Feasibility of Using a Non-Counter Movement Squat to Assess Lower Body Strength in Adults Ages 20-70 years.

by

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ABSTRACT

The purpose of this study was to investigate the Feasibility of Using a Non-Counter Movement Squat to Assess Lower Body Strength in Adults ages 20-70 years. Feasibility was tested by measuring five feasibility metrics described by Bowen et al. (Bowen et al., 2009): Acceptability, Demand, Implementation, Practicality, and Limited Efficacy. Seven male subjects and fifteen female subjects participated in the study. The subjects had their height, weight, body fat percentage by bioelectrical impedance analysis (BIA), and grip strength measured. Subjects performed a warm-up on a cycle ergometer, a Non-Counter Movement Squat Test (NCMST) 1-repetition maximal strength test using a Smith machine, and a cool down on a treadmill. Each subject then completed a post-participation questionnaire used to measure acceptability, Demand was measured by subjects who agreed to participate, implementation was measured by subjects who completed the protocol, practicality was measured by an administrator survey, and limited efficacy was measured by distribution of strength results by age and for all subjects by sex. Results showed acceptance of hypotheses of acceptability, demand, implementation and practicality for both males and females. Limited efficacy was inconclusive for both males and females resulting in rejection of hypothesis. The findings of this study show that further research is needed to compare the NCMST to other lower body muscular strength tests to determine the validity of the NCMST.

DEDICATION

This thesis is dedicated to my loving grandmother Kathryn Mansfield whose love and continue support has aided in this paper coming to fruition. Her fight was much greater than mine, but her love was been unwavering. She was the strongest person that I had ever known and lived her live selflessly for others. I have never known anyone to have such an impact on everyone she met. I will cherish every moment I spent with her and I hope to see her again in the next chapter.

If tears could build a stairway, And memories a lane,

I'd walk right up to Heaven And bring you home again.

No farewell words were spoken, No time to say "Goodbye".

You were gone before I knew it, and only God knows why.

My heart still aches with sadness, and secret tears still flow.

What it meant to love you No one can ever know.

But now I know you want me to mourn for you no more;

To remember all the happy times life still has much in store.

Since you'll never be forgotten, I pledge to you today

A hollowed place within my heart is where you'll always stay.

—*Unknown*

I love you Grandma.

Kathryn Mansfield

September 22, 1942 To June 18, 2019

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TABLE OF CONTENTS

Page

CHAPTER Page

APPENDIX Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Overview

Much of one's health status is determined by health behaviors. Physical activity is a health behavior important for reducing health risks, such as cardiovascular diseases, metabolic diseases, and premature mortality. Muscular strength and endurance are outcomes of physical activity; they are key aspects of most individuals' daily lives and are significant factors in determining one's longevity (Fielding et al., 2011; Nelson et al., 2007). As adults age, sarcopenia becomes a health concern that can limit one's physical function and quality of life. Sarcopenia is defined as a natural loss of muscle mass, strength and quality (Hwang et al., 2012; T. N. Kim & Choi, 2013; Yu, Khow, Jadczak, & Visvanathan, 2016). In most cases the standard for a diagnosis for sarcopenia is two or more standard deviations below the mean reference values for both men and women (Cruz-Jentoft et al., 2019; Han, Bokshan, Marcaccio, DePasse, & Daniels, 2018). It is estimated that nearly a third of the population develops sarcopenia by the age of 60 and nearly half of adults have developed sarcopenia by age 80 (von Haehling, Morley, & Anker, 2010). Maintaining strength throughout the lifespan in excess of the needs for daily living can mitigate the debilitating effects of sarcopenia. Such strength can help individuals continue daily life function with age-related effects of sarcopenia or dynapenia.

Individuals need a certain level of strength to live their daily lives unassisted. While the amount of strength may vary between individuals, trends in sarcopenia and dynapenia across the lifespan may determine a mean strength level needed by age and

sex. Since sarcopenia and dynapenia varies between individuals, the relative strength of individuals decreases at different rates. As an example, strength will differ among each 160 lb., 50-year-old male and also among each 118 lb., 20-year-old female (Eriksen et al., 2016; von Haehling et al., 2010). If one's base level of strength is greater than expected for one's age and sex, the potential decrease in strength from sarcopenia will not influence the individual's ability to live independently. This can result in a better quality of life.

Lower body muscular strength is necessary for everyday activities, whether getting out of bed, standing up from a chair or getting off the toilet. Due to the need for lower body strength in daily movements, the American College of Sports Medicine and the National Strength and Conditioning Association utilize the measurement of lower body strength using a leg press which measures absolute strength (American College of Sports Medicine, 2018; National Strength and Conditioning Association, 2016). However, most leg press machines do not function in a plane of movement that accurately represents daily functions as the test requires users to sit in a chair and press a weight in a horizontal or diagonal plane. By assessing lower body strength capability with a motion similar to daily living (vertical plane), it is possible to assess one's capacity for the activities of daily living capabilities.

Another difficulty in assessing lower body strength relates to the exercises used to test maximum strength. For example, to assess one's capacity to rise from a chair, or toilet, one needs to assess whether the individual has the ability to apply force underneath their body to assist them in standing. Hence, absolute strength is not the only factor in determining functional mobility. Body mechanics and structural integrity of the limbs can

determine one's ability to exert force. If persons show signs of valgus, which is when the knees buckle towards each other when under a load, they may be able to move a weight on a leg press; however, they would not be able to exert sufficient strength to stand up from a seated position without a loss in balance. One's posture is also important in the ability to rise from or descend to a seated position. A common sight in individuals with poor lower body balance is a tendency to lean forward when trying to lower their hips. Loss of balance may be due to insufficient muscle strength in different muscles located in the core (erector spinae, external obliques, internal obliques, multifidus, pelvic floor muscles, rectus abdominis, and transversus abdominis) or hips (psoas and abductors). This can pose difficulties in determining the source of an imbalance because these muscles are not being fully used during a seated leg press that measures leg and hip strength (Saladin, 2011).

Several tests have been developed to examine lower body strength in older populations to help reduce the chance of injury. These include rising from an 18 inch chair multiple times in 30 or 60 seconds as fast as possible [Chair Stand Test] (R. E. Rikli & Jones, 2013) and a leg press repetition max test where the number of reps is known (usually 3 or 5) and the amount of weight is changed to identify one's maximal strength [Repetition Max Test] (American College of Sports Medicine, 2018; National Strength and Conditioning Association, 2016).

Limitations of these tests exist. In the Chair Stand Test, the test is used to measure lower body muscular endurance and, while this is still important, most individuals rarely perform such motions in rapid succession during daily living activities. Most functional difficulties arise when performing actions that require an individual to squat or stand up

from lower than the standard chair height of 18 inches, such as getting off a toilet or when the seat surface is less stable such as a bed or sofa (R. E. Rikli & Jones, 2013). The leg press repetition max test is limited in that leg press machines operate in a field of motion that is significantly different than that of daily living. This creates a limitation in the relation between performance in the test and implementation of that performance to daily activities.

A novel test of lower body strength is the 1-repetion back squat (1-RM). This test requires an individual to start from a standing position with a desired amount of weight loaded onto a barbell and supported by the upper back and shoulders. The individual then lowers his or her body by allowing their knees and hips to flex while maintaining a neutral (flat) back with the chest facing upward (National Strength and Conditioning Association, 2016). Once the individual reaches the bottom of knee and hip flexion, defined by the top of the thighs being parallel with the floor, the individual extends his or her knees and hips at the same rate while keeping their back neutral and chest up until they return to their upright starting position (National Strength and Conditioning Association, 2016). The suitability of the test is unknown for older adults and those not familiar with free weight exercises because the counter movement or descent phase of the squat requires controlling the body with their thighs and hip muscles, referred to as muscle stabilizers. As older adults may lack sufficient strength in their muscle stabilizers, the risk of injury to the knees and back during the descent phase of the squat increases. Some individuals also may have difficulty performing the 1-RM back squat if they have knee or hip problems.

An alternative test to measure lower body strength is to use a Non-Counter Movement Squat Test (NCMST) to assess maximal leg strength using a Smith machine. A Smith machine is a weight machine that consists of a barbell fixed within steel guiderails allowing for only near-vertical movement. To perform the NCMST, an individual starts from a seated position on a box or bench measuring 16 inches from ground to top of the seat. The individual has the bar of the Smith machine lowered onto their shoulders. He or she then extends their knees and hips at the same rate while keeping their back neutral (flat) and chest facing upward until they reach a standing position where the weight is locked into place in the Smith machine. The benefit of performing the NCMST in a Smith machine is that it reduces the risk for injury by removing the decent phase of the exercise where most injuries occur due to a loss in balance or technique (D. R. Clark, Lambert, & Hunter, 2012; Sands, Wurth, & Hewit, 2012). It also allows for greater standardization of the movement pattern used to complete a squat allowing for greater uniformity and ability to compare results between subjects. This will theoretically allow individuals to focus primarily on the direct action of standing up with the weight by reducing the need to worry about loss of balance by excessive forward or backward leaning.

Is the NCMST appropriate for people of all ages? To answer this question, there are certain feasibility characteristics to establish before deeming the test is practical for widespread use. Feasibility is defined as measures used to determine appropriateness of large-scale dissemination of an idea, intervention, or product. Feasibility is measured using the focus areas described by Bowen et al. (Bowen et al., 2009) to include acceptability, demand, implementation, practicality, and limited efficacy. Acceptability is

defined as to what extent a new process or measure is judged as suitable, satisfying, or attractive to both program deliverers and to recipients. Demand is the interest in the study. Implementation is the ability of the subjects to complete the study. Practicality is the extent the strength protocol occurs as intended. Limited efficacy is the ability to collect data as planned. Once feasibility is established, it is possible to determine if a new test protocol can be used on a larger scale and whether it is useful to develop age- and sex-specific norms.

The purpose of this cross-sectional study was to test the feasibility of creating a lower body strength test used to establish relative norms of lower body strength needed for regular daily function within men and women ages 20-70 years.

Purpose of Study

The purpose of this study was to test the feasibility of assessing lower-body muscular strength using a non-counter movement squat on a Smith machine. Measures of feasibility included: acceptability, demand, implementation, practicality, and limited efficacy. Feasibility measures helped to determine if it was possible to conduct a large-scale study to assess lower-body muscular strength.

Research Aims

The aim of this study was to test the feasibility of assessing lower body muscular strength with a non-counter movement 1-repetition maximum (1-RM) squat performed on a Smith machine in adult men and women ages 20-70 years.

Research Hypotheses

Hypothesis 1: At least 65% of the subjects will find the Non-Counter Movement Back squat protocol to be acceptable.

Hypothesis 2: The demand for the Non-Counter Movement Back Squat Protocol will have least 65% of subjects expressing interest enrolling in the study.

Hypothesis 3: For implementation, at least 70% of the subjects will complete the NCMST as intended.

Hypothesis 4: For practicality, at least 65% administrators will find the NCMST appropriate to measure lower body strength.

Hypothesis 5: For limited efficacy, strength data will show a sex-specific, graded decrease in strength by age.

Definition of Terms

Resistance Training: A form of physical activity in which a person moves a given weight, either an external weight or the individual's body weight, through a full range of motion. This form of training usually targets a specific muscle group and is used to strengthen this muscle group.

Muscular Strength: The ability of a muscle or muscle group to develop maximal contractile force in a single contraction.

Squat: An exercise performed by lowering your hips and flexing at the knees and return to a standing position.

Non-Counter Movement Squat: the concentric phase with no eccentric phase of a traditional squat.

Smith Machine: A weight machine that consists of a barbell that is fixed within steel guiderails allowing only near-vertical movement.

Feasibility Metrics: Focus areas described by Bowen et al (Bowen et al., 2009) used to measure various characteristics of a program's feasibility including acceptability, demand, implementation, practicality, and limited efficacy.

Feasibility. Feasibility is defined as measures used to determine appropriateness of larger scale interventions. Feasibility will be measured using the focus areas described by Bowen et al. (Bowen et al., 2009) for each focus area described below.

Acceptability: To what extent this new process or measure is judged as suitable, satisfying, or attractive to both program deliverers and to recipients.

Demand: To what extent this program or method is likely to be used.

Implementation: How effectively the program or method can be utilized to intended subjects in a defined but uncontrolled environment.

Practicality: To what extent this program or method can be used with intended subjects using existing means, resources, and circumstances without outside intervention.

Limited efficacy: whether this program or method shows promise of being successful with intended population even if used in highly controlled settings.

CHAPTER 2

LITERATURE REVIEW

Introduction

Muscular strength is defined as the ability to exert force with no defined standard of measurement. Strength can be measured in many different ways depending on a more specific definition in one or more of three categories: endurance, power, and/ or work (National Strength and Conditioning Association, 2016). This review discusses the literature related to the development and loss of muscle tissue, the types of strength tests for adult and senior populations, and the feasibility of strength testing in adult and senior populations.

Importance of muscle strength on physical function

Leg strength is one of the most important muscular factors required for independence and quality of life. Lower body muscular strength is needed to function effectively support an individual's total body weight to allow for walking, sitting down, standing up with and without carrying additional weight (Landers, Hunter, Wetzstein, Bamman, & Weinsier, 2001). Leg strength also has been associated with the bone mineral density (BMD) of both the legs and the hip. Low strength is associated with low BMD which increases the risk of fractures (K. M. Kim et al., 2018). Fractures of the hip and other weight-bearing bones are very serious because they can dramatically decrease mobility which may be life threatening ("Hip fracture - Symptoms and causes," n.d.).

