ABSTRACT

Lynn A. Darby, Advisor

The Functional Movement Screen (FMS) has been validated as a form of functional movement assessment in young, active populations, but there is potential for this screen to become an assessment tool for the older adult population. Though there are measures of functional fitness validated for older adults, many of these are quantitative measures that focus on scores and not the underlying factors that affect the scores. The FMS uses a qualitative approach to assess function; this approach could assist in identifying functional decline in aging by examining where the functional problem(s) occur(s) within body movement(s). The purpose of this study was to test the reliability (i.e., test-retest) of the FMS total scores and FMS task scores for adults ≥ 50 years of age. The effects of sex, body mass index (BMI), age, body fat percentage (BF), and perceived physical activity [i.e., Community Healthy Activities Model Program for Seniors (CHAMPS) questionnaire] on the FMS total scores were evaluated for Trial 1 and Trial 2. Fifty adults (n = 12 males, n = 38 females) with a mean age of 58.9 ± 6.8 years participated in two sessions (i.e., Trial 1 and Trial 2) of FMS testing separated by 5-7 days. Reliability of the FMS total score was good to high (ICC = 0.89, p < .00) and reliability for the individual task scores ranged from -0.02 to 0.89 representing poor to almost perfect agreement. There were no significant differences for FMS total scores by Sex, or by BMI Category [i.e., non-obese (< 30.0 kg/m²); obese (≥ 30.0 kg/m²)] (ACSM, 2014). For the Age groups (i.e., 50-57 years; 58-80 years), there were significant differences in FMS total score. Significant negative relationships were present between age and FMS total scores, BMI and FMS total scores, and BF and FMS total scores. There was no relationship between CHAMPS scores and FMS total scores. It was concluded that the FMS is a reliable assessment tool for adults 50 years of age and
older and may be used in conjunction with the quantitative assessments that are currently utilized for assessing functional abilities in older adults. It is possible that the combined assessments could provide older adults with the evaluations and knowledge to remain functionally independent across their lifespans.
This work is dedicated to my late mother, Annette Meyers. Without her strength I would not be where I am today.
I would like to this time to thank all of those who have been a major part of this process. Whether it was edits, advice, meetings, or handling my minor “freak-outs” about the thesis process, she was always supportive and available. I would not be where I am today without her. With that, I would also like to extend a thank you to Matt Laurent, Ph.D. and Amy Morgan, Ph.D. Both of these individuals were available to me when needed and were always willing to extend a helping hand. Each of them challenged me to think critically and expand on my professional and academic opportunities. I cannot thank them enough.

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CHAPTER I: INTRODUCTION

How an individual ages may be affected by many factors such as body mass index (BMI), sex, reduced muscle strength and endurance, balance, gait, and socioeconomic status (Spirduso, Francis, & MacRae, 2005). There are factors, such as age, sex, and some diseases (e.g., rheumatoid arthritis, Parkinson’s disease), that are non-modifiable. Other factors are modifiable, unless chronic disease or illness is present. Though the effects of aging cannot be stopped, these can be enhanced or attenuated based on an individual’s decisions throughout the lifespan. The same concept can be applied to functional ability and performance. All individuals who are aging will not lose functional ability at the same rate and/or time, but different factors that alter the rate of aging such as diet and physical activity/exercise habits, disease, smoking, and accidents such as falls will have effects on functional abilities.

To demonstrate that functional decline happens during the aging process, Dickerson and Fisher (1993) measured both familiar and unfamiliar tasks with younger and older individuals. The individuals that participated in this study were 40 females; 20 between the ages of 57 and 84 years and 20 between 20 and 35 years of age. It was hypothesized that there would be no significant differences in mean motor or process skills with the familiar tasks and that there would be significant differences between the skills in the unfamiliar tasks (Dickerson & Fisher, 1993). The authors found that age-related decline is apparent even with tasks that have been practiced throughout the lifespan and are familiar to the older individual. With functional performance declining as an individual ages, health professionals should not assume that tasks can be performed efficiently just because these are familiar to the patient. Proper observation and assessment of the movement or activity should be made before making assumptions for any individual.
There are reliable and valid measures that can be used to assess the functional performance of older adults. Some of these tests include the Continuous Scale Physical Functional Performance (CS-PFP) Test (Cress et al., 1996), the Physical Performance Test (PPT) (Reuben & Siu, 1990), and the Senior Fitness Test (SFT) (Rikli & Jones, 2001). The CS-PFP consists of five subscales which include upper body strength, upper body flexibility, lower body strength, balance and coordination, and endurance. The tasks are differentiated by difficulty (low, moderate, and high levels) and include tasks such as carrying weighted items (i.e., groceries, stock pot), climbing stairs, picking items off the ground, putting on a jacket, reaching, getting up from the floor, sweeping, and a 6-minute walk. The PPT includes functional tasks such as writing a sentence, simulated eating, lifting a book and placing it on a shelf, putting on and removing a jacket, picking a penny up from the floor, doing a circle turn (360 degrees), walking 50 feet, and stair climbing. The SFT tasks include a chair stand, arm curl, 6-minute walk test/2-minute step test, chair sit-and-reach, back scratch, and the 8-foot up-and-go. These tests (e.g., CS-PFP, SFT, and PPT) are not similar based on the tasks that are used to assess physical function, but they are similar in the manner of evaluation. Each test uses objective, quantifiable measures such as time, distance, and amount of weight to score and assess older individuals. The question that remains is, how can the results from these measurements be applied to specific individuals to change their movement patterns in order to enhance their functional movement and strive to reduce and/or reverse functional decline?

The Functional Movement Screen (FMS) is a portion of the Functional Movement System™ and is an assessment tool that is used to evaluate an individual’s fundamental movement patterns. It is comprised of seven whole-body movement patterns that help a health care professional observe an individual’s weaknesses and/or imbalances (Onate et al., 2012). The
seven tests of movement patterns include deep squat, hurdle step, inline lunge, shoulder mobility, active straight-leg raise, trunk stability pushup, and rotary stability (Cook, Burton, Kiesel, Rose, & Bryant, 2010). The movement patterns of shoulder mobility, trunk stability pushup, and rotary stability also incorporate clearing exams that allow for evaluation of pain in the joints that compensate by giving up stability when neighboring body segments have limited mobility (Cook et al., 2010). Each clearing exam follows one specific movement. The clearing exams also help to detect pain that may not be present during the original testing. Scoring of the FMS is done on a 0-3 scale with a score of 0 representing that the participant feels or expresses pain during the movement being tested, a score of 1 being the inability to complete the movement, or loss of balance, a score of 2 representing movement completion with compensatory strategies, and a score of 3 being full completion of the movement.

When utilizing the FMS, the observations made by the health care professional are subjective and examine the quality of the movement in contrast to the quantitative measures that are part of the CS-PFP and SFT for physical function. After weaknesses and imbalances are distinguished, individualized corrective strategies can be prescribed and implemented to compartmentalize the specific movement and help change an individual’s movement pattern. The change in movement pattern could help to prevent and/or improve functional decline. The FMS screening is not difficult to administer once an individual is certified since there is no need for a specific testing laboratory, it is time and cost effective, and is not specific to a particular population or age group. Though the FMS has been predominantly used in young, active populations and athletes, it is possible that the FMS could also be beneficial when used with the general population (Burton, 2011). The whole-body patterns that are tested are commonly used
in everyday life and have been used to predict future injury and identify compensatory strategies and imbalances in young, active individuals.

A unique aspect of the FMS is that it incorporates whole-body movements and follows a kinetic link model to analyze the movement being performed. The inclusion of the kinetic link model relies on the body’s proprioceptive ability within each body segment in order for a movement within this screen to be done properly, without compensatory strategies or musculoskeletal pain (Voight & Hoogenboom, 2007). Observing each body segment separately and assessing where the compensation or pain is produced could help prevent future injuries by relating the movement patterns to the source of the imbalance. A plan could then be designed to help improve the movement and ultimately change the functional pattern to a more efficient movement. Though the FMS has been predominately used to test young, active populations, it has been suggested that the screen could be used within the geriatric, recreational, and workplace populations (Perry & Kohle, 2013).

Perry and Kohle (2013) utilized the FMS to provide normative reference values for healthy, adults (20-65+ years). Another purpose of Perry and Koehle (2013) was to evaluate the impact that certain variables have on FMS scores, which included age, body mass index (BMI), exercise participation, and balance scores. It was determined that the FMS had a negative relationship with BMI and age, showing that higher BMI values and age would negatively affect the FMS composite score. Reliability of the FMS as an assessment of functional ability for the population being tested was not established within this study and thus, it is prudent to evaluate the reliability of this test in an older adult population.

The FMS has been validated as a form of functional movement assessment in healthy populations, but due to its current uses in the field, there is potential for this screen to become an
assessment tool for an older adult population. With the quantitative tests that are frequently used for functional assessment in the older population, the health care professional can measure aerobic capacity, muscle strength and endurance, and flexibility and provide exercise prescriptions to improve these measures over time. However, what if an individual has a lower score that was due to an imbalance, or compensatory strategies were used to improve his/her score? To our knowledge there is no reliable test for older adults examining functional movement in this way.

**Significance**

There is limited research on the use of the Functional Movement Screen (FMS) within the middle-age and older adult populations. The FMS has been validated as a form of functional movement assessment in young, active populations, but due to its current uses in the field, there is potential for this screen to become an assessment tool for an older population. Though there are measures of functional fitness validated for older adults, many of these are quantitative measures that focus on the scores *per se* and not the possible underlying factors that affect the scores. The FMS uses a qualitative approach to assess function, which could assist in identifying functional decline in aging by closely examining where the functional problem(s) occur(s) within a body segment(s). It remains a possibility that evaluating and implementing a change in an older person’s movement pattern can help to attenuate, and/or prevent further functional decline.

**Purpose of the Study**

The purpose of this study was to test the reliability of the Functional Movement Screen (FMS) in adults 50 years of age and older. The effects of age, body mass index (BMI), and sex on FMS total score were evaluated. In addition, the relationships of age, BMI, body fat percentage, and perceived activity level to FMS performance were determined.
Null Hypotheses

(1) It was hypothesized that the Functional Movement Screen (FMS) would not be a reliable assessment of function in men and women 50 years of age and older based on FMS total score from Trial 1 to Trial 2.

(2) It was hypothesized that the individual FMS task scores would not be reliable from Trial 1 to Trial 2.

(3) There would not be significant differences in FMS total scores due to Sex or BMI Category between Trial 1 and Trial 2.

(4) There would not be significant differences between FMS total scores due to Age between Trial 1 and Trial 2.

(5) There would not be negative relationships between FMS total scores and the variables of age, BMI, body fat percentage, and CHAMPS scores for Trial 1 or Trial 2, separately.
CHAPTER II: REVIEW OF THE LITERATURE

The purpose of this study was to test the reliability of the Functional Movement Screen (FMS) total scores and individual task scores for adults 50 years of age and older. Differences between FMS total scores (Trial 1, Trial 2) were also evaluated between groups (Age, Sex, BMI Category). Relationships between FMS total score and age, BMI, body fat percentage, and self-reported physical activity participation using the CHAMPS questionnaire were also assessed.

This chapter provides a summary of the literature for this topic, including content describing the FMS, aging and function, valid and reliable functional tests for older adults, and how the FMS could be used for future research in older individuals.

The Functional Movement System™

What is the Functional Movement Screen (FMS)? The Functional Movement System™ includes two assessments: the Functional Movement Screen (FMS) and the Selective Functional Movement Assessment (SFMA). Each of these assessments was constructed to focus on preventing muscle problems and injuries, rather than acting when these problems or injuries occur. Another goal was to have these assessments used to decrease the risk of injury in those participating in rehabilitation, athletics, fitness, wellness, and performance enhancement. The FMS, developed by Cook and Burton (2007), consists of seven whole-body movement patterns and three clearing exams that can be used by a health care professional to observe an individual’s muscle weaknesses, imbalances, and movement asymmetries (Duncan & Stanley, 2012; O’Connor, Deuster, Davis, Pappas, and Knapik, 2011; Onate et al., 2011). This screen is an observational, qualitative assessment that is used to evaluate an individual’s fundamental movement patterns and analyze the movements being performed. The seven tests, administered in order, are deep squat, hurdle step, inline lunge, shoulder mobility, active straight-leg raise,
trunk stability pushup, and rotary stability (Cook, Burton, Kiesel, Rose, & Bryant, 2010). The clearing exams allow for evaluation of pain in the joints that compensate by giving up stability when neighboring body segments have limited mobility (Cook et al., 2010) and include impingement, prone press-up, and posterior rocking. After weaknesses and imbalances are distinguished, individualized corrective strategies can be prescribed and implemented. Corrective strategies are exercises assigned to individuals with the goal of resolving, or reducing the pain, dysfunction, and difficulty that an individual is having with functional movement patterns (Cook et al., 2010). Though these corrective exercises are individualized, Cook and colleagues (2010) have a systematic approach to designing/assigning these exercises; the first step is screening and assessing the movements. The second is to understand where the dysfunction is originating from and apply one or two corrective exercises. After an initial session using the corrective exercise, the original movement pattern needs to be rechecked and if there is a change in the movement pattern (i.e., dysfunction is corrected), then the individual needs to be rescreened to check for other problem areas, or changes in other movement patterns, due to this correction. The process of screening, assessing, and applying corrections to an individual can be practical in terms of injury prediction/prevention, which is one of the major uses of the FMS.

**Injury Prevention/Prediction.** Injury prevention is one of the major aspects of the FMS that has been explored in previous research, especially in sport and military training (Lisman, O’Connor, Deuster, & Knapik, 2013; Kiesel, Plisky, & Voight, 2007; O’Connor et al., 2011). Kiesel et al. (2007), for example, used the FMS as a tool for pre-screening professional football players to predict injury. Players who attended the training camp were pretested using the FMS prior to the 2005 football season. Common demographic data was not included in the data analysis in order to protect the identity of the players. At the start of the season, 46 players were
included on the active roster and injury was defined as being a member of the injured reserve and having a time loss of 3 weeks, representing a serious injury. The mean FMS score was 16.9 out of a possible 21 ($SD = 3.0$). For those who suffered an injury during the 2005 season, the mean FMS score was 14.3 ($SD = 2.3$), and those who did not suffer injury had a mean score of 17.4 ($SD = 3.1$). A $t$-test revealed a significant difference between the mean scores of those injured and those who were not injured ($df = 44; t = 5.62; p < .05$). A receiver-operator characteristic curve was also created to determine a cut-off value for the FMS, and it was determined that those scoring a 14 or less on the FMS™ increased their chance of injury from 15% to 51% (Kiesel et al., 2007).

