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Robert A. (Tony) English  
*University of Kentucky*

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ABSTRACT OF DISSERTATION

Robert A. (Tony) English

The Graduate School  
University of Kentucky  
2008

CLINICAL FUNCTIONAL TESTING IN PEOPLE 30-60 YEARS OLD.  
EXPECTED PERFORMANCE VALUES AND CORRELATIONS TO MUSCLE FITNESS  
AND ACTIVITY LEVEL

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ABSTRACT OF DISSERTATION

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A dissertation submitted in partial fulfillment of the requirements  
for the degree of Doctor of Philosophy in Gerontology  
in the College of Public Health at the University of Kentucky

By

Robert A. (Tony) English  
Lexington, Kentucky

Co-Directors: Dr. Terry R. Malone, Professor of Rehabilitation Sciences and  
Dr. Lori S. Gonzalez, Professor of Rehabilitation Sciences

Lexington, Kentucky

2008

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## ABSTRACT OF DISSERTATION

### CLINICAL FUNCTIONAL TESTING IN PEOPLE 30-60 YEARS OLD. EXPECTED PERFORMANCE VALUES AND CORRELATIONS TO MUSCLE FITNESS AND ACTIVITY LEVEL

Activity and fitness levels decline through the years from 30 to 60 years of age. Minimal research is available regarding functional assessment tools in this population. Reliable functional tools are needed to reintroduce individuals to appropriate physical activity levels following an injury and to maintain high levels of participation through their lifespan.

The purposes of this study were multiple: 1) determine if three functional tests correspond with neuromotor fitness levels, 2) establish a model of functional tests, activity levels and descriptive data that distinguishes the most from the least fit, 3) describe expected mean functional test performances, and 4) demonstrate the reliability of the three functional tests in a sample of 30-60 year olds. 63 females and 38 males completed activity surveys, a neuromotor fitness test, the star excursion balance test (SEBT), the four square step test (FSST), and the Biering-Sorensen test of trunk extensor muscle endurance. Moderate to high reliability of the functional tests was determined with 29 subjects. The SEBT ( $r=.97$ ), FSST ( $r=.88$ ) and the Biering-Sorensen test ( $r=.64$ ) were reliable. All functional tests were able to distinguish between the most fit and least fit with regards to the fitness tests. A model of the body mass index and the FSST predicted 25% of the variance in fitness level. Functional test means are reported by 10-year age groups and represent expected performance values.

Health care professionals can use this information to compare their patients to this group of healthy individuals. This will allow them to have some idea of how well a person with an injury is performing relative to a healthy individual. Additionally the combination of a person's BMI plus their FSST gives the health care professional some information about an individual level of neuromuscular fitness so that the health care professional can guide their patients toward an appropriate level of physical activity after their injury or illness.

**KEYWORDS:** functional tests, middle aged adults, neuromotor fitness tests, star excursion balance test, four square step test

Robert A. English

April 7, 2008

CLINICAL FUNCTIONAL TESTING IN PEOPLE 30-60 YEARS OLD.  
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AND ACTIVITY LEVEL

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DISSERTATION

Robert A. (Tony) English

The Graduate School  
University of Kentucky  
2008



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EXPECTED PERFORMANCE VALUES AND CORRELATIONS TO MUSCLE FITNESS  
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DISSERTATION

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## TABLE OF CONTENTS

ACKNOWLEDGEMENTS .....	III
TABLE OF CONTENTS .....	IV
LIST OF TABLES.....	VI
LIST OF FIGURES.....	VII
LIST OF FILES.....	VIII
CHAPTER ONE : A VOID OF RELEVANT CLINICAL FUNCTIONAL TESTS .....	1
PURPOSES.....	2
OVERVIEW .....	3
OPERATIONAL DEFINITIONS .....	3
<i>Subject inclusion criteria:</i> .....	3
<i>Subject exclusion criteria:</i> .....	3
<i>Fitness Performance:</i> .....	4
<i>Fitness level:</i> .....	6
<i>Clinical Functional Tests:</i> .....	6
ASSUMPTIONS .....	9
LIMITATIONS .....	10
CHAPTER TWO: RELIABILITY OF CLINICAL FUNCTIONAL TOOLS IN A POPULATION OF PEOPLE 30-60 YEARS OF AGE.....	11
OVERVIEW AND REVIEW OF RELATED RESEARCH .....	11
PURPOSE AND RESEARCH HYPOTHESIS.....	13
METHODOLOGY.....	13
<i>Subjects</i> .....	13
<i>Procedures</i> .....	14
<i>Data analysis</i> .....	18
RESULTS .....	19
DISCUSSION.....	20
STUDY LIMITATIONS .....	23
CONCLUSIONS .....	24
CHAPTER THREE: TYPICAL PERFORMANCE VALUES ON THREE CLINICAL FUNCTIONAL TESTS IN SUBJECTS 30-60 YEARS OLD.....	25
OVERVIEW AND REVIEW OF RELATED RESEARCH.....	25
PURPOSES AND RESEARCH HYPOTHESIS.....	27
METHODOLOGY.....	28
<i>Subjects</i> .....	28
<i>Procedures</i> .....	30
<i>Data analysis</i> .....	31
RESULTS .....	31
DISCUSSION.....	35
STUDY LIMITATIONS .....	39
CONCLUSIONS .....	39

CHAPTER FOUR: RELATIONSHIPS AMONG MUSCLE FITNESS, CLINICAL FUNCTIONAL TESTS AND SELF REPORTED ACTIVITY LEVELS IN 30-60 YEAR OLD HEALTHY, TYPICAL ADULTS .....	40
OVERVIEW AND REVIEW OF RELATED RESEARCH.....	40
PURPOSES AND RESEARCH HYPOTHESES .....	43
METHODOLOGY.....	43
<i>Subjects</i> .....	43
<i>Procedures</i> .....	44
<i>Data Analysis</i> .....	50
RESULTS .....	51
DISCUSSION.....	54
STUDY LIMITATIONS .....	59
CONCLUSIONS .....	59
CHAPTER FIVE: SUMMARY.....	61
OVERVIEW.....	61
PRIMARY PURPOSES AND DATA SUMMARY .....	61
VALUE OF THE CLINICAL TESTS CONSIDERING THE AGING POPULATION.....	64
CONCLUDING COMMENTS.....	67
APPENDICES .....	69
APPENDIX A. RECRUITMENT FLYER.....	69
APPENDIX B. CONSENT TO PARTICIPATE IN THE RESEARCH STUDY.....	70
APPENDIX C. INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE- SHORT FORM.....	74
APPENDIX D. STAGES OF CHANGE OF BEHAVIOR IN EXERCISE TOOL.....	76
APPENDIX E. SELF-EFFICACY AND EXERCISE TOOL .....	77
REFERENCES.....	78
VITA .....	85

## LIST OF TABLES

Table 2.1. Comparison of reliability subject group and whole group.....	14
Table 2.2. Test: Retest Means, Standard Deviations, ICC values, 95% CI .....	20
Table 2.3. Comparison of Day One and Day Two data.....	20
Table 3.1. Descriptive statistics of all subjects.....	28
Table 3.2. Descriptive statistics for all female subjects.....	29
Table 3.3. Descriptive statistics for all male subjects.....	29
Table 3.4. Descriptive statistics for all subjects by age group.....	30
Table 3.5. Performance data for whole group.....	32
Table 3.6. Performance data for all females .....	32
Table 3.7. Performance data for all males .....	32
Table 3.8. Performance data for all subjects by age group.....	33
Table 3.9. Typical performance values by percentiles for subjects 30-39 years old.....	33
Table 3.10. Typical performance values by percentiles for subjects 40-49 years old.....	34
Table 3.11. Typical performance values by percentiles for subjects 50-60 years old.....	34
Table 3.12. Comparison of performance data between age groups 30 to 50 .....	34
Table 3.13. Comparison of performance data among all age groups .....	35
Table 3.14. Comparison of middle aged adults SEBT performance with that reported by Hertel et al, 2006.....	36
Table 4.1. Descriptive statistics of the general demographic characteristics.....	44
Table 4.2. Scoring criteria for the International Physical Activity Questionnaire. ....	48
Table 4.3. Stages of change in exercise behavior and corresponding descriptions .....	49
Table 4.4. Descriptive data for all self-report activity and fitness tools.....	51
Table 4.5. Pearson Product Moment Correlations among all final variables.....	52
Table 4.6. Variables selected for analysis in the regression model with VIFs.....	53
Table 4.7. Results of the one-way ANOVA with Bonferroni adjustment.....	53
Table 4.8. Regression model statistics for each individual variable, the all variable model and model of best fit with regard to fitness composite score prediction.....	54
Table 4.9. Fitness test scores compared to the 50th percentile of ACSM norms .....	57
Table 5.1. Comparison of reliability between studies for each clinical functional test...	63
Table 5.2. Correlations between key variables and all fitness composite scores .....	67

## LIST OF FIGURES

Figure 1.1. Push-ups (modified, from knees for all women).....	4
Figure 1.2. Push-ups (standard push-up for all men).....	5
Figure 1.3. Curl-ups. (note the tape marks at 8 and 12 cm from starting position) .....	5
Figure 1.4. Sit and reach with feet dorsiflexed to neutral and knees straight.....	6
Figure 1.5. Star excursion balance test (Left Anterior Medial, Left Posterior Medial) .....	7
Figure 1.6. Four square step test (view from behind subject; white arrows show beginning path, red arrows show return to starting position) .....	8
Figure 1.7. Biering-Sorenson trunk muscle endurance test .....	8
Figure 2.1. Four square step test (view from behind subject) .....	15
Figure 2.2. Star excursion balance test (Left Anterior Medial, Left Posterior Medial) ....	17
Figure 2.3. Biering-Sorenson trunk muscle endurance test .....	18
Figure 4.1. Curl-ups (note the tape marks at 8 and 12 cm from starting position) .....	45
Figure 4.2. Push-ups (modified, from knees for all women).....	46
Figure 4.3. Push-ups (men performed a standard push-up) .....	46
Figure 4.4. Sit and reach with feet dorsiflexed to neutral and knees straight.....	47