Development and loss of muscle tissue

The physiological processes associated with the development and loss of muscular tissue and strength are similar in persons of differing ages. This section includes

an overview of the anatomy of skeletal tissue, theories of muscle strength gain, sarcopenia (loss of muscle mass), and dynapenia (muscle power loss).

Anatomy of Muscle Tissue

Muscles are composed primarily of slow- and fast-twitch muscle fiber bundles. Slow-twitch fibers (type I) are endurance muscular fibers as they are resistant efficient and fatigue resistant; but have a limited potential for rapid force development. Alternatively, fast-twitch fibers (type II, IIa, and IIx) are the strength and power muscular fibers because they develop force and relax rapidly; thus, having a short-twitch time and a high fatigue rate (American College of Sports Medicine, 2018; Saladin, 2011).

A single muscle is composed of many motor units that consist of components of muscle fibers and motor neurons. A motor unit is a single motor neuron and all the muscle fibers it innervates. A motor neuron delivers the chemical stimulate from the nervous system and uses the information to induce a mechanical response (Saladin, 2011). Muscle fibers consist of myofibrils, mitochondria, and nuclei. Myofibrils are single protein chains within a muscle fiber with the number of myofibrils varying greatly between skeletal muscles and individuals. Figure 1 provides a display of the muscle fiber.

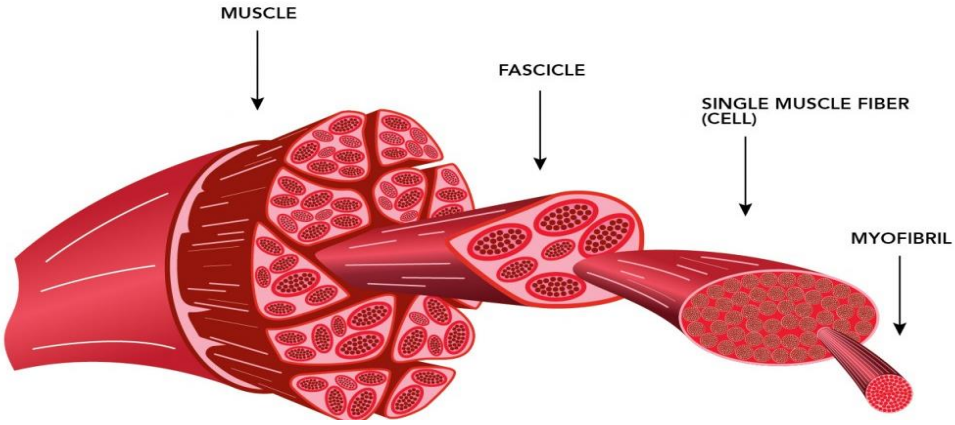

Figure 1: Anatomy of Skeletal Muscle

Adenosine tri-phosphate (ATP) is the base fuel of skeletal muscle and is necessary for all forms of skeletal muscle usage. Sources of energy for short-term to endurance exercise includes phosphocreatine, (ATP), glycogen, and fat. Phosphocreatine (PCr) is highly effective in the initial seconds of all exercise regardless of intensity, but PCr has the largest influence on short-term (1 to 10 seconds), high intensity exercise (National Strength and Conditioning Association, 2016). PCr when combined with the enzyme Creatine Kinase, ATP can be synthesized from adenosine di-phosphate (ADP). Glycogen storage within the muscle is an important source of energy during exercise. Glycogen stores are important for exercise lasting 30 seconds to three minutes. As glycogen stores become depleted, skeletal muscle must rely on slower oxidative energy systems to supply energy to the skeletal muscle. This includes muscle fat stores and delivery of glucose fuel stores. Both glucose fuel stores and fat require oxygen in order to provide ATP to the muscle. By utilizing fat, a nearly limitless supply of energy at a very slow rate can be supplied allowing for low intensity exercises to be performed for many hours. During recovery, PC, ATP, and glycogen stores restore to pre-exercise levels. The recovery period needed to restore sources of energy varies from minutes to days. Recovery in cases such as Olympic or powerlifting, the recovery time ranges from 30 seconds to four minutes depending on the condition of the individual (National Strength and Conditioning Association, 2016). The duration needed to restore CP and ATP is one of the reasons why rest periods are important for maximal effort during maximal exercise attempts.

Theories of Muscle Strength Development

The three primary components of muscular fitness (endurance, strength, and power) are specific to the types of exercise demands on the muscular fibers. Endurance exercise requires muscle groups to perform repeated contractions against a submaximal resistance. Endurance exercise requires contractions continuously until the onset of fatigue without the use of rest periods. Examples of muscular endurance tests are maximal pushups or abdominal crunches. Exercise programs that emphasizes muscular endurance involves performing sets of high repetitions, usually in excess of twelve repetitions per set of specific exercises (National Strength and Conditioning Association, 2016).

Strength exercises are known as having a low speed of contraction against a specific mass. Muscular strength is defined as the force a muscle or group of muscles can exert in one maximal attempt while maintain proper posture. The measurement of muscular strength is performed by lifting a maximum weight for a single repetition, such as a bench press or back squat. Exercise programs that emphasizes muscular strength involve performing sets of low repetitions with a high volume; often in a set of exercises that include less than seven repetitions. Due to the higher energy demand of maximal strength exercises, rest periods of two to five minutes enable sufficient recovery of muscle contractile anatomy and fuel sources. (National Strength and Conditioning Association, 2016).

Two sources of muscular power exist: high-speed power and anaerobic power that relate to the ability of muscle tissue to exert high force while contracting at high speed. Muscular power tests quantify the maximum effort a single repetition with or without

weight in a short period using explosive exercises such as a power clean, push jerk or vertical jump. Exercise programs that emphasizes muscular power are similar to those used to assess muscular strength. The tests involve performing sets of low repetitions with a moderate volume but at higher speeds; a set usually includes one or two repetitions for single effort events such as Olympic lifting or throwing, or three to five repetitions for multi-effort events such as football or soccer. Because muscular power requires high ATP and PC energy demands during the short exertion periods the rest periods should last three to five minutes between sets (National Strength and Conditioning Association, 2016).

Muscle Hypertrophy

Muscle hypertrophy is defined as an increase in size of skeletal muscle through a growth in size of its component cells (Hernandez & Kravitz, n.d.). Hypertrophy training is a term commonly used to describe an exercise program focusing on the increase in muscular strength, muscle mass or the combination of the two. There is not a widely used term used to describe the increase of muscular strength or power without the focus in increasing muscular mass. Muscle hypertrophy is thought to occur in two primary ways: sarcoplasmic hypertrophy and/or myofibrillar hypertrophy.

Sarcoplasmic hypertrophy focuses on increasing the muscle glycogen storage inside of skeletal muscle. This is thought to occur by repetitive muscle contractions that utilize glycogen. As glycogen levels deplete, increased amounts of glycogen are restored during recovery. This increases one's muscular endurance capacity and maximal output of the skeletal muscle (Schoenfeld, 2016). However, it should be noted that this theory has come into question more recently on whether sarcoplasmic hypertrophy occurs.

Myofibril hypertrophy is the increased cross-sectional size of myofibrils. Such hypertrophy increases the overall cross-sectional volume of a muscle increasing its size. Bodybuilders focus primarily on myofibril hypertrophy because the size of the muscle is a crucial factor in competition. However, muscle size is not synonymous with muscle strength. Power lifters are very strong, but they do not focus their training on myofibril hypertrophy.

Sarcopenia

Sarcopenia is defined as a natural loss of muscle mass, strength and quality (Hwang et al., 2012; T. N. Kim & Choi, 2013; Yu et al., 2016). As individuals age muscle mass declines. However, there is no definitive conclusion whether the loss of muscle mass guarantees a loss in strength. Some studies show that the loss in muscle mass has a strong correlation with losses in muscular strength with increasing age resulting in greater amounts of strength lost (von Haehling et al., 2010). Von Haehling et al. found that between the ages of 50 and 60 years, muscular mass decreased on average 1-2% per year. This is accompanied with a decline in strength of approximately 1.5% per year at age 50 with decreases of 3% per year after age 60. This is despite older adults having a similar rate of loss in muscular mass (von Haehling et al., 2010). While there has been no universally accepted method for reversing or reducing cases of sarcopenia, some research suggests that the effects can be reduced through regular exercise prescription methods (Law, Clark, & Clark, 2016; Liguori et al., 2018).

Nomura et al. suggest that sarcopenia is most common in lower extremities (Nomura, Kawae, Kataoka, & Ikeda, 2018). However, since muscular mass is greater in the lower body, the presence of more initial muscular mas may cause the decreases to be

more noticeable. The variation in the changes in muscular mass and strength between fiber types should also be considered. In many cases reductions in muscular strength are of greater concern for those effected by sarcopenia, and this could be due to type II muscle fibers being the first to decline or because strength is what is assessed for a diagnosis of sarcopenia. Three studies show that sarcopenia is associated with many health risks including disability, increased fall risk, loss of independence, and mortality (Janssen, Heymsfield, & Ross, 2002; Janssen, Heymsfield, Wang, & Ross, 2000). In a study performed by Hvid et al. type II muscular fibers showed greater decreases in muscular strength in older adults compared to younger adult atrophy, and they also saw an increase in effort needed in order to retrain older adults type II muscle fibers compared to type I and younger adults (Hvid et al., 2010). Some researchers hypothesize that sarcopenia and dynapenia are more prevalent among diabetic individuals, but a study performed by Huang et al. showed no difference between diabetic and nondiabetic persons in the prevalence of sarcopenia in each given population; especially those with high serum insulin levels, who had adequate levels of vitamin D (Hwang et al., 2012). However, they did show low vitamin D level were present in individuals with sarcopenic obesity, stating, “Low vitamin D was associated with low extremity power and performance because vitamin D level positively influences on muscle strength and muscle mass” (Hwang et al., 2012).

While it is widely recognized that intervention and prevention of sarcopenia is important, there is little consensus about the optimal screening methods for sarcopenia (Yu et al., 2016). Some studies used composition measurements such as bioimpedance analysis to asses muscular mass (Janssen et al., 2002), while another study made

conclusions based upon changes in the individuals Body Mass Index (BMI) (Nomura et al., 2018). The discussion of screening for sarcopenia is beyond the scope of this review of the literature.

Dynapenia

Dynapenia is the term used to describe the loss in muscular power as a component of strength (B. C. Clark & Manini, 2008). Dynapenia becomes apparent in later years as regular daily routines become more difficult despite little to no change in physical appearance. A meta-analysis of eleven longitudinal studies suggest, that dynapenia may be more important than sarcopenia when determining potential health risk of an individual (Mitchell et al., 2012).

Assessing only the cross-sectional volume and size of a muscle as indicators of losses in muscular strength or power is insufficient (B. C. Clark & Manini, 2012). This is because two studies found that the prevention and intervention of dynapenia with exercise training occurred as muscles become stronger in older adults despite having little-to-no change in muscular mass (Law et al., 2016; Orssatto et al., 2018). Thus, Clark & Manini recommend that clinicians assess both age-related sarcopenia and dynapenia using tests developed for each condition. Selected tests for sarcopenia and dynapenia include an assessment of symptoms, Dual X-ray Absorptiometry (DXA), Dynamometer, or walking test.

Types of Strength Tests for Adults and Senior Populations

Muscle strength tests are part of an overall fitness evaluation and are useful in measuring muscle strength baseline and progression in exercise interventions. Muscular fitness is well accepted as a critical component of proper physical function and should be

evaluated with tests developed for specific populations, body parts, and movement purposes (American College of Sports Medicine, 2018). This section describes selected types of tests used to measure leg and hip strength and endurance in adult and senior populations. As dozens of tests are available to test muscle strength, this review is limited to lower-body muscular fitness tests, including the set repetition max squat test, the set repetition leg press test, sit-to-stand test, and proposed Non-Counter Movement Squat Test.

Leg and Hip Strength Test for Adult Populations

Most strength improvement prescriptions use an estimated or measured one-repetition maximum lift of certain muscle groups or body regions against a defined weight. Research related to strength capacity and enhancement prescriptions has focused primarily on athletic populations (National Strength and Conditioning Association, 2016). Accordingly, little is known about strength capacity in non-athletes aside from documenting that strength decreases when not utilized (atrophy) and as individuals age commonly (sarcopenia/ dynapenia). Several position statements (e.g., American College of Sports Medicine, National Physical Activity Guidelines) recommend adults perform resistance training at least twice per week to maintain strength and reduce chances of disabilities occurring (American College of Sports Medicine, 2018; National Strength and Conditioning Association, 2016).

Exercise is very effective at increasing lower body strength through various means. However, physical activity must be constant and maintained in order to reduce the decreases in muscular strength due to lack of use (muscular atrophy), aging (dynapenia), and with various diseases and conditions, such as coronary artery disease, diabetes, or

osteomalacia. Exercising consistently and progressively improves overall muscular capabilities, thus maintaining muscular strength for daily functions (Cheema, Chan, Fahey, & Atlantis, 2014). In addition to leg strength, leg power is important for daily living because power is the ability to overcome resistance in reference to time. For example, as an individual gets out of bed or off a toilet which require a defined level of leg strength and power, the ability to complete these actions in a reasonable amount of time is important for maintaining independence. External actions to reduce resistance are applied often to reduce the power necessary to perform some daily functions. For example, ease in getting off a toilet is aided by raising the height of the toilet seat to reduce the distance an individual must stand (Lee et al., 2018).

Lower body muscular strength has been assessed primarily in three general methods for over 20 years to include the leg press, maximum squat test, and chair test. Each method has its advantages and disadvantages as described below.