O’Connor et al. (2011) compared FMS scores with injury occurrence in Marine Corps Officer candidates during Officer Candidate School (OCS). The primary focus of the study was injury prediction and it was hypothesized that FMS scores would better predict injury over the physical fitness test (PFT) published by the Marine Corps. Eight hundred-seventy four male candidates between 18 and 30 years of age were enrolled in either a six-week short-cycle (SC), or a 10-week long cycle (LC) officer candidate training. Prior to training, the subjects completed a medical screening, and a questionnaire that included information about age, tobacco use, exercise history, and prior injury. The FMS and a PFT regimen consisting of pull-ups, abdominal crunches, and a 3-mile run were then completed by the officer candidates. Injury data was collected throughout the two training camps and were placed in one of four categories: 1) overuse injury, 2) traumatic injury, 3) any injury, and 4) serious injury (O’Connor et al., 2011). It was found that the SC candidates with a FMS score of less than 14 had a 1.19 times higher injury occurrence than personnel with scores above 14. Results were similar with the LC group with candidates obtaining FMS scores of less than 14 having higher rates of injury sustention as
compared to those with higher FMS scores. There were similar findings when comparing PFT scores. Those with PFT scores below 280 were 2.2 times more likely to have an FMS score of less than 14, putting them at a higher risk of injury sustention.

Lisman et al. (2013) also studied injury prediction with Marine Corps personnel with methods similar to O’Connor et al. (2011). Participants ($M = 22.4$ years, $SD = 2.7$) were enrolled in either a six-week short cycle (SC), or 10-week long cycle (LC) training and all participants completed Marine Corps physical fitness test (PFT), the FMS, and questionnaires regarding previous injuries and exercise habits. Injury during the Officer Candidate School (OCS) training was classified into three categories: 1) overuse injury (long-term repetitive injury), 2) traumatic injury (acute, or sudden), and 3) any injury (all injury cases and defined as a combination of overuse and traumatic injuries) (Lisman et al., 2013). Lisman et al. (2013) reported that slower 3-mile run time (RT) ($\geq 20.5$ min) and lower FMS scores ($\geq 14$) put candidates at higher risk for any injury, or traumatic injury. Slower RT time alone put candidates at higher risk for overuse injury and the general sport and exercise (GES) participation question (i.e., “Over the last two months, what was the average number of times per week you exercised or played sports for at least 30 min at a time?”) was an independent predictor of overuse injury. Pull-ups and abdominal crunches were not significantly associated with injury risk. These findings were similar to those of O’Connor et al. (2011), but did expand on the findings of combining the PFT results and FMS scores, showing that once the PFT and FMS test scores were combined the risk for injury was four times higher than just analyzing the individual test scores. Each of these injury prediction/prevention studies concluded that the cut-off for injury was a score $\leq 14$ out of 21 possible points for the FMS, which indicates that the FMS could be used to predict injury risk.
Validity and Reliability of the FMS in Young, Athletic Populations. Although the FMS has been reported to be valid in the young, active populations (athletes and military personnel), reliability must also be established for these populations. Schneiders, Davidsson, Horman, and Sullivan (2011) studied interrater reliability and established normative values using a cross-sectional study design. Two-hundred and nine subjects, including 101 men and 108 women, between the ages of 18-40 years ($M = 21.9$, $SD = 3.7$) were recruited for testing the FMS. In order to be included, participants had to be currently taking part in regular physical activity at either a competitive or recreational level. Each rater had the same amount of clinical experience and the participants were scored at the same time by each rater. The scoring was done independently and without consultation between the raters. The same rater gave directions for each participant. Means, standard deviations, confidence intervals, and frequencies were computed for males and females both separately and combined. The average total score for males and females combined on the FMS was 15.7 ($SD = 1.9$) with females averaging 15.6 and males averaging 15.8. These values were not significantly different ($p > .05$). The interrater reliability for both testers was $r = .971$, signifying excellent reliability, with six of the seven individual task scores demonstrating excellent agreement ($\kappa = 0.86 – 1.00$) between the raters. The seventh task (hurdle step) demonstrated substantial agreement ($\kappa = 0.80$).

Teyhen et al. (2012) designed a study to determine the intrarater and interrater reliability of the FMS component and composite scores of young, healthy military members. Sixty-four individuals, including 53 males and 11 females, participated. The mean age of the participants was 25.2 years ($SD = 3.8$). The raters were described as novice and were physical therapy students who participated in a 20 hours of FMS training. Four of the students were randomly assigned to assess day 1 and day 2 FMS administration (separated by 48-72 hours) for intrarater
reliability and another four students were asked to view participants simultaneously with another
rater in order to establish interrater reliability. Agreement between the individual tasks scores
(i.e., component tests) were analyzed using a weighted kappa statistic, with reliability of the
FMS total score being analyzed using intraclass correlation coefficients (ICCs). The percent
agreement was rated as follows: 80% and above, excellent agreement; 60-79.9%, substantial
agreement; 40-59.9%, moderate agreement; less than 40%, poor to fair agreement (Portney &
Watkins, 2000). Interrater agreement was labeled as substantial to excellent, with five tasks
having excellent agreement (rotary stability = 92% [κ = 0.77], shoulder mobility = 86% [κ =
0.73], active straight leg raise = 84% [κ = 0.69], deep squat = 83% [κ = 0.68], hurdle step = 88%
[κ = 0.67]), and two having substantial agreement (trunk stability push-up = 78% [κ = 0.82], in-
line lunge = 68% [κ = 0.45]). Intrarater agreement demonstrated excellent agreement for five
tasks (rotary stability = 83% [κ = 0.29], shoulder mobility = 81% [κ = 0.68], active straight leg
raise = 80% [κ = 0.60], deep squat = 88% [κ = 0.76], hurdle step = 86% [κ = 0.59], in-line lunge
= 83% [κ = 0.69]) and one demonstrating substantial agreement (rotary stability = 68%). When
analyzing the total FMS score (i.e., composite score), the ICC for interrater reliability was $R =
0.76$ (good reliability) and the ICC for intrarater reliability was $R = 0.74$ (moderate reliability)
(Portney & Watkins, 2000).

Previous studies have demonstrated that the FMS is a reliable measure for young, active
populations when both interrater and intrarater reliability were assessed. There have been other
studies showing similar results in similar populations (i.e., young, active, athletic) (Gribble,
Brigle, Pietrosimone, Pfile, & Webster, 2013; Minick et al., 2010; Shultz, Anderson, Matheson,
Marcello, & Besier, 2013; Onate et al., 2012). Minick et al. (2010) studied the reliability of the
FMS between four raters (i.e., two novices and two experts) The novice raters were classified as
having less than one year of experience using the FMS and the expert raters were classified as having at least 10 years of experience with the FMS. Scores between the two novice raters and the two expert raters were evaluated, along with the pairing the one novice and one expert. The individuals who performed the FMS test were 40 healthy college athletes (23 women, 17 mean, mean age = 20.8 years) When comparing the novice raters (completed introductory FMS training course and had used FMS less than a year), excellent agreement ($\kappa = 0.80 – 1.00$) was demonstrated for six of the 17 tasks. Substantial agreement ($\kappa = 0.65 – 0.77$) was demonstrated on eight tasks, and moderate agreement ($\kappa = 0.53 – 0.54$) was demonstrated on three of the tasks. The expert raters demonstrated excellent agreement ($\kappa = 0.84 – 0.95$) for four of the 17 tasks, substantial agreement ($\kappa = 0.60 – 0.78$) was demonstrated for nine tasks, and moderate agreement ($\kappa = 0.40 – 0.59$). When the novice and expert rater scores were combined, excellent agreement ($\kappa = 0.83 – 1.00$) was demonstrated for 14 of the 17 tasks, with the remaining three tasks demonstrating substantial agreement ($\kappa = 0.74 – 0.79$).

Similar to Minick et al. (2010), Onate et al. (2012) also analyzed reliability of the FMS using an expert and novice rater along with the test-retest using the expert rater. The expert rater was classified as an athletic trainer, was a Certified Strength and Conditioning Specialist (CSCS), and an FMS Certified Specialist. The novice rater was a CSCS, but had no certification for the FMS. Nineteen subjects who were physically active participated as the FMS models (12 men, mean age = 25.08 ± 3.12 years; seven women, mean age = 25.29 ± 2.81 years). Test-retest reliability of the FMS total score was reported as high ($ICC = 0.92$), with the individual task score agreement ranging from 0.16 – 0.84 (i.e., poor – high) when kappa values were used for analysis of the individual components. When comparing the scores of the expert rater to the
scores of the novice rater, the agreement ranged from 0.33 – 1.00 (i.e., fair – high). The interrater reliability results reported by Onate et al. (2012) were similar to those of Minick et al. (2010).

Gribble et al. (2013) studied the reliability of the FMS between groups with different experience utilizing the FMS. The three participants (i.e., two men, one woman) who completed the FMS for analysis were recruited from the university and had a mean age of 20.33 years ($SD = 1.15$ years). Thirty-eight participants were recruited from the university’s athletic training program to assess and score the FMS. The participants consisted of students and faculty in order to include individuals with varying levels of experience with the FMS and were split into three groups based on their experience (i.e., athletic training students [ATS], athletic trainers [AT], and athletic trainers with at least six months experience with the FMS [ATExp]). Gribble and colleagues (2013) found that the ATS demonstrated poor reliability ($ICC = 0.372$), the ATs demonstrated moderate reliability ($ICC = 0.758$) and the ATExp group demonstrated strong reliability ($ICC = 0.946$). When all of the participants were analyzed together, moderate reliability was demonstrated ($ICC = 0.754$).

Shultz et al. (2013) also sought to investigate the test-retest reliability of the FMS total score, along with the interrater reliability between six raters. One of the raters was an undergraduate student who was self-taught and became a FMS certified instructor prior to data collection, and the remaining raters (i.e., one physical therapist, two athletic trainers, and two strength and conditioning coaches) were trained by a certified FMS specialist. The individual who volunteered to take part in the FMS assessment were 39 varsity athletes from a single university (21 women, 18 men). The mean age of the women was $19.6 \pm 1.5$ years and the mean age of the men was $19.7 \pm 1.0$ years. It was reported by Shultz and colleagues (2013) that the test-retest reliability was considered good ($ICC = 0.60$). The interrater reliability of the FMS total
score across all the raters was a kappa value of 0.38 and was classified as poor. The interrater reliability of the individual task scores ranged from poor to high agreement (0.10 – 0.95). The previous studies described have reported and have shown through research that the FMS is a reliable assessment tool for young, active individuals. Though the FMS has been predominantly used in young, active populations and athletes, it is possible that the FMS could also be beneficial for other populations.

**Functional Fitness and the FMS in Older Adults.** The FMS has been primarily used for testing young, active populations and athletes, but it is possible that the FMS could also be beneficial to the general population (Burton, 2011) since it is not specific to a particular population or age group (Perry & Koehle, 2013). The whole-body patterns that are tested are commonly used in everyday life, and have been used to predict future injury and find compensatory strategies and imbalances in young individuals. However, the FMS assessment and process of observing imbalances and competencies may be valuable to older individuals because of the effects of aging on functional performance.

All individuals age, chronologically and biologically, and with this comes the effects of aging. Some of the physical effects of aging include sarcopenia (i.e., decline in muscle mass), increase in fat mass (Davison, Ford, Cogswell, & Dietz, 2002), reduced bone density, decreased maximal oxygen consumption, decreased flexibility, loss of balance, and overall functional decline (Daley & Spinks, 2000). Each of these aging effects could be influenced by factors such as the sex of the older adult (i.e., male or female), physical activity/exercise habits, eating habits, illnesses, tobacco and alcohol use, and accidents such as falls. These factors, except for sex, age, and some illnesses are behavior dependent and can enhance or inhibit the aging process based on decisions made by an individual. The concept of aging being enhanced or inhibited can also be
applied to functional ability and performance, specifically. If an individual chooses to consume an unhealthy diet, not exercise, smoke and drink, etc. then he/she is more likely to negatively impact the process of aging while also hindering his/her functional performance. With a loss in functional ability an individual may not be able to live independently, increasing his/her risk of disability and dependence.

Konopack and colleagues (2008) sought to identify underlying factors, such as sex, age, and self-efficacy (i.e., the belief in one’s self capability to successfully execute specific behaviors), that may affect common measures of functional fitness in older adults. One hundred and ninety individuals ($M = 69.4$ years, range = 58-84 years), who were primarily female ($n = 125$) were asked to complete questionnaires assessing demographics (i.e., age, sex, race, education, annual income, and marital status) and self-efficacy. Five items from the Senior Fitness Test (SFT) (Rikli & Jones, 2001) were tested. These SFT tests were eight-foot up-and-go, the chair stand test, arm curl test, chair sit-and-reach, and the back scratch. Aerobic capacity was assessed using an individualized maximal graded exercise protocol. Participants walked at a minimum of 3 mph on a 0% grade, with the grade increasing 2-3% every 2 minutes until exhaustion (Konopack et al, 2008). The test was terminated at the participant’s discretion. All five SFT tasks were correlated with sex, age, and self-efficacy, and Konopack et al. (2008) grouped the tasks into two factors termed “flexibility” and “physical power”. “Flexibility” included the chair sit-and-reach and the back scratch, and “physical power” included the chair stand, arm curl eight-foot up-and-go, and the $VO_{2max}$. The participant’s sex was the only significant predictor variable for “flexibility”, with women being more flexible than men ($p < .001$). In terms of “physical power”, the predictor variables represented a poor fit for the data, but post hoc measures determined that the correlations of the arm curl and chair stand, alone, would
improve the fit of the model. It was also determined that those who were male, younger, and who had higher self-efficacy had greater physical power. For both “flexibility” and “physical power” the addition of income, educational level, and health status did not change the fit of the model. Since the addition of income, educational level, and health status did not change the model, these were controlled for in the final model with the determinants of functional fitness being age, sex, and exercise self-efficacy. It was stated that future studies should also focus on additional factors that could influence functional fitness and ability in the aging population. These factors may include genetic factors, body composition, and physical activity behaviors/perceived physical activity.