## LIST OF FILES

1. English Dissertation 4-14-08

## CHAPTER ONE: A VOID OF RELEVANT CLINICAL FUNCTIONAL TESTS

People aged 30-60 represent about 42% of the United States population according to the 2000 census information, are a population thought to be in transition from greater activity to lesser, and are reported to manifest joint and muscle strength changes observed in a typically aging population (Krems, Luhrmann, & Neuhauser-Berthold, 2004; Pober, Freedson, Kline, McInnis, & Rippe, 2002; "United States Age Distribution," 2007). As changes in activity levels continue through life, functional testing of this age group becomes an important component of physical therapy evaluation in determining if a client is performing at an expected level when the therapist and patient are considering a return to or modification of the patient's activity levels. The situation in which a middle aged person does not return to pre-injury activity level or returns without adequate rehabilitation must be avoided to minimize the possibility of re-injury. Functional testing in younger and older populations has been used for many years to help rehabilitation specialists document the status of patients and determine when to allow their return to work or sport activity (Augustsson, Thomee, & Karlsson, 2004; Barber-Westin, Noyes, & McCloskey, 1999; Eastlack, Axe, & Snyder Mackler, 1999). Much has been published regarding high intensity lower extremity functional tests developed to assess readiness for activity after injury and subsequent rehabilitation (Augustsson et al., 2004; Barber-Westin et al., 1999; Eastlack et al., 1999; Fitzgerald, Lephart, Hwang, & Wainner, 2001; Greenberger & Paterno, 1995; Juris et al., 1997; F R Noyes & Barber-Westin, 1997; O'Donnell, Thomas, & Marks, 2006; Petschnig, Baron, & Albrecht, 1998; Wilk, Romaniello, Soscia, Arrigo, & Andrews, 1994). Likewise, functional testing of older adults related to fall risk has been studied and tests in this area have been developed that are lower in impact on these subjects with less tolerance of activities that stress the joints of the lower extremities and spine (Dite & Temple, 2002; Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995; Steffen, Hacker, & Mollinger, 2002; Whitney, Marchetti, Morris, & Spario, 2007).

Since the middle aged population has different physical characteristics than older and younger counterparts, it may not be appropriate to generalize testing results from younger or older populations to this age group. Choosing functional tests for this population that can be standardized and used across diagnoses requires the selection of tests challenging and sensitive enough to be utilized with confidence. These tests must be reliable with this population and able to accurately determine valid outcomes.



Results from appropriate clinical functional tests may allow clinicians to use one or two tests for information related to patient status instead of more extensive, time consuming tests. More specific tests for this population may give rehabilitation specialists information regarding the relationships between function and impairment and clinical functional tests and function in the community or work place. With typical or descriptive performance values established within this middle aged population, performance in standard functional tests may also be used to compare values between patient performance and the expected performance and also be used as a predictor of future activity levels serving as possible motivation for people to remain active and prevent declining participation throughout aging.

### **Purposes**

For the above reasons, several lower impact, but challenging clinical functional tests have been selected to be used with a population of middle aged men and women. These tests have been reported in the literature to be reliable and valid with younger and older age groups, but not with the middle aged population. This study will compare performance on these functional tests and compare the performance to neuromotor fitness performance and self reported activity and exercise levels. Therefore, the primary purposes of this dissertation were to:

1. Determine if the star excursion balance test (SEBT), four square step test (FSST) and Biering-Sorensen trunk extensor muscle endurance test (BS) correspond to the neuromotor fitness performance levels of subjects (30-60 years old) as determined by performance on a series of muscle fitness tests. (Hypothesis: Better performance on each test will correspond to the highest one-third and poorer performance will correspond to the lowest one-third of fitness level demonstrated.)
2. Determine if any set of demographic information, functional test performances, or self reported activity levels exists that distinguishes the highest from the lowest one-third of participants in neuromotor fitness performance. (Hypothesis: Subjects who report the highest levels of activity and exercise and who perform at the highest levels on the clinical functional tests will demonstrate higher levels of neuromotor fitness.)
3. Determine a set of expected values in the performance of the 2 lower extremity functional tests (SEBT and FSST) and the trunk extensor muscle endurance test (Biering-Sorensen) for subjects in 10-year age groupings within the sample population. (Hypothesis: Descriptive values will be significantly different between the youngest and oldest groups.)

4. Demonstrate the reliability of the two lower extremity functional tests (star excursion balance test (SEBT) and four square step test (FSST)) and the Biering-Sorensen trunk extensor muscle endurance test (BS) in a population of subjects ranging in age from 30-60 years old. (Hypothesis: There will be a high to very high statistically significant correlation in test retest data collected using all tests.)

### **Overview**

This document is divided into five chapters. The first introduces the three part study and its purposes. The next three chapters are written as individual research papers. Chapter Two will establish the intratester test-retest reliability of the clinical tests used in the study. The third chapter will describe the typical values for each of the clinical tests studied. Since the study is limited in scope, norms cannot be established, but preliminary typical or expected values can be determined based on the performances in this study. These typical values will be documented in cohorts based on age group and sex. Typical values for the entire group and all men and women will be described as well as values for men and women ages 30-39, 40-49 and 50-60. Chapter Four will be used to demonstrate that the functional tests show accuracy in identifying the highest and lowest performers in the neuromotor fitness tests. This chapter will also include analysis of which tests, self reported activity levels, and demographic information represent the best model that correlates with the people who demonstrate the highest and lowest fitness levels. Chapter Five will summarize the total project and make conclusions and recommendations based on the findings.

### **Operational Definitions**

**Subject Inclusion Criteria:** Study subjects were asymptomatic, typical, healthy people that range in age from 30-60 years old. An attempt was made to recruit approximately even numbers of men and women. There was no attempt to exclude anyone based on race or ethnicity.

**Subject Exclusion Criteria:** Subjects were excluded if they had any condition resulting in balance impairments, acute lower extremity or back injury in the previous month, or reported pain in the lower extremity or back that limited ability to walk at the time of data collection. Anyone with a cardiac history or hypertension who had moderate activity restrictions was also excluded. These exclusion criteria were well defined in all advertisements for volunteers and resulted in very accurate self selections with no one who volunteered being excluded.

**Fitness Performance:** A measure of muscle fitness was used as the neuromotor fitness performance standard. This measure was based on three simple fitness tests used in the Canadian Fitness Survey and their corresponding normal performance values. The tests included total number of curl-ups performed without rest up to 75, total number of push-ups performed without rest, and a sit and reach test of muscle flexibility done in a long sitting position (ACSM's *Guidelines for Exercise Testing and Prescription*, 2000). (Figures 1.1-1.4) Each total was compared to the performance of the group in the 50<sup>th</sup> percentile for the particular age and sex and a "fitness score" was assigned. For example, a 35 year old female who performed 10 push-ups would have a score of 0.71 based on her performance of 10 divided by the performance at the 50<sup>th</sup> percentile of those previously studied which was 14. Each of the three tests was scored in this fashion and a total neuromotor fitness performance score was assigned to the individual based on the summation of the comparison of each test. A fitness performance score of three represents someone who is performing at the 50<sup>th</sup> percentile on all three tests for his/her age group and sex.

Figure 1.1. Push-ups (modified, from knees for all women)



Figure 1.2. Push-ups (standard push-up for all men)



Figure 1.3. Curl-ups. (note the tape marks at 8 and 12 cm from starting position)



Figure 1.4. Sit and reach with feet dorsiflexed to neutral and knees straight.



**Fitness Level:** The total population was divided into thirds for purposes of stratifying the highest neuromotor fitness performances from the lowest. A categorical variable was given to each group as follows: the lowest group was assigned a 0, middle group 1 and highest group 2. This was done to enhance meaningful statistical analysis.

**Clinical Functional Tests:** Three clinical tests of balance, coordination, stepping, and muscle endurance were chosen to compare to the level of performance on the fitness tests. The star excursion balance test (SEBT) is a test of dynamic stability and balance requiring the subject to stand on one foot and reach out along a predetermined line as far as possible with the other leg. This test has been studied in populations ranging from 14-35 and over 60, but not in a middle aged population (Hertel, Braham, Hale, & Olmsted-Kramer, 2006; Hertel, Miller, & Denegar, 2000; Kinzey & Armstrong, 1998; Plisky, Rauh, Kaminski, & Underwood, 2006a, 2006b; Stockert & Barakatt, 2005).

The four square step test (FSST) is a test of dynamic balance, coordination, and stepping that has been studied in older adults and established as a good predictor of falls using a cut-off score of minimal performance (Dite & Temple, 2002; Whitney et al., 2007). This low impact dynamic test has yet to be studied with middle aged people.

Finally, the Biering-Sorenson trunk extensor muscle endurance test was used to measure the endurance of the trunk extensor muscles. This has been studied in several

populations, and was used to determine the influence trunk muscle endurance may have in fitness and in performance of the dynamic stability and balance tests. Normal performance values reported will be compared to the values obtained in this study(Keller et al., 2004; Keller, Hellesnes, & Brox, 2001; Latimer, Maher, Refshauge, & Colaco, 1999; Ropponen, Gibbons, Videman, & Battie, 2005). Figures 1.5-1.7 illustrate the testing equipment and positions.

