A Predictive Study of Fall Risk in Cardiac Phase II Rehabilitation Patients

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With Deepest Gratitude,

Marcia K. Himes

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Table of Contents

List of Tables

Abstract

Fall prevention, and the subsequent reduction of fall-related injuries, is critically important for preserving independence among older adults. Cardiac phase II rehabilitation (CR) is a comprehensive medically supervised program allowing individuals with certain cardiac diagnoses or cardiac procedures to exercise in a safe environment. The relationship among lower extremity strength, lower extremity blood flow, and fall risk in community-dwelling older adults has been established; however, that relationship in the CR population remains unknown. This cross-sectional study used exploratory analysis to determine if the 30 second chair stand test (CST) and the ankle brachial index (ABI) could predict the score on the Functional Gait Assessment (FGA). A convenience sample ($N = 57$) of individuals aged 50 years and older, enrolled in a CR program, were selected. Data were collected during a single testing session. No correlation was found between the ABI and FGA score ($r = .02$, $p = .438$). A significant positive correlation was found between the CST and FGA score ($r = .71$, $p < .001$). Moreover, the CST significantly predicted the overall FGA score, accounting for 45% of the variance, $F(2,54) = 23.97$, $p < .001$, $R^2 = .47$. Coefficient analyses revealed that the ABI was unrelated to FGA scores ($\beta = -0.05$, $p = .608$) and could be ignored; however, the CST was a significant predictor of FGA scores ($\beta = 0.69$, $p < .001$) and could be used by CR healthcare professionals as a fall-risk screening measure.

Keywords: fall risk, cardiac phase II rehabilitation, 30 second chair stand test, ankle brachial index, Functional Gait Assessment, predictive ability

A Predictive Study of Fall Risk in Cardiac Phase II Rehabilitation Patients

Fall prevention, and the subsequent reduction in fall-related injuries, is critically important for preserving health and independence among older adults. Falling, or fear of falling, can predispose an individual to falls, which may result in self-limited activity, disability, or even death (Toebes, Hoozemans, Furrer, Dekker, & van Dieën, 2015). Falls are the leading cause of injury-related deaths and are the most common cause of nonfatal injuries and hospital admissions for trauma among adults aged 65 years or older (Burns, Stevens, & Lee, 2016; Carroll, Slattum, & Cox, 2005; Centers for Disease Control and Prevention [CDC], 2016).

Falls have great financial impact on the individual and society. Medical costs incurred due to injuries sustained from a fall increase rapidly with age (Stevens, Corso, Finkelstein, & Miller, 2006; Ward et al., 2015). In 2000, health care systems in the United States (U.S.) spent $19 billion for care attributed to falls among older adults. By 2012, that figure increased to $30 billion, and in 2015 direct medical costs submitted to Medicare associated with falls totaled over $31 billion (Burns, Stevens, & Lee, 2016).

Falls typically result from a complex and interdependent mix of medical and physical factors. For example, Aoyama, Suzuki, and Kuzuya (2015) found that reduced lower extremity strength predicted falls in community-dwelling older females. Cho, Bok, Kim, and Hwang (2012) described how decreased lower extremity strength was associated with increased fall risk in the elderly and McDermott et al. (2002) indicated lower extremity blood flow measurements were highly correlated with lower extremity function. Additionally, Davies and Kenny (1996) reported that cardiovascular issues accounted for a large percentage of patients who were seen emergently for unexplained or recurrent falls.

Cardiac phase II rehabilitation is a comprehensive medically supervised program allowing individuals with a diagnosis of myocardial infarction, stable angina, heart failure, valvular heart disease, or individuals post-surgical procedures such as coronary artery bypass grafting and cardiac transplantation to be monitored and to exercise in a safe environment (Price, Gordon, Bird, & Benson, 2016). Due to physiological changes and cardiac issues superimposed on the typical aging process, cardiac phase II rehabilitation patients may be at increased fall risk compared to community-dwelling older adults. The relationship among lower extremity strength, lower extremity blood flow, and fall risk in community-dwelling older adults has been established; however, that relationship in the cardiac phase II rehabilitation population remains unknown. The purpose of this study was to determine if lower extremity strength and lower extremity blood flow were predictors of fall risk among cardiac phase II rehabilitation patients. To address the study purpose, the following hypotheses were tested: 1) Hypothesis 1: there will be a statistically significant positive relationship between ankle brachial index (ABI) values and the functional gait assessment (FGA) scores, 2) Hypothesis 2: there will be a statistically significant positive relationship between 30 second chair stand test (CST) scores and the FGA scores, and 3) Hypothesis 3: the ABI and the CST will statistically significantly predict the FGA score among participants. Results of this study provide insight into characteristics which may lead to increased fall risk. Information from this study may be used to identify patients who are at increased fall risk, facilitate intervention to reduce fall risk, while improving the quality and length of life in the cardiac phase II rehabilitation population.

Literature Review

Prediction of fall risk is important in facilitating patient education, fall prevention, and interventions to reduce fall-related injuries. Each year, 2.5 million older adults fall, resulting in injuries that must be treated in an emergency room. One-fifth of those falls result in serious injuries such as fractures or traumatic brain injuries, and over 700,000 adults are hospitalized each year due to fall-related injuries (CDC, 2016b). Additionally, only around 50% of those who are hospitalized after a fall will live longer than one year (Rubenstein, 2006).

Falls have great financial implications on the individual and society. In the year 2000, expenditures reached $198 million for medical treatment for fall related injuries in the U.S. (Stevens, Corso, Finkelstein, & Miller, 2006). By 2010, the total lifetime cost related to fatalities, hospitalizations, or treatment in an emergency department for unintentional injuries due to falls exceeded $111 billion (Verma et al., 2016). In 2015, direct medical costs for fatal and nonfatal fall related injuries surpassed $31.9 billion. The incidence of falls and subsequent fall-related injuries in older adults is trending upward each year and costs associated with medical treatment related to falls are a substantial financial burden on the U.S. economy (Burns, Stevens, & Lee, 2016).

The National Institute on Aging (2016) reported that several medical and physical risk factors may lead to increased fall risk: muscle weakness, especially in the legs; poor balance; postural hypotension; medications; and sensory deficits. Shubert, Schrodt, Mercer, Busby-Whitehead, and Giuliani (2006) indicated that early detection of mobility and balance impairments is critical for maintaining independence in older adults. Increased fall risk in older adults can be multifactorial in origin and may be caused from a combination of intrinsic or extrinsic factors, predisposing an individual to falls (Berry & Miller, 2008; Dionyssiotis, 2012). According to Lee, Lee, and Khang (2013), the strongest independent fall risk factors for older adults include previous falls, weakness, gait or balance impairments, and psychoactive medications. In addition, frailty has been linked to increased fall risk in this population (deVries, Peeters, Lips, & Deeg, 2013).

Tinetti, Speechley, and Ginter (1988) indicated that a positive correlation exists between the number of risk factors and fall risk. As the number of risk factors increase, there is a subsequent increase in fall risk (Tinetti et al., 1988). Older adults who have cardiac conditions often possess multiple intrinsic and extrinsic risk factors related to increased fall risk, which may render this population more susceptible to falls than their healthy counterparts (Afilalo, Karunananthan, Eisenberg, Alexander, & Bergman, 2009; Goel et al., 2010). Therefore, it is critical that we investigate how falls are related to health factors in people with cardiac conditions throughout the stages of care in order to enhance services.