Dickerson and Fisher (1993) conducted a study in which younger and older participants performed unfamiliar and familiar tasks, hypothesizing that there would be no significant differences in Assessment of Motor Process Skills (AMPS) scores with the familiar tasks, but that scores would be significantly different between the younger and older individuals for the unfamiliar skills. The AMPS measures the ability of participants to perform instrumental activities of daily living (IADLs), which are complex tasks that allow an individual to function independently. Money management, shopping, and managing medications are a few examples of IADLs. Forty, healthy, white women (20 participants between 57 and 84 years of age and 20 participants between 20 and 35 years of age) were recruited for the study. Educational level between the two age groups was not significantly different. Participants were filmed within their home performing two familiar tasks and one unfamiliar task. Dickerson and Fisher (1993) found that younger participants did have higher AMPS scores than the older participants under all conditions. Older individuals, even with familiar tasks, had age-related declines. These
researchers did not take into account any body composition measures or other physical measurements representative of aging, such as muscle mass, sarcopenia, balance capabilities, etc.

Obesity has been associated with functional limitations (Jain, Al-Adawi, Dorvlo, & Burke, 2008) and is more prevalent in the older population. In the elderly population a higher BMI has been identified as a strong predictor of functional decline and disability (Apovian, Frey, Rogers, McDermott, & Jensen, 1996; Davison et al. 2002; Zoico et al., 2003). Davison et al. (2002) investigated the association between various body composition measures and functional limitations in men and women ages 70 years and older. The relationship of sarcopenia and sarcopenic obesity (i.e. high body fat and low muscle mass) to functional limitations were also analyzed. Participants, consisted of 1,591 females ($M = 77.3$ years, $SD = 2.2$) and 1,391 males ($M = 76.3$ years, $SD = 1.7$), and were utilized from the National Health and Nutrition Examination Survey (NHANES III) that was conducted from 1988-1994. Interviews concerning functional limitations were conducted within the home of the participant and then, the participant was invited to have anthropometric data measured. Participants had their body fat percentage, muscle mass, sarcopenic obesity, and body mass index (BMI) evaluated. The researchers found that the men and women that expressed having functional limitations were significantly older than those who did not report functional limitations. BMI categories of underweight, overweight, and obese were also associated with functional limitations for women, and those women within the highest group for body fat percentage were twice as likely to report functional limitations. There was no relationship between their amount of muscle mass and report of limitations, and the level of sarcopenic obesity and limitations. Davison et al. (2002) also found that higher body mass index (BMI) values correlated with functional limitations for men. Men within the higher fat mass category were 1.5 times more likely to have functional limitations, with sarcopenic
obesity having no relationship to functional limitations. The non-significant association between sarcopenic obesity and functional limitation was similar to the findings in women, suggesting that sarcopenic obesity does not play a role in functional limitation. In conclusion, there was no evidence of a relationship between sarcopenic obesity and functional limitations, but it was suggested that future studies should reassess the sarcopenia using longitudinal data.

The results of Davison et al. (2002) were similar to those of Apovian et al. (2002) in terms of BMI measures and function. In order to evaluate physical function across BMI categories, Apovian and colleagues (2002) studied a modified version of the Physical Performance Test (PPT) in combination with some of the tasks from the Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT) to evaluate physical function across BMI categories. The Physical Performance Test (PPT) assesses multiple domains of physical function using objective, quantifiable measures that replicate activities of daily living (ADLs). The tasks taken from the FICSIT trials were the accelerated chair stand, hand-grip dynamometry for the dominant and non-dominant hand, two static balance tests, and four one-legged stance tests. Eighty-eight females (M = ~70 years) with BMI values > 22 kg/m² participated in the study. Participants were separated in BMI categories (22 to < 27 kg/m²; 27 to < 30 kg/m²; ≥ 30 kg/m²) and took part in the modified PPT and FICSIT trials. There was no significant difference in age between the BMI groups, but there were associations between BMI and functional performance, concluding that higher BMI may impede functional performance (Apovian et al., 2002). For example, while controlling for age, upper-body function and lower-body function were related to BMI, with these upper and lower body tasks being more difficult in the older, obese women. The upper-body functions included putting on and removing a jacket, picking up a penny, writing a sentence, and simulated eating. The lower-body functions included a one-legged
stance with eyes open and with eyes closed, static balance where one foot was totally in front of the other, and stair climbing. There was no evidence for links between BMI and strength, or standing coordination, but by focusing on the upper and lower body functions in future studies/interventions, there may be a possibility that programs/interventions can be designed to help improve independent living of older, obese women.

Because the FMS has been reported to be a reliable assessment for older individuals, it would be beneficial to distinguish which correlates of aging had effects on the composite score. This would further demonstrate and help determine if the test was a good measure of function in older individuals and if natural, functional decline, due to aging, could be slowed and/or reversed. Expanding on the research from the young, active population, Perry and Koehle (2013) collected normative data for the FMS on middle-aged adults. Age, BMI, the Healthy Physical Activity Participation Questionnaire (HPAPQ) and Balance Error Scoring System, or BESS (measurement of static balance) were examined to identity factors that could influence FMS score. There were 622 participants from various athletic backgrounds who were tested by a level 1 FMS certified exercise physiologists. Testing of the FMS was conducted throughout the year at different times of day. Prior to the FMS assessment the participants were tested for static balance using the BESS and physical activity intensity and frequency using the HPAPQ. The age range of the participants was from 20-65+ years with the mean age calculated as 50.9 years ($SD = 10.8$). Regression analyses were performed to determine which variables would affect FMS score. Researchers found that age ($t(622) = -4.37, p < .001$) and BMI ($t(622) = -4.37, p < .001$) were negatively associated with FMS, and the HPAPQ score ($t(622) = 4.69, p < .001$) was positively associated with FMS scores. Each of these variables (i.e. age, BMI, HPAPQ) had significant predictive value. The BESS had no significant relationship with the FMS. ANOVAs
revealed significant differences between FMS scores in high (≥ 30 kg/m²) and low (< 30 kg/m²) BMI values ($F_{[621]} = 33.98, p < .0001$). Participants with a higher BMI achieved lower FMS scores ($M = 12.45, SD = 2.91$) than those with lower BMI values ($M = 14.39, SD = 2.76$). Perry and Koehle (2013) also gave examples of populations and situations where the FMS could be utilized aside from athletic and military injury prediction or prevention. These populations or situations include recreational athlete injuries, workplace related injuries, and the geriatric population to assess functional mobility.

As detailed earlier, the FMS is a reliable test for populations that are young, active, and/or athletic. Reliability has been established with both interrater and intrarater reliability in these populations, but this is not the case for older individuals. Validity has also been established within the younger population in the case of injury prediction/prevention. Similar reliability, validity of the FMS for older individuals has not been established. However, there are other tests available that allow us to assess functional performance that are both reliable and valid for the older population.

**Valid and Reliable Functional Tests for Older Adults**

*Continuous Scale Physical Functional Performance (CS-PFP) Test.* The Continuous Scale Physical Functional Performance Test (CS-PFP) is a measure of functional performance for older adults, or those with chronic disease or acute injury (http://www.coe.uga.edu/cs-pfp/index.html; Cress, Petrella, Moore, & Schenkman, 2005). When the CS-PFP was first validated, Cress et al. (1996) stated “This new measure called ‘continuous scaled physical functional performance’ (CS-PFP), utilizes a continuous scale to quantify physical functional performance of the whole body as well as across physical domains”. This test uses different continuous scales such as time, weight, and distance in order to avoid any ceiling or floor effects.
(Cress et al., 1996) and the total score ranges from 0-100. Since participants can choose their weights for certain tasks and can take as much time as needed while performing these tasks, it is denoted as a continuous scale test. The performance that are used replicate functional tasks of daily life and are grouped into upper body strength, upper body flexibility, lower body strength, balance and coordination, and endurance. An overall rating of perceived exertion (RPE) for the entire test is also measured at the conclusion using the Borg Scale (Borg, 1998). The scores for each test are quantified by weight, time, and/or distance. Limitations with using the CS-PFP are that a specialized lab must be used in order to conduct testing and, dependent on the population being tested, the length of time that it takes to test each individual can be approximately 60 minutes (http://www.coe.uga.edu/cs-pfp/index.html).

In a validation study of the CS-PFP (Cress et al., 1996), 148 participants from three different living-status categories (community dwellers, independent living within a long-term care facility, and dependent living within a long-term care facility) were tested for maximal oxygen consumption using direct measurement during a ramp testing protocol on a cycle ergometer, strength, range of motion, gait, balance, reaction time, self-perceived function, and functional performance. It was hypothesized that those who are living independently within the community would have higher physical performance than individuals living in long-term care facilities. Self-perceived function was determined through self-defined health status using the Sickness Impact Profile (SIP), self-perceived function using Health Survey (SF36) and Instrumental Activities of Daily Living (IDAL). Construct validity, which is defined as a test measuring what it is intended to measure, was determined by calculating analysis of variances (ANOVAs) to determine mean differences between the groups in terms of physical performance, physical functional performance, physical functional domains, and psychosocial factors. There
were significant differences in individual task scores and total CS-PFP scores between the three groups. Community dwellers scored higher than both long-term care facility groups, with the independent group scoring higher than the dependent group within a long-term care facility. Lower RPE scores were recorded with the community dwellers verses the long-term care facility groups. There were no significant differences between the groups in terms of the IADL scale. In conclusion the scores from the CS-PFP were significantly correlated with the physical performance measures that it represents.

**Physical Performance Test (PPT).** As previously stated, the Physical Performance Test (PPT) assesses multiple domains of physical function using objective, quantifiable measures. This test also replicates activities of daily living (ADLs) (Apovian et al., 2002; Reuben & Siu, 1990) and also measures the capabilities necessary for other instrumental activities of daily living (IADLs) that are more difficult to measure (Reuben & Siu, 1990). The dimensions of function that this test was designed to measure are upper body strength and dexterity, mobility, coordination, and endurance. Scoring the PPT involves timed measurements, giving a single, easy to calculate score that can be interpreted by an individual with limited training. Reuben and Siu (1990) reported the validation of the PPT when quantifying performance capability in the elderly population. A total of 183 individuals participated in the study and had a mean age of 73 years (range = 46-94 years). Participants were given a questionnaire for demographic information, functional status, and recreational activities along with the Mini-Mental State Examination. The PPT was then administered. In order to assess validity, both construct and concurrent, the PPT (nine-item and seven item scales) were compared to the self-reported measures of physical function. The PPT was correlated with Katz Activities of Daily Living ($r = .65$ and $r = .50$), the hierarchical scale of instrumental and basic activities of daily living ($r = .69$
and $r = .56$), a modified four-item Rosow-Breslau scale ($r = .80$ and $r = .69$), and Tinetti gait score ($r = .78$ and $r = .69$). There were moderate positive correlations when PPT was compared to mental health ($r = .24$ and $r = .32$), perceived health status ($r = .32$ and $r = .27$), and mental status ($r = .47$ and $r = .40$) with weak, negative correlations when compared to age ($r = -.24$ and $r = -.18$). It was determined that the PPT is reliable and demonstrates concurrent and construct validity when compared to other functional status measures. When this study was conducted, it was stated that more research would need to be conducted, however, the PPT provides a simple and reliable objective measure of physical function for older adults (Reuben & Siu, 1990).

Apovian et al. (2002) tested a modification of the PPT combined with tests used from previous clinical trials to evaluate physical function in elderly women with different body mass index (BMI) values. Modifications were made to the PPT because in a preliminary study, Apovian, Frey, Rogers, McDermott, and Jensen (1996) found that body fat and PPT score were significantly associated, however, analysis of individual tasks did not clearly identify which tasks contributed the most to the association. This finding suggests that combinations of tasks, rather than single tasks alone, may better describe obesity-related declines in performance. Apovian et al. (2002) tested 90 women over the age of 65 years with BMI measures greater than 22 kg/m². Eight out of the original nine PPT tasks were combined with 10 tests from the past clinical trials for this study. The eight PPT tasks included writing a sentence, simulating eating, lifting a book, putting on and removing a jacket, picking up a penny from the floor, performing a full circle turn, walking 50 feet, and climbing one flight of stairs. Relationships between BMI and functional performance were found, suggesting that those with greater BMI values were less functional than those with lower BMI values. It was also found that when controlling for age, BMI explained modest variation in lower-body function ($5\%; p = 0.032$) and upper-body
function (13.7%; $p < 0.001$). BMI did not explain any variation in standing coordination or strength. Apovian et al. (2002) suggested that interventions that focus on the upper and lower body functions may help provide elderly, obese women with a more independence and improvement in function.

**Senior Fitness Test (SFT).** The Senior Fitness Test (SFT) (Rikli & Jones, 2001) measures the functional ability of the older adult and whether the older adult may be at risk for loss of functional ability. This test also measures different domains of physical function through a series of tasks that are assessed using objective, quantitative measures. The specific tasks that are tested in the SFT include a 30 second chair stand, arm curl, chair sit-and-reach, back scratch, six minute walk, two minute step test, and eight-foot up-and-go, and height and weight.

In a study conducted by Rikli and Jones (1999), reliability and validity were assessed for the SFT. To test for reliability, 82 adults (48 women and 34 men) over the age of 60 years were recruited and each task of the SFT, except the six minute walk, was conducted on the same day. Two to five days later, these tests were administered again. The six minute walk was conducted about three weeks after the other tasks, with a retest of the six minute walk taking place two to five days later. Using one-way ANOVAs, the intraclass correlation coefficients were calculated with the R values for all the test items ranging from .80 to .98, representing that the test was reliable. Three different types of validity were established for the individual tasks of the SFT by Rikli and Jones (1999). These included content validity, criterion validity, and construct validity. Content validity, referring to the degree to which a test reflects a domain of content, was demonstrated through literature review and opinions of experts who have had experience with the individual tasks of the SFT.
In order to establish construct validity comparisons of the SFT, scores were made between the participants who were regular exercisers verse those who were not regularly active (Rikli & Jones, 1999). It was assumed that those who exercise regularly would have higher levels of functional fitness. There were also comparisons made across different age groups (i.e. 60-69, 70-79, and 80-89 years of age). One hundred and ninety male and female participants with a mean age of 76.2 years ($SD = 6.7$) participated in the construct validity studies, except the six minute walk test which consisted of 77 men and women ($M = 73.1$ years, $SD = 7.2$) solicited from a different retirement residence. Results showed that each of the SFT tasks were able to differentiate between regular and not regular exercisers. In terms of the age group comparisons, each task demonstrated construct validity across a decade with the exception of the chair-stand task. Significant performance declines were identified between 70 years to 80 years of age, but not between 60 years to 70 years. Overall the SFT was found successful in measuring performance on a continuous scale across different functional ability levels. Researchers gave positive feedback in regards to the training techniques, equipment that was utilized, space required, and time requirements of the test givers, as well as participants who reported feeling motivated and enjoying the test (Rikli & Jones, 1999).