Maximum Squat Test (squat max test)

The squat max test is performed free form, most commonly with a barbell. Here the individual lowers his or her body by allowing their knees and hips to flex while maintaining a neutral (flat) back with the chest facing upward (National Strength and Conditioning Association, 2016). The advantages of the max squat test are that it is performed in a field of motion very similar to lifestyle activities allowing it to assess the usable strength of an individual. The squat max test is also very effective at allowing a test administrator to identify weaknesses in posture and technique such as varus or valgus knees. By having the ability to identify weaknesses in form the tester has the opportunity to correct these issues prior to prescribing exercise to improving the functional

capabilities. The squat max test also has disadvantages. While the test is excellent for assessing lower body strength, it may not be suitable for all ages and experience levels. The squat max test also can be difficult to standardize due to variances in techniques and ranges of motion (Lorenzetti et al., 2018). The squat max test is usually most effective when working with younger more active individuals with some level of experience in weightlifting. Using the squat max test can cause decreases in the validity if used in populations unfamiliar with weightlifting due to their lack of experience with the motion (National Strength and Conditioning Association, 2016; Sands et al., 2012). In addition, the test can lose validity if some individuals apply a plyometric response during the squat action to achieve maximal effort during the test (Myer et al., 2014).

Maximum Leg Press Test (Leg press max test)

To assist in countering some of the difficulties of the max squat test, the leg press max test has been used to assess leg strength. The leg press max test is performed on leg press weight machines. Leg press machines are effective at isolating the range of motion and limiting the need for familiarity as compared to the squat max test that uses a barbell. Leg press machines are widely available making them accessible to the public through most commercial gyms. However, there are many variations of leg press machines that operate through various angles and positions making standardization difficult between different leg press machines. Maximal leg test-based assessments have been shown to be a reliable method for testing changes in strength in various muscle groups as long as the equipment used is consistent (Seo et al., 2012). One advantage of the leg press max test is that the weight of the individual has little-to-no influence on the weight lifted during the test. This is helpful for test standardization. The biggest disadvantage in using leg press

machines to assess leg strengths is that the majority leg press machines do not function in a field of motion that is representative of daily activities making functional performance more difficult to evaluate.

Sit-to-Stand Test

An alternative to the squat or leg press is the chair or sit-to-stand test, which is primarily used in senior populations, defined as individuals 65 years and older. ("Demography - Elderly population - OECD Data," n.d.; R. Rikli & Jones, 2013). In senior populations the Sit-to-Stand test is used to assess lower body muscular function. This test involves timing the number of repetitions of standing and sitting one performed in 30 seconds or one minute; the 30-second option is most common in elderly populations. The Sit-to-Stand test can be done virtually anywhere with a flat surface and requires only a chair with a 18-inch seat height; (R. Rikli & Jones, 2013). The test is most commonly used in elderly populations because of its simplicity and accessibility. A limitation is the test is a measurement of muscular endurance, not muscle strength or power. While muscular endurance is important, it does not accurately represent the total muscular function of the legs and hips when assessing daily usable muscular function. (Cadore, Pinto, Bottaro, & Izquierdo, 2014; Fielding et al., 2011; National Strength and Conditioning Association, 2016). Another limitation is that the 18-inch chair seat height is higher than the height where older adults have trouble raising from a seated position (16 inches). Thus, this test may not predict difficulty in raising from a seated position at seated heights lower than 18 inches. (Lee et al., 2018).

Summary

In summary, lower body muscular strength is a component of many fitness protocols. Some tests measure muscular strength (squat max test and leg press) and other measure muscular endurance (Sit-and-Stand). While the tests are specific to the ages and skills of the populations being assessed, it is important to assure that tests of muscular strength do measure muscular strength and not muscular endurance.

Feasibility of muscular fitness tests for adult and senior populations

Little is known about the ability of senior adults to perform tests of muscular strength since no tests for muscular strength have been developed for senior populations. Hence, there is a need to assess the feasibility of strength testing in senior populations. Feasibility is defined as measures used to determine appropriateness of large-scale dissemination of an idea, intervention, or product. Feasibility is measured in this study using the focus areas described by Bowen et al. (Bowen et al., 2009) to include acceptability, demand, implementation, practicality, and limited efficacy.

Acceptability

Acceptability represents to what extent the new process (NCMST) is deemed suitable, satisfying, and/or attractive by the recipients or subjects. Since a test whether useful or not is only as beneficial as its ability to be used. If individuals are unwilling to participate in the NCMST then there is limited usefulness for the establishment of the protocol.

Demand

Demand represents the interest in participating in the NCMST helping to estimate the interest in participating in more general uses. An unlimited supply of an item means

nothing if there is no demand for said item. The demand for a better lower body strength test may exist, but the recognition of the NCMST to satisfy this demand must be tested in order to indicate whether supply and demand intersect.

Implementation

Implementation represents the ability or extent to which the NCMST can be performed and administered as intended in laboratory and community settings. Little is known if the NCMST can be implemented by exercise professionals with their clients and patients to assess their lower body strength capabilities. Since many exercise professionals do not work in research environments it is important that the NCMST be usable in applicable situations to be useful for various individuals.

Practicality

Practicality allows for the determination if a process or procedure (NCMST) can be administered in various settings. Little is known if exercise professionals with limited experience in assessing strength in adult populations are able to administer the NCMST. Implementation focuses on practice settings. Understanding the practicality of the NCMST identifies ways the test can be administered by exercise professionals successfully. For example, is it practical to administer the test without a Smith Machine or with equipment needed for warm up and cool down?

Limited efficacy

In a feasibility study the sample size is usually not large enough to give a significant representation of the population being tested. Limited efficacy of the NCMST allows investigators to determine if the test is effective in a smaller sample and tests established protocols for its implementation.

Summary

Studies show the importance of assessing and improving lower muscular strength for both athletic performance and physical function for quality of life. Evaluating lower body muscular strength allows coaches and trainers to effectively prescribe exercise to best suit the needs of the individuals. This can include identifying optimizing lifestyle activities, competing in sports, or in getting out of bed unassisted every morning. Studies evaluating lower body muscular strength in various aged populations have used various protocols, but many are missing key components of muscular strength through a range of motion needed to perform essential activities in senior populations.

CHAPTER 3

METHODS

This chapter describes the subject characteristics, study design, and descriptions of procedures.

Subjects

Sample. The target sample was to include 40 adults (20 men and 20 women), ages 20 - 70 years in 10 age groups. A goal of two men and two women were to be enrolled in each 5-year age group (Appendix A). When all available spots for either sex or age group were filled, then other interested persons were placed on a waitlist to be used to fill dropouts and to measure demand.

Recruitment Procedures. Subjects were recruited by advertisements placed on social media such as Facebook and Instagram, sent out via email delivery blast. Flyers were posted in high foot traffic areas around the Downtown ASU Campus in Phoenix AZ, and word of mouth was used in the Phoenix metropolitan area. Copies of the advertisement and the flyer are located in Appendix B & C. Subjects interested in the study responded to a study eligibility link developed for this study. They received and completed an online pre-screening questionnaire (Google Forms, Mountain View, CA) to determine if they met the preliminary eligibility criteria of age, sex, and physical activity experience (Appendix D).

Inclusion and Exclusion Criteria. Inclusion criteria included: (a) meet the age (ages 20-70 years) and sex (male, female) recruitment stratification requirements, (b) could communicate in English, and (c) were able to provide written informed consent. Exclusion criteria included: (a) any orthopedic conditions that precluded lifting weights,

(b) individuals who knowingly have osteopenia or osteoporosis, (c) those who could knowingly squat two times their body weight or leg press three times their body weight, (d) self-reported acute or chronic illness, or medical conditions exacerbated by exercise such as heart, liver, kidney, blood, respiratory disease, peripheral vascular disease, active cancer, (e) uncontrolled blood pressure, or (f) pregnant. Inclusion criteria was determined during the screening questionnaire. Exclusion criteria was determined by the screening questionnaire and the PARQ+ administered during the visit (Appendix E).

Procedures and Materials

The study design was cross-sectional. The study required one visit lasting approximately one to two hours. Subjects who met the screening eligibility criteria were invited to the ASU Downtown Campus Sun Devil Fitness Center Laboratory, Room 209. Study staff explained the purpose of the study and answered questions as needed.

Procedures to identify exclusion criteria. Prior to any study activities, all persons read and signed an informed consent approved by the Arizona State University Office of Research and Integrity. Inclusion criteria was determined by the screening questionnaire. Exclusion criteria was identified with the PAR-Q+. Subjects without exclusion criteria were invited to complete the study measures.

Measures. Subjects performed a series of measurements prior to the standardized Non-Counter Movement 1 rep max protocol (NCMST). The measurements occur in the following order, (1) height in centimeters (cm), (2) body weight in kilograms (kg) with percent body fat computed by the Tanita scale, (3) handgrip strength in kg, (4) warm-up on a cycle ergometer, (5) watched a video on how to perform the Non-Counter Movement Squat (NCMS), (6) NCMST (7) cool-down on a treadmill, (8) end of study

questionnaire, and (9) gift card receipt. Feasibility metrics were determined from study data. A description of the measures is listed below.

Body Height. Body height was measured in centimeters twice with subjects standing upright in bare feet and back against the wall with hair down using a SECA 206 Roll-up Measuring Tape (Hamburg, Germany). The tape measure was lowered to contact the top of the head. The number displayed on the tape measure indication box was recorded in cm. This took about 5 minutes.

Body Weight and Percent Body Fat. Subjects had their weight in kilograms (kg) measured wearing clothes and in bare feet by standing on a TANITA (MC-780U Multi Frequency Segmental Body Composition Analyzer, Arlington Heights, IL). Their height in cm, age in years, sex, and activity level were inputted and programmed into the machine prior to taking measurements. The device measured weight in kg and percent body fat. These measurements were recorded twice to assure accuracy. This took about 4 minutes.

Handgrip Strength. Handgrip strength was measured using a Smedley III Analog Grip Strength Dynamometer (Ann Arbor, Michigan). The subject stood for the duration of the measurements. The grip was adjusted so that the second joint of the fingers was bent to grip the handle. The subject then held the handgrip dynamometer with their arm extended directly out in front of them. With the dynamometer set to zero the subject squeezed the handgrip dynamometer with their hand as hard as possible without bending the elbow and without holding their breath (to avoid Valsalva maneuver). The results were recorded in kg. These steps were repeated for the left hand. The procedure repeated two more times with each hand for a total of three attempts each side. The highest

reading of each hand was added together to determine final score (American College of Sports Medicine, 2018).

The Non-Counter Movement Squat (NCMS), Warm-up, and Cool-down. The protocol started with all subjects viewing an instructional video of how the protocol technique worked (https://youtu.be/tyOuD9U5vZE). The video showed the entire NCMST and included: (1) an introduction for the equipment being used for the strength test, the warm-up and the cool down, (2) how the strength test was to be performed with a demonstration of the equipment in use, including adjustments made for height, and (3) statement of the expectations and rights of the subject including the right to stop at any time. Following the video, subjects performed a 5-minute warmup on a cycle ergometer (Monark 988E Cycle Ergometer, 928E, Monark, Vansbro, Sweden) at an intensity based on a self-reported fitness level (low (450 kgm), moderate (600 kgm), high (900 kgm) as established by the Astrand protocol (Astrand, 1960). Subjects then completed the lower-body strength test using the following procedures: (1) Subjects moved into the Smith Machine (Yukon Linear Counter Balanced Smith Machine Bedford Heights, Ohio, USA) and sat on a 16-inch bench where an administrator adjusted the bar height to fit their body proportions, (2) Once the bar height was adjusted to match the individuals shoulder height, the subjects performed 10 repetitions with only the bar weight (30 lbs.) to familiarize subjects with the movement pattern. A repetition was defined as moving from a squatting position to a fully erect position and back to a squatting position, (3) Subjects then selected a weight in lbs. that they believed they could complete a set of 6 to 8 repetitions, subjects then perform 6-8 repetitions following a rest period, (4) Following each set of repetitions, subjects rested for 2 minutes. During the recovery, the research

assistant or administrator adjusted the weight to the subject's estimated 1-RM in lbs. which was estimated as a standardized increase. Increases were based off a rating of perceived exertion (RPE) score between 6 and 20. Weight increase was calculated by: 20 – RPE x 5%. For example, if a subject gave a RPE score of 16 the weight was increased by 20% for the subjects following attempt, if the following attempt resulted in an RPE score of 20 the test was concluded Figure 3 show all potential increases, if a score of less the 20 was given an additional increases were made using the same RPE chart, and (5) The subjects performed a single concentric (upward) phase repetition starting from a seated position on the bench; they placed the weight on the rack at the top of the lift. After the repetition the subject gave the administrator an RPE to allow proper increases or cessation of exercise. Figure 2 presents an illustration of the exercise.