Reduced Lower Extremity Strength and Fall Risk

Sarcopenia, or age-associated loss of muscle tissue, is responsible for the loss of skeletal muscle fiber mass and can result in profound muscle weakness (Roubenoff & Hughes, 2000). Doherty (2003) indicated that individuals whose age is in the 70s and 80s demonstrated a 20-40% reduction in maximum voluntary muscle contractile strength due to sarcopenia. The amount of reduction in skeletal muscle mass has been positively correlated with the degree of functional limitation, disability, and fall risk in older adults (Roubenoff & Hughes, 2000; Doherty, 2003).

In addition to age related changes in skeletal muscle mass, strength impairments in specific groups of lower extremity muscles, such as ankle dorsiflexors and hip extensors have been associated with falls (Daubney & Culham, 1999). Moreland, Richardson, Goldsmith, and Clase (2004) conducted a systematic review and meta-analysis to determine if muscle weakness was a risk factor for falls, which muscles groups were potentially involved, and the magnitude of muscle weakness associated fall risk in older adults. Results of this study indicated that lower extremity weakness is a clinically important and statistically significant risk factor for falls; however, the relative contribution of specific muscles or groups of muscles could not be determined (Moreland et al., 2004). More recently, Ding and Yang (2015) investigated the contribution of specific muscles groups for balance recovery after a slip (near fall) in older adults. Weakness in the knee flexor and extensor muscle groups was found to be linked to slip-related falls during gait. Furthermore, muscle weakness was determined to be a limiting factor for balance recovery in older adults. For example, a one-unit reduction in knee extensor strength more than tripled the odds of a slip-related fall (Ding & Yang, 2016). Additionally, Pijnappels, van der Burg, Reeves, and van Dieën (2008) described how leg extension strength is important during the recovery process following a loss of balance episode to restore balance and stability.

Reduction in the ability to perform activities of daily living and a decline in functional mobility have been associated with decreased muscle strength and can be a predictor of fall risk (Pijnappels et al., 2008). For example, Berry and Miller (2008) and Ward et al. (2015) reported the inability to rise from a chair without the use of arms and reduced lower extremity strength increases fall risk. Seo, Yates, Norman, Pozehl, and Kupzk (2014) supported this finding and described that lack of lower extremity strength affected an individual's ability to perform activities such as transitioning from sitting to standing, walking, or stair climbing, any of which can significantly impact quality of life. McDermott, Fried, Simonsick, Ling, and Guralnik (2000) reported that patients with peripheral arterial disease (PAD) exhibited walking difficulty and a reduction in lower extremity strength. Papa, Garg, and Dibble (2015) described how reduced lower extremity strength was linked to a degradation of postural control, which increased fall risk. Finally, Guralnik, Ferrucci, Simonsick, Salive, and Wallace (1995) further indicated that decreased lower extremity strength may result in the inability to perform daily activities and predicts future disability.

Reduced Lower Extremity Blood Flow and Fall Risk

Overall reduction in blood flow and vascular conductance is a typical phenomenon of the healthy aging process (Dinenno, Jones, Seals, & Tanaka, 1999). Skeletal muscle accounts for the vast majority of total tissue in the lower extremity and places a great demand on the cardiovascular system due to oxygenation and blood flow requirements (Dinenno et al., 1999). With the addition of cardiovascular disease risk factors, such as metabolic syndrome, reduction of peripheral blood flow may be further compromised due to increased sympathetic nervous system activity. Sympathetic nervous system activation leads to vasoconstriction of the vasculature in the lower limbs, resulting in the inability of the cardiovascular system to augment blood flow to the lower extremities and may lead to limitations in functional mobility (Dinenno et al., 1999).

Whole body thallium-201 scintigraphy has been used to evaluate blood flow distribution during exercise in older adults with cardiac dysfunction. Using this technique, maldistribution of blood flow to the lower extremities was found during exercise and could be a contributing factor of exercise intolerance (Wada et al.,1997). Secher and Volianitis (2006) supported this finding and indicated that blood flow distribution to the lower extremities may be limited if cardiac output is compromised, which may be the case in patients with cardiac dysfunction. A reduction in cardiac output may lead to increased peripheral resistance and a reduction in lower extremity blood flow by increasing sympathetic nervous system activity (Secher & Volianitis, 2006).

Heart failure has also been implicated in the reduction of lower extremity blood flow in older adults. Lindsay et al. (1996) found that individuals with heart failure demonstrated a reduction in blood flow in the lower extremities compared to their healthy counterparts. Moreover, the severity of heart failure dictated the amount of absolute blood flow in the lower extremities. This reduction in lower extremity blood flow is due to impairment in endothelium function and vasodilator response (Lindsay et al., 1996). Additionally, Shiotani et al. (2002) indicated that blood flow in the legs was markedly reduced during upright exercise in older adults who have heart failure. This result was attributed to a reduction in venous pressure caused by an ineffective muscle pump and attenuation of the lower extremity vasodilating response during exercise. Blunted blood flow in older adults with heart failure may lead to a vicious cycle where reduction in blood flow may lead to compensatory activation of the sympathetic nervous system and further exacerbation of the problem (Shiotani et al., 2002).

Peripheral arterial disease is a common diagnosis encountered in older adults who have cardiovascular disease. It causes degeneration and destruction of the arteries, leading to a reduction in oxygenated blood flow to the lower extremities. Weiss, Casale, Koutakis, Nella and Swanson (2013) reported that PAD resulted in oxidative damage and a reduction in the myofiber cross-sectional area of the gastrocnemius by 29.3%. Furthermore, McDermott et al. (2002) indicated that the reduced blood flow caused by PAD is linked to shorter walking distance, slower walking velocity, lower levels of physical activity, and impaired standing balance. Ultimately, decreased functional performance, such as the inability to rise from a chair, has been linked to increased fall risk in older adults (Ward et al., 2015), impacting quality of life in older adults (Lefebvre et al., 2013).

Reduced lower extremity blood flow has not been directly linked to fall risk; however, McDermott et al. (2002) indicated that reduced lower extremity blood flow is related to impairments in standing balance and a lower level of physical activity. According to Papa et al.

(2015), impairments in standing balance, postural control, and muscle fatigue may increase fall risk; therefore, it is reasonable to hypothesize that reduced lower extremity blood flow may lead to increased fall risk. Many individuals enrolled in the cardiac phase II rehabilitation program are diagnosed with conditions such as heart failure, PAD, and coronary artery disease, conditions which can lead to restricted blood flow to the lower extremities; this may make them more susceptible to falls.

Fall Risk in the Cardiac Rehabilitation Population

It has been established that increased fall risk in older adults can be attributed to risk factors such as decreased muscle strength or reduced blood flow in the lower extremities; however, Berg, Alessio, Mills, and Tong (1997) indicated that there is likely an underestimation of the role that cardiovascular abnormalities play in fall risk. Mozaffarian et al. (2014) reported that 85.6 billion adults have been diagnosed with some type of heart disease and 5.7 million of those individuals have heart failure. Moreover, symptoms linked to heart failure such as decreased exercise tolerance, shortness of breath, cognitive dysfunction, and postural hypotension have been associated with falls (Saczynski et al., 2013). A systematic review by Lee, Pressler, and Titler (2015) indicated that patients with heart failure had 1.86 times greater odds of falling, especially when on medications such as benzodiazepines and digoxin, when compared to the general population of older adults.