Figure 1.5. Star excursion balance test (Left Anterior Medial, Left Posterior Medial)



Figure 1.6. Four square step test (view from behind subject; white arrows show beginning path, red arrows show return to starting position)

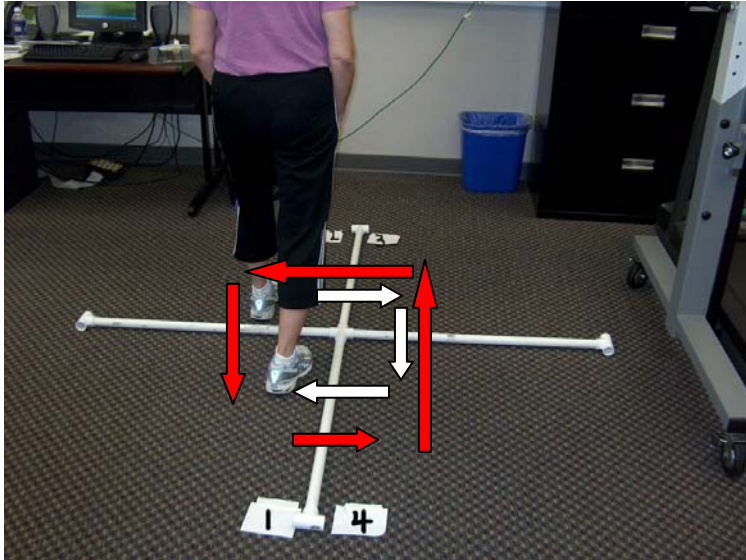
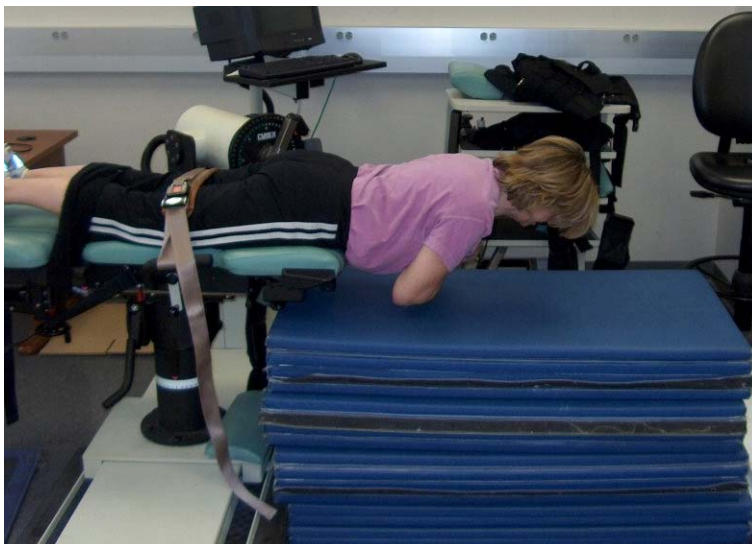


Figure 1.7. Biering-Sorenson trunk muscle endurance test



Three self report scales were used that gave the subjects an opportunity to report perceived activity and exercise levels. The International Physical Activity Questionnaire (IPAQ) was used so subjects could report the minutes in a seven day period they spent in vigorous, moderate and walking activities. This tool has been demonstrated as reliable and valid in 12 countries and several languages worldwide(Craig et al., 2003). The stage of change of exercise behavior (SOC) was used to establish by self report whether a subject was currently exercising three or more days per week, not exercising at all, interested but not exercising or no longer exercising. The score given was based on the stage of change of behavior that corresponded to the statement selected by the subject: 1 = Precontemplation (I do not currently exercise and have no intention to start in the next 6 months), 2 = Contemplation (I do not currently exercise, but am thinking of starting in the next 6 months), 3 = Preparation (I currently exercise some, but not regularly), 4 = Action (I currently exercise regularly, but have done so in the last 6 months), 5 = Maintenance (I currently exercise regularly and have done so for longer than 6 months), and 6 = Relapse (I have exercised regularly in the past, but am not doing so currently). This tool has been used extensively in several subject populations regarding smoking cessation, weight loss and exercise(Laforge et al., 1999; Marcus, Selby, Niaura, & Rossi, 1992; McAuley, Courneya, Rudolph, & Lox, 1994). A self efficacy in exercise scale was also used to establish the confidence a subject had to exercise regularly three days per week in nine different situations that may be considered limiting factors. Each condition was scored by the subject on a 0-10 scale with 10 being absolutely confident they would exercise three days per week in the situation described. The score given for self efficacy in exercise was the sum of the nine individual scores for a total possible range of 0-90. This tool has also been shown to be reliable and valid in its application(de Jong, Hopman-Rock, Tak, & Klazinga, 2004; Elavsky et al., 2005; Marcus et al., 1992).

### **Assumptions**

The following assumptions were made in the data collection phase of the study:

1. All subjects honestly reported medical/injury history and were truly pain free during the activities performed.
2. All subjects honestly reported exercise frequency, activity levels and attitudes toward exercise.
3. All subjects gave their best effort in the performance of all physical tests including the fitness and clinical tests.



4. The volunteer subject pool fairly represents the population in a mid-sized city with a major university.

### **Limitations**

The following study limitations are noted:

1. The volunteer subjects may be those who are more active and interested in exercise and desiring affirmation, which could skew the results of the study.
2. Subjects knew the results of performance levels on the clinical tests after Day One testing and may have given a greater effort on Day Two testing.
3. Despite attempts to minimize the learning effect in the clinical tests, Day Two testing may have been enhanced by subjects learning the tasks.
4. Although the self report surveys included clear instructions and questions from the subjects were answered as needed, some subjects may have misunderstood the directions resulting in inaccurate activity data.

## CHAPTER TWO: RELIABILITY OF CLINICAL FUNCTIONAL TOOLS IN A POPULATION OF PEOPLE 30-60 YEARS OF AGE

### **Overview and Review of Related Research**

As people age, physical strength, flexibility and functional performance decline (Krems et al., 2004; Nitz & Choy, 2004; Poher et al., 2002). In order to select appropriate clinical functional tests, there is a need to acknowledge this decline and select clinical tools that consider the aging body, yet are challenging and sensitive for a particular population. Functional testing of middle age adults has been studied on a limited basis and people in this age group represent a variety of levels of activity (Pratt, Macera, & Blanton, 1999). There is no clear reason for this lack of testing, but some thoughts include: this population is generally healthy and participates adequately in their socially defined roles, they are generally active in mild to moderate amateur activities, and it is not considered important to test their maximal performance abilities.

On the other hand, since younger people perform many physically challenging activities related to work and amateur and professional sports, injury prevention and rehabilitation activities drive research with this population. Return to sport and activity is important for this young age group because the return to high levels of performance is a goal of these clients and their respective teams (Augustsson et al., 2004; Greenberger & Paterno, 1995; Juris et al., 1997; Marx et al., 2001; Mattacola & Dwyer, 2002; F.R. Noyes, Barber, & Mangine, 1991; Wilk et al., 1994). Since functional testing of young athletes is common, these test results can be generalized to the population of younger adults in the same age groupings. Since there is a cost in dollars and time to return this population to their work or sport, there has been a strong drive to determine criteria for safe and effective return to activity.

Many of the tests used with young adults include high impact activities such as a single leg hop for distance, timed 6-meter single leg hop, crossover hop, triple hop and others (Fitzgerald et al., 2001; Gaunt & Curd, 2001; Itoh, Kurosaka, Yoshiya, Ichihashi, & Mizuno, 1998; O'Donnell et al., 2006; Petschnig et al., 1998; Sekiya, Muneta, Ogiuchi, Yagishita, & Yamamoto, 1998; Tsiokanos, Kellis, Jamurtas, & Kellis, 2002). Reported correlations between quadriceps strength performance and these functional tests vary from  $r = .62$  to  $r = .81$  (Greenberger & Paterno, 1995; Tsiokanos et al., 2002; Wilk et al.,

1994). However, these types of tests are often used to help determine return to activity based on performance compared to the subject's uninvolved leg(Augustsson et al., 2004; Fitzgerald, Axe, & Snyder-Mackler, 2000; Fitzgerald et al., 2001; Itoh et al., 1998; Juris et al., 1997). It may be inappropriate to use these high impact tests on middle aged adults who are beginning to show degenerative changes related to aging. However, challenging and sensitive tests need to be developed for use with this subject group to help determine their functional levels and when return to activity is appropriate and safe.

Just as in the younger population, in the older population there is a financial incentive to determine factors that may predict and prevent injury. Older adults are responsible for a very large percentage of health care costs. Falls and their resulting injuries make up a large percentage of these costs(Dite & Temple, 2002; Guralnik et al., 1995; Newton, 2001). Clinical functional tests such as the Berg Balance Scale, Functional Reach test, timed up and go and others are used frequently to help predict the likelihood of falling and to establish a performance standard by which to measure progress in rehabilitation(Dite & Temple, 2002; Newton, 2001; Thomas & Lane, 2005). Although these types of clinical functional tests are valuable with older adults, they may not be challenging or sensitive enough to be used with middle aged adults. They appear to have a significant ceiling effect with younger populations.

Two clinical functional tests have been reported in the literature recently that may have value with the middle aged population. The star excursion balance test (SEBT) has been used with adolescents and younger adults (15-35 years old) and even adults over 65 as a measure of dynamic balance and stability(Gribble, Hertel, Denegar, & Buckley, 2004; Hertel et al., 2000; Kinzey & Armstrong, 1998; Nakagawa & Hoffman, 2004; Stockert & Barakatt, 2005). The four square step test (FSST) has been used with older adults (over 65 years old) as a measure of dynamic balance and fall prediction(Dite & Temple, 2002; Whitney et al., 2007). Both tests have applicability to the middle aged population. Each test is one that has less impact on joint structures so the tests may not negatively affect early degeneration in the lower extremity and spine. Both tests also challenge the subject to move outside their base of support and depend on several physiological systems to maximize performance(Shumway Cook & Woollacott, 2007).

Over the years, trunk extensor strength and endurance have been thought to contribute to overall dynamic posture, stability and function(Chok, Lee, Latimer, & Tan, 1999; Karatas, Cetin, Bayramoglu, & Dilek, 2004; Suni et al., 1998). One simple, clinical

method for measuring this variable which has been thoroughly studied is the Biering-Sorenson trunk muscle endurance test (BS). This procedure tests the subject's ability to maintain a static trunk extension position against gravity for a length of time(Alaranta, Hurri, Heliovaara, Soukka, & Harju, 1994; Keller et al., 2001; Latimer et al., 1999; Moreau, Green, Johnson, & Moreau, 2001; Ropponen et al., 2005). Test-retest reliability in subjects with low back symptoms and asymptomatic subjects has been reported(Alaranta et al., 1994; Latimer et al., 1999; Simmonds et al., 1998). Mean endurance times for the Biering Sorenson test have also been reported(Moreau et al., 2001). In addition, normative values of performance in asymptomatic subjects have been published(Alaranta et al., 1994).