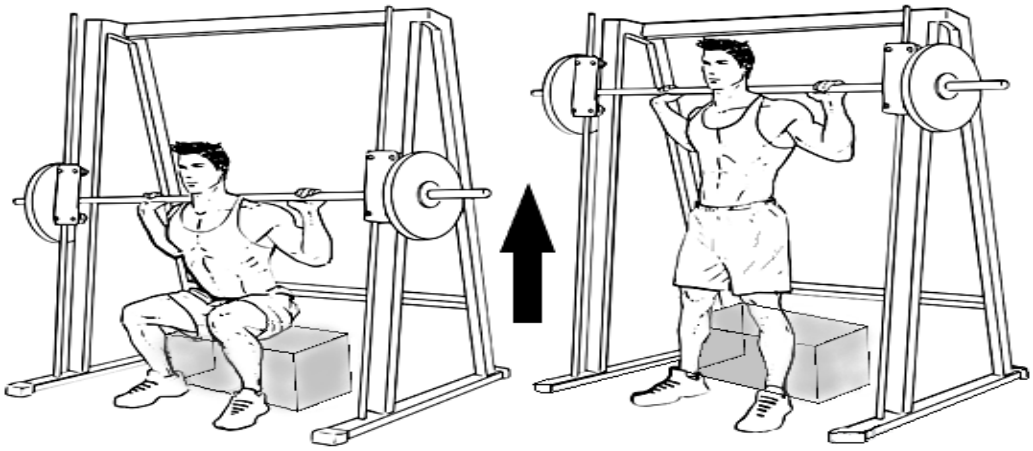

Figure 2. Non-Counter Movement Squat

Steps 4 and 5 were repeated until one of five scenarios occurred: (1) the subject failed to complete the lift, (2) the subjects completed four maximal attempts, (3) the administrator determined it was unsafe to continue, (4) Subject had an RPE score of 20 or, (5) the subject wished to stop. All data was recorded on a data collection sheet created for this

study (Appendix F). Any modifications to the protocol were noted for each subject to assess the implementation of the strength test. At the end of the weightlifting, subjects performed a 2-minute cool down by walking at 2.5 mph on a treadmill at a 0% incline (TrackMaster Treadmill, TM-500, Full Vision inc, Newton, Kansas, USA).

RPE Scale	% Increase	RPE Scale	% Increase	RPE Scale	% Increase
6	+ 70%	11	+ 45%	16	+ 20%
7	+ 65%	12	+ 40%	17	+ 15%
8	+ 60%	13	+ 35%	18	+ 10%
9	+ 55%	14	+ 30%	19	+ 5%
10	+ 50%	15	+ 25%	20	+ 0%

Figure 3. Rating of perceived exertion weight increase

Subject post-study survey: Upon completion of all study activities, subjects completed a post-study survey to determine the acceptability of the NCMS protocol. The questionnaire includes 5 questions on a 4-point Likert scale asking about the NCSM test and 3 free response opinion questions about their experience during the study (Appendix G). The questionnaire was used to measure the acceptability of the NCMST.

Receipt for study payment: Following completion of the survey, subjects signed a receipt for a $15 USD amazon gift card for their participation in the study.

Administrator post-study survey. Upon completion of all subject administration, administrators completed a post study survey to determine the practicality of the NCMS protocol. The questionnaire included 9 questions on a 4-point Likert scale asking about the NCSM test administration and 3 free response opinion questions about their

experience during the study (Appendix H). The questionnaire was used to measure the practicality of the NCMST.

Feasibility Measures

Acceptability: The acceptability of the strength test allowed for the measurement of whether subjects found the NCMST to be satisfactory and whether they believed the strength test produced meaningful results. Acceptability was measured by an acceptability questionnaire (Appendix G) given to subject immediately post cool-down. The questionnaire included 5 questions on a 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) that asks the subjects about their opinion of the strength test, the questionnaire also had 3 free response question designed to collect feedback on pros and cons of the strength test. The scores of the 4-point Likert scale were analyzed using a score of 3 or higher as acceptable and any score lower than 3 as unacceptable. The acceptable scores were then summed and divided by the total number of Likert scores and multiplied by 100 to compute a percentage.

Demand: Demand allowed for the measurement of whether there was interest in participating in a lower body strength assessment demand was expressed as a percent, computed by dividing the number of persons enrolling in the study or being placed on a waitlist by the number of persons responding to the recruitment link and multiplied by 100.

Implementation: The validity of a test becomes less important if numerous modifications are required in order to administer the strength test. To test whether the NCMST could be implemented the way it was intended, modifications made to test were noted on each subject's data collection form. The proportion of modifications made from

all tests were expressed as a percent, computed by dividing the number of modifications made by the number of tests performed and multiplied by 100.

Practicality: One of the largest concerns when designing or conducting a test is the practicality of whether that test can be administered in common testing conditions or whether specific skills, equipment, or environments are needed in order to get usable results. Practicality was measured by a practicality questionnaire (Appendix H) given to test administrators immediately after their participation. The questionnaire included 9 questions on a 4-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree) that asks the administrators about their opinions of the strength test, the questionnaire also had 3 free response question designed to collect feedback on pros and cons of the strength test. The scores of the 4-point Likert scale were analyzed using a score of 3 or 4 as practical and a score of 1 or 2 as impractical. Practical scores were then divided by the total number of Likert scores and multiplied by 100 to compute a percentage.

Limited Efficacy: Limited efficacy was measured by recording the weight lifted by the study subjects and evaluating the distribution of weight lifted by sex within age groups.

Data Management

All of the data and research materials were obtained specifically for research purposes. The data included screening, exercise, demand, acceptability, implementation, and practicality measures. All person's responding to the screening questions were assigned an identification number. To preserve confidentiality, immediately after enrollment, each subject was assigned an identification number that corresponded to the

screening identification number by which each research sample was identified by for further analysis, thus avoiding identification by non-qualified individuals. This number was used to label all data sheets associated with a given subject. Electronic data was stored on a password protected computer hard drive. Consent forms, data containing subject names, and data collection forms were stored in a locked file in a secured office. The principal investigator, co-investigators, and student working with the research team were the only individuals with immediate access to the data.

Data Analysis

The statistical analysis of the data was conducted with the use of SPSS 25 (Statistical Package for the Social Sciences, Version 25, IBM Corporation, Armonk, New York, USA). Descriptive variables included age in years, sex as male or female, days of physical activity per week, blood pressure in mmHG, height in cm, weight in kg, BMI computed as weight in kg/height in meters squared, percent body fat, grip strength in kg, self-reported physical activity level as light (0-1 Days), moderate (2-4 Days) or heavy (5+ Days), bar height, warm up repetition weight, maximal strength attempts and corresponding RPE scores.

Descriptive statistics were computed as the means, standard deviations, and medians for non-normal distributions, ranges, and percentages as applicable for data collected. Feasibility metrics were acceptability, demand, implementation, practicality, and limited efficacy. The calculations being used to compute the feasibility metrics are located in Appendix I. The data distribution was analyzed, and significance was determined through the comparison of percentages. Acceptability and practicality were expressed as a percent, computed by dividing the Likert scale responses of 3 (agree) and

4 (strongly agree) by the total number of Likert scale scores, multiplied by 100, as collected from each acceptability and practicality questionnaire (Appendix G and Appendix H). Demand was expressed as a percent, computed by dividing the number of persons enrolling or being placed on a waitlist by the number of persons responding to the recruitment link, multiplied by 100. Implementation was expressed as a percent, computed by dividing the number of modifications made to the NCMST by the number of tests performed, and multiplied by 100. Limited efficacy was determined by expert opinion of the strength test administrators to determine if the strength scores decline across age by sex, as hypothesized.

CHAPTER 4

Results

Introduction

The purpose of this study was to test the feasibility of using a Non-Counter Movement Squat to test the lower body strength of men and women between 20-70 years of age. The study sample was recruited from the greater metropolitan Phoenix area between January and April 2019. Subjects included 7 males and 15 females. All subjects met the inclusion and exclusion criteria and completed all study measures.

Subject Demographics

The distribution of subject's age ranges is presented in Table 1 separately for males and females and the entire sample.

Table 1

Distribution and Sample Size of Subjects Age Ranges

Age Group	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-70	Total
Males	1	2	1	1	1	1	0	0	0	0	7
Females	2	2	1	1	0	2	2	2	1	2	15
Total	3	4	2	2	1	3	2	2	1	2	22

Means and standard deviations for the subject demographic data by sex are presented in Table 2. As compared to females, males were heavier, taller, could lift more, and had stronger grip strength. Males also had a lower percent body fat and exercised less often than women.

Table 2

Sample Size, Means, and Standard Deviations for the Descriptive Variables by Sex

	MALE (*n=7*)			FEMALE (*n=15*)		
VARIABLES	*(n)*	*M*	*SD*	*(n)*	*M*	*SD*
Weight (kg)	7	92.70	19.34	15	66.58	13.14
Height (cm)	7	178.45	10.67	15	162.30	7.15
BMI (weight kg/height m2)	7	29.76	9.68	15	25.40	5.57
Body fat (%)	7	23.67	9.62	15	29.88	9.21
Right grip strength (kg)	7	53.43	7.98	15	29.31	4.65
Left grip strength (kg)	7	50.90	8.37	15	27.49	5.03
Days/week exercise	7	2	2.24	15	3.40	1.45

Results for the feasibility metrics of acceptability, demand, implementation, and practicality are presented by sex in Table 3. As compared to males, females reported lower acceptability and practicality scores and a higher demand score. There was no difference in the implementation scores between males and females.

Table 3

Feasibility Metrics Results of Acceptability, Demand, Implementation, and Practicality by Sex

Gender	Males (*N*=7)	Females (*N=15*)
Feasibility Metric	%	%
Acceptability (3 or 4 response on subject acceptability survey)	100%	97.1%
Demand (subjects screened who agree to participate)	72.7%	79.5%
Implementation (subjects who complete the protocol)	100%	100%
Practicality (3 or 4 response on test administrators survey)	100%	94.4%

The means and standard deviations for feasibility scores of limited efficacy as measured by the maximal 1-Repetition Squat test in lbs. and the percentage of body weight lifted are presented by sex in Table 4. As compared to females, males lifted a heavier weight and reached a higher weight-to-body ratio. With the exception of the male subject in age bracket 30-34, males younger than 40 years lifted a higher maximal weight and percent of body weight than males older than 40 years. No patterns were observed in females for the maximal weight lifted and the weight lifted as a percent of body weight.

Table 4.

Feasibility metric for limited efficacy

Age Group	20- 24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-70
MALES (*n*)	1	2	1	1	1	1	0	0	0	0
Maximum Weight Lifted (lbs.)	356 (0)	386 (160)	63.2 (0)	340 (0)	265 (0)	246 (0)	N/A	N/A	N/A	N/A
Weight Lifted as a Percent of bodyweight	1.72 (0)	1.9 (.66)	.42 (0)	1.57 (0)	1.32 (0)	86 (0)	N/A	N/A	N/A	N/A
FEMALES *(n)*	2	2	1	1	0	2	2	2	1	2
Maximum Weight Lifted (lbs.)	224 (43.0)	116 (24.7)	125 (0)	156 (0)	N/A	195 (24.7)	118 (35.2)	163 (65.8)	146 (0)	116 (25.5)
Weight Lifted as a Percent of bodyweight	1.73 (.26)	.99 (.19)	.73 (0)	1.15 (0)	N/A	1.02 (.15)	.75 (.14)	.90 (.32)	.94 (0)	1.04 (.34)

Note: for maximal 1-reptition squat tests strength in lbs. and the percent of body weight lifted by sex. Values are presented as the *M (SD)*

Subject comments for the acceptability feasibility metric questionnaire are presented in Table 5. Respondents were asked to identify aspects of the protocol they deemed to be their most and least favorite aspect of the study and how the test could be improved. The most frequent response was related to the ‘most favorite parts of test’ with 17 responses. The most common favored reasons were related to the performance of the Non-Counter Movement Squat and speaking to the administrator. The ’least favorite parts of the test’ received 15 responses. The most common response was related to disliking the intensity and/or duration of the warm-up and disliking the location and/or availability of the study participation times. Suggestions of how the test could be improved were varied with 9 responses. The only repeated response was related to the location and/or availability of time for participation. In addition, some individuals suggested the Smith machine should be bolted down or provide an option to perform the squat without a Smith machine.

Table 5

Subject's Comments by Type for the Acceptability Feasibility Metric Questionnaire

Type	Comments
Most Favorite	
	Where I am lifting w/ my legs
	Assessing my own abilities
	Testing my one-rep max
	Seeing what my max was
	Being able to reach my limit & really knowing my limit
	Challenge
	The box makes the exercise easier
	The information will help individual suffering with this issue
	Seeing the amount of weight, I could have on my shoulders and still stand up
	Learning how much I could lift
	The smith machine was easy to use
	Before doing the test, I thought there was no way I could life my own bodyweight. I was so surprised what I was capable of
	Talking with researcher
	I like the box, so I know how low I need to squat
	Speaking with Alex
	I felt I could really push the bar
	Very comprehensive explanation of test

Least Favorite
Always thirsty
How comfortable the bench was
Doing a cardio warm-up for 5 minutes before squatting. It might have been more beneficial to do a lighter warm-up
Warm up
There wasn't really anything I didn't like but would recommend using a squat pad
Not meeting my expectations
I don't like squat
It was uncomfortable on my neck, but it was fine when the plastic rest was added to the bar
The bike seemed kind of long
The warm-up & cool down. I don't think the bike/treadmill match up with the weight training
I was worried I would not do well
I liked it all. Least fav was maybe warm up
Do not like the smith machine
Box was low
Bar was uncomfortable on my neck

Improvements
Location of test
Begin by telling subject he/she can use any stance
I think support can be provided if subject cannot stand up with the bar only
I would recommend bolting down the smith machine
The testing room had limited availability. It would have made scheduling easier if there were more available times
I wish I could have tried test before study so I would know my strength levels better
Version without smith machine
Length of test
Neck towel?