In the cardiac rehabilitation setting, older adults are predisposed to several of the aforementioned risk factors due to their cardiac condition or multiple co-morbidities (Kreizman & Allen, 2005). Vascular disease of the myocardium and peripheral vasculature are often superimposed on age-related factors, resulting in a reduction of functional mobility and strength (Lakatta, 1993). Jansen et al. (2016) indicated that cardiovascular disorders such as heart failure, low blood pressure, and arrhythmias are strongly correlated to fall risk and must be considered when evaluating fall risk.

Kuys et al. (2013) described how older adults with heart failure may be more susceptible to falls as a result of musculoskeletal pain, polypharmacy, orthostatic hypotension, reduced sensation, and shortness of breath with household activities. Additionally, van der Velde, Stricker, Roelandt, Cate, and van der Cammen (2007) found that certain diagnoses such as pulmonary hypertension and heart valve regurgitation were indicative of increased fall risk. Heart valve regurgitation has been directly linked with a reduction in peak cardiac output, which can lead to the inability to meet circulatory demands. If circulatory demands are unmet, an individual can sustain a fall due to poor cerebral perfusion. Valvular issues were positively and strongly associated with fall risk. As the severity of valve regurgitation increased, the likelihood of an individual sustaining a fall increased (van der Velde et al., 2007).

Individuals enrolled in a cardiac phase II rehabilitation program have had a recent cardiac-related surgery or some other type of cardiac event. After cardiac surgery, there is often a decline in functional mobility (Cahalin, LaPier, & Shaw, 2011). A coronary artery bypass graft (CABG) is a surgical procedure that is widely used for revascularization of the heart. Following a CABG procedure, individuals are restricted from performing certain types of movements to reduce complications from surgery and to promote healing of the chest cavity (Cahalin, LaPier, & Shaw, 2011). Additionally, these individuals may self-limit physical activity due to pain and are more likely to develop functional impairments such as the inability to rise from a chair, which may translate into a permanent functional disability (LaPier, 2014). Due to the direct effects of coronary heart disease related to cardiac performance and indirect effects, such as incisional infections or hemodynamic instability, this population may fear physical activity and self-limit their daily activity (LaPier, 2014). Both of which have been shown to increase fall risk (Renfro, Maring, Bainbridge, & Blair, 2016).

In summary, several cardiovascular associations with falls have been identified. Older adults admitted to a cardiac rehabilitation program may have multiple comorbidities and risk factors that could lead to increased fall risk. These findings highlight the need to determine tests and measures that would enable practitioners to assess fall risk in the cardiac rehabilitation population and in a cardiac rehabilitation setting.

Significance of the study

A thorough review of peer-reviewed, English journals has identified gaps in the literature regarding specific risk factors such as the ability of lower extremity strength or lower extremity blood flow to predict fall risk in the cardiac phase II rehabilitation population. Several studies support premises that reduced lower extremity strength may lead to increased fall risk in the older adult population and a reduction in lower extremity blood flow may be linked to postural instability. Specific studies regarding the ability of reduced lower extremity strength and lower extremity blood flow to predict fall risk in the cardiac phase II rehabilitation population have not been reported. Several investigators cite the need for future studies to determine the specific factors related to fall risk and the importance of reducing fall risk in the cardiac phase II rehabilitation population. For example, Puthoff and Saskowski (2013) described the need for implementation of physical performance assessments and fall risk screening in the cardiac population. Kuys et al. (2013) indicated that education regarding falls, modifiable risk factors, and strategies to improve balance were lacking in the cardiac rehabilitation population. Insight into the predictive ability of lower extremity strength and lower extremity blood flow to determine fall risk may expedite the use of appropriate interventions to prevent fall-related injuries, reducing overall fall risk, thus improving the quality and length of life of cardiac phase II rehabilitation patients.

Method

Study Design

This cross-sectional, exploratory study was conducted at the CoxHealth cardiac rehabilitation department in Springfield, Missouri from April 1, 2017 to July 13, 2017. The Institutional Review Board at the University of Indianapolis and Missouri State University and the legal department at CoxHealth approved the study prior to recruitment and enrollment of participants.

Participants

A convenience sample of cardiac phase II patients receiving rehabilitation services at CoxHealth was recruited and consecutively assigned to the study until the required sample size was achieved. The nurses in the cardiac phase II rehabilitation department recruited participants during the enrollment process into the cardiac phase II rehabilitation program (CRP) by providing each individual who was admitted to the CRP with a flyer explaining the research project, giving each individual an equal opportunity to participate. If a patient was interested in participating in the study, the cardiac nurse provided the primary investigator with contact information and the investigator made contact with the patient to set up an appointment.

An a priori sample size estimation was conducted using G*Power, version 3.1 (Faul, Erdfelder, Lang, & Buchner, 2009). The calculation was based on using a linear multiple regression, fixed model, single regression coefficient test with two predictor variables and the following parameters: two-tailed test, alpha of .05, power of .80, and a moderate effect size of eta = 0.15. The study required a minimum of 55 participants to detect a statistically significant effect, if one existed.

Only patients who met the following inclusion criteria were eligible to be included in this study: (a) age 50 years or older, (b) no history of neurological disorders affecting the central nervous system including stroke, traumatic brain injury, or spinal cord injury, and (c) able to read and understand the English language. Patients were excluded from the study if they met any of the following exclusion criteria: (a) taking medication than could affect balance and reporting dizziness due to the medication, (b) cognitively unable to perform test procedures as determined by the individual's inability to complete a three-step command, (c) unable to stand independently for 20 minutes, or (d) an orthopedic injury, surgery, or a fracture within the last six months.

Data Collection

Data collection took place at CoxHealth cardiac rehabilitation department. Demographic and participant characteristic information (age, race, and gender) were collected from a chart review. All participants were screened for the following co-morbidities and potential confounding variables during the inclusion and exclusion criteria screening process: medications that might cause dizziness, orthopedic injuries, neurological issues, and impaired cognitive ability. Each participant was assigned a unique identification number that was recorded on all paperwork in order to de-identify the data. The following outcome data were collected: lower extremity blood flow as measured by the ankle brachial index (ABI), lower extremity strength as measured by the 30 second chair stand test (CST), and fall risk as measured by the Functional Gait Assessment (FGA). Data were recorded into a password protected Excel spreadsheet by the primary investigator (M.K.H).

Operationalization of variables. Fall risk was measured using the FGA. Lower extremity strength was measured by counting the number of sit-to-stand repetitions completed in 30 seconds during the chair stand test, and lower extremity blood flow was examined by comparing the systolic blood pressure in the ankle to the systolic blood pressure in the brachial artery using the ABI.