### **Purpose and Research Hypothesis**

There is a need for appropriately challenging clinical functional tests in the middle aged population. The SEBT, FSST and Biering-Sorenson test all seem to meet the criteria of being challenging while simultaneously having a lower impact on joint structures of maturing adults. Although reliability of the SEBT and FSST has been reported in the populations tested, there have been no studies which include the middle aged population. Even though there have been reports of reliability of the Biering Sorenson test, there is a need to establish reliability in this population for comparison to the other clinical functional tests being studied. In an effort to determine the reliability of these clinical functional tests in the middle aged population, the purpose of this study was to demonstrate the test-retest reliability of the two lower extremity functional tests (SEBT and FSST) and the Biering-Sorensen trunk extensor muscle endurance test in a population of healthy subjects ranging in age from 30-60 years old. (Hypothesis: The tests will be considered to have acceptable between day reliability if  $r$  is greater than or equal to 0.75)(Portney & Watkins, 2000).

### **Methodology**

#### *Subjects*

This study was part of a larger study of descriptive performances of clinical tests and comparison of the performance on the clinical tests with self reported activity and physical fitness performance. Subjects were recruited from the local university community, churches and wellness centers by way of flyers (Appendix A) and web site postings. Other subjects were recruited via word of mouth from across the geographic

area. Of the 101 typical, healthy adults aged 30-60 who volunteered to participate in the full study, 29 volunteered to participate in the reliability portion. These 29 subjects included 10 males and 19 females and ranged in age from 30-59 (mean= 43.62, sd= 8.83). The 29 subjects included 11 in the 30 year old group, seven in the 40 year old group and 11 in the 50 year old group. A simple t-test was used to examine the performances of this group compared to the entire sample. Small, but significant differences were noted when comparing the reliability group with the whole group. See Table 2.1 for details.

Table 2.1. Comparison of reliability subject group and whole group.

Functional Test	Reliability Group mean	Whole Group Mean	Mean Difference	Significance
SEBT total	386 cm	360 cm	26 cm	< .01
FSST	4.87 sec.	5.05 sec	.18 sec	< .01
Biering-Sorensen	125.6 sec.	117.3 sec.	8.3 sec.	< .01

Characteristics of the subjects used in the reliability study include the following means: height =168.8 cm (sd = 7.17), weight =72.6 kg (sd = 18.22) and BMI = 25.4 kg/m<sup>2</sup> (sd = 6.14). Each subject met the inclusion criteria described in Chapter One and signed a consent form approved by the University of Kentucky Institutional Review Board to participate. (Appendix B)

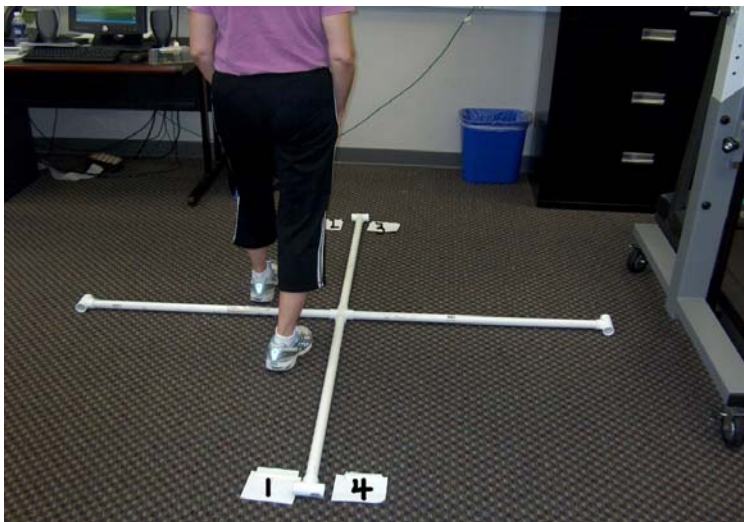
#### *Procedures*

Three testers were recruited to implement the three functional tests. Each was trained in the specific application of one of the tests and scripts were written for them to follow to avoid variance in instructions and methods of testing. Training included teaching each individual the method of testing for specific functional tests as described below. Since each tester was assigned to test only one functional test, intertester reliability was not done prior to the study. After training of all the evaluators, subjects were recruited and preliminary data were collected to include blood pressure, heart rate, height, weight, and leg length. Order of performance of the functional tests was based on availability of each station as the clinical functional tests were being performed simultaneously in the research lab. During testing on Day One, order of the functional test application was documented and the same order was used on Day Two for each

individual to avoid confounding variables associated with order in which the tests were given. Each evaluator measured the same test each day.

The FSST was applied on a thinly carpeted surface and subjects stepped over one inch diameter PVC pipes connected perpendicularly with a T collar. Subjects were instructed to remain facing the same direction as the starting position throughout the test. After instruction and demonstration in how to perform the test, each subject started in Square One facing Square Two and was asked to complete the stepping task as quickly and safely as possible. Upon the command “go”, the subjects stepped forward into Square Two, right side stepped into Square Three, stepped backward into Square Four and then side stepped left into Square One. The stepping pattern was then reversed until the subjects ended back in Square One. The stopwatch timing was started when the subject’s foot landed in Square Two and was stopped when both feet touched down back in Square One. Subjects were not allowed to hop, touch the pipes or cross one leg over the other. If any of these errors occurred, the trial was halted and the subject was given another trial. The number of retrials performed by each subject was documented(Dite & Temple, 2002; Whitney et al., 2007). After demonstration and instructions, the subjects were given 1 practice trial followed by 2 other trials. All three trials were timed and the times were recorded and the fastest of these was used for statistical analysis(Dite & Temple, 2002; Whitney et al., 2007). See Figure 2.1 for an illustration of the test.

Figure 2.1. Four square step test (view from behind subject)



The SEBT was performed in a way that combined features of previous studies and was conducted in a manner consistent with ease of use in the clinical setting. The

SEBT has been described using 8 directions of reach with each foot(Earl & Hertel, 2001; Gribble, 2003; Gribble & Hertel, 2003). This is not a clinically feasible methodology due to time constraints. Kinzey and Armstrong(Kinzey & Armstrong, 1998) demonstrated reliability using the SEBT in only 2 directions (anterior medial and posterior medial) while standing on each foot. Hertel and colleagues recently determined that redundancy exists in using 8 directions of reach and suggested anterior medial, medial and posterior medial directions are adequate in evaluating performance in subjects with chronic ankle instability using the SEBT(Hertel et al., 2006).

Gribble and Hertel described the importance of normalizing the reach in the SEBT by leg length(Gribble & Hertel, 2003). Several authors allowed the subject to lightly touch the floor to mark the reach distance more accurately and a position of hands on iliac crests is used to offer standardization of subject position and movement(Gribble, 2003; Gribble & Hertel, 2003; Gribble et al., 2004; Hertel et al., 2006; Nakagawa & Hoffman, 2004). With these studies in mind, the SEBT was applied as follows. Instructions were consistently given to each subject by the same tester. Prior to test trials, each subject was given 6 practice trials in each direction to neutralize the learning effect(Gribble, 2003; Gribble & Hertel, 2003; Hertel et al., 2006; Kinzey & Armstrong, 1998). Subjects were instructed to stand in the middle of the star with the midfoot in the center. Each subject placed hands on the iliac crests and reached into either the anterior medial or posterior medial direction as determined by a coin toss. The order of testing was documented and replicated during day two testing. Subjects balanced on the stance leg and reached in the appropriate direction along a taped line as far as possible while maintaining balance and lightly touched the floor with the foot prior to returning to the starting position. If the touch was determined to be too heavy by the evaluator, the stance foot moved, the hands were lifted off the iliac crests or the subject lost balance, the test was discarded and another trial was allowed. Trial errors were recorded.

After the subject reached and touched the floor lightly, the evaluator, positioned on the floor along the line reached, marked the distance, measured it with a standard tape measure, and erased the mark. Upon recovery of balance, the subject was given a second trial and third trial in the same direction. This procedure was repeated for each of two directions of reach while standing on each foot.

Figure 2.2. Star excursion balance test (Left Anterior Medial, Left Posterior Medial)



The Biering-Sorenson test of trunk extensor muscle endurance is a frequently used test that has been studied extensively. Normative values of performance have been reported (Alaranta et al., 1994). The test is performed in a variety of ways on varying surfaces, but essentially the subject must maintain a horizontal position in prone with the upper body and trunk unsupported for as long as possible (Alaranta et al., 1994; Keller et al., 2001; Latimer et al., 1999; Moreau et al., 2001; Ropponen et al., 2005). Procedures for this study were as follows. Subjects were positioned prone on a Cybex Norm chair with anterior superior iliac spines at the edge of the chair and upper body off the chair resting on a stack of floor exercise mats and a pillow. The legs were strapped onto the chair at mid-calf and mid-thigh and the subject was positioned in a horizontal plane and asked to hold this position as long as possible. The time was started when the subject was in position and unsupported. Subjects' arms were crossed over the chest and the gaze was directed toward the floor with the neck in a neutral position with respect to flexion and extension. The tester reminded the subjects to remain horizontal if this position was not maintained. Timing was stopped when the subject quit, if the position could not be maintained or at a maximum of 240 seconds (Alaranta et al., 1994).

The Cybex Norm chair was used due to its stability and location in the lab. The chair back was reclined so that a horizontal surface was established and subjects were positioned prone with the upper body off the chair and supported initially on a stack of four floor exercise mats and a pillow. Once the legs were strapped securely to the chair,



the patient was assisted into the horizontal position and the time was started as above(Alaranta et al., 1994). One trial established the time for this test and was recorded in seconds.

Figure 2.3. Biering-Sorenson trunk muscle endurance test



After completion of Day One testing, each subject was scheduled for a follow-up data collection day no earlier than seven days from Day One. On Day Two, all three clinical functional tests were repeated in the same order as on Day One testing.

#### *Data Analysis*

Data were analyzed using SPSS version 15.0 (Chicago). Test-retest reliability of the two testing days of data was analyzed using the Intraclass Correlation Coefficient model 3. For the FSST and Biering Sorenson tests, ICC (3, 1) was used as only the best single trial was recorded for analysis. Reliability of the SEBT was analyzed using ICC (3, 3) since an average of three trials was used to represent performance in this test(Portney & Watkins, 2000; Shrout & Fleiss, 1979). The means, standard deviations, 95% confidence intervals and standard errors of measure were also calculated for each of the tests studied.

SEBT reach data were measured in centimeters and three trials in each direction were recorded. The average distance reached was normalized to the individual's leg length and was expressed as a percentage of the leg length in the results.