Note: Most Favorite = most favorite part of the test; Least Favorite = least favorite part of the test; Improvements = what could be improved for the test

The reasons that potential subjects were excluded from participating in the study are presented by sex in Table 6. A total of 40 females and males were excluded from participation. The most common reason for exclusion of females was the number of subjects needed in a specific age group was already filled. This caused 27 females being waitlisted. Three females were excluded for knowingly being able to squat double their bodyweight and an additional three were excluded as they were unable to be scheduled because they could not attend the testing schedules when offered. The primary reason for males being excluded was scheduling availability with 11 males being unable to participate. Two males were excluded for knowingly being able to squat double their bodyweight and having osteoporosis or osteopenia.

Table 6

Reasons for Excluding Potential Subjects from the Study Separately for Men and Women

Reason	Male (*N*= 23)	Female (*N*= 44)
Not in study age range	1	1
Recruitment pool filled	0	27
Unable to speak English	0	0
Failed to give informed consent	0	0
Orthopedic conditions	0	0
Osteopenia or osteoporosis	1	0
Able to squat two times bodyweight	1	3
Self-reported chronic condition or medical illness	0	0
Pregnant	0	0
Other listed issue	0	0
Unavailable during available testing times	11	30

Note: Subjects can be excluded for multiple reasons

Administrator's comments on the practicality questionnaire are presented in Table 7. Respondents were asked to identify aspects of the protocol they deemed most and least favorite and how the test could be improved. The 'favorite part of the test' both had to do with the functional and practical application of the NCMST. The 'least favorite part of the test' had to do with the RPE weight increase system and the Smith machine as an equipment component when working with more experienced population groups. Suggestions for how the test could be improved included adjustments to the RPE weight increase to allow for reattempts at lower weights when the increase was to extreme resulting in a fail.

Table 7

Administrator's Comments by Type on the Practicality Feasibility Metric Questionnaire (N=2).

Type	Comments
Most Favorite	
	Like the functional and practical application of NCMST compared to CMST.
	The potential opportunities the NCMST would allow when assessing lower body muscular strength.
Least Favorite	
	The need to use RPE and equation to increase how much weight.
	Would like to see a modification that would allow for application without the Smith machine. It became less practical when working with young and experienced subjects.
Improvements	
	Adjustments could be made do RPE equation to allow for another attempt if the jump is to large resulting in failed attempt.

CHAPTER 5

DISCUSSION

Overview

This study investigated the feasibility of using a Non-Counter Movement Squat (NCMST) as a measurement of lower body muscular strength with a Smith machine in males and females between the ages of 20 to 70 years. The results suggested the protocol was acceptable, has sufficient demand among potential subjects, and was practical in males and females. The study also showed a favorable implementation for males and females. It was difficult to ascertain limited efficacy with the data obtained due an inability to recruit the target number of subjects.

The goal for the limited efficacy was to show that the maximum amount of weight lifted decreased with increasing age group. This was not shown likely due to a small sample size with some age groups having zero participants. Even though a larger sample size may have shown a reduced amount of weight lifted with increasing age groups (limited efficacy of the NCMST), the findings suggest that the test is feasible as it has good demand, acceptability, and is practical for use. Since normative values do not exist for men and women 20 -70 years of age in performing a 1-repetition maximum squat test, it is difficult to compare the NCMST values to a leg press or counter movement squat test without having the same individual perform multiple tests under similar conditions.

Protocol Considerations

The bench height was set at 16 inches off the ground. The reason for setting the bench height at this height was to create a test that could be used to measure lower body strength as it related to functional requirements of lifestyle behaviors, such as getting off

of a toilet (Rikli & Jones, 2013). It should be noted that lowering to the height of the bench at 16 inches was seemingly harder for older subjects than it was for younger subjects. This suggests that being able to lower one's body to the height of a toilet and raise up from it may be enhanced by performing squats at the height of the bench and that the ability of squatting at this depth could potentially be assessed by the NCMST. However, this speculation needs to be tested empirically.

The use of a Rating of Perceived Exertion (RPE) with an equation to calculate weight increase show potential as being a potential option for standardized increases during 1-repetition max tests. However, one fault found when testing was with lower score for stronger individuals resulting in larger increases which may be too much. The RPE formula was most accurate when individuals were approaching their maximal potential. Another suggested modification would be to have a protocol to allow for reattempt after a fail if the increase was too much, as some individuals may have underestimated the difficulty resulting in a failed attempt on their next set. This can be an issue as it could result in subjects' final successful attempt being a type II error since the increase was too much even though the previous attempt was not difficult based upon RPE.

Subjects completed an acceptability questionnaire that included three optional free response questions to identify subjects most favorite and least favorite parts of the study and to provide suggestions on how the study could be improved. Seventeen responses were collected for the most favorite responses which provide various positive opinions of the NCMST. Many subjects felt confident that they had been able to perform near their maximal 1-RM squat abilities. The least favorite responses included 15

remarks with strong negative opinions of the protocol. Responses included displeasure of the warm-up as being too difficult or too long a duration; these responses were given primarily by individuals who indicated that they had low cardiovascular fitness. Others commented that the length of the warmup was beginning to cause leg fatigue. The majority of improvement recommendations involved suggestions for improving the comfort of the barbell on the subjects' shoulders and/or a familiarity on how to squat as low to the ground as the test required. Another recommendation was that the Smith machine be bolted to the floor to reduce movements of the machine among those who could lift large amounts of weight.

Relative to limited efficacy, one outlier was identified among male subjects, resulting in a significant decrease in the mean weight lifted by male subjects. This outlier subject indicated he did no forms of physical activity and was in self-proclaimed "bad shape". Aside from this outlier, the trend of percent of bodyweight lifted appeared to be a better measure among men when attempting to compare data between ages. This was true for the percent of bodyweight lifted which declined by age. The strength data for females was much more sporadic than males with no apparent trend of weight lifted by age groups. The results could be due partially to the activity level of the subjects which varied from low to high levels of fitness. Another theory as to why the expected trend of decline in strength did not occur could be due to the exclusion criteria. Since the exclusion criteria included many health conditions including bone, acute, and chronic illnesses the statistical likelihood of finding such individuals especially among females was potentially significantly decreased with age. Additional studies are needed to evaluate these findings.

Ideally, larger sample sizes are needed to test the strength of limited efficacy with the expected decline in 1-RM max weight squat lifted across the age group ranges.

Study Limitations

This study had four major limitations that may have influenced the results. First, the greatest limitation of the study was the availability of the equipment for testing. Due to the equipment being located in a high traffic classroom where exercise classes were taught, scheduling was difficult, especially for potential subjects in the various age groups. The availability resulted in nearly 21% of individuals interested being excluded before adjusting for waitlisted subjects. Second, the male subjects reported significantly fewer days per week of exercise performed and, without knowing the average duration per day of exercise performed, there may have been significant differences in strength and fitness levels between the age groups. Third, due to difficulty scheduling subjects to perform the protocol, the sample size, especially in the male group, was smaller than predicted. This likely limited the ability to identify a decreasing strength level with increased age groups (limited efficacy) of the NCMST as hypothesized. Fourth, due to the location of the Smith machine in a student classroom it was not possible to bolt the machine to the floor. Thus, when testing individuals who were able to lift in excess of 275lbs, the equipment had the potential of shifting which created a safety concern. When working with stronger individuals, the Smith machine should be properly secured to the floor.

Practical Application

The NCMS feasibility results suggest that the NCMST may be a practical for test to assess lower body strength but that additional studies are needed to determine its

efficacy among adult males and females. Further, a direct comparison of the 1-RM maximal strength values between other lower body strength tests may be useful in determining the utility of the NCMST. It is interesting to note, that while not part of the study aims, the correlation between the handgrip strength and the 1-RM maximum weight lifted was on the order of $r = 0.76$ for all subjects. In particular, the correlation for males was $r = 0.72$ and the correlation for women was $r = 0.27$. This suggests that overall strength in males may be consistent with the weight lifted in the squat test whereas the same may not be true in women.

Some modifications to the protocol may be needed to increase the test's practicality. These include a more simplified warm-up, increased rest time between the sets for some individuals, adjustments to the RPE weight increase equation for individuals who have a failed attempt after a large increase, and the standard availability of neck support such as towels or manta rays for individuals who do not like the bar directly on their shoulders. Also, it is unknown if using the Smith machine for safety is needed to perform the test safely. A comparison of the results of the NCMST with and without a Smith machine should be explored with individuals experienced in weight training. If the results are similar with and without the Smith machine, the applicability of the test would increase to better allow exercise professionals without access to a Smith machine to use the same protocol to test their subjects.

Summary

The purpose of this study was to test the feasibility of using a NCMS to test the lower body muscular strength of males and females, ages 20 to 70 years. Results showed that the NCMST is feasible for practicality, demand, acceptability, and implementation.

However, the limited efficacy of the test requires additional research with more subjects to test the hypothesis that squat strength decreases with age. Additional studies also are needed that study the relationship between the NCMST and other lower body strength assessments as well as with and without the Smith machine.

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APPENDIX A

TARGET SUBJECT DISTRIBUTION

Age	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-70	Total
Males (n)	2	2	2	2	2	2	2	2	2	2	20
Females (n)	2	2	2	2	2	2	2	2	2	2	20
Total	4	4	4	4	4	4	4	4	4	4	40

APPENDIX B

EMAIL SENT TO THOSE INTERESTED IN PARTICIPATION

Non-Counter Movement Squat Study Participation Inbox x

Alex Stark <alexstark700@gmail.com> 4:08 PM (0 minutes ago)

to me

Dear (Insert Name),

I am an MS degree student in the College of Health Solutions at Arizona State University under the direction of Dr. Barbara Ainsworth (barbara.ainsworth@asu.edu). I am conducting a research study to examine the feasibility of a new lower body maximal strength protocol. This research may identify a new way of measuring lower body maximal strength that can help predict quality of life. I am inviting your participation in the screening process, which will consist of answering questions regarding health history, demographics, and scheduling availability. You have the right to not answer any question, and to stop participation at any time.

We are recruiting healthy adults between the ages of 20 and 70 years. Your participation in this survey is voluntary. If you choose not to participate or to withdraw from the survey at any time, there will be no penalty. Your responses to this survey will be confidential. If you meet the criteria for this study, you will be contacted to schedule an in-person appointment at the downtown campus of Arizona State University.

If you have any questions concerning the research study, please contact me at Ajstark1@asu.edu. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.

By completing this survey, you are agreeing to be contacted by investigators (via e-mail) to schedule an appointment, should you qualify.

Below you will find a link to an 11-question screening questionnaire that will be used determine your eligibility.

Please answer all the questions honestly and in the way that you believe best represents you. All questions are required unless otherwise stated. If we determine that you are eligible to participate you will be contacted and invited to schedule a time to come to the lab located at the Downtown Phoenix ASU Campus to participate.

I appreciate your time and interest!

https://goo.gl/forms/9e01KKjbJbKE7NQg1

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Alex Stark
B.S Exercise and Wellness
Graduate Student | Exercise and Wellness/ Fitness and Conditioning
Arizona State University
Cell: 530 318-8292
Alexstark700@gmail.com

Reply Forward

APPENDIX C

SUBJECT RECRUITMENT FORM

ASU College of Health Solutions

ARIZONA STATE UNIVERSITY

Healthy Individuals

(Both Men and Women)

Are wanted for a research study looking at the feasibility of a new lower body strength test

Eligibility

- Men & Non-pregnant women ages 20-70
- Can communicate in English
- No orthopedic conditions that preclude lifting weights
- No restrictions that would limit participation in physical activity

Description

- 1 visit to the Downtown ASU campus
- Total time commitment ~ 3 Hours
- Fitness and Body Composition assessments (BIA, Lower body strength test)
- Cardiovascular warm up and cool down (stationary bike and treadmill)
- Subjects who complete the study will be compensated $15 for their participation

Participation is Voluntary

Interested?

Go to: https://goo.gl/forms/9e01KKjbJbKE7NQg1

Want more info?

Contact Alexander Stark: Ajstark1@asu.edu OR (530) 313-8292

APPENDIX D

SCREENING QUESTIONAIRE

Non-Countermovement Squat Study

Screening Questionnaire

I am a MS degree student in the College of Health Solutions at Arizona State University under the direction of Dr. Barbara Ainsworth (barbara.ainsworth@asu.edu). I am conducting a research study to examine the feasibility of a new lower body maximal strength protocol. This research may identify a new way of measuring lower body maximal strength that can help predict quality of life. I am inviting your participation in the screening process, which will consist of answering questions regarding health history, demographics, and scheduling availability. You have the right to not answer any question, and to stop participation at any time.

We are recruiting healthy adults between the ages of 20 and 70 years. Your participation in this survey is voluntary. If you choose not to participate or to withdraw from the survey at any time, there will be no penalty. Your responses to this survey will be confidential. If you meet the criteria for this study, you will be contacted to schedule an in-person appointment at the downtown campus of Arizona State University.

If you have any questions concerning the research study, please contact me at Ajstark1@asu.edu. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.

By completing this survey, you are agreeing to be contacted by investigators (via e-mail) to schedule an appointment, should you qualify.

I appreciate your time and interest!

Email address: _____

Instructions:

Description: Thank you for showing interest in participating in a study testing the feasibility of a new lower body strength test. This form will be used to determine your eligibility for the study.