Instrumentation

Ankle brachial index. The ABI is a non-invasive screening tool used to identify PAD or a lack of blood flow in the lower extremities by comparing systolic pressures in the lower leg to systolic pressures in the upper arm (Wound Ostomy and Continence Nurses Society, 2012). In a clinical setting, the ABI is used to determine perfusion status of the lower extremities. A ratio of 1.0 is considered normal, less than 0.9 indicates lower extremity arterial disease, and a ratio of greater than 1.3 is prognostic of elevated perfusion or incompressible vessels (Wound Ostomy and Continence Nurses Society, 2012). The ABI demonstrates good inter-rater reliability (ICC .423) (Holland-Letz et al., 2007), has high specificity (83.3% - 99.0%), and good accuracy (72.1% - 89.2%) when used to diagnose peripheral arterial disease (Xu et al., 2010).

30 second chair stand test. The CST is an assessment of lower extremity strength and endurance (CDC, 2016). The participant is assessed on the number of sit to stand repetitions completed in a 30 second time frame. The CST has excellent test-retest reliability ($.84 < R < .92$) and criterion validity ($r = .77$, 95% CI [0.64, 0.85]) in community dwelling older individuals (Jones, Rikli, & Beam, 1999).

Functional Gait Assessment. The FGA is a tool that is used to assess an individual's ability to maintain balance during 10 different gait tasks (Wrisley, Marchetti, Kuharsky, & Whitney, 2004). The maximum score for the FGA is 30 points and a score of less than or equal to 22 indicates a significant fall risk in community-dwelling older adults (Wrisley & Kumar, 2010). The FGA demonstrated excellent interrater reliability (ICC = .93, $p < .001$) (Walker et al., 2007) and criterion validity when compared to the Berg Balance Scale in community dwelling older adults ($r = .84$, $p < .001$) (Wrisley & Kumar, 2010). Due to subjectivity when scoring the FGA, reliability of the investigator's ability to score the FGA was assessed prior to data collection. The investigator watched video administration and scored a FGA on five individuals. Additionally, the investigator rescored the videos weekly for three weeks. Reliability testing was conducted prior to data collection with an average ICC value of .998 (95% CI [.99, 1.00], $p <$ .001).

Procedures

The primary investigator met with each patient who expressed interest in participating in the study to determine eligibility. During the interview, the investigator had the individual follow a three-step command to determine whether the individual had the cognitive capacity to complete the testing sequence for the research study. The patient was asked to (a) say "Hello," (b) tap the arm of a chair three times, and (c) say "I'm ready." If the individual successfully completed the screening procedure, the remainders of the inclusion and exclusion criteria were reviewed to determine if the patient was eligible to participate in the research study. If the patient met the eligibility requirements, the investigator explained the purpose of the research study, as well as the risks and benefits of participating in the research study. The researcher then explained the HIPAA requirements, including how data would be utilized and secured. Potential participants were encouraged to ask questions, and the primary investigator reviewed any unclear information and answered all questions. At that point, all patients who wished to participate in the research study were asked to complete the informed consent form.

Before the testing procedure began, the primary investigator collected demographic information and entered it into an Excel spreadsheet. The same investigator administered all tests to each participant. Identical instructions on how to complete each test were given to each participant. Tests were administered in the following order for all participants: ABI, CST, five-minute rest break, and then FGA. Randomization of the tests was considered to reduce test order bias; however, it was determined that due to the physical requirements of the CST and FGA and potential fatigue effect of the CST, the order should remain consistent. The five-minute rest break was given to each participant between the CST and FGA to avoid potential interference with scores on the FGA if the patient was fatigued after the CST. Participants wore a gait belt during the CST and FGA, which enabled the investigator to assist if balance was compromised, reducing fall risk. No participants fell or required use of the gait belt during the study. Data were recorded after each test into an Excel spreadsheet.

The ABI test was administered after the participant had rested in a supine position for 10 minutes. The investigator calculated the ABI by taking the systolic blood pressure of the posterior tibialis artery in the ankle on both legs and the brachial artery in both arms using a sphygmomanometer and a Huntleigh M2 Doppler ultrasound (Doppler) (Huntleigh Diagnostics, 2016). Initially, the sphygmomanometer was placed around the ankle and the Doppler signal of the posterior tibialis artery was located. The sphygmomanometer was inflated until the Doppler signal disappeared. Once the Doppler signal disappeared, the sphygmomanometer was inflated an additional 20 mmHg and then slowly deflated until the Doppler signal reappeared. The value on the sphygmomanometer at which the Doppler signal reappeared was recorded for the ankle. The process was repeated on the other leg and then both arms using the brachial artery. The highest value obtained for the ankle and the highest value for the arm were obtained, the highest value obtained in the ankle was divided by the highest value in the arm (Wound Ostomy and Continence Nurses Society, 2012).

The CST was administered using a straight back chair with no arms and a seat height of 17 inches. The investigator read a script providing the participant with instructions on how to complete the testing procedure. Prior to beginning the test, the participant was instructed to cross their arms, placing them across their chest. When the investigator was ready to initiate the test, the investigator said “go.” The participant then assumed a full standing position and then sat back down, repeating the procedure as quickly as possible for 30 seconds. When 30 seconds had elapsed, the investigator instructed the participant to “stop” and recorded the number of sit to stand repetitions completed by the participant. If the individual was over halfway to a standing position when the investigator said “stop” the repetition was counted (CDC, 2016a).

Finally, the FGA was administered and the participant was required to complete 10 activities while walking. The investigator read the standardized instructions for the activity prior to initiation of each activity. After each activity was completed, a score ranging from 0-3 was assigned by the investigator for the activity. After all 10 activities were completed, the investigator totaled the individual scores and assigned an overall score. The maximum score that could be assigned for the FGA was 30.

After completion of the third station, the primary investigator reviewed the results of the tests and answered any questions. Total time to complete the study was approximately 45 minutes. To ensure participant privacy, all data were secured in a locked filing cabinet at Missouri State University in the Department of Physical Therapy.

Data Screening and Analysis

The raw data for each participant were entered into a password protected Excel spreadsheet. Data analyses were conducted using IBM® SPSS® for Windows, Version 24 (IBM Corp., Armonk, NY). Data screening was used to identify accuracy, missing data, outliers, linearity, and heteroscedacity. No violations of the data assumptions were found. Descriptive statistics were calculated; nominal data were reported as frequencies and percentages, and continuous data were reported as means and standard deviations (Table 1). Normality of the data was assessed using the Shapiro-Wilk test. Bivariate comparisons were conducted on patient demographic variables to look for differences between those at risk for falls. Continuous variable comparisons were conducted using an independent *t*test. No significant differences were found. Nominal data were compared using a Fisher's exact test, and correlations were performed using a Pearson product-moment coefficient of correlation. If a correlation was found to be statistically significant, correlation strength was interpreted using Munro's descriptive terms: r = .00 -.25: Little, if any correlation; r = .26 - .49: Low correlation; r = .50 - .69: Moderate correlation; r = .70 - .89: High correlation; and r = .90 - 1.00: Very high correlation (Keller & Kelvin, 2013). A multiple linear regression was used to test the research hypothesis and assess the predictive relationship between the variables to determine if lower extremity strength and lower extremity blood flow could predict the score on the functional gait assessment, indicating the presence or absence of fall risk. Variables were introduced into the regression model simultaneously using the Enter method. All tests were two-tailed, and an alpha level of .05 was considered statistically significant.