Comparison of FMS and Validated Functional Tests for Older Adults. Each of the validated and reliable functional performance tests for older adults assess function using quantitative measures such as time, weight, height, etc. Though these measures are a valuable source to assess an older individual’s functional ability by performing everyday tasks, it may be beneficial to focus on where specific functional declines within movements are originating. With functional performance and ability naturally declining with age, there may be some value in closely examining the quality of the movement for this population. By screening and assessing
an older individual on their functional imbalances or compensatory strategies, their movement patterns could change and become more efficient. This change could happen by determining where within the body segments those imbalances or strategies are originating from. Personalized interventions could then be built to concentrate on those specific areas within the body, joints, muscles, etc. More efficient movements may reduce further functional decline and increase their functional movement, ability, and performance, helping to lower risk for injury that could result in dependent living or disability.

Conclusion

The Functional Movement Screen (FMS) is a subjective, qualitative measure of functional movement that has been predominately used in the younger, active population. There have been no noted studies on the reliability and validity of the FMS within the older adult population, and though there are studies that have established reliability and validity in testing function in older adults, most of the tests are quantitative measures and fail to assess the quality of one’s movement.

Perry & Koehle (2013) set out to determine FMS scores within a middle-aged population and did report that some correlates of functional fitness such as BMI, age, sex of an individual, and perceived physical activity did influence FMS composite scores. This information from Perry & Koehle (2013) is a base for future FMS research in older adults; however, the reliability for the FMS within this population also needs to be established. If reliability and validity are established, the FMS could be used in this population for qualitative assessment, and may be paired with the quantitative tests of functional fitness to fully evaluate older adults’ functional abilities.
CHAPTER III: METHODS

Participants

The participants in this study were 12 male and 38 female adults 50 years of age and older (\(M = 58.9, \ S.D. = 6.8\), range = 50-80). Exclusion criteria included uncontrolled cardiovascular disease, uncontrolled hypertension, limb deformity, use of mobility aid, and/or any report of musculoskeletal injury that could affect performance on the Functional Movement Screen (FMS). Permission for this study was granted by the Human Subjects Review Board at Bowling Green State University (BGSU) and written informed consent was obtained from all participants before data collection.

Instruments or Apparatus

The Functional Movement Screen (FMS) developed by Cook and Burton (1997) was utilized for this study. A FMS test kit includes a four-foot dowel rod, two smaller dowel rods, a small-capped piece, and an elastic band that are specific for the seven screened movements was used.

Procedures

Participants were recruited by advertising on community boards at public businesses, email through Campus Updates provided by Bowling Green State University (BGSU), word of mouth, and direct communication. Fifty-one individuals were recruited for testing, with one participant excluded for not being able to complete all movements of the FMS. Each participant had his/her consultation and testing (Trial 1 and Trial 2) at the same location, ensuring continuity of the setting. Participants were asked to follow the instructions for pre-testing that included not consuming alcohol 24 hours before the testing, not participating in vigorous exercise 24 hours before testing, and not eating, drinking, or smoking 2-3 hours before testing. For each day of
testing participants were asked to consume their normal amounts of caffeine and dress in
exercise clothing. They were asked to wear shorts and a t-shirt, but did have the option of
wearing exercise pants for comfort and reduced anxiety.

Data collection by the same FMS certified exercise professional was conducted on two
separate occasions (e.g., trials) separated by five to seven days. Previous studies have utilized
both novice and expert raters for observation and scoring of the FMS test and both levels of
raters have been shown to be reliable (Onate et al., 2012; Gribble, Brigle, Pietrosimone, Pfile, &
Webster, 2013).

A test-retest design was used to investigate the reliability of the FMS. Day one consisted
of an initial consultation and Trial 1 testing using the FMS. Written informed consent, a medical
history questionnaire, and the CHAMPS Activities Questionnaire for Older Adults (kcal/week
from physical activity) (Stewart et al., 2001) were completed. After all forms and questionnaires
were completed, resting heart rate, taken manually, and resting blood pressure taken manually
using a stethoscope and blood pressure cuff were measured. Height was measured using a
stadiometer (Detecto Scale Company, Webb City, Missouri, USA). Body fat percentage was
determined via bioelectrical impedance (BIA) with the InBody230 (Biospace Company, Korea).
Weight (kg) and body mass index (BMI) were also recorded using BIA apparatus. There was an
opportunity for participants to become familiar with the FMS movements and scoring. Each
score of the task (i.e., 1, 2, or 3) was matched with a photo of that movement and participants
were informed on what they would be asked to do for each movement. There was also a chance
for the participants to ask questions about the movements before starting Trial 1 and Trial 2. Each
initial consultation portion lasted about 20-30 minutes with Trial 1 of the FMS following the
initial consultation.
Five to seven days later the participant returned to the same location as Trial 1 for their Trial 2 testing using the FMS. Trial 1 and Trial 2 testing lasted approximately 10-20 minutes. Administration procedures, instructions, and scoring based on Cook, Burton, Kiesel, Rose, and Bryant (2010) were followed.

The seven tests of the FMS, administered in order, were the deep squat, hurdle step, inline lunge, shoulder mobility, active straight-leg raise, trunk stability pushup, and rotary stability (Cook et al., 2010). Shoulder mobility, trunk stability pushup, and rotary stability were also completed as clearing exams. The clearing exams allow for evaluation of pain in the joints thought to be caused by lack of stability when adjacent body segments have limited mobility (Cook et al., 2010). Each clearing exam follows one specific test. The impingement clearing test follows shoulder mobility, the prone press-up clearing test follows trunk stability pushup, and the posterior rocking clearing test follows the rotary stability tests. These clearing exams also help to detect pain that may not be present during the seven original tests. See Appendix H and Appendix I for FMS testing descriptions and clearing exam descriptions.

Both testing sessions (i.e., Trial 1 and Trial 2) included the completion of the seven designated movement patterns. Each participant had up to three attempts for each movement before proceeding to the next movement. Observation for scoring was done from both the frontal and sagittal views. Dependent on the movement, the rater would start from the frontal or sagittal view. The rater would then move around the participant to fully observe the movement being performed and record accordingly. The scoring of each movement ranges from 0 to 3. A score of zero indicates that the participant feels, or expresses pain during the movement being tested. A score of 1 indicates the inability to complete the movement, or loss of balance. A score of 2 represents movement completion with compensatory movement strategies, and a score of 3
indicates full completion of the movement without any pain or compensatory movement strategy. The highest score after three attempts was recorded on the FMS recording form (Appendix G). For the movements that are measured bilaterally, including the hurdle step, inline lunge, shoulder mobility, impingement clearing test, active straight-leg raise, and rotary stability, the lowest raw score between the left and right side was used as the final score for that test. Scoring for the clearing portions, after only one attempt, were either positive or negative with positive representing pain (a zero for the score) and a negative representing no pain.

**Statistical Analysis**

A test-retest design was used to test the reliability of the FMS in adults ≥ 50 years of age. Means and standard deviations for total FMS scores, age, height, weight, BMI, body fat percentage, and CHAMPS scores were calculated. Total FMS scores from Trial 1 and Trial 2 were analyzed using intraclass correlation coefficients (ICCs) with 95% confidence intervals. Reliability coefficients for scores for each FMS task were analyzed using a weighted kappa statistic. Weighted kappa values were interpreted as follows: 0.81-1.00 is excellent agreement, 0.61-0.80 is substantial agreement, 0.41-0.60 is moderate agreement, 0.21-0.40 is fair agreement, 0-0.20 is slight agreement, and any value below zero is poor agreement (Kundel & Polansky, 2003).

In order to compare total FMS™ scores by Time (i.e., Trial 1 and Trial 2), Sex, and by BMI Category [i.e., non-obese (< 30.0 kg/m²) and obese (≥ 30.0 kg/m²)] (ACSM, 2014) a 2 x 2 x 2 (within, between, between) mixed model repeated measures analysis of variances was used. A 2 x 4 (within, between) analysis of variance was also used to compare Time (i.e., Trial 1 and Trial 2) and Age (i.e., 50-54 years, 55-59 years, 60-64 years and 65+ years). Effect size was reported as partial eta-squared (η²_p) (Tabachnick and Fidell, 2012). Observed power was
reported from SPSS analyses. Pearson correlation coefficients were calculated to analyze relationships between total FMS scores and age, BMI, body fat percentage, and CHAMPS scores. A significance level of $p \leq 0.05$ was set \textit{a priori} for all analyses except for the comparison of FMS total scores by Age. For this analysis a significance level of $p \leq 0.10$ was set for exploratory analysis.
CHAPTER IV: RESULTS

The purpose of this study was to test the reliability of the Functional Movement Screen (FMS) total scores and individual task scores for adults 50 years of age and older. Differences between FMS total scores (Trial 1, Trial 2) were also evaluated between groups (Age, Sex, BMI). Relationships between FMS total score and age, BMI, body fat percentage, and self-reported physical activity participation using the CHAMPS questionnaire were also assessed.

Participant Demographic Data

Means and standard deviations for demographics of the participants are presented in Table 1. Fifty participants volunteered for the current study; this included 12 males and 38 females. The mean age for all 50 participants was 58.9 years ($SD = 6.8$), with the males having a mean age of 61.4 years ($SD = 7.5$) and the females having a mean age of 58.1 years ($SD = 6.5$). The average BMI values of the participants all were below the category of “obese” (ACSM, 2014). Obesity is defined of having a BMI of $\geq 30 \text{ kg/m}^2$ (ACSM, 2014), and the average of all BMI value was 26.3 kg/m$^2$ ($SD = 4.6$), males had an average of 27.6 kg/m$^2$ ($SD = 2.8$), and females had an average of 25.9 kg/m$^2$ ($SD = 5.0$), respectively. Table 2 shows the average FMS total scores and individual task scores for Trial 1 and Trial 2. The mean total FMS scores for Trial 1 and Trial 2 were 11.7 ($SD = 2.5$) and 11.6 ($SD = 2.3$), respectively. For Trial 1 and Trial 2 the individual tasks with the lowest average scores were the deep squat (Trial 1 mean = 1.4, $SD = 0.5$; Trial 2 mean = 1.4, $SD = 0.5$) and the trunk stability push-up (Trial 1 mean = 1.4, $SD = 1.0$; Trial 2 mean = 1.4, $SD = 0.9$). The individual task with the highest score for both Trial 1 and Trial 2 was the active straight-leg raise (Trial 1 mean = 2.4, $SD = 0.6$; Trial 2 mean = 2.4, $SD = 0.6$).
Table 1

**Demographic Data for the Participants (N = 50)**

<table>
<thead>
<tr>
<th></th>
<th>Combined (N = 50)</th>
<th>Males (n = 12)</th>
<th>Females (n = 38)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>58.9</td>
<td>6.8</td>
<td>61.4</td>
</tr>
<tr>
<td>Height (in)</td>
<td>65.0</td>
<td>3.3</td>
<td>69.2</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71.8</td>
<td>15.8</td>
<td>84.2</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>26.3</td>
<td>4.6</td>
<td>27.6</td>
</tr>
<tr>
<td>Body Fat (%)</td>
<td>34.2</td>
<td>8.0</td>
<td>27.7</td>
</tr>
<tr>
<td>CHAMPS (kcals/week)</td>
<td>3933.6</td>
<td>5112.6</td>
<td>4185.0</td>
</tr>
</tbody>
</table>

*Note. BMI = Body Mass Index; CHAMPS = Community Healthy Activities Model Program for Seniors*

Table 2

**Average FMS Total Scores and Individual Task Scores for Trial 1 and Trial 2 (N = 50)**

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th></th>
<th>Trial 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
<td><strong>Mean</strong></td>
<td><strong>SD</strong></td>
</tr>
<tr>
<td>Total Score</td>
<td>11.7</td>
<td>2.5</td>
<td>11.6</td>
<td>2.3</td>
</tr>
<tr>
<td><strong>Individual Task Scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep Squat</td>
<td>1.4</td>
<td>0.5</td>
<td>1.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Hurdle Step</td>
<td>1.5</td>
<td>0.5</td>
<td>1.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Inline Lunge</td>
<td>1.5</td>
<td>0.8</td>
<td>1.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Shoulder Mobility</td>
<td>2.0</td>
<td>1.0</td>
<td>1.8</td>
<td>1.1</td>
</tr>
<tr>
<td>Active Straight-Leg Raise</td>
<td>2.4</td>
<td>0.6</td>
<td>2.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Trunk Stability</td>
<td>1.4</td>
<td>1.0</td>
<td>1.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Rotary Stability</td>
<td>1.6</td>
<td>0.6</td>
<td>1.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>

*Note. FMS = Functional Movement Screen*

**Reliability of the FMS Total Score and FMS Individual Task Scores**

Good to high reliability was observed ($ICC = 0.89$), 95% CI [0.80, 0.94] (Onate et al., 2012) for the FMS total scores between Trial 1 and Trial 2. Figure 1 shows the relationship between Trial 1 and Trial 2 FMS total scores. This relationship was significant ($r = .80$, $p < .001$)
between the two trials. The ratio of the variance caused by Trial 2 \((R^2)\) was 0.64 indicating that 64\% of the variance in Trial 1 scores could be accounted for by Trial 2 scores.

![Figure 1](image.png)

**Figure 1.** Relationship of FMS Trial 1 and FMS Trial 2 \((N = 50)\). FMS = Functional Movement Screen

Weighted kappa values for the individual FMS task scores are presented in Table 3. Scores ranged from -0.02 to 0.89 (i.e., poor to almost perfect agreement) (Kundel & Polansky, 2003). The deep squat (0.89) and rotary stability (0.81) were classified as “almost perfect”, the hurdle step (0.61) was classified as “substantial”, the inline lunge (0.53) was classified as “moderate”, the shoulder mobility and trunk stability push-up were classified as “fair”, and the active straight-leg raise (-0.02) was classified as “poor”.

\[ Y = 0.8732X + 1.5359, \text{SEE} = 1.54 \]
\[ r = .800, p < .000 \]
\[ ICC = 0.89, R^2 = 0.6404 \]
Agreement of Individual Task Scores of the FMS between Trial 1 and Trial 2 (N = 50)

<table>
<thead>
<tr>
<th>FMS Individual Tasks</th>
<th>Weighted Kappa</th>
<th>Strength of Agreement*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Squat</td>
<td>0.89</td>
<td>Almost Perfect</td>
</tr>
<tr>
<td>Hurdle Step</td>
<td>0.61</td>
<td>Substantial</td>
</tr>
<tr>
<td>Inline Lunge</td>
<td>0.53</td>
<td>Moderate</td>
</tr>
<tr>
<td>Shoulder Mobility</td>
<td>0.27</td>
<td>Fair</td>
</tr>
<tr>
<td>Active Straight-Leg Raise</td>
<td>-0.02</td>
<td>Poor</td>
</tr>
<tr>
<td>Trunk Stability Push-up</td>
<td>0.40</td>
<td>Fair</td>
</tr>
<tr>
<td>Rotary Stability</td>
<td>0.81</td>
<td>Almost Perfect</td>
</tr>
</tbody>
</table>

*Note. FMS = Functional Movement Screen; *Strength of Agreement (Kundel & Polansky, 2003)

Differences in FMS Total Score Due to Sex and BMI Category

Participants were divided into groups by Sex and BMI Category in order to compare differences in FMS total score. The FMS scores by Sex can be found in Table 4 and by BMI Category in Table 5. Mixed model two-way, repeated measures analyses of variance revealed no significant main effect for the FMS total scores by Sex ($F_{[49]} = 0.00, df = 1, p = 0.99, \eta^2_p = 0.00, 1-\beta = 0.05$), or by BMI Category ($F_{[49]} = 0.013, df = 1, p = 0.91, \eta^2_p = 0.00, 1-\beta = 0.05$). There was no significant interaction for Sex and BMI Category for the FMS total score ($F_{[49]} = 2.59, df = 1, p = 0.11, \eta^2_p = .053, 1-\beta = 0.35$).