$[Average\ reach\ distance\ (cm) / leg\ length\ (cm)] \times 100 = normalized\ average\ reach$

The data from each of four reach distances were then summed to establish a total SEBT score. Reliability analysis was performed on the average of each individual direction and the summed total score.

FSST data were collected as time in seconds. The fastest trial was accepted as the value to be analyzed. Biering-Sorenson test results were also measured in seconds and recorded as such up to a limit of 240 seconds.

To evaluate the effect of learning, the Day One and Day Two means were compared using paired t-tests to determine if a significant difference existed between the data. A meaningful difference was defined as having a p value of less than or equal to 0.05.

## Results

Correlation coefficients give researchers a value that can describe the strength of the relationship between measures. These values have been described verbally as follows:

< .20:	slight; almost negligible relationship
.20 - .40:	low correlation; definite but small relationship
.40 - .70:	moderate correlation; substantial relationship
.70 - .90	high correlation; marked relationship
> .90	very high correlation; very dependable relationship (Domholdt, 1993; Guilford, 1956)

Reliability with relationship to the corresponding correlations has been described as follows:

< .50:	Poor reliability
.50 - .75:	Moderate reliability
> .75:	Good reliability (Portney & Watkins, 2000)

Means and standard deviations are displayed in Table 2.2. In this study, all clinical functional tests had reliability ranging from an ICC value of .64 for the Biering-Sorenson trunk muscle endurance test to .97 for the SEBT total (See Table 2.2).

Table 2.2. Test: Retest Means, Standard Deviations, ICC values, 95% CI

Clinical Test	Mean	Standard	Mean	Standard	ICC Value	95% CI
	Day One	Deviation	Day Two	Deviation		
SEBT RAM	95.33	5.89	95.33	6.11%	.94	.87-.97
SEBT RPM	98.35	8.89	98.21	9.06%	.95	.89-.98
SEBT LAM	95.92	7.33	95.63	6.36%	.86	.70-.94
SEBT LPM	96.32	8.74	96.74	9.37%	.93	.86-.97
SEBT Total	385.92	27.58	385.90	27.57%	.97	.93-.98
FSST	4.87 sec.	1.01	4.67 sec.	0.87	.88	.74-.94
BS	120.63 sec.	46.59	139.56 sec.	52.06	.64	.34-.82

The results of the t test showed a significant difference between Day One and Day Two testing for the FSST and the Biering-Sorensen test, but not for the SEBT. See these results in Table 2.3 below.

Table 2.3. Comparison of Day One and Day Two data

	Mean Difference	Std. Dev.	SEM	95% CI	Sig.
SEBT total	.02	10.08	1.87	-3.81 – 3.86	.99
FSST	.19	.44	.08	.021 - .358	.03
BS	-18.93	39.67	7.73	-34.02 - -3.84	.02

## Discussion

The primary purpose of this chapter was to demonstrate the reliability of the clinical functional tests selected for study. All of the clinical functional tests studied demonstrated moderate to good reliability. According to the verbal description of

reliability offered by Portney and Watkins, all but the Biering-Sorensen test results are considered to have good reliability (Portney & Watkins, 2000). The Biering Sorenson test demonstrated moderate reliability in this population of 29 asymptomatic subjects which is comparable to previous reports that reliability of this test in typical uninjured adults ranges from 0.63 – 0.83 (Alaranta et al., 1994; Keller et al., 2001; Latimer et al., 1999). Reliability of the Biering Soreneson test is reported to be higher in symptomatic subjects indicating it may be a better predictor of trunk extensor muscle endurance when the dysfunction present limits performance of the test. In a study by Ropponen and colleagues, (Ropponen et al., 2005) it was determined that symptomatic subjects stopped the test due to pain more often than any other reason. With the asymptomatic subjects in this study, hamstring aching and fatigue, back fatigue and boredom were commonly cited as reasons for stopping the test. Interestingly, when subjects were told their score on this test, they often made the statement that they could have gone on longer. Upon retesting, it is noted the mean test value was significantly higher than the Day One test value (Day One mean= 119.78 sec, Day Two mean= 138.25 sec,  $p = .02$ ). This indicates the subjects held the test position longer on Day Two and may have done so based on the knowledge of their Day One test results. Knowledge of these results may have accounted for the lower reliability associated with this measure.

The four square step test reliability of .88 is good and represents a high correlation. This compares favorably to the reliability values reported by Dite and Temple (Dite & Temple, 2002) and Whitney and colleagues (Whitney et al., 2007) ( $r = 0.93-0.98$ ) with older adult subjects who had balance and vestibular problems. In a younger population of asymptomatic, healthy individuals, it seems reasonable to expect a wide variance in performance levels among the subject pool. This variability may be present due to the absence of a condition that may impair their performance. This variance could also be a result of learning the test pattern. The FSST is a unique test and appears to be a novel test when introduced. Despite FSST times that showed very high Intraclass Correlation Coefficients (Day One to Day Two performance:  $r = 0.90$ ,  $p < .01$ ), there was statistical significance when comparing the mean difference in these scores ( $p = .03$ ) Since none of the subjects in this study had any reported balance or vestibular dysfunction, the good reliability observed indicates this test can be reliably applied to a middle aged population. However, the faster performance may be due to a learning effect. Post hoc analysis of the three trials for each testing day showed that the third trial was the fastest 65% of the time. The second trial was fastest 27% of the time

and the first trial only 8% of the time. In order to remain true to the established method of performance, only 1 practice was given, followed by two trials. Within the same testing period there appeared to be consistent, but slightly improving performance among trials, but between days a larger difference was noted. This could be explained by the subjects being familiar with the test on Day Two. Seven days may not be a long enough period to account for the learning effect. More practice trials prior to data acquisition may be needed with this population.

The speed with which the FSST was performed may also limit the reliability (mean speed = 4.87 sec. (sd = +/-1.01). In the study by Dite and Temple,(Dite & Temple, 2002) the comparison group of healthy people over 65 years old had a mean FSST score of 8.7 sec (sd = +/- 1.31) Lack of variability in the test data for this study, may have resulted in a lower reliability. The reported reliability of the test in this middle aged population should lead to further studies to validate the use of the FSST with different patient populations that may exhibit balance and/or lower extremity functional limitations.

So despite moderate to good reliability in the Biering-Sorensen test and the FSST, there were significant differences noted between Day One and Day Two results due to the reasons stated above. However, there were no significant differences noted between days testing on the SEBT. (See Table 2.3)

Reliability of the star excursion balance test (SEBT) is good to excellent depending on which measure is used. A total score in the SEBT has been reported to be the sum of the average reach in each direction(Nakagawa & Hoffman, 2004). This is the approach used in this study. However, all four reach directions were also calculated for reliability purposes. In the present study, reliability of each direction ranged from  $r = .76$  for right reach in the posterior medial direction to  $.94$  for right reach in the anterior medial direction. Total SEBT reliability was excellent at  $r = .97$ . The SEBT has been described in several different fashions. SEBT reliability measures have been reported to range anywhere from 0.67 to 0.96(Hertel et al., 2000; Kinzey & Armstrong, 1998; Plisky et al., 2006a). Reach in all eight possible directions was reported with good reliability(Hertel et al., 2000). Reach in only the four directions used in this study was reported to be moderately reliable(Kinzey & Armstrong, 1998). Reach in only three directions has also been reported to be reliable(Hertel et al., 2006). Variations of the reach include hands free or on the iliac crests, toe tapping or remaining in the air and standing on the very center of the star or standing within a box placed in the center of the star(Gribble, 2003; Gribble & Hertel, 2003; Gribble et al., 2004; Hertel et al., 2006;

Nakagawa & Hoffman, 2004). Normalizing the reach distance based on leg length is also important in standardizing the results(Gribble & Hertel, 2003). The combination used in the methodology for this study has not been specifically reported, but was used related to its ease and speed of replication in the clinic and in an attempt to standardize the procedure.

Learning effect was minimized in the SEBT by having each subject practice the reaching six times in each direction(Gribble & Hertel, 2003; Hertel et al., 2000). The differences in reliability between individual reach directions may be because of the methods used by subjects to achieve the maximum reach. All anterior reaching was done with the trunk upright and the hip and knee flexed while reaching with the opposite leg in the anterior medial direction. The center of gravity must be maintained and with the leg reaching forward, erect trunk position and flexion of the hip and knee is the preferred strategy observed. When reaching in the posterior direction, the reaching leg was counterbalanced by forward trunk flexion in most subjects. However, this varied trial by trial and related to the possible options for attaining maximum reach, may have resulted in slightly less reliability between Days One and Two. Despite this, the reliability of the SEBT in all directions was over  $r = .76$  and three of the four directions ranged from  $r = .86 - .94$ .

Use of the total SEBT normalized reach value had excellent reliability of  $r = .97$ . This measure is a summation of the four reach averages normalized to leg length. Normalization to leg length is critical in attempting to establish typical performance measures in a test such as this. Raw reach data would certainly be skewed toward longer reaches for people with longer legs. Normalization standardizes the methodology accounting for different body sizes among subjects and allowing for this test to be used for comparison among people as well as within individuals during rehabilitation. It is interesting that the sum of these four reach measures is a more reliable value than those of each individual reach. The larger values utilized with the total SEBT score may provide for a statistical model that yields higher reliability.

### **Study Limitations**

The two major limitations of this study are that subjects received knowledge of the results of their performance on the clinical tests after Day One testing and may have given a greater effort on Day Two testing. Also, despite attempts to minimize the learning effect in the clinical tests, Day Two testing may have been enhanced by

subjects learning the task and limited trials may have strengthened the learning effect in the FSST. Future research studies should address this possible learning effect.

### **Conclusions**

All three clinical tests studied are reliable for use in a healthy, asymptomatic, middle aged population. High test-retest reliability may allow clinicians to use these tests to monitor progress through a clinical intervention episode of care. However, prior to use in a patient population, reliability and validity of these tests should be established. Knowledge of the reliability of the tests in a healthy, asymptomatic population does not allow generalization to other populations. The high reliability reported is promising for establishment of reliability in patient populations and will also allow confident pursuit of typical performance values in each test for use as a measurement standard based on age for clinical populations.