Results

A total of 60 participants were enrolled in the study. When verifying the data input into the excel spreadsheet, an error was found in an age calculation and one participant did not meet the minimum age requirement. Two participants were unable to complete the testing procedures. Scores from these three participants were excluded from the data analyses ($n = 57$).

An exploratory data analysis using a Shapiro-Wilk test revealed that neither the ABI nor the FGA variables significantly deviated from normality beyond $p < .05$; however, the CST was not normally distributed. Residuals met the assumption of independence (Durbin-Watson = 2.15) and no autocorrelation was found. Linearity and homoscedasticity were assessed visually using a plot of standardized residuals against the predicted values. Collinearity statistics indicated that multicollinearity was not an issue (ABI, Tolerance = .99; CST, Tolerance = .99) and met the assumption of collinearity with a VIF < 10 and Tolerance > .01 (Field, 2013).

Participant Characteristics

The final sample of 57 cardiac phase II rehabilitation patients were predominantly male (73.7%) and White (92.9%), with a mean age of 68.58 years old. Of the 57 participants, 61.4% were at risk for falls. Details regarding demographics of the sample are contained in Table 1.

Descriptive Statistics

Descriptive statistics for age, ABI, CST, and the FGA are contained in Table 2.

Results for Correlational Analyses

The relationship among the ABI, CST and FGA. Hypothesis 1 stated that the ABI would relate significantly positively with the FGA among participants. A Pearson product-moment correlation coefficient was used to test Hypothesis 1. As shown in Table 3, the ABI was very weakly and positively correlated with the FGA, $r = .02$, $p = .438$, and was not statistically significant. Therefore, hypothesis 1 was not supported. The r^2 value of .0004 means that only .04% of the variance in the FGA was explained by the ABI.

Hypothesis 2 stated that the CST would relate significantly positively with the FGA. Hypothesis 2 was tested using a Spearman's rho correlation due to the non-normal distribution of the CST. The CST was statistically significantly moderately positively correlated, with the FGA, $r = .71$, $p < .001$. Hypothesis 2 was supported. The r^2 value of .46 means that 46% of the variance in the FGA was explained by CST indicating a small to medium effect size (Cohen, 1988).

Procedure and Results for Multiple Regression Test

Procedure for multiple regression. A multiple regression analysis was used to test hypotheses 3 relating to the relationship between the ABI, CST, and FGA. The two predictors (ABI and CST) were regressed to the dependent variable (FGA) in a forced entry regression analysis.

The prediction of the FGA from the ABI and CST. Hypothesis 3 stated that the ABI and the CST would statistically significantly predict the FGA score among participants. In the final model, the CST significantly predicted the overall FGA score and accounted for just over 45% of variance, $F(2,54) = 23.97$, $p < .001$, $R^2 = .47$. Analyses of the coefficients revealed that the ABI was largely unrelated to FGA scores ($\beta = -0.05$, $p = .608$); however, the CST was a significant predictor of the score on the FGA ($\beta = 0.69$, $p < .001$). Overall, Hypothesis 3 was supported. Regression coefficients and standard errors can be found in Table 3.

Binomial Logistic Regression

A binomial logistic regression was performed to ascertain the effects of the CST on the likelihood that participants were at risk for falls, as determined by an FGA score of less than or equal to 22. The model was statistically significant, $X^2(1) = 25.90$, $p < .001$. The model explained 49.6% (Nagelkerke R^2) of the variance in FGA scores and correctly classified 80.7%

of the cases. Sensitivity was 77.3%, specificity was 82.9%, positive predictive value was 73.9%, and negative predictive value was 85.3%. Higher scores on the CST were associated with better scores on the FGA, indicating reduced fall risk.

Discussion

The purpose of this study was to investigate whether the ABI or CST could predict the score on the FGA. As expected, the CST did predict a significant portion of the score on the FGA; however, the ABI was a poor predictor. The results of this study both support and expand previous research.

Consistent with the literature, no correlation was found between the ABI and fall risk as measured by the FGA ($r = .02$, $p = .438$). Moreover, the standardized beta value for the ABI ($\beta = -.05$, $p = -.516$) indicated that the ABI did not significantly contribute to the model and should be removed. In a previous study, Gardner and Montgomery (2001) described that the ABI was not significantly correlated with balance and falls in individuals with intermittent claudication ($p > .05$). In this study, although the ABI was not significantly correlated with scores on the FGA, a definite trend was observed. When examining individual participant scores, as the ratio approached 1.20 or was less than 0.90 the scores on the FGA tended to be lower and most were indicative of fall risk. In a cardiac rehabilitation setting, if a healthcare practitioner performs an ABI and the results are less than 0.90 or approaching 1.20, further testing may be warranted to rule out fall risk in this population.

The CST was found to be significantly and positively correlated with the FGA. More importantly, the CST was found to be a positive predictor of the FGA ($\beta = .69$, $p <.001$, accounting for 45.1% of the variability in the FGA ($R^2 = .47$, $p < .001$), and was a significant contributor to the explanatory power of the model. For every one unit of change in the CST, there was a .68 unit change in the FGA score. Ward et al. (2015) reported a similar finding using the 5-repetition chair stand test (5CST). A time of greater than 16.7 seconds on the 5CST was an independent predictor of injurious falls in the older adult population. Moreover, times of greater than 16.7 seconds on the 5CST were associated with increased fall risk.

A logistic regression was conducted to determine how the study results could be applied clinically. The CST was highly sensitive and specific, indicating that the score from the CST could identify individuals who were at risk for falls 77.3% of the time and identify those individuals who were not at risk for falls 82.9% of the time. Additionally, the CST demonstrated a moderately high positive predictive value, which would allow cardiac rehabilitation clinicians to predict fall risk using the CST with 73.9% accuracy. Reider and Gaul (2015) reported a similar finding using the 5 repetition sit to stand test (5RSTS) in community-dwelling older adults. In this study, the 5RSTS test was an effective screening tool that could identify older adults who were at high risk for falls (Reider & Gaul, 2015).

Study Limitations

Limitations of this study include that participants in this study were a nonrandom sample of convenience from a single outpatient cardiac rehabilitation program. This may limit the ability to generalize findings to other patient populations. Studies have shown that co-morbidities can increase fall risk in the older adult population. A quick screen was conducted to determine if the patient met the inclusion and exclusion criteria for the study (i.e., had chronic medical conditions that may impact test results); however, data on specific co-morbidities were not collected. The outcome assessments used did not have established validity in this patient population. Finally, the mean ABI score was 0.98 (essentially normal) with only 12% having a score of less than 0.90

or greater than 1.20. The lack of ABI scores outside these ranges may have affected the ABI study results.

Conclusion

Results of this study indicate that the ABI was not an effective predictor of fall risk; therefore, the ABI scores can be ignored. The CST predicted a significant portion of the FGA score and may be substituted for the FGA as a fall-risk screening measure in the cardiac rehabilitation population. The CST is a very quick, effective, and affordable option to determine fall risk. By using the CST, once fall risk is determined, cardiac rehabilitation professionals can refer the patient to another healthcare professional, such as a physical therapist, who could perform a more comprehensive balance evaluation and recommend subsequent treatment intervention to reduce fall risk. Future studies should be conducted to determine if established scores on the CST for community dwelling older individuals can predict fall risk in this population.