Table 4

Functional Movement Screen (FMS) Data Stratified by Sex (N = 50)

<table>
<thead>
<tr>
<th></th>
<th>Males (n = 12)</th>
<th>Females (n = 38)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>FMS Trial 1</td>
<td>10.7</td>
<td>2.2</td>
</tr>
<tr>
<td>FMS Trial 2</td>
<td>11.0</td>
<td>2.2</td>
</tr>
</tbody>
</table>

*Note. FMS = Functional Movement Screen
Table 5

*FMS Data Stratified by BMI Category (N = 50)*

<table>
<thead>
<tr>
<th>BMI Category</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-obese</td>
<td>39</td>
<td>12.1</td>
<td>2.5</td>
<td>11.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Obese</td>
<td>11</td>
<td>10.4</td>
<td>2.2</td>
<td>10.7</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Note. Non-obese = < 30 kg/m²; Obese = ≥ 30 kg/m² (ACSM, 2014); FMS = Functional Movement Screen

**Differences in FMS Total Score Due to Age**

The participants of the current research were separated into four groups based on their ages. Grouping was done similar to Perry and Koehle (2013) with the participants divided into a 50-54 years group, 55-59 years group, 60-64 years group, and a 65+ year group. Table 6 shows the FMS scores by Age group. A 2 x 4 mixed model analysis of variance revealed a significant difference in FMS total score due to Age ($F_{[49]} = 2.29$, $df = 3$, $p = 0.09$, $\eta^2_p = 0.130$, $1-\beta = 0.541$). Post hoc measures using Fisher’s LSD revealed that the 50-54 years group had significantly greater FMS total scores than the 60-64 years group ($p = 0.04$) and the 65+ years group ($p = 0.09$). The 55-59 years group had significantly higher FMS total scores than the 60-64 years group ($p = 0.06$).

Table 6

*FMS Data Stratified by Age (N = 50)*

<table>
<thead>
<tr>
<th>Age Group</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-54**</td>
<td>16</td>
<td>12.3</td>
<td>1.9</td>
<td>12.4</td>
<td>1.5</td>
</tr>
<tr>
<td>55-59*</td>
<td>16</td>
<td>12.6</td>
<td>2.3</td>
<td>11.8</td>
<td>2.0</td>
</tr>
<tr>
<td>60-64</td>
<td>9</td>
<td>10.2</td>
<td>2.4</td>
<td>10.6</td>
<td>3.0</td>
</tr>
<tr>
<td>65+</td>
<td>9</td>
<td>10.6</td>
<td>3.4</td>
<td>11.0</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Note. *p ≤ 0.10, > 60-64 group regardless of trial. **p ≤ 0.10, > 65+ group regardless of trial. FMS = Functional Movement Screen
**Correlations**

Pearson correlation coefficients revealed significant negative relationships between age and Trial 1 FMS score \( (r = -.362, p = .010) \), age and Trial 2 FMS score \( (r = -.302, p = .033) \), BMI and Trial 1 FMS score \( (r = -.457, p = .001) \), BMI and Trial 2 FMS score \( (r = -.308, p = .029) \), body fat percentage (BF) and Trial 1 FMS score \( (r = -.396, p = .004) \), and BF and Trial 2 FMS score \( (r = -.292, p = .039) \). As all of these “characteristic variables” (i.e., age, BMI, and BF) increased, the total FMS scores for both Trial 1 and Trial 2 decreased. There was no significant relationship between perceived physical activity (i.e., CHAMPS) and Trial 1 FMS score \( (r = -0.03, p = .823) \) or Trial 2 FMS score \( (r = -0.76, p = .598) \).

Figure 2 shows the significant negative relationship between FMS total score and age. The correlation is classified as having a medium effect based on the \( r \) value for Trial 1 \( (r = -.362) \) and Trial 2 \( (r = -.302) \) (Rosenthal & Rosnow, 1984). This negative relationship is showing that as the age of an individual increases, the FMS score will decrease. In the current study age explained 13.1% of the variance of the FMS total score for Trial 1 and 9.1% of the variance of the FMS total score for Trial 2.
Figure 2. Correlation of age (yrs) and Functional Movement Screen (FMS) Total Score by Trial (n = 50).

Figure 3 represents the relationship of body mass index (BMI) values and FMS total score. This relationship was also found to be a significant negative correlation and signifies that the higher the BMI value, the lower the FMS total score is. The correlation is classified as having a medium-high effect based on the $r$ value for Trial 1 ($r = -0.457$) and medium for Trial 2 ($r = -0.308$) (Rosenthal & Rosnow, 1984). For this relationship the BMI values explain 20.9% of the variance of the FMS total scores for Trial 1 and 9.5% of the variance of the FMS total scores for Trial 2.
Figure 3. Correlation of BMI and Functional Movement Screen (FMS) total score by Trial (n = 50).

Figure 4 represents the significant, negative relationship representing the effect of body fat percentage (BF) on FMS total score. This shows that the higher the BF, the lower an individual’s FMS total score. The correlation is classified as having a medium effect based on the \( r \) value for Trial 1 \( (r = -0.396) \) and low-medium for Trial 2 \( (r = -0.292) \) (Rosenthal & Rosnow, 1984). For this relationship the BF percentage explains 15.7% of the variance of the FMS total score for Trial 1 and 8.5% of the variance of the FMS total score for Trial 2.
Figure 4. Correlation of body fat percentage and Functional Movement Screen (FMS) total score by Trial (n = 50).
The purpose of this study was to test the reliability of the Functional Movement Screen (FMS) total scores and individual task scores for adults 50 years of age and older. Differences between FMS total scores (Trial 1, Trial 2) were also evaluated between groups (Age, Sex, BMI). Relationships between FMS total score and age, BMI, body fat percentage, and self-reported physical activity participation using the CHAMPS questionnaire were also assessed.

**Reliability of the Functional Movement Screen (FMS)**

**FMS Total Score.** In the present study the test-retest reliability was good (*ICC* = 0.89) within the older adult population (≥ 50 years of age) when a FMS certified rater was utilized for observation and scoring. This is a similar finding to that of Onate et al. (2012) who found reliability to be high (*ICC* = 0.92) for a young, active population with a certified FMS rater being utilized. The reliability standards used within the current study are based on the ranges used in Onate et al. (2012).

The reliability of the FMS total scores has been established, but only for younger, active populations such as collegiate and professional athletes and military personnel (Minick et al., 2010; Onate et al., 2012; Shultz, Anderson, Matheson, Marcello, & Besier, 2013; Teyhen et al., 2012). Onate and colleagues (2012) studied the reliability of the FMS on physically active, healthy males and females. Onate and colleagues (2012) reported that the test-retest reliability was high with an intraclass correlation coefficient (*ICC*) value of 0.92. Shultz et al. (2013) also studied test-retest reliability on varsity athletes from the National Collegiate Athletic Association Division IA at a single university. The test-retest reliability had an *ICC* value of 0.60, which was considered good (Shultz et al., 2013), but was lower than the ICCs that were previously reported by Onate et al. (2012) and Teyhen et al. (2012).
Teyhen and colleagues (2012) found that test-retest reliability was considered good (ICC = 0.74) when healthy armed services members were tested. This was a lower value than the previous study done by Onate et al. (2012) and that of the current research. The reliability results from previous studies are comparable to the current study and it should be noted that results from the current study support the FMS assessment as reliable for older adults.

**FMS Task Scores.** Another purpose of the current study was to determine the reliability of each task score of the FMS. There are seven movements (i.e., task scores) of the FMS and these include the deep squat, the hurdle step, the inline lunge, the shoulder mobility, the active straight-leg raise, the trunk stability pushup, and the rotary stability. The current study utilized a FMS certified exercise professional and tested the reliability of the individual FMS task scores using weighted kappa values. A kappa value is used to determine agreement between two different situations with a weighted kappa putting more emphasis on the large differences between the different situations rather than the small differences (Sim & Wright, 2005). When compared to the final scores for each component of the novice raters from Minick et al. (2010), two of the tasks (i.e., deep squat, hurdle step) shared the same agreement [excellent/almost perfect (0.89), substantial (0.61)]. When comparing the remaining tasks the results from the current study were lower for levels of agreement for the inline lunge (0.53), shoulder mobility (0.27), active straight-leg raise (-0.02), and trunk stability (0.40). A higher level of agreement was shown for rotary stability (0.81) as compared to Minick et al. (2010).

Minick et al. (2010) studied the reliability of the seven individual task scores for test administrators with different levels of FMS training. Minick et al. (2010) analyzed the data using a weighted kappa statistic. When comparing the novice raters of this study (Minick et al., 2010) (completed introductory FMS training course and had used FMS less than a year), excellent
agreement (0.80 – 1.00) was demonstrated for six of the 17 tasks (squat, right shoulder mobility, left shoulder mobility, total shoulder mobility, active straight-leg raise total, trunk stability pushup). Substantial agreement (0.65 – 0.77) was demonstrated on eight tasks (right hurdle step, left hurdle step, hurdle step total, inline lunge total, right and left active straight-leg raise, right and left rotary stability), and moderate agreement (0.53 – 0.54) was demonstrated on three of the tasks (right inline lunge, left inline lunge, rotary stability total). Teyhen et al. (2012) also used the weighted kappa statistic for individual task analysis when novice raters were scoring. Teyhen and colleagues (2012) tested a young, athletic population with the individual FMS tasks scored by novice examiners with the kappa values ranging from 0.29-0.76. These values are similar to Minick et al. (2010).

The current research further demonstrates that the FMS is a reliable assessment for older adults. It should be noted that previous studies did not report poor agreement in any of the tasks unlike the current study. This may be due to the sample of the population that was being tested. For the current study older individuals were assessed while Minick et al. (2010) and Teyhen et al. (2012) had young, healthy individuals participate in their FMS testing. It is hypothesized that this could account for the increased variability in scores for the separate tasks within the FMS because older individuals may have an increased risk of poor flexibility, musculoskeletal strength, balance, and decreased physical function. These age related increases in variability may have also been affected by other correlates of functional fitness such as sex, body composition measures, and day-to-day variability of testing. Most likely the lower agreement scores for older adults in the current study reflect a wider range of scores (i.e., variability) as compared to their younger counterparts.
Effects of Sex on the FMS Performance Scores

Previous studies have examined the differences between males and females in terms of functional fitness, with more emphasis on individual components of function such as flexibility, physical strength/power, and balance. Konopack et al. (2008) found that females demonstrated a higher “flexibility” and men demonstrated higher “physical power” when functional fitness tasks were divided into these categories. The tasks that were split into “flexibility” and “physical power” were five tasks from the Senior Fitness Test (SFT). The chair sit-and-reach and back scratch were used for the “flexibility” group and the chair stand, eight-foot up-and-go, arm curl, and a maximal aerobic fitness test were used for the “physical power” group. This was further demonstrated in the current study with females having higher average scores for the flexibility movements of the FMS for Trial 1 and Trial 2. These movements include the shoulder mobility test [means for Trial 1 and Trial 2: Female = 2.1 and 1.9 (SD = 1.0 and 1.1), Male = 1.8 and 1.7 (SD = 1.1 and 1.2)] and the active straight-leg raise [means for Trial 1 and Trial 2: Female = 2.6 and 2.6 (SD = 0.6 and 0.6), Male = 1.8 and 1.8 (SD = 0.4 and 0.4)].

Even though the FMS does not utilize fatigue-induced physical power to execute the individual task movements and is versatile enough for males and females (Cook et al., 2010, Perry & Koehle, 2013), the trunk stability push-up test does have different hand positions between sexes. This change in hand position is based on average lean body mass differences. It is the distribution of lean body mass in the upper extremities that accounts for strength differences between males and females (Cook, Burton, Kiesel, Rose, & Bryant, 2010), but the restructured hand-placement of the trunk stability push-up helps to make the FMS a more sensitive assessment to distinguish between males and females.
When examining the individual tasks of the FMS, there were some differences based on the different abilities between males and females (i.e., males having more muscle strength and females having greater flexibility). However, as stated, the FMS total score does not assess or observe physical strength or power, but is based on how an individual moves without inducing fatigue or a vast amount of physical exertion outside of everyday movements. It has been shown that the FMS is versatile for both males and females to complete (Cook et al., 2010, Perry & Koehle, 2013). The current study found that males and females did not significantly differ on the FMS total scores. However, for individual task scores, the current study demonstrated that for Trial 1 and Trial 2 males demonstrated higher average trunk stability push-up scores ($M = 1.5$, $SD = 1.1$; $M = 1.7$, $SD = 0.8$) than the female participants ($M = 1.3$, $SD = 1.0$; $M = 1.3$, $SD = 1.0$). This was in agreement with the reporting of Konopack et al. (2008) that male participants demonstrated higher “physical power” than the female participants.

**Effects of BMI Category on the FMS Performance Scores**

BMI has been shown to be negatively correlated with functional fitness indicating that obesity is associated with functional limitations (Jain, Al-Adawi, Dorvlo, & Burke, 2008). For the current study the variable of BMI Category using BMI, was split into non-obese ($< 30.0$ kg/m$^2$) and obese ($\geq 30.0$ kg/m$^2$) based on the number of participants that were tested and previous research (Perry & Koehle, 2013). Though BMI had a significant negative correlation with the FMS composite score for Trial 1 ($r = - .457$, $p = .001$) and Trial 2 ($r = -.308$, $p = .029$), there were no significant differences found between BMI Category (i.e., non-obese and obese) for total FMS score in the current research. Perry and Koehle (2013) did not have this outcome, and found significant differences between FMS scores in high and low BMI participants with post hoc comparisons revealing that those with lower BMI values scored higher on the FMS. A
possible reason for not detecting any differences in FMS score based on BMI Category in the current research could have been due to the sample size of the groupings. Out of 50 participants there were 39 non-obese individuals and 11 obese individuals. Future comparisons with an equal number of participants per group may permit a statistical analysis with increased power to detect a difference, if present.