## CHAPTER THREE: TYPICAL PERFORMANCE VALUES ON THREE CLINICAL FUNCTIONAL TESTS IN SUBJECTS 30-60 YEARS OLD

### **Overview and Review of Related Research**

There have been many studies of factors that may contribute to injuries in older adults (Guralnik et al., 1995; Newton, 2001; Pavol & Pai, 2007; Schulz, Ashton-Miller, & Alexander, 2007; Thomas & Lane, 2005). The injuries that result from falls and other balance disturbances are costly from economic, time, energy and emotional perspectives (Findorff, Wyman, Nyman, & Croghan, 2007; Stevens, Corso, Finkelstein, & Miller, 2006). Research aimed at the factors that contribute to injuries in older adults helps scientists and clinicians choose intervention programs that effectively rehabilitate injured older adults and develop preventative programs in hopes of minimizing the number and severity of injuries to this population of people (Schulz et al., 2007; Westlake, Wu, & Culham, 2007).

Clinical functional testing is one method used to identify deficits in older adults that lead to increased incidence of falls and fall related injuries. A number of tests for dynamic balance and function have been developed, validated and demonstrated to be reliable with older adults (Dite & Temple, 2002; Duncan, Weiner, Chandler, & Studenski, 1990; Newton, 2001; Podsiadlo & Richardson, 1991; Shumway Cook, Brauer, & Woollacott, 2000; Stockert & Barakatt, 2005; Whitney et al., 2007). Many of these tests have established performance levels enabling comparisons of patient performance. This comparison allows practitioners to identify people with higher risk of falling and suffering injuries. For instance, Dite and Temple (Dite & Temple, 2002) have determined that performance on the four square step test (FSST) slower than 15 seconds, identified the individuals in the sample who had reported multiple falls. Those who performed the test in less than 15 seconds were considered to be non-multiple fallers. The Berg Balance Scale has established scores that reflect progressively greater risk for falls (Shumway Cook, Baldwin, Polissar, & Gruber, 1997). Greater fall risk is also indicated by a performance of 14 seconds or greater on the timed up and go test (Shumway Cook et al., 2000).

The research that has been done with older adults in this area is valuable, but it is interesting that little research has been done with the middle aged population in these areas. People aged 30-60 represent a population in transition from greater activity to



lesser and are reported to manifest joint and muscle strength changes observed in a typically aging population. Activity decline over these years in the lifespan is generally considered to be a slow progression that occurs over years (Krems et al., 2004; Nitz & Choy, 2004; Pober et al., 2002). This slow decline indicates that older adults who perform functional tests at levels that place them in high risk categories may have slowly declined over years to this level of performance (Isles, Choy, Steer, & Nitz, 2004). This study has as one of its goals to establish functional tests specific for use in testing middle aged adults that are related to valid clinical functional tests used with older adults to begin to identify when and what leads to functional decline in earlier years.

When considering injuries that occur as a result of falls, there are many factors that contribute to falls which must be studied. Key areas for study may include dynamic and static balance, strength in the lower extremities and trunk, and cognitive function. Several authors have reported the influence of lower extremity strength on falls (Eriksrud & Bohannon, 2003; Hess, Woollacott, & Shivitz, 2006; Nakao et al., 2006). Little has been reported on the influence of trunk strength on falls or the relationship between trunk strength and balance. However, in rehabilitation, trunk strength and stability are considered valuable to overall function. One's ability to remain upright during functional activities involves both static and dynamic stabilizers of the trunk, pelvic girdle and lower extremities. Studies have been developed based on the perception that falls often occur during movement and dynamic measures of balance should thus be used to identify those at risk for falls (Bernhardt, Ellis, Denisenko, & Hill, 1998; Patla, Frank, & Winter, 1992). For these reasons, it is important to study tests of dynamic balance and their relationship to trunk strength, falls, and overall function.

Two clinical functional tests of dynamic balance that have been studied in young and older adult populations are the star excursion balance test (SEBT) and the four square step test (FSST). The SEBT is a test that has a low impact on the joint structures of the lower extremities and trunk, yet challenges many of the systems that contribute to dynamic balance as subjects attempt to reach outside their perceived limits of stability (Earl & Hertel, 2001; Gribble, 2003; Hertel et al., 2000; Kinzey & Armstrong, 1998). The FSST is a challenging test of stepping in multiple directions while clearing a low obstacle as quickly as possible without making an error or losing balance. This assesses multiple balance systems as well as cognition and coordination (Dite, Connor, & Curtis, 2007; Dite & Temple, 2002; Whitney et al., 2007). Just as dynamic balance contributes to successful function, there is growing evidence that trunk strength and

stability are key factors in optimal functional performance. This is especially true in people with chronic low back pain and neurological conditions(Dvir, 1997; Keller et al., 2004; Tanaka, Hachisuka, & Ogata, 1997). It is therefore important to establish performance standards for dynamic balance, correlate this to trunk strength, and utilize this information in clinical physical therapy practices to guide intervention selection and progression. Age and sex related typical performance standards can be used to measure progress during rehabilitation and to educate clients regarding current abilities. Once current abilities compared to standard functional tests are identified, intervention can be planned that may help improve dynamic balance, trunk endurance, and strength which may serve to prevent injury and slow the functional decline that often occurs during the aging process.

### **Purposes and Research Hypothesis**

Study results have demonstrated that there is a relationship between trunk extensor muscle endurance and low back pain(Biering-Sorensen, 1984). Trunk muscle strength, size, and endurance are also significantly affected by acute and chronic low back pain(Dvir, 1997; Keller et al., 2004). Low back pain is one of the most common musculoskeletal complaints that people report throughout the lifespan(Cassidy, Cote, Carroll, & Kristman, 2005). It is reasonable to think that as lower extremity and back pain and injury present, activity levels decrease, affecting overall strength, endurance and function negatively. If typical age and sex related dynamic balance and trunk extensor muscle endurance performance levels can be identified, health care practitioners can potentially better identify people at risk for future injury and might help them prevent injury through exercise programs in the middle aged years. Therefore, the purposes of this study were: 1) to determine a set of typical, descriptive values in the performance of the two lower extremity functional tests (SEBT and FSST) and the trunk extensor muscle endurance test (Biering-Sorensen test) for this sample of men and women, 2) describe the typical values by sex, 3) report the typical performance values by percentile within each 10-year age cohort, and 4) compare performance between groups in 10-year age cohorts within the sample population of 30-60 year olds. (Hypothesis: Descriptive values will be significantly different between the youngest and oldest groups.)

## Methodology

### *Subjects*

This study was part of a larger study of reliability of clinical tests and comparison of the performance on the clinical tests with self reported activity and physical fitness performance. Subjects were recruited from the local university community, churches, and wellness centers by way of flyers and web site postings. Other subjects were recruited via word of mouth from across the geographic region. In total 101 subjects (63 females, 38 males) volunteered and all met the inclusion criteria of being between the ages of 30-60 years old and healthy. Exclusion criteria included: any condition resulting in balance deficits, acute lower extremity or back injury in the previous month, or reported pain in the lower extremity or back that limited their ability to walk at the time of the study. All subjects also reported they had no cardiac condition at the time of the study that limited them from participating in moderate intensity exercise. Each subject signed a consent form approved by the University of Kentucky IRB prior to participation. The descriptive statistics for the entire study population are displayed in Table 3.1. These data are also displayed in Tables 3.2 and 3.3 for the study population by sex and in Table 3.4 for all subjects by age group.

Table 3.1. Descriptive statistics of all subjects

	Number	Mean	Range	Std. Deviation
Age	101	44.24	30-60	8.36
Height (meters)	101	1.69	1.47-1.91	.083
Leg Length (centimeters)	101	87.22	77-101	5.09
Weight (kilograms)	101	74.16	47-128	16.83
Body Mass Index (kilograms/meter <sup>2</sup> )	101	25.94	17.82-45.9	5.05

Table 3.2. Descriptive statistics for all female subjects

	Number	Mean	Range	Std. Deviation
Age	63	44.3	30-58	8.11
Height (meters)	63	1.65	1.47-1.79	.062
Leg Length (centimeters)	63	85.03	77-94	4.19
Weight (kilograms)	63	69.53	47-128	15.83
Body Mass Index (kilograms/meter <sup>2</sup> )	63	25.64	17.82-45.9	5.05

Table 3.3. Descriptive statistics for all male subjects

	Number	Mean	Range	Std. Deviation
Age	38	44.13	30-60	8.88
Height (meters)	38	1.76	1.63-1.91	0.07
Leg Length (centimeters)	38	90.84	82-101	4.34
Weight (kilograms)	38	81.84	52.5-125.5	15.78
Body Mass Index (kilograms/meter <sup>2</sup> )	38	26.44	18.94-36.93	4.18

Table 3.4. Descriptive statistics for all subjects by age group

	Mean	Range	Std. Deviation
Age group: 30 (n=35)	34.7	30-39	2.85
40 (n= 27)	43.8	40-49	2.53
50 (n=39)	53.1	50-60	2.67
Height (cm) 30	170.6	156.5-190	8.44
40	168.8	146.5-191	9.18
50	166.9	149-184.5	7.44
Leg Length (cm) 30	88.1	77-101	5.42
40	87.2	77-100	5.55
50	86.4	78-95	4.38
Weight (kg) 30	74.8	51-114	16.04
40	76.5	47-128	21.47
50	72	50.3-109.5	13.83
BMI (kg/m <sup>2</sup> ) 30	25.6	18.4-42.9	4.75
40	26.6	18.9-45.9	5.97
50	25.8	17.8-40	4.70

### *Procedures*

After subject recruitment as described above, preliminary data were collected on each subject by a licensed physical therapist to include blood pressure, heart rate, height, weight, and leg length. Body mass index was calculated for each subject (weight in kg divided by the height in meters squared). Testing procedures for the FSST, SEBT, and Biering-Sorensen trunk extensor muscle endurance test were followed as outlined in Chapter Two. Reliability of these measurements with this population is adequate and was reported in Chapter Two.