References

Afilalo, J., Karunananthan, S., Eisenberg, M. J., Alexander, K. P., & Bergman, H. (2009). Role of frailty in patients with cardiovascular disease. *Amercian Journal of Cardiology, 103*(11), 1616-1621. doi:10.1016/j.amjcard.2009.01.375

Aoyama, M., Suzuki, Y., & Kuzuya, M. (2015). Muscle strength of lower extremities related to incident falls in community-dwelling older adults. *Journal of Gerontology & Geriatric Research, 4*(2), 1-5. doi: 10.4172/2167-7182.1000207

Berg, W. P., Alessio, H. M., Mills, E. M., & Tong, C. (1997). Correlates of recurrent falling in independent community-dwelling older adults. *Journal of Motor Behavior, 29*(1), 5-16. doi: 10.1002/clc.4960200914

Berry, S. D., & Miller, R. R. (2008). Falls: Epidemiology, pathophysiology, and relationship to fracture. *Current Osteoporosis Reports, 6*(4), 149-154. doi:10.1007/s11914-008-0026-4

Burns, E. R., Stevens, J. A., & Lee, R. (2016). The direct costs of fatal and non-fatal falls among older adults - United States. *Journal of Safety Research, 58*, 99-103. doi: 10.1016/j.jsr.2016.05.001

Cahalin, L. P., LaPier, T. K., Shaw, D. K. (2011) Sternal precautions: Is it time for change? Precautions versus restrictions - a review of literature and recommendations for revision. *Cardiopulmonary Physical Therapy Journal*, *22*(1) 5-15.

Carroll, N. V., Slattum, P. W., & Cox, F. M. (2005). The cost of falls among the community-dwelling elderly. *Journal of Managed Care & Specialty Pharmacy, 11*(4), 307-316. doi: 10.18553/jmcp.2005.11.4.307

Centers for Disease Control and Prevention. (2016a). *30 second chair stand test.* Retrieved from: http://www.cdc.gov/steadi/pdf/30_second_chair_stand_test-a.pdf

Centers for Disease Control and Prevention. (2016b). *Injury prevention & control: Data & statistics (WISQARS)*. Retrieved from Centers for Disease Control and Prevention: http://www.cdc.gov/injury/wisqars/

Cho, K. H., Bok, S. K., Kim, Y. J., & Hwang, S. L. (2012). Effect of lower limb strength on falls and balance of the elderly. *Annals of Rehabilitation Medicine, 36*(3), 386-393. doi: 10.5535/arm.2012.36.3.386

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Davies, A. J., & Kenny, R. A. (1996). Falls presenting to the accident and emergency department: Types of presentation and risk factor profile. *Age and Ageing*, *25*(5), 362-366. doi: 10.11093/ageing/25.5.362

Daubney, M. E., & Culham, E. G. (1999). Lower-extremity muscle force and balance performance in adults aged 65 years and older. *Physical Therapy, 79*(12), 1177-1185.

Dinenno, F. A., Jones, P. P., Seals, D. R., & Tanaka, H. (1999). Limb blood flow and vascular conductance are reduced with age in healthy humans. *Circulation, 100*(2), 164-170. doi:10.1161/01.CIR.100.2.164

Ding, L., & Yang, F. (2016). Muscle weakness is related to slip-initiated falls among community-dwelling older adults. *Journal of Biomechanics, 49*(2), 238-243. doi:10.1016/j.jbiomech.2015.12.009

Dionyssiotis, Y. (2012). Analyzing the problem of falls among older people. *International Journal of General Medicine, 2012*(5), 805-813. doi:10.2147/IJGM.S32651

Doherty, T. J. (2003). Invited review: Aging and sarcopenia. *Journal of Applied Physiology, 95*(4), 1717-1727. doi:10.1152/japplphysiol.00347.2003

Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*(4), 1149-1160. doi:10.3758/BRM.41.4.1149

Field, A. (2013) *Discovering Statistics Using IBM SPSS Statistics* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Gardner, A., & Montgomery, P. (2001). Impaired balance and higher prevalence of falls in subjects with intermittent claudication. *Journal of Gerontology*, *56A*(7), M454-458.

Goel, K., Shen, J., Wolter, A. D., Beck, K.M., Leth, S. E., Thomas, R. J., . . . Perez-Terzic, C. M. (2010). Prevalence of musculoskeletal and balance disorders in patients enrolled in phase II cardiac rehabilitation. *Journal of Cardiopulmonary Rehabilitation and Prevention, 30*(4), 235-239. doi:10.1097/HCR.0b013e17387

Guralnik, J. M., Ferrucci, L., Simonsick, E. M., Salive, M. E., & Wallace, R. B. (1995). Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *The New England Journal of Medicine, 332*(9), 556-561. doi:10.1056/NEJM199503023320902

Holland-Letz, T., Endres, H. G., Biedermann, S., Mahn, M., Kunert, J., Groh, S., . . . Diehm, C. (2007). Reproducibility and reliability of the ankle-brachial index as assessed by vascular experts, family physicians and nurses. *Vascular Medicine, 12*(2), 105-112. doi: 10.1177/1358863X07077281

Huntleigh Healthcare Ltd. - Diagnostic Products Division. (2016). dopplex ®: The new vascular assessment range. Retrieved from: http://www.huntleigh-diagnostics.com/_assets/img/2017%20PDFs/Vascular%20Range%20Brochure%20772469UK-4.pdf.

Jansen, S., Bhangu, J., de Rooij, S., Daams, J., Kenny, R. A., & van der Velde, N. (2016). The association of cardiovascular disorders and falls: A systematic review. *Journal of the American Medical Directors Association, 17*(3), 193-199. doi:10.1016/j.jamda.2015.08.022

Jones, C. J., Rikli, R. E., & Beam, W. C. (1999). A 30-s Chair-Stand Test as a measure of lower body strength in community-residing older adults. *Research Quarterly for Exercise and Sport, 70*(2), 113-119. doi: 10.1080/02701367.1999.10608028

Kellar, S. P., & Kelvin, E. A. (2013). *Munro's statistical methods for health care research*. (6th Ed.). New York, NY: Wolters Kluwer.

Kreizman, I. J., & Allen, D. A. (2005). Aging with cardiopulmonary disease: The rehab perspective. *Physical Medicine and Rehabilitation Clinics of North America, 16*(1), 251-265. doi:10.1016/j.pmr.2004.08.001

Kuys, S., van der Ham, E., Phty, B., Hwang, R., Adsett, J., Phty, B., & Mandrusiak, A. (2013). Falls and musculoskeletal pain in older adults with chronic heart failure. *Cardiopulmonary Physical Therapy Journal, 24*(4), 12-17.

Lakatta, E. (1993). Cardiovascular regulatory mechanisms in advanced age. *Physiological Reviews, 73*(2), 413-467.

LaPier, T. K. (2014). Functional deficits at the time of hospital discharge in older patients following coronary artery bypass surgery - A pilot study. *Cardiopulmonary Physical Therapy Journal, 25*(4), 98-105.