Previous research has also shown that obesity within the older adult population predicts functional decline and disability (Apovian, Frey, Rogers, McDermott, & Jensen, 1996; Davison et al. 2002; Zoico et al., 2003). Davison, Ford, Cogswell, & Dietz (2002) sought to investigate the association between various body composition measures and functional limitations in men and women ages 70 years and older. Davison et al. (2002) reported that higher BMI values correlated with functional limitations for both the men and women who participated in the study.

Effects of Aging on the FMS Performance Scores

Age is another variable that can negatively affect functional fitness in an individual and ultimately the FMS score. This can be due to a number of effects such as decreased flexibility, loss of balance, decreased muscle mass, and more. Similar to Perry and Koehle (2013) the results of the current study revealed that age did affect an individual’s total FMS score. After separating participants into six different age groupings (20-39, 40-49, 50-54, 55-59, 60-64, 65+) Perry and Koehle (2013) found that FMS scores were highest in the 20-39 age group ($M = 15.08$) and lowest in those $\geq 65$ years of age ($M = 12.68$). Participants were grouped similar to Perry and Koehle (2013) in the current study and included the groups of 50-54 years, 55-59 years, 60-64 years, and 65+ years. There were significant differences between age groups with the 50-54 years group having significantly greater FMS total scores than the 60-64 years group and the 65+ years group. It is also noted that the 55-59 years group had significantly higher FMS total scores
than the 60-64 years group. The average FMS scores for Trial 1 and Trial 2 for the current study can be found in Table 6 were 12.3 (SD = 1.9) and 12.4 (SD = 1.5) for the 50-54 age group, 12.6 (SD = 2.3) and 11.8 (SD = 2.0) for the 55-59 age group, 10.2 (SD = 2.4) and 10.6 (SD = 3.0) for the 60-64 age group, and 10.6 (SD = 3.4) and 11.0 (SD = 3.0) for the 65+ age group, respectively. For the age groups from Perry and Koehle (2013) the average FMS score for those participants can be found in Table 7.

Table 7

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Men Mean</th>
<th>Men SD</th>
<th>Women Mean</th>
<th>Women SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-54</td>
<td>14.0</td>
<td>2.3</td>
<td>14.6</td>
<td>2.9</td>
</tr>
<tr>
<td>55-59</td>
<td>13.6</td>
<td>2.7</td>
<td>13.7</td>
<td>2.6</td>
</tr>
<tr>
<td>60-64</td>
<td>13.0</td>
<td>2.7</td>
<td>12.9</td>
<td>3.2</td>
</tr>
<tr>
<td>65+</td>
<td>12.6</td>
<td>3.3</td>
<td>13.2</td>
<td>3.0</td>
</tr>
</tbody>
</table>


These average scores from Perry and Koehle (2013) are higher than those from the current research. A possible explanation for this difference is that those who volunteered to participate in the Perry and Koehle (2013) study were also taking part in a preventative health screen at a multidisciplinary health care clinic. It was explained by Perry and Koehle (2013) that these were individuals with frequent access to a health facility since this health assessment may have been paid for by employers. The current study also had a variety of individuals from different backgrounds, but the majority of the participants were university professors and may not have been habitually partaking in physical activity.

Previous studies have examined the different effects of aging on functional decline (Dickerson & Fisher, 1993, Konopack et al., 2008). Dickerson and Fisher (1993) investigated how younger and older participants compared when performing both familiar and unfamiliar
tasks. It was hypothesized that there would be no significant differences in Assessment of Motor Process Skills (AMPS) scores with the familiar tasks, but that scores would be significantly different between the younger and older individuals for the unfamiliar skills (Dickerson & Fisher, 1993). Dickerson and Fisher (1993) found that younger participants did have higher AMPS scores than the older participants under all conditions and that even when performing familiar tasks, older individuals had age-related declines.

Konopack and colleagues (2008) assessed specific correlates of function (i.e., age, biological sex, and self-efficacy) and how these related to a functional assessment for testing older adults. It was found that age had significant, negative correlations with the chair stand task and aerobic fitness and a significant, positive relationship between the eight-foot up-and-go and age. Each of the other components were negatively correlated with age, or very close to zero, suggesting that age does effect the functional performance and ability of an individual.

**Relationships between FMS and Age, BMI, Body Fat Percentage, and Perceived Physical Activity**

Pearson correlations revealed significant negative relationships between age, BMI, body fat percentage (BF) and the total FMS scores for Trial 1 and Trial 2. This reveals that when an individual was older, had a higher BMI value, or a higher BF percentage, the total FMS score for either trial would be lower. For both the current study and the study done by Davison et al. (2002) it was found that higher body fat percentage and higher BMI values were associated with greater functional limitations. Perry and Koehle (2013) also found that age and BMI were negatively associated with FMS, revealing that those who were younger and had lower BMI values achieved higher FMS total scores.
There was no relationship between perceived physical activity (i.e., CHAMPS) and Trial 1 FMS score or Trial 2 FMS score. When physical activity and FMS scores were evaluated by Perry & Koehle (2013), there was a significant positive relationship. This illustrated that with more physical activity being performed by an individual, the higher the FMS scores would be. For the current study, the relationships for CHAMPS and Trial 1 and Trial 2 FMS scores were negative relationships. This unexpected relationship between physical activity and physical function in the current study could be explained by the time of year that the current study took place. During testing, which took place between the months of January and April, participants would make comments about how they usually take part in certain activities when the weather was less cold, snowy, and icy. Some of the questions that were scored on the CHAMPS questionnaire included gardening, swimming, and other outdoor activities. If participants did not have access to a fitness facility, or were unable to complete exercise at home due to the weather, these may have impacted the CHAMPS physical activity scores.

Limitations

It is important to note some limitations to this study. One limitation was the number of participants who were recruited for this study to assess differences between Sex, BMI Category, and Age. Previous researchers examining reliability and differences between groups have recruited a greater number of individuals for participation. For example, Perry and Koehle (2013) who examined group differences for the FMS had 622 participants. The sample size \( N = 50 \) of the current research had limited power and effect size to identify age group differences, so for exploratory statistics the significance level was set at \( p < 0.10 \) to identify any group differences. With a greater number of participants, the current research may have been
comparable to the number of participants in Perry & Koehle (2013) and allowed for more specific comparisons of the results.

The number of participants who were used in the current research ($N = 50$) may have also influenced the results when examining the differences between BMI Category (i.e., non-obese, obese). It was found in other research (Perry & Koehle, 2013) that there were significant differences in the FMS scores between non-obese and obese individuals. This was not the case within the current research where power and effect size was limited while investigating BMI categories. However, BMI was correlated with total FMS demonstrating a relationship between BMI and FMS total score. As BMI increased, FMS total score decreased.

Data collection took place from the month of January through April. One of the variables within the current study was the CHAMPS physical activity questionnaire and the participants had to recall their physical activity over the past four weeks from the time of their initial consultation. Some of the activities that were asked to be recalled were golfing, swimming, gardening, and other outdoor activities. The majority of the participants made comments about how they would usually be partaking in these activities, but since data collection was occurring over the winter months and the participants could only recall activities from the past four weeks, they were not able to account for the outdoor activities. It is possible that if a physical activity questionnaire that did not focus on just the past four weeks of activity was used in the current study, then there may have been a significant, positive relationship between physical activity and FMS total scores similar to that reported by Perry and Koehle (2013).

While performing the FMS, participants were asked to report any feeling of pain when doing the movements of the assessment. In order to assess pain a definition was read to participants before starting each trial of the FMS and was read as, “a physical feeling that
includes any distress, tenderness, burning, aching, pinching, jamming, radiating, sharpness or soreness that is unqualified or unexplained” (Cook et al., 2010). After each attempt of each task the participants were asked if they felt any pain in any of the manners mentioned above. If yes, then a score of zero was given. Due to this subjective measure of pain by the participant, it is possible that pain may have not been represented properly, in terms of not reporting pain. There were many comments made about how the pain was “normal”, due to aging effects (i.e., joint pain, muscle weakness). With this, the feelings expressed by the participants may have been more painful at one point, but over time this pain has become a “normal” feeling and may not be representative of pain, subjectively, any longer. Pain may have not been reported properly, representing a higher FMS score when not reported, or a lower score even when the movement could be completed by the participant.

**Future Research**

To our knowledge this is one of the first studies to explore the reliability of the Functional Movement Screen (FMS) for the older adult population. Normative values have been set as a result of Perry and Koehle (2013), in terms of average FMS total score by age group (i.e., Table 7), but they did not address reliability of the FMS. However, reliability has been set for younger, active populations such as the military and collegiate/professional athletes. Along with reliability, cut-off values for the FMS have also been established for the young, active populations (Kiesel, Plisky, & Voight, 2007). It was reported by Kiesel et al. (2007) that professional football players who scored less than a 14 on the FMS had an increased risk for injury. Future research should investigate the risk of injury for the older adult population and determine whether this cut-off can be utilized or needs to be changed in order to accommodate age related effects.
Perry and Koehle (2013) used regression analysis to determine the impact that certain variables (i.e., age, BMI, and physical activity level) have on FMS score prediction. This idea of FMS score prediction could be expanded to include the individual task scores of the FMS. Future research could focus on what role the task scores play in predicting the FMS total score. By taking the seven individual tasks of the FMS and profiling the tasks into possible categories (i.e., flexibility, balance, etc.), researchers may be able to determine how certain task scores affect the total FMS score. This could be useful in looking at specific problem areas of the individual such as their flexibility and balance, or it could be used to make the screen only utilize the tasks that best predict the total FMS score.

**Summary**

The results from this study indicated that the FMS is a reliable assessment tool for individuals 50 years of age and older based on intrarater reliability. In terms of the relationship between task scores from Trial 1 to Trial 2 for the seven individual FMS tasks, two of the tasks had almost perfect agreement (deep squat, rotary stability), one had substantial agreement (hurdle step), one had moderate agreement (inline lunge), two had fair agreement (shoulder mobility, trunk stability), and one demonstrated poor agreement (active straight-leg raise) (Kundel & Polansky, 2003). It was also determined that there were no significant differences between males and females for FMS composite scores, and between obese and non-obese participants for FMS total scores. However, when the participants were divided by age into four age groups, there was a significant difference due to age for the FMS total scores. In terms of relationships between variables, Pearson correlation coefficients revealed significant, negative relationships; the greater the age, BMI, or % body fat, the lower the FMS score. There was no
significant relationship between self-reported weekly physical activity and the FMS composite scores.

It is important for future research to continue evaluating the FMS with older adults. There are reliable assessments for functional fitness within this population, but it is believed that the underlying factors that affect function need to be observed, identified, and if possible, corrected using corrective strategies (Cook et al., 2010). There is the possibility that evaluating and implementing a change within an older individual’s movement pattern could help prevent and/or reduce functional decline. Overall, the qualitative approach of the FMS in combination with the quantitative assessments that are currently utilized within the field could provide older adults with the evaluations and knowledge to maintain good quality of life and remain functionally independent across the lifespan.
REFERENCES


APPENDIX A: RECRUITMENT FLYER

Interested in Learning About Your Functional Movement?

A study being conducted at Bowling Green State University is in need of volunteers to be tested and evaluated in a research study. The study will be conducted over the next 3 months and will consist of one 40 minute session and one 20 minute sessions, both consisting of exercise. Exercise sessions will be separated by one week.

To qualify for the study:

1. You must:
   a. Be 50 years of age and older

2. You must NOT:
   a. Have uncontrolled high blood pressure
   b. Have uncontrolled cardiovascular disease
   c. Have any limb deformity
   d. Use a mobility aid such as a cane or walker to stand or walk
   e. Have any report of injury or pain that could affect testing performance

3. You DO NOT have to currently be physically active

**BENEFITS:** By participating in this study you will have your BMI, body fat percentage, resting blood pressure, and resting heart rate measured. You will also have your functional movement tested and evaluated with movements that use muscular strength, flexibility, and balance. These tests will be free of charge. You will receive these results, which could be taken to an exercise specialist and made into an individual functional movement exercise program if you so choose.

If you are interested in learning more about this opportunity please contact:

Melissa Fawcett
Phone: 330-591-1088
Email: mafawce@bgsu.edu
You have indicated that you might be interested in participating in a research project that is being conducted by a graduate student at Bowling Green State University. If you were to participate, you would be asked to complete two visits to either the Exercise Physiology lab at BGSU, or other public facility such as the Bowling Green Community Center, or Senior Center. Each of these visits will involve exercise. The first session will also involve paperwork and measurements such as height, weight, body fat percentage, resting blood pressure, and resting heart rate. You will then be asked to perform a functional movement test that involves muscular strength, flexibility, and balance. The exercises that you will be asked to perform are a squat, hurdle step, shoulder flexibility, leg raise, pushup, and a stability/balance test on your hands and knees. There will also be three (3) tests for joint/movement pain associated with the seven (7) functional movement tests. The functional movement tests will be performed up to three (3) times each and the pain tests will be performed one time. Five to seven days later you will be asked to return and perform the same tests again in the same order. If you are interested please contact me in order to obtain more information and details about the research project. You may also include dates and times that you may be available for the first day of testing. By contacting me for more details and/or scheduling the first day of testing you are NOT agreeing to participate. All participation is voluntary and you may decide to not participate, or stop participating, at any time.
MEDICAL HISTORY QUESTIONNAIRE

All information given is personal and confidential. It will enable us to better understand you and your health and fitness habits. In addition, we will use this information to classify your health status according to the American College of Sport Medicine (ACSM) recommendations for risk stratification (ACSM, 2014). Please let us know if and when you have changed your medication (dose & type), diet, exercise or sleeping habits within the past 24 or 48 hours. It is very important for you to provide us with this information.

NAME______________________________________ AGE_________________ DATE_________________

OCCUPATION________________________________________________________________________________________

1. *FAMILY HISTORY

Check each as it applies to a **blood relative**:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Attack</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sudden Death</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary Revascularization</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If yes, give values:
- Age at onset____ yrs; relation to you _____________
- Father’s Age____; Deceased_____; Age at death______
- Mother’s Age____; Deceased_____; Age at death______

(*Before 55 yr. in father or first-degree male relative)

2. PERSONAL HISTORY

Check each as it applies to you:

* Age (men ≥ 45 yr; women≥ 55 yr)   yes_____ no_____

* Current Cigarette Smoking   yes_____ no______ unsure______
   (or quit within 6 mo or exposure to environmental tobacco smoke)

* Sedentary Lifestyle   yes_____ no______ unsure______
   Not participating in at least 30 min of moderate intensity physical activity on at least 3 days/wk for at least 3 months.