SEBT reach data were measured in centimeters. After six practice trials in each direction, three trials in each of two directions with each leg (total of four reach directions per subject) were recorded. A normalized average was then calculated based on each subject's leg length. The raw reach data were averaged and then divided by the leg length and multiplied by 100 to give a percentage value of reach compared to leg length as follows:

$$[\text{Average reach distance (cm)} / \text{leg length (cm)}] \times 100 = \text{normalized average reach}$$

The data from each of four reach distances were then summed to establish a total SEBT score. FSST data were collected as time in seconds. One practice trial was followed by two more trials. The fastest of the three trials was accepted as the value to be analyzed. Biering-Sorenson test results were also measured in seconds and recorded as such up to a limit of 240 seconds on one trial.

#### *Data Analysis*

Descriptive analysis of data was performed using SPSS software, version 15 (Chicago, IL). The means, ranges, standard deviations, 95% confidence intervals, and standard errors of measure were calculated for each of the tests studied. These data were analyzed as a whole group, all males, all females, and all subjects by age cohort divided by decades of life to include 30-39, 40-49, and 50-60. Since each of the age cohorts did not have equal numbers of males and females, data were not divided and analyzed based on sex within the age groups. The age group data were further separated into percentiles of performance in a similar manner as normative data are presented by the American College of Sports Medicine (*ACSM's Guidelines for Exercise Testing and Prescription*, 2000). Additionally, the performances by each age group and sex were compared using t-tests to determine significant differences in performance between the cohorts. An a priori level of significance of  $p \leq 0.05$  was set to determine if differences existed.

#### **Results**

Descriptive statistics related to performance of all three tests are displayed in Tables 3.5-3.8 for the whole sample, all females and all males and all subjects by age group. Tables 3.9-3.11 display the typical performances on the 3 tests by age group and percentiles of performance. Performance on each test was compared between the 30

and 50 year old age cohorts in Table 3.12. There were no statistically significant differences between age groups 30 and 40 and only the results of the FSST showed a significant difference in the 40 and 50 year old cohorts. Although there was an observable decline in performance from decade to decade, the only significant performance differences were between the youngest and oldest participants of the study. Means and standard deviations of all cohorts are displayed for comparison in Table 3.13

Table 3.5. Performance data for whole group  
(SEBT individual reach directions as follows: RAM =right anterior medial, RPM = right posterior medial, LAM = left anterior medial, LPM = left posterior medial)

	Range	Mean	Std. Deviation	SEM
RAM	62 -110	93%	8.21	.82
RPM	52 -114	94%	10.53	1.05
LAM	64 -111	94%	8.23	.82
LPM	49 -114	93%	11.40	1.13
SEBT total	227 - 444	374	35.76	3.56
FSST	3.25- 9.69	5.05 sec	1.07	.11
BS	24.59 -240.0	117.35 sec	56.26	5.6

Table 3.6. Performance data for all females

	Range	Mean	Std. Deviation	SEM
RAM	62- 10	92%	7.87	.99
RPM	52 - 112	93%	10.75	1.35
LAM	64 - 111	93%	8.35	1.05
LPM	49 - 111	92%	11.40	1.44
SEBT total	227 - 433	370	36.24	4.57
FSST	3.62 - 9.69	5.11	1.18	.15
BS	27.34 - 240.0	125.29	58.49	7.37

Table 3.7. Performance data for all males

	Range	Mean	Std. Deviation	SEM
RAM	67 - 110	95%	8.64	1.40
RPM	73 - 114	96%	9.99	1.62
LAM	76 - 109	95%	7.83	1.27
LPM	56 - 114	94%	11.47	1.86
SEBT total	273 - 444	380	34.47	5.59
FSST	3.25 - 6.72	4.94	.87	.14
BS	24.59 - 240.00	104.18	50.37	8.17

Table 3.8. Performance data for all subjects by age group

		Range	Mean	Std. Deviation	SEM
RAM	30	80- 110	96%	7.9	1.3
	40	62 - 104	93%	8.9	1.7
	50	67 - 103	91%	7.6	1.2
RPM	30	76 - 114	97%	9.8	1.7
	40	52- 112	93%	12.7	2.5
	50	72 - 108	92%	9.0	1.5
LAM	30	78- 111	97%	7.6	1.3
	40	64- 109	93%	8.9	1.7
	50	69 - 106	92%	7.8	1.3
LPM	30	71 - 114	96%	10.7	1.8
	40	49 - 109	93%	13.0	2.5
	50	56 - 107	91%	10.7	1.7
SEBT total	30	311- 444	385	33.4	5.6
	40	227 - 430	372	41.1	7.9
	50	273 - 418	366	32.1	5.1
FSST	30	3.3 -6.5	4.8 sec.	.8	.1
	40	3.6 - 9.7	5.2 sec.	1.3	.3
	50	3.6 - 8.5	5.2 sec.	1.1	.2
BS	30	44- 240	123 sec.	41.3	7.0
	40	25 - 240	115 sec.	66.0	13.0
	50	27 - 240	114 sec.	60.1	9.62

Table 3.9. Typical performance values by percentiles for subjects 30-39 years old

	10 <sup>th</sup> percentile	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>
RAM	83.92	89.89	95.37	102.9	106.27
RPM	82.60	90.29	96.54	104.37	110.34
LAM	86.56	90.40	98.19	102.48	107.04
LPM	80.14	89.15	96.10	105.91	109.67
SEBT total	334.44	363.18	387.41	410.20	427.42
FSST	5.85	5.22	4.81	4.13	3.70
BS	67.88	89.54	124.33	146.8	182.73



Table 3.10. Typical performance values by percentiles for subjects 40-49 years old

	10 <sup>th</sup> percentile	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>
RAM	82.86	87.68	94.81	98.74	102.99
RPM	80.32	83.82	94.57	101.19	108.22
LAM	81.18	88.59	92.59	99.27	101.67
LPM	75.37	87.32	97.07	100.54	107.15
SEBT total	329.99	344.75	380.95	397.62	415.40
FSST	7.01	5.72	4.82	4.29	4.10
BS	30.51	65.18	117.60	144.44	240

Table 3.11. Typical performance values by percentiles for subjects 50-60 years old

	10 <sup>th</sup> percentile	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	90 <sup>th</sup>
RAM	80.68	88.41	90.15	97.45	101.81
RPM	80.30	86.90	90.45	98.88	103.31
LAM	80.11	88.04	92.38	98.01	100.75
LPM	73.08	84.85	92.59	98.15	101.80
SEBT total	309.09	355.69	366.09	392.79	397.07
FSST	6.72	5.68	5.16	4.34	3.87
BS	47.31	63.78	98.39	141.66	232.24

Table 3.12. Comparison of performance data between age groups 30 to 50

	t statistic	Sig.	Mean Difference	95% CI
RAM	2.38	0.02	4.30	.70 – 7.9
RPM	2.36	0.02	5.16	.80 – 9.52
LAM	2.62	0.01	4.70	1.12 – 8.26
LPM	2.04	0.05	5.07	.12 – 10.03
SEBT total	2.53	0.01	19.22	4.06 – 34.39
FSST	-1.99	0.05	-0.44	-.87 - 0
BS	.80	0.45	9.72	-14.05 – 33.88

Table 3.13. Comparison of performance data among all age groups

Variable	30 yr	30 yr	40 yr	40 yr	50 yr	50 yr
	mean	Std.Dev.	mean	Std.Dev.	mean	Std. Dev.
RAM	95.8%	7.89 cm	92.8%	8.90 cm	91.5%*	7.64 cm
RPM	96.9%	9.78 cm	93.4%	12.75 cm	91.7%*	9.04 cm
LAM	96.6%	7.57 cm	92.6%	8.91 cm	91.9%*	7.79 cm
LPM	95.8%	10.66 cm	93.2%	12.89 cm	90.7%*	10.69 cm
SEBT total	385.0	33.37	370.4	40.84	366.0*	32.5
FSST	4.75	0.79	5.24	1.34	5.19*	1.05
BS	123.49	41.29	116.94	67.77	115.40	60.01

\* indicates a significant difference ( $p < .05$ ) between 30 and 50 year olds

## Discussion

Typical performance data for the SEBT or FSST have not been collected with healthy adults in the age ranges studied, so no comparisons can be made with published data. In this study, it is noted that males consistently performed better in each test compared to females except in the Biering-Sorensen test. Although there were observable differences in performance levels between sexes, these differences were not statistically significant. The Biering-Sorensen test data are different than the data previously reported (Alaranta et al., 1994). The performance of subjects in this study was substantially higher than that reported by Alaranta and colleagues and women performed better than men. Women in this study were able to maintain the test position for the Biering-Sorensen test a mean of 125.29 sec. Alaranta and colleagues reported a mean of 89 sec. for their sample of women. This difference may be because of the substantial difference in the number of subjects in each study. The current study had only 68 females whereas the previously reported study had a female subject pool of 233. Another key difference in the samples is the females in Alaranta's study included those who were both asymptomatic and symptomatic. These two reasons could have led to the mean difference of nearly 35 seconds in the samples. There were also slight, but comparable differences in the performance comparing the men in this study with those of Alaranta and colleagues (Alaranta et al., 1994). They reported a mean of 98 seconds for the 242 men in their study. In the current study, the mean was 104.18 seconds.

Although there were slight differences, they were similar figures for the men in both studies.

Kinzey and Armstrong(Kinzey & Armstrong, 1998) report only the reliability of their SEBT procedure, but Hertel(Hertel et al., 2006) reported performance on the SEBT in all 8 directions with a group of healthy subjects with an average age of 21. SEBT performance of Hertel's subjects is displayed alongside data from this investigation in Table 3.14 and shows the subjects in this study were able to reach substantially further. One reason for this difference could be that subjects in this study only reached in two directions with each foot, whereas the subjects in Hertel's study reached in 8 directions with each foot and fatigue could have been a factor. Despite similar testing procedures, Hertel's sample of college aged students performed at a level below even the 50 year old group in the current study. A larger sample size in the currently reported study may also have influenced the results and may explain the difference in the performances between the studies.

Table 3.14. Comparison of middle aged adults SEBT performance with that reported by Hertel et al, 2006.