Directions: Please check one box per question that best represents you. If you have any questions please reach out to Alex Stark, Study leader for clarification at Ajstark1@asu.edu.
* Required

Survey Questions:

1. What is your age? *
NCMSTSQ01

- ❑ >19
- ❑ 20-24
- ❑ 25-29
- ❑ 30-34
- ❑ 35-39
- ❑ 40-44
- ❑ 45-49
- ❑ 50-54
- ❑ 55-59
- ❑ 60-64
- ❑ 65-70
- ❑ Over 70

Exclude if less than 19 or older than 70 years old

2. What is your Gender *
NCMSTSQ02

- ❑ Female
- ❑ Male *(Skip to question 4)*

3. Are you pregnant?
NCMSTSQ03

- ❑ Yes
- ❑ No

Exclude if # 3 is Yes

4. Are you able to walk on a treadmill at up to 2.5 mph and ride a stationary bike for 5 minutes? *
NCMSTSQ04

- ❑ Yes
- ❑ No
- ❑ Do not know

Exclude if one or more answers to # 4-7 is No

5. Has your healthcare provider ever said you should not participate in weight lifting activities?
NCMSTSQ05

- ❑ Yes
- ❑ No

6. Do you have any bone or joint problems (for example, ankle, back, hip, knee, or arthritis) that could be made worse by a change in your physical activity?
NCMSTSQ06

- ❑ Yes
- ❑ No
- ❑ Do not know

7. Can you squat double your bodyweight or leg press triple your bodyweight? *
NCMSTSQ07

- ❑ Yes
- ❑ No
- ❑ Do not know

8. On average how many days per week do you intentionally exercise? *
NCMSTSQ08

- ❑ 0
- ❑ 1
- ❑ 2
- ❑ 3
- ❑ 4
- ❑ 5 or more

9. Do you know of any other reasons that you should not participate in weight lifting? *
NCMSTSQ09

- ❑ Yes
- ❑ No

Exclude if # 9 is Yes

10. If Yes please describe here, if no put N/A
NCMSTSQ10

_____
_____
_____

11. If selected for study participation, are you willing to travel to the Downtown ASU Campus in Phoenix One time to participate in the study? *
NCMSTSQ11

- ❑ Yes
- ❑ No

Exclude if # 11 is No

APPENDIX E

PHYSICAL ACTIVITY READINESS QUESTIONAIRE PLUS

2018 PAR-Q +

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition **OR** high blood pressure?		
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?		
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).		
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? PLEASE LIST CONDITION(S) HERE:		
5) Are you currently taking prescribed medications for a chronic medical condition? PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:		
6) Do you currently have (or have had within the past 1 2 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer NO if you had a problem in the past, but it does not limit your current ability to be physically active. PLEASE LIST CONDITION(S) HERE:		
7) Has your doctor ever said that you should only do medically supervised physical activity?		

If you answered NO to all of the questions above, you are cleared for physical activity.

Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

Start becoming much more physically active — start slowly and build up gradually.

Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).

You may take part in a health and fitness appraisal.

If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION

If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

You have a temporary illness such as a cold or fever; it is best to wait until you feel better.

You are pregnant - talk to your health care practitioner, your physician a qualified exercise professional, and/or complete the ePARmed-K+ at www.eparmedx.com before becoming more physically active.

Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

2018 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c If NO go to question 2

1a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO
(Answer NO if you are not currently taking medications or other treatments)

1b. Do you have joint problems causing Rain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylosis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)? YES NO

1c. Have you had steroid injections or taken steroid tablets regularly for more than 3 months? YES NO

2. Do you currently have Cancer of any kind?

If the above condition(s) is/are present, answer questions 2a-2b If NO go to question 3

2a. Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of YES NO plasma cells), head, and/or neck?

2b. Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)? YES NO

3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm

If the above condition(s) is/are present, answer questions 3a-3d If NO go to question 4

3a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO (Answer NO if you are not currently taking medications or other treatments)

3b. Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction) YES NO

3c. Do you have chronic heart failure? YES NO

3d. Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months? YES NO

4. Do you have High Blood Pressure?

If the above condition(s) is/are present, answer questions 4a-4b If NO go to question 5

4a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO
(Answer NO if you are not currently taking medications or other treatments)

4b. Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? YES NO
(Answer YES if you do not know your resting blood pressure)

5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes Yes NO

If the above condition(s) is/are present, answer questions 5a-5e If NO go to question 6

5a. Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician- prescribed therapies?

5b. Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness. YES NO

Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, OR the sensation in your toes and feet? YES NO

5d. Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)? YES NO

5e. Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future? YES NO

2018 PAR-Q+

Do you have any Mental Health Problems or Learning Difficulties? This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome

If the above condition(s) is/are present, answer questions 6a-6b If NO go to question 7

6a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO
(Answer NO if you are not currently taking medications or other treatments)

6b. Do you have Down Syndrome AND back problems affecting nerves or muscles? YES NO

6. Do you have a Respiratory Disease? This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure

If the above condition(s) is/are present, answer questions 7a-7d If NO go to question 8

7a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO (Answer NO if you are not currently taking medications or other treatments)

7b. Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy? YES NO

7c. If asthmatic, do you currently have symptoms of chest tightness, wheezing, labored breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week? YES NO

7d. Has your doctor ever said you have high blood pressure in the blood vessels of your lungs? YES NO

8. Do you have a Spinal Cord Injury? This includes Tetraplegia and Paraplegia
If the above condition(s) is/are present, answer questions 8a-8c If NO go to question 9

Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? YES NO
(Answer NO if you are not currently taking medications or other treatments)

8b. Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting? YES NO

8c. Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)? YES NO

9. Have you had a Stroke? This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event
If the above condition(s) is/are present, answer questions 9a-9c If NO go to question 10

9a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies?
(Answer NO if you are not currently taking medications or other treatments) YES NO

9b. Do you have any impairment in walking or mobility? YES NO

9c. Have you experienced a stroke or impairment in nerves or muscles in the past 6 months? YES NO

10. Do you have any other medical condition not listed above or do you have two or more medical conditions?
If you have other medical conditions, answer questions 10a-10c If NO read the Page 4 recommendations

Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months OR have you had a diagnosed concussion within the last 12 months? YES NO

10b. Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)? YES NO

Do you currently live with two or more medical conditions? YES NO

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE: _____

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

01-11-2017

2018 PAR-Q+

If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active:

It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.

You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week< including aerobic and muscle strengthening exercises.

As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.

If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered YES to one or more of the follow-up questions about your medical condition:

You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the ePARmed-X+ at www.eparmedx.com and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

You have a temporary illness such as a cold or fever; it is best to wait until you feel better.

You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.comb before becoming more physically active.

Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted. The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

For more information, please contact The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Key References Public Health Agency of Canada or the BC Ministry of Health Services.

Email: eparmedx@gmail.com

Citation for PAR-Q+

Warburton DEA, Jamnik VK, Bredin SSD, and Gledhill N on behalf of the PAR-Q+ Collaboration. The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). Health & Fitness Journal of Canada 2011.

1. Jamnik VK, Warburton DER, Makarski J, McKenzie DC, Shephard RJ, Stone J, and Gledhill N. Enhancing the effectiveness of clearance for physical activity participation; background and overall process. APNM 2011.
2. Warburton DEP., Gledhill N, Jamnik VK, Bredin SSD, McKenzie DC, Stone J, Charlesworth S, and Shephard RJ. Evidence-based risk assessment and recommendations for physical activity clearance; Consensus Document. APNM 201 1.
36(S1):S266-s298,
3. Chisholm DM, Collis ML, Kulak LL Davenport W, and Gruber N. Physical activity readiness. British Columbia Medical Journal.1975;17:375-3
4. Thomas S, Reading J, and Shephard RJ. Revision of the Physical Activity Readiness Questionnaire (PAR•Q. Canadian Journal of Sport Science 1992;1734 338•345.

APPENDIX F

NON-COUNTER MOVEMENT SQUAT STUDY DATA COLLECTION SHEET

Date: _____
ID#: _____

Non-Counter Movement Squat Study

DATA COLLECTION FORM

(Station Tester's Name_____)

Measurements:

Height: Wearing no shoes against wall using SECA tape measure:

_____ (Cm)

Height: NCMSHTCM
Trial 1: _____
Trial 2: _____

Weight: From printed receipt of TANITA

_____ (Kg)

Height: NCMSWTKG
Trial 1: _____
Trial 2: _____

Percent Fat: From printed receipt of TANITA

_____ (Pct)

Height: NCMSBFPCT
Trial 1: _____
Trial 2: _____

Handgrip Strength

(Station Tester's Name_____)

Measured with subject standing holding dynamometer Perpendicular to torso with arm extended

Handgrip Score: Best Right hand + Best Left hand

_____ (Kg)

Height: NCMSHGDSR	
Right Hand Trial 1:	_____ (Kg)
Right Hand Trial 2:	_____ (Kg)
Right Hand Trial 3:	_____ (Kg)

Height: NCMSHGDSL	
Left Hand Trial 1:	_____ (Kg)
Left Hand Trial 2:	_____ (Kg)
Left Hand Trial 3:	_____ (Kg)

Date: _____
ID#: _____

Non-Counter Movement Squat

(Station Tester's Name_____)

Bike Warm-Up: low (450 kgm), moderate (600 kgm), high (900 kgm)

_____ (KGM)

Starting Bar Height:

Number that corresponds to bar height when resting on subjects' shoulders while seated on the box.

_____ (Number)

Repetition Warm-up (6-8):

_____ (Lb.)

Non-Counter Movement Squat Max:

_____ (Lb.)

Height: NCMS1RMA
NCMS Max Attempt 1: _____(Lb.) _____(RPE)
NCMS Max Attempt 2: _____(Lb.) _____(RPE)
NCMS Max Attempt 3: _____(Lb.) _____(RPE)
NCMS Max Attempt 4: _____(Lb.) _____(RPE)

Completed Treadmill Cooldown: _____ (Y/N)

Did the NCMST need to be modified: _____(Y/N)

Completed Post Survey: _____ (Y/N)

Signed Gift Receipt: _____ (Y/N)

Modification:
_____
_____
_____

2/2

APPENDIX G

SUBJECT POST PARTICIPATION QUESTIONAIRE

Date: _____
ID#: _____

Non-Counter Movement Squat Protocol Feasibility Trials

Post Participation Questionnaire

Acceptability of Protocol

Time: _____

Participants Identification Number: _____

Now that you have completed the strength test we would like to ask you your opinion.

Please use the example below to help you answer the questions.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

1.	I felt like everything I did helped me do my best:	1	2	3	4
2.	I felt safe will performing the test:	1	2	3	4
3.	I would be willing to do the test again:	1	2	3	4
4.	The strength test was with in my capabilities:	1	2	3	4
5.	This test is a good measure of my strength:	1	2	3	4

Please explain your favorite part of participating in the strength test: _____

_____

_____

_____

Please explain your least favorite part of participating in the strength test: _____

_____

_____

_____

Can you think of anyway the strength test could be improved? _____

_____

_____

_____

APPENDIX H

ADMINISTRATOR POST PARTICIPATION QUESTIONAIRE

Date: _____
ID#: _____

Non-Counter Movement Squat Protocol Feasibility Trials

Post Participation Questionnaire

Practicality of Protocol

Time: _____

Test administrators name: _____

Now that you have completed administering the NCMST we would like to ask you your opinion.

Please use the example below to help you answer the questions.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

1.	I felt like I could administer this test on my own:	1	2	3	4
2.	The testing procedures were easy to perform and explain:	1	2	3	4
3.	I believe the NCMST is safe:	1	2	3	4
4.	The NCMST would be usable in a non-lab-based setting:	1	2	3	4
5.	I you select the NCMST to test lower body strength:	1	2	3	4
6.	The NCMST is a good test for men under 50:	1	2	3	4
7.	The NCMST is a good test for men over 50:	1	2	3	4
8.	The NCMST is a good test for women under 50:	1	2	3	4
9.	The NCMST is a good test for women over 50:	1	2	3	4

Please explain your favorite part of the NCMST: _____

_____

Please explain your least favorite part of NCMST: _____

_____

Can you think of anyway the test could be improved? _____

_____

_____

_____

_____

1/1

APPENDIX I

FEASIBILITY DEFINITIONS AND COMPUTATION METRICS

Feasibility Measures	Definitions	Metrics
Acceptability	The extent to which the NCMST was judged as suitable and attractive to subjects.	Subject Agreement Rate: $\frac{\text{Likert scores that are} \geq 3 \text{ by subjects}}{\text{All Likert scores by subjects}} \times 100$
Demand	To what extent this program or method is likely to be used.	Interest Rate: $\frac{\text{Number of subjects that agree to participate or are placed on waitlist}}{\text{Number of subjects that complete the screening survey}} \times 100$
Implementation	How effectively the NCMST can be utilized to intended subjects in a defined but uncontrolled environment	Success Rate: $\frac{\text{Number of subjects that complete the study without modifications}}{\text{Number of subjects that complete the study}} \times 100$
Practicality	To what extent the NCMST can be used with intended subjects using existing means, resources, and circumstances without outside intervention.	Administrator Agreement Rate: $\frac{\text{Likert scores that are} \geq 3 \text{ by administrators}}{\text{All Likert scores by administrator}} \times 100$
Limited Efficacy	Whether the NCMST shows promise of being successful with intended population even if used in highly controlled settings.	Recording the weight lifted by the study subjects and evaluating the distribution of weight lifted by sex within age groups

APPENDIX J

RECRUITMENT STATUS TO MEASURE DEMAND

	Males			Females		
Age	**Enrolled**	**Waitlist**	**Not Eligible/ Quit**	**Enrolled**	**Waitlist**	**Not Eligible/ Quit**
20-24	1	12	1	2	10	0
25-29	2	1	0	2	9	1
30-34	1	0	0	1	3	0
35-39	1	0	0	1	3	0
40-44	1	0	0	1	0	0
45-49	1	0	0	2	0	0
50-54	0	0	0	2	0	0
55-59	0	0	0	2	0	0
60-64	0	0	1	1	0	0
65-69	0	0	0	2	0	1
Totals	6	13	2	16	25	2