Lee, A., Lee, K.-W., & Khang, P. (2013). Preventing falls in the geriatric population. *The Permanente Journal, 17*(4), 37-39. doi:10.7812/TPP/12-119

Lee, K., Pressler, S. J., Titler, M. (2015). Falls in patients with heart failure: A systemic review. *Journal of Cardiovascular Nursing*, *31*(6), 555-561.

Lefebvre, K. M., Cody, C., Jayne, E., Mason, J., Monaghan, R., & Palombaro, K. (2013). Facilitators and barriers to implementation of the ankle brachial index in outpatient physical therapy practice: A qualitative study. *Cardiopulmonary Physical Therapy Journal, 24*(1), 7-13.

Lindsay, D., Holdright, D. R., Clarke, D., Anand, I. S., Poole-Wilson, P. A., & Collins, P. (1996). Endothelial control of lower limb blood flow in chronic heart failure. *Heart, 75*(5), 469-476. doi:10.1136/hrt.75.5.469

McDermott, M. M., Fried, L., Simonsick, E., Ling, S., & Guralnik, J. M. (2000). Asymptomatic peripheral arterial disease is independently associated with impaired lower extremity functioning. *Circulation*, *104*(4), 1007-1012.

McDermott, M. M., Greenland, P., Liu, K., Guralnik, J. M., Celic, L., Criqui, M. H., . . . Clark, E. (2002). The ankle brachial index is associated with leg function and physical activity: The walking and leg circulation study. *Annals of Internal Medicine, 136*(12), 873-883. doi:10.7326/0003-4819-136-12-200206180-00008

Moreland, J. D., Richardson, J. A., Goldsmith, C. H., & Clase, C. M. (2004). Muscle weakness and falls in older adults: A systematic review and meta-analysis. *Journal of the American Geriatrics Society, 52*(7), 1121-1129. doi:10.1111/j.1532-5415.2004.52310.x

Mozaffarian, D., Benjamin, E. J., Go A. S., Arnett, D. K., Blaha, M. J., Cushman, M., …Turner, M. B. (2015) Heart disease and stroke statistics - 2015 update: A report from the American Heart Association. *Circulation*, *131*, e29-e322.

National Institute on Aging. (2016). Falls and older adults: Causes and risk factors. *NIHSeniorHealth: Build with You in Mind*. Retrieved from http://nihseniorhealth.gov/falls/causesandriskfactors/01.html

Papa, E. V., Garg, H., & Dibble, L. E. (2015). Acute effects of muscle fatigue on anticipatory and reactive postural control in older individuals: A systematic review of the evidence. *Journal of Geriatric Physical Therapy, 38*(1), 40-48.

doi:10.1519/JPT.0000000000000026

Pijnappels, M., van der Burg, J. C., Reeves, N. D., & van Dieën, J. H. (2008). Identification of elderly fallers by muscle strength measures. *European Journal of Applied Physiology, 102*(5), 585-592. doi:10.1007/s00421-007-0613-6

Price, K. J., Gordon, B. A., Bird, S. R., Benson, A. C. A review of guidelines for cardiac rehabilitation exercise programmes: Is there an international consensus? *European Journal of Preventive Cardiology*, *23*(16) 1715-1773.

Puthoff, M.L., & Saskowski, D. (2013). Reliability and responsiveness of gait speed, five times sit to stand, and hand grip strength for patients in cardiac rehabilitation. *Cardiopulmonary Physical Therapy Journal, 24*(1), 31-37.

Reider, N., & Gaul, C. (2016). Fall risk screening in the elderly: A comparison of the minimal chair height standing ability test and 5-repetition sit-to-stand test. *Archives of Gerontology and Geriatrics*, *65*(2016) 133-139.

Renfro, M., Maring, J., Bainbridge, D., & Blair, M. (2016). Fall risk among older adult high-risk populations: A review of current screening and assessment tools. *Current Geriatric Reports*, *5*(3), 161-171.

Rubenstein, L. (2006). Falls in older people: epidemiology, risk factors and strategies for prevention. *Age & Ageing*, *35*(2)ii37-ii41.

Roubenoff, R., & Hughes, V. A. (2000). Sarcopenia: Current concepts. *Journal of Gerontology: Medical Sciences, 55A*(12), M716-M724. doi:10.1093/gerona/55.12.M716

Saczynski, J.S., Go, A.S., Magid, D.J., Smith, D.H., McManus, D.D., Allen, L., …Gurwitz, J.H. (2013). Patterns of comorbidity in older adults with heart failure: The cardiovascular research network PRESERVE study. *Journal of the American Geriatric Society*, *61*(1), 26-33.

Secher, N. H., & Volianitis, S. (2006). Are the arems and legs in competition for cardiac output? *Medicine & Science in Sports & Exercise, 38*(10), 1797-1803. doi:10.1249/01.mss.0000230343

Seo, Y., Yates, B. C., Norman, J. F., Pozehl, B., & Kupzyk, K. (2014). Comparisons of dyspnea, fatigue, and exercise intolerance between individuals with heart failure with high versus low knee extensor muscle strength. *Cardiopulmonary Physical Therapy Journal, 25*(1), 11-17.

Shiotani, I., Sato, H., Sato, H., Yokoyama, H., Ohnishi, Y., Hishida, E., . . . Hori, M. (2002). Muscle pump-dependent self-perfusion mechanism in legs in normal subjects and patients with heart failure. *Journal of Applied Physiology, 92*(4), 1647-1654. doi:10.1152/japplphysiol.01096.2000

Shubert, T. E., Schrodt, L. A., Mercer, V. S., Busby-Whitehead, J., & Giuliani, C. A. (2006). Are scores on balance screening tests associated with mobility in older adults. *Journal of Geriatric Physical Therapy, 29*(1), 33-39.

Stevens, J. A., Corso, P. S., Finkelstein, E. A., & Miller, T. R. (2006). The costs of fatal and non-fatal falls among older adults. *Injury Prevention*, *12*(5), 290-295. doi: 10.1136/ip.2005.011015

Toebes, M. J., Hoozemans, M. J., Furrer, R., Dekker, J., & van Dieën, J. H. (2015). Associations between measures of gait stability, leg strength and fear of falling. *Gait & Posture, 41*(1), 76-80. doi: 10.1016/j.gaitpost.2014.08.015

Tinetti, M. E., Speechley, M., & Ginter, S. F. (1988). Risk factors for falls among elderly persons living in the community. *New England Journal of Medicine, 319*(26), 1701-1707. doi:10.1056/NEJM198812293192604

van der Velde, N., Stricker, B. H., Roelandt, J. R., Ten Cate, F. J., & van der Cammen, T. J. (2007). Can echocardiographic findings predict falls in older persons. *PLoS One, 2*(7), e654-e661. doi:10.1371/journal.pone.0000654

Verma, S. K., Willetts, J. L., Corns, H. L., Marucci-Wellman, H. R., Lombardi, D. A., & Courtney, T. K. (2016). Falls and fall-related injuries among community-dwelling adults in the United States. *PLoS One*, *11*(3), 1-14. doi:10.1371/journal.pone.0150939