* Obesity – BMI >30 kg·m⁻²   yes_____ no______ unsure______
   If yes, give value: ______kg·m⁻²
   Waist circum. > 40” men; 35” women: yes_____ no______

* High Blood Pressure   yes_____ no______ unsure______
   Systolic Blood Pressure >140mmHg or diastolic >90mmHg
   (Note: values confirmed by measures on two separate occasions)
   If yes, give value: ______ / ______ mmHg.

* Dyslipidemia   yes_____ no______ unsure______
   Total Serum Cholesterol >200 mg·dl⁻¹; value: ______ mg·dl⁻¹
   LDL-C ≥ 130 mg·dl⁻¹; value: ______ mg·dl⁻¹
   HDL-C ≤ 40 mg·dl⁻¹; value: ______ mg·dl⁻¹
   On lipid lowering medication: yes_____ no______ unsure______

* PreDiabetes   yes_____ no______ unsure______
   Impaired fasting glucose ≥ 100; ≤125 mg·dl⁻¹; value: ______ mg·dl⁻¹
   Impaired glucose tolerance test: yes_____ no______ unsure______
   (Note: values confirmed by measures on two separate occasions)

*Negative Risk Factor:   yes_____ no______ unsure______
   HDL ≥ 60 mg·dl⁻¹; value: ______ mg·dl⁻¹

Have you ever had:
- Diabetes   yes_____ no______ unsure______
- Tuberculosis   yes_____ no______ unsure______
- Heart Attack   yes_____ no______ unsure______
- Angina   yes_____ no______ unsure______
- EKG Abnormalities   yes_____ no______ unsure______
- Asthma   yes_____ no______ unsure______
- Emphysema   yes_____ no______ unsure______
- Stroke   yes_____ no______ unsure______
- Severe Illness   yes_____ no______ unsure______
- Hospitalized   yes_____ no______ unsure______
- Black Outs   yes_____ no______ unsure______
- Gout   yes_____ no______ unsure______
- Nervousness   yes_____ no______ unsure______
- Joint Problems   yes_____ no______ unsure______
- Allergy   yes_____ no______ unsure______
- Convulsions   yes_____ no______ unsure______
- Paralysis   yes_____ no______ unsure______
- Headaches   yes_____ no______ unsure______
- Depression   yes_____ no______ unsure______
- Chest Pain   yes_____ no______ unsure______
- Arm Pain   yes_____ no______ unsure______
- Indigestion   yes_____ no______ unsure______
- Ulcers   yes_____ no______ unsure______
- Overweight   yes_____ no______ unsure______
- Hernia   yes_____ no______ unsure______
- Back Pain   yes_____ no______ unsure______
- Leg Cramps   yes_____ no______ unsure______
- Low Blood Pressure   yes_____ no______ unsure______
- Insomnia   yes_____ no______ unsure______

For Office Use Only:

_____ Sum of positive and negative *CVD risk factors* (according to Table 2.2. ACSM (2014)

**NOTE:** All risk factors are explained verbally to each person completing the questionnaire.

Classification according to ACSM (2014, p. 26) (check one): _____ Low risk < 2; _____Moderate risk ≥ 2; _____High risk (known disease)
3. MEDICAL HISTORY

Name of your physician
__________________________________________________________________________________

Date of your most recent physical examination
__________________________________________________________________________________

What did the physical examination include?
__________________________________________________________________________________

Have you ever had an exercise EKG? Yes____ No_____

Are you presently taking any medications? Yes_____ No_____  List name and dosage
( Including over-the-counter medications and/or herbs)

Have you ever taken:

<table>
<thead>
<tr>
<th>Medication</th>
<th>Yes____ No_____ unsure____</th>
<th>Insulin</th>
<th>Yes____ No_____ unsure____</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digitalis</td>
<td>yes_____ no_____ unsure_____</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitroglycerin</td>
<td>yes_____ no_____ unsure_____</td>
<td>Pronestyl</td>
<td>yes_____ no_____ unsure_____</td>
</tr>
<tr>
<td>High Blood Pressure</td>
<td>yes_____ no_____ unsure_____</td>
<td>Vasodilators</td>
<td>yes_____ no_____ unsure_____</td>
</tr>
<tr>
<td>Medication</td>
<td></td>
<td>Other</td>
<td>yes_____ no_____ unsure_____</td>
</tr>
<tr>
<td>Sedatives</td>
<td>yes_____ no_____ unsure_____</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inderal</td>
<td>yes_____ no_____ unsure_____</td>
<td>If yes, list medications:</td>
<td></td>
</tr>
</tbody>
</table>

4. EXERCISE HISTORY

Do you exercise? Yes_______ No_______  What activity________________________________________________________

How long have you been exercising?________________________________________________________

How many days do you exercise? How many minutes per day?________________________________

What kinds of shoes do you work out in?____________________________________________________

Where do you usually exercise?_____________________________________________________________

Do you monitor your pulse during your workout?_____________________________________________
5. **HEALTH HISTORY**

<table>
<thead>
<tr>
<th>Height</th>
<th>Weight</th>
<th>At Age 20</th>
<th>At Age 30</th>
<th>At Age 40</th>
<th>One Year Ago</th>
<th>Most Weighed</th>
<th>Least Weighed</th>
</tr>
</thead>
</table>

Do you use Health Foods?  Yes____ No____ List __________________________________________________________

Do you take Vitamin pills?  Yes____ No____ List __________________________________________________________

Approximate your daily intake:  Coffee____ tea______ coke______ beer______ wine______ liquor_____

Do you smoke or use tobacco products?  Yes____ No____

If yes, approximate your daily usage:  Cigarettes____ Cigars_____ Pipes_____ Chewing Tobacco_____

Did you ever smoke?  Yes____ No____ How many years?________ Age when you quit_________

Approximate the number of hours you work per week?__________ Vacations weeks per year _________________

Home Status:  Very happy________ Pleasant________ Difficult_______ Problem__________

Work Status:  Very happy________ Pleasant________ Difficult_______ Problem__________

Do you feel you are stressed?  Yes____ No____ Unsure________

Are you worried about your health?Yes____ No____ Unsure_______

6. **APPROXIMATE A TYPICAL 24 HOUR DAY FOR YOU**

<table>
<thead>
<tr>
<th>Number of hours:</th>
<th>Work</th>
<th>TV</th>
<th>Relaxation/Leisure activities</th>
<th>Driving/Riding</th>
<th>Eating</th>
<th>Exercise</th>
<th>Sleep</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional information from client interview to further assess health/coronary risk status:

_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
_____________________________________________________________________________________________________
INFORMED CONSENT STATEMENT

Project Title: Reliability of the Functional Movement Screen™ Scores for Older Adults

Investigator: Melissa A. Fawcett, B.S. Phone (330) 591-1088
Advisor: Professor Lynn A. Darby, Ph.D. Phone (419) 372-6903

Introduction: You are being asked to participate in a research study to determine the reliability of functional movement tests used with adults 50 years and older. Your age, body mass index (BMI), gender, body fat percentage, and physical activity questionnaire scores will also be compared to your test score to determine if there is any relationship.

Your participation in this study will require two visits. At the first visit, you will be provided with information about the study and directions for your participation. The first visit will either take place at the Exercise Physiology Lab, or at another public facility (i.e. Senior Center, Community Center, etc.). You will then be tested using functional movement tests (squat, hurdle step, lunge, back scratch, leg raise, pushup, balance/stability on hands and knees), with me as your score rater. After one week you will return to the same location as your first visit for the second visit. You will be tested using the same test as your first visit. You may ask questions at any time. If at any time during the study you would like to stop participating, you may do so. You are not required to complete the study.

If you have any uncontrolled cardiovascular disease, uncontrolled high blood pressure, any type of limb deformity, use a mobility aid such as a cane or walker to stand or walk, or report any injury or pain that could affect your performance on the tests being used, you will not be able to participate at this time.

Purpose: The purpose of this research study is to test the reliability of specific functional movement tests as a measure of functional performance for adults ages 50 years and older. The effects of variables such as age, BMI, gender, body fat percentage, and physical activity questionnaire scores on your test scores will also be evaluated. A testing kit specific to the functional movement test will be used to test each participant and I will be recording your scores.

Procedure: The research procedures will consist of your voluntary involvement in two sessions. For the first session, you will be given information about your participation in the study, what you need to do as a participant, and a medical history form will be completed. Resting blood pressure, resting heart rate, weight (kg), height (m), body fat percentage, and a physical activity questionnaire will also be taken at this time. You will then have your functional performance tested with functional movement tests. After one week you will return and perform the test again. Your participation will take a total of approximately 1 hour. This will break down to 20 minutes for information and demographic measures and 20 minutes for each testing session. During the first visit you and I will sit down and go over the informed consent. We will go over each section in detail. You may ask questions at anytime and I will answer them to your
satisfaction. After you have been informed, you can either agree to participate, or not. If you decide to participate you will sign the informed consent and a copy will be given to you. There is a chance that you will be filmed for reliability purposes and you will be informed if you were chosen randomly to be filmed. A separate consent form asking for your permission to be filmed will be provided, and you will either agree, or not. If you do not want to be filmed, this will not affect your participation in the remainder of the study. After the informed consent you will complete a medical history questionnaire and will have your resting blood pressure, resting heart rate, weight (kg), height (m), and body fat percentage measured. You will then fill out a physical activity questionnaire. There will also be an opportunity for you to become familiar with the movements used in the test that will be scored. You will then perform the functional movement tests. After completion you will schedule an appointment time for your second session. The first and second session will be scheduled 5 – 7 days apart from each other. An explanation of each movement is given below:

- Squat down and back up. If you are unstable while performing the movement, equipment may be used to help you complete the task.

- Step over an elastic hurdle that comes up to the bottom of your knee with one foot and bring the same foot back over the hurdle to where it started. This will be repeated with the opposite leg.

- Step forward with one foot, moving in a downward motion until your thigh is parallel with the floor. Bring forward foot back to return to a standing position. This will be repeated with the opposite leg.

- Make a fist with both hands and bring one arm behind your head as far as possible. Bring your opposite arm behind your back and bring your fists as close together as possible. This will be repeated with your arms performing the opposite movement.

- Place palm of your hand on the opposite shoulder. Raise your elbow as high as possible with your hand remaining in contact with your shoulder.

- While on the floor, lay on your back with your arms at your sides. Raise one leg as high as you can, keeping your knee straight. Your other leg should remain down and straight. This will be repeated with the opposite leg.

- While on the floor, lay on your stomach with the balls of your feet touching the floor. Have your hands be palm down on the floor. If you are a man, have your thumbs lined up with the top of your forehead. If you are a woman, have your thumbs lined up with your chin. Keeping your knees and hips straight, press up your body into a pushup position (up on the balls of your feet and hands). You starting hand position can be changed if needed.
with the top of your forehead. If you are a woman, have your thumbs lined up with your chin. Keep your hips in contact with the floor and press up with your hands.

- Begin in a position where you are on your hands and knees. At the same time, extend one arm forward while straightening the same sided leg behind you. Keeping the arm and leg in the air, bring the extended leg and arm together, touching knee to elbow. This will be repeated with the opposite leg and arm.

- Begin in a position where you are on your hands and knees. Move into a position to where your buttock touches. Keep your hands out in front of you, with your arms straight and hands flat on the floor.

For both sessions you will be asked to not consume alcohol, participate in vigorous exercise, and eat, drink, or smoke 2-3 hours prior to testing. Water and snacks (pretzels, granola bars, fruit, etc.) will be offered after you complete the measurement for body fat percentage. You will also be advised to consume your normal amounts of caffeine and dress in form fitting clothes for the test. Testing will be done in the Exercise Physiology Lab, or other fitness facility and will consist of seven tasks to test your functional performance. Each of the tasks will be done three times and will be scored by me. This process will last approximately 20 minutes.

The second session will follow the exact same protocol as the first session.

**Risks:** As with any form of physical activity there are associated risks such as cardiovascular events (heart attack, stroke, and death), muscle weakness, shortness of breath, and muscle pain. Though risks are possible with participation, those risks are no greater than what you experience in your everyday life.

There will always be another individual present (graduate student or advisor) during testing. We will be First Aid and CPR certified. If you experience any shortness of breath or muscle pain there will be chairs and exercise mats that you can sit and/or lie on. You will be asked to stay in the gym so the investigator can monitor you until your symptoms go away (after about 15 or 20 minutes). In the unlikely event of symptoms do not go away, or any other serious, physical injury, immediate medical treatment will be obtained at Wood County Hospital, Bowling Green, Ohio. The cost of such treatment will be at your expense.

**Benefits:** The benefits for your participation in this study are that you will have your Body Mass Index (BMI), resting blood pressure, and resting heart rate measured. You will also receive your scores from the functional movement testing. These scores can help evaluate pain, the different strategies you might use to perform a task because of the pain, and if you have unstable movements. It can then be determined where on your body that unstableness is coming from. With your results an individual functional movement exercise program can be made by any exercise specialist.

In terms of future research, your participation will help evaluate whether the tests we used could be a reliable assessment of functional performance in older adults. The test has not been show to be reliable in older adults and this could be a useful tool in evaluating functional performance.
All data and information will be given to you when you have finished the study, or if you decide to stop participating, at a time that you and the investigator can review your data with you. You are encouraged to ask questions concerning your results in order to be fully informed and maximize your benefits.

**Confidentiality:** Information you provide will remain confidential and your identity will not be revealed. Any data collected will be stored on a password protected computer and/or flash drive that will remain in a locked room. Only myself, as the primary investigator, and my advisor will have access to this information. Individual results will be identified by a numerical code and will be combined with other subjects’ data for summary and analysis. Again, your name and any other identity-revealing information will not be stored on the computer and/or flash drive. Your identity will not be revealed in any published results.

**Voluntary Participation:** Your participation in this study is voluntary, and you are not required to answer any questions that you do not feel comfortable answering or do any of the tasks involved with the study. You can stop your participation in this study at any time. If you have any relationship with Bowling Green State University, please be aware that your decision to participate or not will have no impact on that relationship.