APPENDIX K

REASONS FOR EXCLUSION

Reason	Male (N= 23)	Female (N= 44)
Not in study age range	1	1
Recruitment pool filled	0	27
Unable to speak English	0	0
Failed to give informed consent	0	0
Orthopedic conditions	0	0
Osteopenia or osteoporosis	1	0
Able to squat two times bodyweight	1	3
Self-reported chronic condition or medical illness	0	0
Pregnant	0	0
Other listed issue	0	0
Unavailable during available testing times	11	30

APPENDIX L

SUBJECT ANTHROPOMETRIC AND STRENGTH DATA

	Mean Score	SD	Range		Mean Score	SD	Range
Men (N=7)				**Women (N=15)**			
Age (Yrs.)	32.7	9.05	21-46	Age (Yrs.)	45.4	16.0	22-69
Height (Cm)	178.5	10.67	160-193.2	Height (Cm)	162.3	7.15	152.4-174.6
Weight (Kg)	92.7	19.34	68.6-129.2	Weight (Kg)	66.6	13.14	50.4-89.8
Bia (Pct.)	23.7	9.62	12.5-40	Bia (Pct.)	29.9	9.2	16-43.6
Handgrip Strength (Kg)	103.9	17.57	84-128	Handgrip Strength (Kg)	59.2	9.67	43.5-80.5
Starting Bar Height (In.)	8.6	1.5	7-10	Starting Bar Height (In.)	7.4	1.0	6-9
NCMST Max (Lbs.)	259.6	115.6	63.2-386	NCMST Max (Lbs.)	132.1	46.2	68.2-224

APPENDIX M

WRITTEN INFORMED CONSENT FORM

Feasibility of Using a Non-Counter Movement Squat to Assess Lower Body Strength in Adults ages 20-70 years

Investigators: *Dr. Barbara Ainsworth, College of Health Solutions, Arizona State University (Principal Investigator) and Alexander J. Stark (Co-Investigator), College of Health Solutions, Arizona State University*

Why am I being invited to take part in a research study?

We invite you to take part in a research study because you are between 20 and 70 years of age, are healthy, cannot squat double bodyweight or leg press triple bodyweight, and do not have any major health problems such as heart trouble, lung, kidney or liver problems, active cancer, or existing muscle/ bones injuries.

Why is this research being done?

The study being done to identify the best practices for determining the feasibility of testing lower body muscular strength with a non-counter movement back squat in older adults. This is important because lower body muscular strength is a key factor in daily living and total body muscular strength declines as we age increasing risk of the inability to live independently.

How long will the research last?

You will visit the Downtown Sun Devil Fitness Complex for one (1) visit that will last about one and a half (1.5) hours.

How many people will be studied?

We will recruit 40 adults from the greater Phoenix area to participate in this research study.

What happens if I say yes, I want to be in this research?

It is up to you to decide whether or not to participate. Your participation will involve coming to the test site where the study will be explained to you; we will answer any questions you may have and you will be asked to sign this consent. After signing the consent form, you will complete screening tests to confirm that you are eligible for the study. If you are eligible for the study, you will perform a series of weight lifting tasks and complete an end-of-study questionnaire in the following order.

- Fill out and sign a questionnaire called the PAR-Q+ to acknowledge that you are suitable to perform exercise.
- Complete a questionnaire about your weight lifting and exercise experience to ensure that you meet the criteria for participation. If you are eligible, you will be performing the following tasks.
- Have your measurement of your height, weight, body fat, and hand grip strength measured.
- Perform the weight lifting protocol with the following steps
  1. Watch a video explain demonstrating how the test will be performed.

2. Warm-up for 5 minutes on a stationary cycle at an intensity suited for your fitness level (low, moderate, high). You can stop cycling at any time you wish.
3. Perform the weight lifting activities as described below.
    a. First, you will sit on a bench placed inside a Smith machine where the study staff will measure the correct height for the weight lifting bar to rest on your shoulders. The Smith machine is a protective cage that controls the path of the bar to prevent muscle injuries during weight lifting. All weight lifting activities will involve raising from a seated position on the bench to a standing position inside the Smith machine with the bar resting on your shoulders. Each weight lifting activity will be followed by a 2-minute seated rest period.
    b. Next, you will familiarize yourself with the weight lifting movement by performing 10 repetitions of the weight lifting activity with the weight of the bar only. This will be followed by a 2-minute rest.
    c. During the resting period, you will identify a weight that you believe that you can lift for 6-8 repetitions. You then will complete 6-8 repetitions at the identified weight. This will be followed by a 2-minute rest.
    d. During your rest, the study staff will explain the process of how he/she will identify the highest weight you can lift for 1 repetition. Since the highest weight you can lift is unknown, you will have 4 weight-lifting trials to identify the highest weight you can lift for 1 repetition. Following each 1-repetition lift, you will rest for 2 minutes. The study staff will increase the weight during your rest period. You will stop the repetitions if you reach your maximum weight lifted or decide to stop lifting a weight at any time. Once you reach your maximum weight lifted, the study staff will record the maximum weight on a data recording form.
4. After you list your maximum weight, you will perform a cool down by walking on a treadmill for 3 minutes at 2.5 mph. You can walk at a slower speed if you so desire.
5. You will then walk freely in the laboratory for an additional 3 minutes to ensure you are fully recovered.
6. The study will end with you filling out a questionnaire at the end of the study.

Time Commitment: Approximately 60-90 minutes.

What happens if I say yes, but I change my mind later?

You can leave the research at any time; it will not be held against you.

If you decide to leave the research, you will no longer be eligible for $15 compensation and will not be eligible to see the results of the study. If you decide to leave the research, contact the investigator so that the investigator can notate in your data that you no longer are interested in being part of the study.

If you stop being in the research project, data collected up to the point of your withdrawal from the study will remain with the research team to ensure the integrity of the research project. These

data will be handled the same as research data. If you decide to stop the research project, no explanation is required.

Is there any way being in this study could be bad for me?

Abnormal Screening Tests. In the case that one or more of the screening tests results are abnormal, a member of the research team will inform you. The study team will advise you to check these results with your physician or health care provider.

Exercise Testing. Muscle soreness or cramps may occur following weight lifting. These are common side effects of exercise and can be reduced with an adequate warm-up and cool-down. Exercise may also expose you to a low risk of cardiovascular events, such as a heart attack or stroke, especially if you have a predisposing condition such as high blood pressure. However, a cardiovascular event such as a heart attack or stroke is a very rare potential risk in individuals without a predisposing condition. Our screening procedures are specifically designed to minimize your risks.

Confidentiality. There is a general risk of disclosure of personal sensitive data in a clinical investigation. To minimize this risk only the investigators and the laboratory personnel will have access to your personal information. All research data containing your name will be locked in the Principal Investigator's office. To preserve confidentiality, immediately after enrollment you will be assigned a code by which each research sample will be identified for further analysis, thus avoiding identification by technicians or non-qualified individuals.

Other unforeseen or unknown risks may occur. As with any research, there is some a possibility that you be subject to risks that have not yet been identified. You will be closely monitored for any unforeseen risks.

You should not be pregnant while in this research study.

Is there any way being in this study could be bad for me?

Abnormal Screening Tests. In the case that one or more of the screening tests results are abnormal, a member of the research team will inform you. The study team will advise you to check these results with your physician or health care provider.

Exercise Testing. Muscle soreness or cramps may occur following weight lifting. These are common side effects of exercise and can be reduced with an adequate warm-up and cool-down. Exercise may also expose you to a low risk of cardiovascular events, such as a heart attack or stroke, especially if you have a predisposing condition such as high blood pressure. However, a cardiovascular event such as a heart attack or stroke is a very rare potential risk in individuals without a predisposing condition. Our screening procedures are specifically designed to minimize your risks.

Confidentiality. There is a general risk of disclosure of personal sensitive data in a clinical investigation. To minimize this risk only the investigators and the laboratory personnel will have access to your personal information. All research data containing your name will be locked in the Principal Investigator's office. To preserve confidentiality, immediately after enrollment you will be assigned a code by which each research sample will be identified for further analysis, thus avoiding identification by technicians or non-qualified individuals.

Other unforeseen or unknown risks may occur. As with any research, there is some a possibility that you be subject to risks that have not yet been identified. You will be closely monitored for any unforeseen risks.

You should not be pregnant while in this research study.

What happens to the information collected for the research?

Efforts will be made to limit the use and disclosure of your personal information, including research study and medical records, to people who have a need to review this information. We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization.

Federal law provides additional protections of your medical records and related health information. These are described in an attached document.

What else do I need to know?

If you agree to take part in this research study, we will pay you for your time and effort. All study-related costs associated with your participation will be paid by funds allocated to the research team. If you drop out or are excluded, you will not be eligible to receive $15 compensation for completion of all study tests.

There will be no cost to you, the subject, during your participation in this study other than the cost of travel to and from the Downtown Sun Devil Fitness Complex. If you agree to participate in the study, then consent does not waive any of your legal rights. However, no funds have been set aside to compensate you in the event of injury. However, if any injury occurs due to the experimental procedures, first aid will be provided. If there is a situation that the research team believes needs attention by a primary care practitioner, you will be referred to the Nurse Practitioner Clinic on the Downtown Arizona State University campus (approximately two (2) blocks from the lab). If any injury occurs after the Nurse Practitioner Clinic is closed, you should seek attention at an urgent care facility. If a medical emergency were to occur during this study, we will call "911" to bring emergency medical personnel to the lab. You will be responsible for any costs incurred.

Your participation may be stopped by the research team without your consent if

1) *You do not meet the inclusion/exclusion criteria of this study.*
2) *You experience adverse events such as extreme muscle soreness or inability to complete the measurements during the visit*
3) *The study physician determines that your participation in this study will interfere with your safety and well- being.*

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, you may e-mail Dr. Barbara Ainsworth, study Principal Investigator at Barbara.ainsworth@asu.edu or call 480-208-5877 (9-5 pm) or the study co-investigator Alexander Stark at ajstark1@asu.edu (any time) or (530) 313-8292 (9-5 pm).

This research has been reviewed and approved by the ASU Bioscience IRB ("IRB"). You may talk to them at (480) 965-6788 or research.integrity@asu.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research participant.
- You want to get information or provide input about this research.

Signature documents your permission to take part in this research.

Signature of participant	Date
Printed name of participant	
Signature of person obtaining consent	Date
Printed name of person obtaining consent	

My signature below documents that the information in the consent document and any other written information was accurately explained to, and apparently understood by, the participant, and that consent was freely given by the participant.

Signature of witness to consent process	Date
Printed name of person witnessing consent process	

APPENDIX N

NCMS LIVE SUBJECT DEMOSTRATION IMAGE


NCMST Subject Demonstration
NCMST Subject Demonstration

APPENDIX O

BIOSCIENCE HRP-503B FORM

Instructions and Notes:

- Depending on the nature of what you are doing, some sections may not be applicable to your research. If so mark as "NA".
- When you write a protocol, keep an electronic copy. You will need to modify this copy when making changes.

1 Protocol Title

Non-Counter Movement Squat Test

2 Background and Objectives

Provide the scientific or scholarly background for, rationale for, and significance of the research based on the existing literature and how will it add to existing knowledge.

- Describe the purpose, specific aims, or objectives.
- State the hypotheses to be tested.
- Describe the relevant prior experience and gaps in current knowledge.
- Describe any relevant preliminary data.

Lower body muscular strength is necessary for everyday activities, whether getting out of bed, standing up from a chair or getting off the toilet. Due to the need for lower body strength in daily movements, the American College of Sports Medicine and the National Strength and Conditioning Association utilize the measurement of lower body strength using a leg press which measures absolute strength (ACSM, 2018; NSCA, 2016). However, most leg press machines do not function in a plane of movement that accurately represents daily functions as the test requires users to sit in a chair and press a weight in a horizontal or diagonal plane. By assessing lower body strength capability with a motion similar to daily living (vertical plane), it is possible to assess one's capacity for the activities of daily living capabilities.

Purpose: To test the feasibility of using a Non-Counter Movement Squat Test (NCMST) to measure lower body strength in men and women between 20 and 70 years of age. Using the feasibility metrics established by Bowen et al.

Hypothesis: The Non-Counter Movement Squat Test will be a feasible way to assess lower body muscular strength in men and women ages 20 to 70.

3 Data Use

Describe how the data will be used. Examples include:

- Dissertation, Thesis, Undergraduate honors project
- Publication/journal article, conferences/presentations
- Results released to agency or organization
- Results released to participants/parents
- Results released to employer or school
- Other (describe)

The data collected from this study will be utilized for the completion of a master's thesis. This data may also be presented at local and/or national research conferences. The long-term plan is to publish these data in a peer-reviewed research journal.

4 Inclusion and Exclusion Criteria

Describe the inclusion and the exclusion criteria for the study.
Describe how individuals will be screened for eligibility.
Indicate specifically whether you will target or exclude each of the following special populations:

- Minors (individuals who are under the age of 18)
- Adults who are unable to consent
- Pregnant women
- Prisoners
- Native Americans
- Undocumented individuals

We will study up to 40 healthy Men and Women (20 - 70 years of age), distributed so that 2 males and 2 females will each span 5-year increments (I.e. 20-24,25-29,30-34, etc).
Before enrollment, all subjects will complete an online screening survey via Google Forms online questionnaire services. Subjects will be invited to the Downtown Sun Devil Fitness Center if they are between 20-70 years old and can communicate and are competent to provide written informed consent.

