34 lbs	55 lbs (27.5)	40 lbs
110	40lbs (20)	26 lbs	45 lbs (22.5)	32 lbs	50 lbs (25)	38 lbs	55 lbs (27.5)	44 lbs
115	40lbs (20)	29 lbs	45 lbs (22.5)	36 lbs	50 lbs (25)	42 lbs	55 lbs (27.5)	49 lbs
120	40lbs (20)	32 lbs	45 lbs (22.5)	39 lbs	50 lbs (25)	46 lbs	55 lbs (27.5)	53 lbs
125	40lbs (20)	35 lbs	45 lbs (22.5)	43 lbs	50 lbs (25)	50 lbs	55 lbs (27.5)	58 lbs
130	40lbs (20)	38 lbs	45 lbs (22.5)	46 lbs	50 lbs (25)	54 lbs	55 lbs (27.5)	62 lbs
135	40lbs (20)	41 lbs	45 lbs (22.5)	50 lbs	50 lbs (25)	58 lbs	55 lbs (27.5)	67 lbs
140	40lbs (20)	44 lbs	45 lbs (22.5)	53 lbs	50 lbs (25)	62 lbs	55 lbs (27.5)	71 lbs
145	40lbs (20)	47 lbs	45 lbs (22.5)	57 lbs	50 lbs (25)	66 lbs	55 lbs (27.5)	76 lbs
150	40lbs (20)	50 lbs	45 lbs (22.5)	60 lbs	50 lbs (25)	70 lbs	55 lbs (27.5)	80 lbs
155	40lbs (20)	53 lbs	45 lbs (22.5)	64 lbs	50 lbs (25)	74 lbs	55 lbs (27.5)	85 lbs
160	40lbs (20)	56 lbs	45 lbs (22.5)	67 lbs	50 lbs (25)	78 lbs	55 lbs (27.5)	89 lbs
165	40lbs (20)	59 lbs	45 lbs (22.5)	71 lbs	50 lbs (25)	82 lbs	55 lbs (27.5)	94 lbs
170	40lbs (20)	62 lbs	45 lbs (22.5)	74 lbs	50 lbs (25)	86 lbs	55 lbs (27.5)	98 lbs
175	40lbs (20)	65 lbs	45 lbs (22.5)	78 lbs	50 lbs (25)	90 lbs	55 lbs (27.5)	103 lbs
180	40lbs (20)	68 lbs	45 lbs (22.5)	81 lbs	50 lbs (25)	94 lbs	55 lbs (27.5)	107 lbs
185	40lbs (20)	71 lbs	45 lbs (22.5)	85 lbs	50 lbs (25)	98 lbs	55 lbs (27.5)	112 lbs
190	40lbs (20)	74 lbs	45 lbs (22.5)	88 lbs	50 lbs (25)	102 lbs	55 lbs (27.5)	116 lbs
195	40lbs (20)	77 lbs	45 lbs (22.5)	92 lbs	50 lbs (25)	106 lbs	55 lbs (27.5)	121 lbs

Appendix I

BORG Scale – Rate of Perceived Exertion

RPE	Description	Intensity Level
7	Easy	
8		
9	Very Light	
10		50% MHR
11	Fairly Light	
12		60% MHR
13	Somewhat	
14	Hard	70% MHR
15		
16	Hard	80% MHR
17		
18	Very Hard	90% MHR
19	Very, Very Hard	
20		