**Contact Information:** If you have any questions or comments about this study, you can contact me, Melissa Fawcett at 330-591-1088 or mafawce@bgsu.edu, or my advisor, Dr. Lynn Darby, at 419-372-6903 or ldarby@bgsu.edu. If you have questions about the conduct of this study or your rights as a research participant, you may contact the Chair, Human Subjects Review Board, Bowling Green State University, 419 372-7716 or hsr@bgsu.edu.

**Authorization:** I have read this document and the study has been explained to me. I have been informed and have had all of my questions answered. I volunteer to participate in this study. I know that I will receive a copy of this informed consent.

____________________________________________________________________  __________
Participant’s Signature                                     Date

____________________________________________________________________
Printed name

Melissa A. Fawcett, B.S.
Graduate Assistant
124 Eppler South, BGSU
O: 419-372-0212
C: 330-591-1088
mafawce@bgsu.edu
APPENDIX E: ANTHROPOMETRIC AND RESTING MEASURES
RECORDING FORM

Participant #: __________

Anthropometric and Resting Measurements

Weight _______________ lbs. _______________ kg

Height ________________ in ________________ m

BMI _______________ kg/m$^2$

Resting HR _______________ bpm

Resting Blood Pressure _______________ mmHg
Body Composition

<table>
<thead>
<tr>
<th></th>
<th>Values</th>
<th>Lean Body Mass</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Body Water</td>
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</tr>
<tr>
<td>Dry Lean Mass</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Body Fat Mass</td>
<td></td>
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</tbody>
</table>

Body Composition Analysis

<table>
<thead>
<tr>
<th></th>
<th>Under</th>
<th>Normal</th>
<th>Over</th>
<th>UNIT</th>
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<tbody>
<tr>
<td>Weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skeletal Muscle Mass</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body Fat Mass</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Body Composition

Body composition testing is the process of measuring the components of your body, in short what you're made of. Weight alone is not a clear indication of good health because it does not distinguish how many pounds are fat and how many pounds are lean body mass. By regularly monitoring your Body Fat, and Muscle Mass or muscular development, you can understand how your diet, lifestyle and exercise regime are influencing your body composition. Knowing what's working for you can help you target and reach your wellness, appearance and longevity goals.

Body Composition Analysis

What we're made of impacts our health, appearance and our capabilities. Too much Body Fat increases our risk of developing diseases such as diabetes, heart disease and cancer. Carrying too much weight places undue strain on our joints, heart and vital organs. Ideally, the Skeletal Muscle Mass graph to the left should reach or surpass the normal range and the Body Fat Mass graph should be falling within the Normal Range.

Obesity Analysis

<table>
<thead>
<tr>
<th></th>
<th>Under</th>
<th>Normal</th>
<th>Over</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI Body Mass Index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBF Percentage of Body Fat</td>
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</tr>
</tbody>
</table>

\[
\text{BMI} = \frac{\text{Weight}}{\text{Height}^2}, \text{m}^2
\]

\[
\text{PBF} = \frac{\text{Fat}}{\text{Weight}} \times 100
\]

Segmental Lean Analysis

Use this section to understand how your muscle mass is distributed throughout your body. Your segmental distribution could indicate that you have maintained or developed muscle mass proportionately. You may discover that you have a tendency toward a disproportionate amount of muscle in your legs or your trunk and arms. Genetically there are inherent tendencies toward more or less musculature in any of these areas. It's true that you can't "spot lose" fat but you can develop or maintain certain muscles by using them more.

Basal Metabolic Rate

<p>| |</p>
<table>
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<tbody>
<tr>
<td>BMR</td>
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</table>

The BMR is the minimal number of calories needed to sustain life at a resting state. BMR is directly correlated with Lean Body Mass. With age muscle depletes and BMR steadily decreases.
The Functional Movement Screen

SCORING SHEET

<table>
<thead>
<tr>
<th>NAME</th>
<th>DATE</th>
<th>DOB</th>
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<tbody>
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</table>

ADDRESS

CITY, STATE, ZIP

PHONE

SCHOOL/AFFILIATION

SSN | HEIGHT | WEIGHT | AGE | GENDER
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PRIMARY SPORT | PRIMARY POSITION
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HAND/LEG DOMINANCE | PREVIOUS TEST SCORE
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<thead>
<tr>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>TEST</th>
<th>RAW SCORE</th>
<th>FINAL SCORE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEEP SQUAT</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HURDLE STEP</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INLINE LUNGE</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHOULDER MOBILITY</td>
<td>L</td>
<td></td>
<td></td>
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<tr>
<td>R</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>IMPINGEMENT CLEARING TEST</td>
<td>L</td>
<td></td>
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<tr>
<td>R</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACTIVE STRAIGHT-LEG RAISE</td>
<td>L</td>
<td></td>
<td></td>
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<tr>
<td>R</td>
<td></td>
<td></td>
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<tr>
<td>TRUNK STABILITY PUSHUP</td>
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<tr>
<td>PRESS-UP CLEARING TEST</td>
<td></td>
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<tr>
<td>ROTARY STABILITY</td>
<td>L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>POSTERIOR ROCKING CLEARING TEST</td>
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<td></td>
<td></td>
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<tr>
<td>TOTAL</td>
<td></td>
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</tbody>
</table>

**Raw Score:** This score is used to denote right and left side scoring. The right and left sides are scored in five of the seven tests and both are documented in this space.

**Final Score:** This score is used to denote the overall score for the test. The lowest score for the raw score (each side) is carried over to give a final score for the test. A person who scores a three on the right and a two on the left would receive a final score of two. The final score is then summarized and used as a total score.
APPENDIX H: VERBAL INSTRUCTIONS FOR FUNCTIONAL MOVEMENT SCREEN

APPENDIX 10

VERBAL INSTRUCTIONS FOR THE FUNCTIONAL MOVEMENT SCREEN

The following is a script to use while administering the FMS. For consistency throughout all screens, this script should be used during each screen. The bold words represent what you should say to the client.

Please let me know if there is any pain while performing any of the following movements.

DEEP SQUAT

EQUIPMENT NEEDED: Dowel

INSTRUCTIONS

- Stand tall with your feet approximately shoulder width apart and toes pointing forward.
- Grasp the dowel in both hands and place it horizontally on top of your head so your shoulders and elbows are at 90 degrees.
- Press the dowel so that it is directly above your head.
- While maintaining an upright torso, and keeping your heels and the dowel in position, descend as deep as possible.
- Hold the descended position for a count of one, then return to the starting position.
- Do you understand the instructions?

Score the movement.
The client can perform the move up to three times total if necessary.
If a score of three is not achieved, repeat above instructions using the 2 x 6 under the client’s heels.
HURDLE STEP

EQUIPMENT NEEDED: DOWEL, HURDLE

INSTRUCTIONS

- Stand tall with your feet together and toes touching the test kit.
- Grasp the dowel with both hands and place it behind your neck and across the shoulders.
- While maintaining an upright posture, raise the right leg and step over the hurdle, making sure to raise the foot towards the shin and maintaining foot alignment with the ankle, knee and hip.
- Touch the floor with the heel and return to the starting position while maintaining foot alignment with the ankle, knee and hip.
- Do you understand these instructions?

Score the moving leg.
Repeat the test on the other side.
Repeat two times per side if necessary.

INLINE LUNGE

EQUIPMENT NEEDED: DOWEL, 2x6

INSTRUCTIONS

- Place the dowel along the spine so it touches the back of your head, your upper back and the middle of the buttocks.
- While grasping the dowel, your right hand should be against the back of your neck, and the left hand should be against your lower back.
- Step onto the 2x6 with a flat right foot and your toe on the zero mark.
- The left heel should be placed at __________ mark. This is the tibial measurement marker.
- Both toes must be pointing forward, with feet flat.
- Maintaining an upright posture so the dowel stays in contact with your head, upper back and top of the buttocks, descend into a lunge position so the right knee touches the 2x6 behind your left heel.
- Return to the starting position.
- Do you understand these instructions?

Score the movement.
Repeat the test on the other side.
Repeat two times per side if necessary.
SHOULDER MOBILITY

EQUIPMENT NEEDED: MEASURING DEVICE

INSTRUCTIONS

- Stand tall with your feet together and arms hanging comfortably.
- Make a fist so your fingers are around your thumbs.
- In one motion, place the right fist over head and down your back as far as possible while simultaneously taking your left fist up your back as far as possible.
- Do not “creep” your hands closer after their initial placement.
- Do you understand these instructions?

Measure the distance between the two closest points of each fist.
Score the movement.
Repeat the test on the other side.

ACTIVE SCAPULAR STABILITY (SHOULDER CLEARING)

INSTRUCTIONS

- Stand tall with your feet together and arms hanging comfortably.
- Place your right palm on the front of your left shoulder.
- While maintaining palm placement, raise your right elbow as high as possible.
- Do you feel any pain?

Repeat the test on the other side.
ACTIVE STRAIGHT-LEG RAISE

EQUIPMENT NEEDED: DOWEL, MEASURING DEVICE, 2X6

INSTRUCTIONS

- Lay flat with the back of your knees against the 2x6 with your toes pointing up.
- Place both arms next to your body with the palms facing up.
- Pull the toes of your right foot toward your shin.
- With the right leg remaining straight and the back of your left knee maintaining contact with the 2x6, raise your right foot as high as possible.
- Do you understand these instructions?

Score the movement.
Repeat the test on the other side.

TRUNK STABILITY PUSHUP

EQUIPMENT NEEDED: NONE

INSTRUCTIONS

- Lie face down with your arms extended overhead and your hands shoulder width apart.
- Pull your thumbs down in line with the ___ (forehead for men, chin for women).
- With your legs together, pull your toes toward the shins and lift your knees and elbows off the ground.
- While maintaining a rigid torso, push your body as one unit into a pushup position.
- Do you understand these instructions?

Score the movement.
Repeat two times if necessary.
Repeat the instructions with appropriate hand placement if necessary.

SPINAL EXTENSION CLEARING

INSTRUCTIONS

- While lying on your stomach, place your hands, palms down, under your shoulders.
- With no lower body movement, press your chest off the surface as much as possible by straightening your elbows.
- Do you understand these instructions?
- Do you feel any pain?
ROTOR STABILITY

EQUIPMENT NEEDED: 2 X 6

INSTRUCTIONS

- Get on your hands and knees over the 2x6 so your hands are under your shoulders and your knees are under your hips.
- The thumbs, knees and toes must contact the sides of the 2x6, and the toes must be pulled toward the shins.
- At the same time, reach your right hand forward and right leg backward, like you are flying.
- Then without touching down, touch your right elbow to your right knee directly over the 2x6.
- Return to the extended position.
- Return to the start position.
- Do you understand these instructions?

Score the movement.
Repeat the test on the other side.
If necessary, instruct the client to use a diagonal pattern of right arm and left leg.
Repeat the diagonal pattern with left arm and right leg.
Score the movement.

SPINAL FLEXION CLEARING

INSTRUCTIONS

- Get on all fours, and rock your hips toward your heels.
- Lower your chest to your knees, and reach your hands in front of your body as far as possible.
- Do you understand these instructions?
- Do you feel any pain?
APPENDIX I: FUNCTIONAL MOVEMENT SCREEN SCORING CRITERIA

FMS SCORING CRITERIA

DEEP SQUAT

- **3**
  - Upper torso is parallel with tibia or toward vertical
  - Femur below horizontal
  - Knees are aligned over feet
  - Dowel aligned over feet

- **2**
  - Upper torso is parallel with tibia or toward vertical
  - Femur is below horizontal
  - Knees are aligned over feet
  - Dowel is aligned over feet
  - Heels are elevated

- **1**
  - Tibia and upper torso are not parallel
  - Femur is not below horizontal
  - Knees are not aligned over feet
  - Lumbar flexion is noted

The athlete receives a score of zero if pain is associated with any portion of this test. A medical professional should perform a thorough evaluation of the painful area.
The athlete receives a score of zero if pain is associated with any portion of this test. A medical professional should perform a thorough evaluation of the painful area.
INLINE LUNGE

1

Loss of balance is noted

2

Dowel contacts not maintained | Dowel does not remain vertical | Movement noted in torso
Dowel and feet do not remain in sagittal plane | Knee does not touch behind heel of front foot

3

Dowel contacts maintained | Dowel remains vertical | No torso movement noted
Dowel and feet remain in sagittal plane | Knee touches board behind heel of front foot

*The athlete receives a score of zero if pain is associated with any portion of this test. A medical professional should perform a thorough evaluation of the painful area.*
RELIABILITY OF THE FMS FOR OLDER ADULTS

SHOULDER MOBILITY

3
Fists are within one hand length

2
Fists are within one-and-a-half hand lengths

1
Fists are not within one and half hand lengths

The athlete will receive a score of zero if pain is associated with any portion of this test. A medical professional should perform a thorough evaluation of the painful area.

CLEARING TEST
Perform this clearing test bilaterally. If the individual does receive a positive score, document both scores for future reference. If there is pain associated with this movement, give a score of zero and perform a thorough evaluation of the shoulder or refer out.
ACTIVE STRAIGHT-LEG RAISE

Vertical line of the malleolus resides between mid-thigh and ASIS
The non-moving limb remains in neutral position

Vertical line of the malleolus resides between mid-thigh and joint line
The non-moving limb remains in neutral position

Vertical line of the malleolus resides below joint line
The non-moving limb remains in neutral position

The athlete will receive a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.
3

The body lifts as a unit with no lag in the spine

Men perform a repetition with thumbs aligned with the top of the head
Women perform a repetition with thumbs aligned with the chin

2

The body lifts as a unit with no lag in the spine
Men perform a repetition with thumbs aligned with the chin | Women with thumbs aligned with the clavicle

1

Men are unable to perform a repetition with hands aligned with the chin
Women unable with thumbs aligned with the clavicle

The athlete receives a score of zero if pain is associated with any portion of this test.
A medical professional should perform a thorough evaluation of the painful area.

SPINAL EXTENSION CLEARING TEST

Spinal extension is cleared by performing a press-up in the pushup position. If there is pain associated with this motion, give a zero and perform a more thorough evaluation or refer out. If the individual does receive a positive score, document both scores for future reference.
Rotary Stability

1. Inability to perform a diagonal repetition

2. Performs a correct diagonal repetition

3. Performs a correct unilateral repetition

The athlete receives a score of zero if pain is associated with any portion of this test. A medical professional should perform a thorough evaluation of the painful area.

**Spinal Flexion Clearing Test**

Spinal flexion can be cleared by first assuming a quadruped position, then rocking back and touching the buttocks to the heels and the chest to the thighs. The hands should remain in front of the body, reaching out as far as possible. If there is pain associated with this motion, give a zero and perform a more thorough evaluation or refer out. If the individual receives a positive score, document both scores for future reference.