Inclusion criteria include: (a) meet the age (ages 20-70 years) and sex (male, female) recruitment stratification requirements, (b) can communicate in English, and (c) are able to provide written informed consent.

Exclusion criteria include: (a) any orthopedic conditions that preclude lifting weights, (b) individuals who knowingly have osteopenia or osteoporosis, (c) those who can knowingly squat two times their body weight or leg press three times their body weight, (d) self-reported acute or chronic illness, or medical conditions exacerbated by exercise such as heart, liver, kidney, blood, respiratory disease, peripheral vascular disease, active cancer, or (e) pregnant. Inclusion criteria will be determined during the screening questionnaire. Exclusion criteria will be determined by the screening questionnaire and the PARQ+ administered during the visit.

5 Number of Participants

Indicate the total number of participants to be recruited and enrolled

- Provide a rationale for the proposed enrollment number
- What percentage of screened individuals will likely qualify for the study?

40 adults (20 male and 20 female)
2 for each sex for each age bracket of 5 years (20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69)
We believe that this number of subjects will be adequate to test the feasibility of a full-scale study.

6 Recruitment Methods

- Describe when, where, and how potential participants will be identified and recruited.
- Describe materials that will be used to recruit participants. (Attach copies of these documents with the application.)
- Does any member have a dual role with the study population?

Subjects will be recruited by advertisements placed on social media such as Facebook and Instagram sent out via email delivery blast. Flyers will be posted in high foot traffic areas around the Downtown ASU Campus in Phoenix AZ, and word of mouth in the Phoenix metropolitan area. All advertisements will direct interested participants to Mr. Stark or to the screening questionnaire. Subjects will complete a brief online (Google Forms) screening questionnaire, which will be reviewed by Mr. Stark. Following the screening, qualified subjects will be invited to the Arizona State University Downtown Pheonix Campus for a formal informed consent process.

7 Study Timelines

Describe:

- The duration of an individual participant's participation in the study.
- The duration anticipated to enroll all study participants.
- The estimated date for the investigators to complete this study (up to and including primary analyses).

Duration of an individual participant's participation in the study is expected to be one visit lasting about one and a half hours. The study is estimated to be completed by May 2019.

8 Procedures Involved

Describe and explain the study design. Provide a description of all research procedures being performed and when they are performed.
Describe procedures including:

- The documents/ measures / devices/ records /sampling that will be used to collect data about participants. (Attach all surveys, scripts, and data collection forms.)
- What data will be collected including long-term follow-up?
- All drugs and medical devices used in the research and the purpose of their use, and their regulatory approval status.
- Describe the available compensation (monetary or credit that will be provided to research participants).
- Describe any costs that participants may be responsible for because of participation in the research.

Subjects that qualify based on answers to the questionnaire and following description of the study and receiving consent will then undergo exercise testing during the same, single visit. All procedures will follow established standard operating procedures for the downtown phoenix SNHP laboratory.

Itemized Overview of Proposed Procedures:

1. Review of online screening responses
2. Review of study
3. Any questions will be answered
4. Signing of consent form
5. PAR-Q+ will be completed following the obtainment of written consent and reviewed with the subject prior to any participation.
6. Height and weight measures.
7. Percent bodyfat measurement via Tanita BIA (TANITA MC-780U Multi Frequency Segmental Body Composition Analyzer, Arlington Heights, IL).
8. Handgrip Dynameter (Smedley III Analog Grip Strength Dynamometer Ann Arbor, Michigan).
9. Non-counter movement squat Protocol (NCMS)

NCMS:

a. Demonstration of protocol – video on screen
b. Warm-up – cycle ergometer (5 min) at pace determined by self-determined fitness level (75W untrained,100W moderately trained, or 150W for well-trained participants. (Intensities based off Astrand protocol) (Monark 988E Cycle Ergometer, 928E, Monark, Vansbro, Sweden)
c. Establish bar height – sit on box 16 inches and adjust bar to shoulders in Smith Machine (Yukon Linear Counter Balanced Smith Machine Bedford Heights, Ohio, USA)
d. Lift bar only for 10 reps to familiarize motion and ROM (2:00 min rest)
e. Self-select weight comfortably for 6-8 reps (2:00 min rest)
f. Technician adds weights (low as 5lbs) for 1 Repetition Max attempt based off RPE score, rack in place [max 4 attempts] – get out and sit for 2 minutes between reps
g. Cool-down walk on treadmill for 2.5 mph 0% incline for 2 minutes (TrackMaster Treadmill, TM-500, Full Vision inc, Newton, Kansas, USA)

Length of visit: Approx. 1.5 hours; Location: Sun Devil Fitness Complex (Downtown)

9 Withdrawal of Participants

Describe anticipated circumstances under which participants will be withdrawn from the research without their consent.
Describe procedures that will be followed when participants withdraw from the research, including partial withdrawal from procedures with continued data collection.

Subjects may be withdrawn from the study if they do not meet the inclusion/exclusion criteria. Also, subjects can leave the research at any time without explanation.

10 Risks to Participants

List the reasonably foreseeable risks, discomforts, hazards, or inconveniences to the participants related the participants' participation in the research. Include as may be useful for the IRB's consideration, the probability, magnitude, duration, and reversibility of the risks. Consider physical, psychological, social, legal, and economic risks. Reference this information when appropriate.

- If applicable, indicate which procedures may have risks to an embryo or fetus should the participant be or become pregnant.
- If applicable, describe risks to others who are not subjects.

Exercise – There are some risks associated with exercise. Subjects may experience muscle tightness, muscle soreness and fatigue (immediate and/or 24-hour onset), shortness of breath, lightheadedness, and rarely a pulled muscle. Risks associated with maximal strength testing are extremely minimal. Surveys place the event rate at approximately 0 to 6 deaths or cardiac arrests per 10,000 tests and 2 to 10 MIs per 10,000 tests. Further, based on our screening assessment, all individuals approved to participate will be classified as only moderate risk (or lower) by the American College of Sports Medicine, indicating no medical supervision is required during vigorous exercise (Medicine, 2013). In addition, exercise training has an excellent safety record even in patients with established cardiovascular disease (Lavie, 2001).

Loss of Confidentiality – Divulgation of personal sensitive data is a general risk of clinical investigations involving human subjects

Description of How the Risks will be Minimized:

Exercise – The risks associated with the exercise will be minimized by screening and identifying a healthy subject population and by proper warm up prior to the exercise session. In addition, most injuries occur during the counter movement phase of the lift which will not be performed during maximal attempts.

Equipment: with the use of a Smith machine (Yukon Linear Counter Balanced Smith Machine Bedford Heights, Ohio, USA) we will significantly reduce the need of stabilization and technique inexperience which are primary causes of injury in resistance training.

11 Potential Benefits to Participants

Realistically describe the potential benefits that individual subjects may experience from taking part in the research. Include the probability, magnitude, and duration of the potential benefits. Indicate if there is no direct benefit. Do not include compensation or benefits to society or others.

There will be no direct benefit of the subjects participating in these studies. However, subjects will have access to all their results. All data collection techniques proposed are very well documented to provide minimal risk to the subjects and are far outweighed by the benefit of the information that will be acquired from this study.

12 Setting

Describe the sites or locations where your research team will conduct the research.

- Identify where research procedures will be performed.
- For research conducted outside of the ASU describe:
  - Site-specific regulations or customs affecting the research.
  - Local scientific and ethical review structures in place.

All research will take place at the Downtown Sun Devil Fitness Complex (SDFC) building. All exercise will be performed in the exercise physiology laboratory on the second floor of the Downtown Sun Devil Fitness Complex Building (room #209).

13 Multi-Site Research

If this is a multi-site study where you are the lead investigator, describe the processes you will use to ensure communication among sites, such as:

- Each site has the most current version of the protocol, consent document, and HIPAA authorization.
- Required approvals have been obtained at each site (including approval by the site's IRB of record).
- Describe processes you will use to communicate with participating sites.
- Participating sites will safeguard data as required by local information security policies.
- Local site investigators conduct the study appropriately.

☐ Not Applicable

14 Resources Available

Describe the qualifications (e.g., training, experience, oversight) of you and your staff as required to perform your roles. When applicable describe knowledge of the local study sites, culture, and society. Provide enough information to convince the IRB that you have qualified staff for the proposed research.

Describe other resources available to conduct the research: For example, as appropriate:

- Describe your facilities.
- Describe the availability of medical or psychological resources that participants might need as a result of any anticipated consequences of the human research.
- Describe your process to ensure that all persons assisting with the research are adequately informed about the protocol, the research procedures, and their duties and functions.

Facilities - All equipment, infrastructure and instrumentation are readily available to the research team (see "12 Settings"). The Downtown Sun Devil Fitness Complex building contains ample space to perform the protocol including a dedicated exercise lab (room #209).

15 Prior Approvals

Describe any approvals that will be obtained prior to commencing the research. (E.g., school, external site, funding agency, laboratory, radiation safety, or biosafety approval.)

Researchers conducting data collection have their Lab Safety Training, CPR certification and CITI Training approval.

16 Data Management and Confidentiality

Describe the data analysis plan, including procedures for statistical analysis.

Describe the steps that will be taken to secure the data during storage, use, and transmission.

- Training, authorization of access, password protection, encryption, physical controls, certificates of confidentiality, and separation of identifiers and data

Describe how data and any specimens will be handled:

- What personal identifiers will be included in that data or associated with the specimens?
- Where and how data or specimens will be stored?
- How long the data or specimens will be stored?
- Who will have access to the data or specimens?
- Who is responsible for receipt or transmission of the data or specimens?
- How will data and specimens be transported?
- If data or specimens will be banked for future use, describe where the specimens will be stored, how long they will be stored, how the specimens will be accessed, and who will have access to the specimens.
- Describe the procedures to release data or specimens, including: the process to request a release, approvals required for release, who can obtain data or specimens, and the data to be provided with specimens.

All of the data and research material will be obtained specifically for research purposes. These data will include: Exercise data and screening data. All data will be stored in a locked cabinet and/or on a password protected computer hard drive. The principal investigator, co-investigators, and student working with the research team will be the only individuals with immediate access to the data.

All data containing the names of volunteers will be stored in a locked file in the PI's office. To preserve confidentiality, immediately after enrollment each subject will be assigned a identification number by which each research sample will be identified for further analysis, thus avoiding identification by non-qualified individuals. This code will be used to label all data sheets associated with a given subject.

17 Safety Monitoring

This is required when research involves more than Minimal Risk to participants. The plan might include establishing a data monitoring committee and a plan for reporting data monitoring committee findings to the IRB and the sponsor. Describe:

- The plan to periodically evaluate the data collected regarding both harms and benefits to determine whether participants remain safe.
- What data are reviewed, including safety data, untoward events, and efficacy data?
- How the safety information will be collected (e.g., with case report forms, at study visits, by telephone calls with participants).
- Who will review the data?

The safety and progress of this study will be the responsibility of the principal investigator. The risk level associated with this study is estimated to be minimal. The plan for monitoring this study will include a review screening for results and other available data by the principal investigator and a review of data safety. To ensure full safety, monitoring the recruitment, enrollment, retention, adverse events, and study procedures will be integral. Each subject will be screened for full possible exclusion criteria before the study and follow ups will be done post study.

Non-serious anticipated adverse events- such as muscle soreness will be reported the principle investigator to identify if the severity is abnormal or not. Unanticipated adverse events will be reported to the Arizona State University IRB within 24 hours of occurrence. If an item in the protocol is the main cause of this issue, the study will be suspended until modifications to the protocol are forwarded to the IRB for review.

Data Management- All study data will be collected by the research team, recorded on data flow sheets, and stored in locked file cabinets or databases in a secure area of the principal investigator's office. Interim data will be reviewed by the principal investigator. The subject's right to confidentiality will be protected at all times and no subject will be identified by name in any publication that results from this research.

18 Consent Process

Describe the process and procedures process you will use to obtain consent. Include a description of:

- Who will be responsible for consenting participants?
- Where will the consent process take place?
- How will consent be obtained?
- If participants who do not speak English will be enrolled, describe the process to ensure that the oral and/or written information provided to those participants will be in that language. Indicate the language that will be used by those obtaining consent. Translated consent forms should be submitted after the English is approved.

Mr. Stark will be responsible for the consenting participants as they are guided through the consent process. Consent will be obtained at the beginning of their visit by going through a consent form with the participant. This will be done in a private room in the Downtown Sun Devil Fitness Complex building. Adequate time will be allotted for a full review of the consent form and the risks associated with the study.

19 Investigational New Drug or Devices

If the drug is investigational (has an IND) or the device has an IDE or a claim of abbreviated IDE (non-significant risk device), include the following information:

- Identify the hold of the IND/IDE/Abbreviated IDE.
- Explain procedures followed to comply with FDA sponsor requirements for the following:

	Applicable to:		
FDA Regulation	**IND Studies**	**IDE studies**	**Abbreviated IDE studies**
21 CFR 11	X	X	
21 CFR 54	X	X	
21 CFR 210	X		
21 CFR 211	X		
21 CFR 312	X		
21 CFR 812		X	X
21 CFR 820		X	

Not Applicable

20 CITI

Provide the date that the members of the research team have taken the CITI training for human participants. This training must be taken within the last 4 years. Additional information can be found at: http://researchintegrity.asu.edu/training/humans

Alexander Stark – Passed 1/20/2017