Wada, O., Asanoi, H., Miyagi, K., Ishizaka, S., Kameyama, T., Ishise, H., . . . Iniue, H. (1997). Quantitative evaluation of blood flow distribution to exercising and resting skeletal muscles in patients with cardiac dysfunction using whole-body Thallium-201 scintigraphy. *Clinical Cardiology, 20*(9), 785-790. doi:10.1002/clc.4960200914

Walker, M., Austin, A., Banke, G., Foxx, S., Gaetano, L., Gardner, L., . . . Penn, L. (2007). Reference group data for the functional gait assessment. *Physical Therapy, 87*(11), 1468-1477. doi: 10.2522/ptj.20060344

Wound Ostomy and Continence Nurses Society. (2012). Ankle brachial index. *Journal of Wound, Ostomy and Continence Nursing, 39*(2S), S21-S29. doi: 10.1097/WON.0b013e3182478dde

Ward, R. E., Leveille, S. G., Beauchamp, M. K., Travison, T., Alexander, N., Jette, A. M., & Bean, J. F. (2015). Functional performance as a predictor of injurious falls in older adults. *Journal of the American Geriatrics Society, 63*(2), 315-320. doi: 10.1111/jgs.13203

Weiss, D. J., Casale, G. P., Koutakis, P., Nella, A. A., & Swanson, S. A. (2013). Oxidative damage and myofiber degeneration in the gastrocnemius of patients with peripheral arterial disease. Journal of Translational Medicine, *11*, 1-9.

Wrisley, D., & Kumar, N. (2010). Functional gait assessment: Concurrent, discriminative, and predictive validity in community-dwelling older adults. *Physical Therapy, 90*(5), 761-773. doi: 102522/ptj.20090069

Wrisley, D., Marchetti, G., Kuharsky, D., & Whitney, S. (2004). Reliability, internal consistency, and validity of data obtained with the functional gait assessment. *Physical Therapy, 84*(10), 906-918.

Xu, D., Li, J., Zou, L., Xu, Y., Day, H., Pagoto, S., & Ma, Y. (2010). Sensitivity and specificity of the ankle-brachial index to diagnose peripheral artery disease: A structured review. *Vascular Medicine, 15*(5), 361-369.

Table 1

Descriptive Statistics for Demographic Data (N = 57)

	M	*SD*	Minimum	Maximum
Age (years)	68.58	9.10	51.00	86.00
	N	Percent		
Gender				
Male	40	70.1		
Female	17	29.9		
Race				
White/Caucasian	53	92.9		
Latino/Hispanic	4	7.1		

Table 2

Descriptive Statistics for Study Variables (N = 57)

Variable	*M*	*SD*	ABI	CST
Age (years)	68.58	9.10		
ABI	0.98	0.09		
CST	11.35	4.20	.105	
FGA	20.21	6.18	.021	.68**

Note: ABI = ankle brachial index; CST = chair stand test; FGA = functional gait assessment; **p < .01, two-tailed.

Table 3

M*ultiple Regression Results for ABI, CST, and FGA (N = 57)*

Variable	*B*	*SE*	*t*	*p*	95% CI
Model 1					
ABI	-3.39	6.56	-0.52	.608	[-16.54, 9.76]
CST	1.02	0.15	6.92	< .001	[0.72, 1.31]

Note: ABI = ankle brachial index; CST = chair stand test; FGA = functional gait assessment; CI = confidence interval.

Appendix A

Are you at risk for falls?

We are looking for individuals who are:

1) Cardiac Rehab Phase II Patients
2) 50 years or older

Research Study Purpose:

To determine if leg weakness or reduced blood flow in your legs increases your risk for falls

Research Study Contact Information:

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Appendix B

Can lower extremity strength and lower extremity blood flow predict the score on the Functional Gait Assessment in cardiac rehabilitation phase II patients
Certification of Informed Consent

I hereby agree to participate as a volunteer in a research project to determine if lower extremity strength and lower extremity blood flow can predict the score on the Functional Gait Assessment in cardiac rehabilitation phase II patients. Lower extremity strength will be measured by the 30 Second Chair Stand Test. Lower extremity blood flow will be measured using the ankle brachial index. Functional balance will be measured using the Functional Gait Assessment.

Description of Procedures:

The ankle brachial index will be used to assess blood flow in your legs. The blood pressure in your arm will be compared to the blood pressure in your leg.

You will also complete the Functional Gait Assessment (FGA) and the 30 Second Chair Stand Test (CST). The FGA will test how well you walk while doing different tasks – such as walking while turning your head. The CST will test your leg strength.

Completion of test procedures will take approximately 40 minutes.

I understand that the Institutional Review Board has access to records that identify subjects by name, but other than this, confidentiality will be maintained except as required by law. Records will be kept in a locked filing cabinet housed in the Department of Physical Therapy at Missouri State University.

Benefits of Participation

1) I may gain knowledge of my relative risk for falls and specific risk factors for falls. Knowledge of fall risk may help prevent future falls. Additionally, individuals participating in the project may be referred to a physician or physical therapy if they are at risk of falling.
2) Measuring my risk for falls prior to participation in the cardiac rehabilitation phase II program may help prevent falls that could occur during treatment

Risks for Participation

3) The risks associated with this study are minimal and include the following:
    a) Participants may be at risk for falls during the assessment. In order to minimize that risk, I understand that I will be required to wear a gait belt to facilitate guarding by an investigator.
    b) My scores on the balance and strength assessments may indicate that I am at risk for falls. This may make me less confident in my ability to avoid falls in the future. An investigator will discuss these results with me and advise me of appropriate actions to take in order to minimize their risk for future falls. These actions may include referral to a physician for further examination.
    c) If my scores on the balance assessments indicate that I am not at risk for falls, I may feel more confident in my ability to avoid falls in the future. An investigator will discuss these results with me and advise me of appropriate actions to take in order to minimize

their risk for future falls. Low risk of falling does not guarantee I will not fall in the future.

4) I am free to refuse to participate in this research project or to withdraw my consent and discontinue participation in the project at any time without prejudice to me, or effect on my relationship with this institution.

5) I understand that the procedure will take approximately forty-five minutes to finish.

6) The primary investigators, Marcia K. Himes, DPT and Barbara S. Robinson, DPT, will answer any questions that I have concerning my participation in this research project.

7) Participation in this research project is voluntary, without being coerced or forced, and is without compensation.

8) If I suffer personal injury as a result of participation in this investigation, no compensation is or will be available for payment of my lost wages or other losses. I fully understand that Missouri State University assumes no liability for any damages.

I certify that I have read and understand this document of informed consent and was given the opportunity to have questions answered by the investigators and consent to participate in this research project.

____ ____________________

Subject Name **Date Signed**

____

Signature of Subject

____

Signature of Witness

I have discussed with this subject the procedures involved in this study, as well as the possible benefits and risks involved. I believe he/she understands the contents of this consent form, and is competent to give legally effective and informed consent.

I hereby agree to conduct this investigation in accordance to the procedures set forth in the project description, to uphold the ethical guidelines set forth in the Code of Federal Regulations 45 CFR 46, and to report to the committee any outcomes or reactions to the balance assessment that were not anticipated in the risks description and might influence the committee's decision to sustain approval of the project.

____ ____________________

Signature of Responsible Investigator **Date Signed**

A COPY OF THIS FORM HAS BEEN GIVEN TO ME. ________ (Subject's Initials)