(RAM = right anterior medial reach direction, RPM = right posterior medial, LAM = left anterior medial, LPM = left posterior medial)

SEBT Direction	Hertel et al 2006	English 2008
RAM (cm)	84	93.32
RPM (cm)	90	93.96
LAM (cm)	82	93.69
LPM (cm)	90	93.12
SEBT (total) (cm)	346	374.09

The FSST first described by Dite and Temple(Dite & Temple, 2002) and subsequently by Whitney and colleagues(Whitney et al., 2007) has been used with older adults only. The current study is the first to utilize the test with a population of younger people in the 30-60 age range. Times recorded in this study are substantially faster than those in either of the other studies, but those studies were performed with subjects who had a documented balance deficit. Understanding the speed with which this test can be accomplished in younger people in the middle aged years of the life

continuum gives practitioners a gauge to use in understanding how people perform in a novel activity when they are healthy. This information can then be used as a standard by which to measure status on the test and progress through rehabilitation. As Dite and Temple(Dite & Temple, 2002) and Whitney and colleagues(Whitney et al., 2007) demonstrated, the test shows excellent sensitivity and specificity in identifying fallers. Knowing the typical performance levels for healthy people through the life continuum allows physical therapists to make clinical judgments about functional dynamic balance and gives them the opportunity to initiate preventative interventions that may reduce the recurrence of falls later in life.

With regard to performance comparisons by decade of life, there is a statistically significant decline in performance on the SEBT and FSST from the fourth to the sixth decades of life. No differences were noted from the 30-40 age groups and only the FSST showed a significant difference in the 40-50 groups. There were also no statistically significant differences in performance among any combination of the groups on the Biering-Sorensen test. The differences noted in the SEBT and FSST between the 30 and the 50 year olds gives clinicians and researchers valuable information regarding when declines in dynamic balance and coordination may begin to occur. It would seem that during the 40s a decline begins that is seen as significant in the 50s when compared to performance in the 30s. This knowledge may allow clinicians to introduce balance and stability exercises with patient populations in this age range. If future studies demonstrate interventions have a positive impact on performance, prevention of significant performance decline in the middle aged years may have a positive impact on function and fall prevention in the older adult years.

In order to accurately compare people to established performance standards, percentiles are commonly used(*ACSM's Guidelines for Exercise Testing and Prescription*, 2000). Often with fitness information as well as clinical functional tests, normative values are reported to be used as a standard for comparison with the groups being tested. Standards or typical performance for the SEBT and the FSST have not been established. This lack of standard performance values has several potential explanations. The SEBT is a relatively new test of dynamic stability and balance that has not been studied extensively. It has primarily been studied with younger athletic populations(Gribble, 2003; Gribble et al., 2004; Hertel et al., 2006; Hertel et al., 2000; Kinzey & Armstrong, 1998; Plisky et al., 2006a, 2006b). One study has been reported that used this test with older adults(Stockert & Barakatt, 2005). No studies have used

middle aged subjects in studying the SEBT. Another explanation for a lack of normative values is the technique of performance of the test has been reported in several different manners. Some researchers use eight directions, some three, and others two with each foot(Gribble, 2003; Hertel et al., 2006; Kinzey & Armstrong, 1998; Plisky et al., 2006a). Procedures for completing the reach also vary, including lightly tapping the toe on the surface or not allowing the foot to touch the surface. Some studies normalize the reach to leg length and others do not(Gribble & Hertel, 2003; Hertel et al., 2006; Kinzey & Armstrong, 1998; Nakagawa & Hoffman, 2004). This variability in methodology may be a primary reason why there has not been a study that has published normative values.

There are similar reasons for the lack of established performance standards for the FSST. This test is also relatively new being first reported in 2002(Dite & Temple, 2002). That study and subsequent studies have been limited to older adult populations and populations with considerable impairments in balance(Dite et al., 2007; Dite & Temple, 2002; Whitney et al., 2007). The FSST is a unique and novel stepping test that challenges the subject to step in different directions, quickly and over an object while maintaining balance and avoiding errors. This type of test gives clinicians the opportunity to evaluate movement patterns and dynamic balance. The test has been shown to be sensitive and specific in identifying older adults who are multiple fallers, but no attempt has been made to establish normative performances for this test.

In the current study, all 101 subjects are included to establish typical performances by percentiles. Since there were not enough subjects to establish norms, typical performances by percentile for each age group tested are reported. There is no breakdown by sex. All the healthy subjects in the 30 -60 year old age group tested in this study were able to complete the FSST in less than 10 seconds. However, the ranges in each age group show a variance that may have meaning in identifying healthy subjects at greater risk for developing balance and coordination deficits.

SEBT performance by percentiles in the three age groups is also reported. Since no normative studies have been reported, the data here can be considered a start in trying to establish performance standards for the SEBT. There is a wide variance noted between those performing at the 10<sup>th</sup> percentile compared to the 90<sup>th</sup> in each age group. Further studies are needed to establish accurate normal values of performance in the middle and older adult age groups and to study correlations between functional test performances in the healthy state compared to subjects who have balance and coordination deficits.

### **Study Limitations**

The sample population used in this study represents the major limitation of the study. Volunteers in each age group may have been people interested in fitness and who regularly exercised. This limits the generalizability of the study findings to a more narrow population. Subject recruitment in future studies should be broadened to try to include a more physically diverse group of subjects.

### **Conclusions**

Performance on three clinical functional tests by healthy middle aged adults has been reported. The performances have been categorized by sex, and age group. Comparisons between age groups demonstrate a significant difference in the performances of the SEBT and FSST between the 30 and 50 year old age groups. Performances by age group have been divided into percentiles for use with screening and with patient populations to advise them regarding performance on these tests and how patients compare to a sample of typical performances.

## CHAPTER FOUR: RELATIONSHIPS AMONG MUSCLE FITNESS, CLINICAL FUNCTIONAL TESTS AND SELF REPORTED ACTIVITY LEVELS IN 30-60 YEAR OLD HEALTHY, TYPICAL ADULTS

### Overview and Review of Related Research

Activity levels, physical fitness and attitude toward exercise and fitness have all been shown to have positive relationships with function and injury prevention (Arraiz, Wigle, & Mao, 1992; Laffrey, 2000; Laforge et al., 1999). In fact, people who maintain a moderate level of fitness have an advantage over those less fit when studying mortality rates in large populations of people with cardiovascular disease and other conditions (Arraiz et al., 1992). As people age, there is a decline in muscle strength, endurance, and flexibility which may lead to the demonstrated increase in falls and other related injuries (Dirks & Leeuwenburgh, 2005; Robinson, Gordon, Wallentine, & Visio, 2002; Roma, Chiarello, Barker, & Brenneman, 2001). With this decline in muscle function there is a resultant decrease in activity levels. In 1994, it was reported that fatal and nonfatal falls accounted for over \$20 billion in direct medical care and productivity losses. It has been projected that falls will increase from almost 14 million to over 17 million per year from 1995 to 2020. This will result in projected increases in costs related to falls of \$64 billion to \$85 billion over the same time period. As falls and resulting injury become more common in the population, costs of health care and living increase (Englander, Hodson, & Terregrossa, 1996; Findorff et al., 2007; Pynoos, Rose, Rubenstein, Choi, & Sabata, 2006; Rizzo et al., 1998). An anticipated result of more falls and injury is a decrease in confidence to perform activities, quality of life, physical activity, and function (Brown, 1999; Devereux, Robertson, & Briffa, 2005; Hart Hughes, Quigley, Bulat, Palacios, & Scott, 2004).

Multiple research studies have demonstrated the relationships between muscle strength, functional ability, and falls that lead to injury (Guralnik et al., 1995; Newton, 2001; Thomas & Lane, 2005). Most of this research has targeted the older adult population who suffers the majority of these injuries. Weakness and decreased functional ability are not, however, conditions that present consistently with advancing age. These impairments usually develop during the aging process as a result of minor or severe injuries earlier in life or because of decreased activity levels (Kirkendall & Garrett, 1998; Latham, 2004).

Since muscle strength and flexibility have significant correlations to fall risk and injury in older adults it is appropriate to test muscle fitness to determine functional standards and risk of injury. Over the years, fitness tests have been developed and norms of performance established through research. Components of these fitness tests specifically address different systems such as muscle strength, endurance, flexibility and total body endurance(*ACSM's Guidelines for Exercise Testing and Prescription*, 2000; Kirkendall & Garrett, 1998; Suni et al., 1998). The standards or norms established by studying various fitness tests allow researchers and clinicians to compare client performance to established norms and guide them in fitness using functional assessments. These comparisons can then lead to appropriate interventions.

As fitness performance norms have been established, research has also increased our understanding in the realm of perceived activity levels, self efficacy, and exercise and behavioral readiness to exercise. The International Physical Activity Questionnaire (IPAQ) has been developed and shown to be reliable in 12 countries and has set a standard of 150 MET-minutes/week of moderate intensity activity. This level of activity is proposed as the minimum for appropriate activity in adults(Craig et al., 2003).

Marcus and colleagues(Marcus, Pinto, Simkin, Audrain, & Taylor, 1994; Marcus et al., 1992) have studied self efficacy and exercise and developed a tool that measures the confidence a person has that he will exercise at least three times per week given a set of circumstances that may limit one's exercise habits. This tool has been shown to be valid and reliable in a number of sample populations. The work on self efficacy has been extensive and the application to exercise behaviors is appropriate(Dallow & Anderson, 2003; Marcus et al., 1994; Marcus et al., 1992). Related to self efficacy in exercise is the Transtheoretical Model of behavior change applied to exercise. Using this model, researchers have devised a tool that questions the client about exercise frequency, intensity, and duration. This tool comes from extensive work in smoking cessation and weight loss studies and establishes a client's stage of willingness to change behaviors(DiClemente & Prochaska, 1982; DiClemente et al., 1991; Marshall & Biddle, 2001; Prochaska & Velicer, 1997). Both of these tools are easy to administer and give the researcher valuable information about a subject's likelihood to exercise regularly. In combination with the IPAQ, these tools may yield several sources of similar information that can be correlated with each other and with clinical and muscle fitness performance tests.



Clinical functional tests are commonly used to establish a client's status related to tasks of functional significance. Many tests are used with a wide variety of clients. Functional testing in younger and older populations has been used for many years to help rehabilitation specialists document the status of patients and determine when to allow them to return to work or sport activity(Augustsson et al., 2004; Barber-Westin et al., 1999; Eastlack et al., 1999; Fitzgerald et al., 2001; Greenberger & Paterno, 1995; Juris et al., 1997; F R Noyes & Barber-Westin, 1997; O'Donnell et al., 2006; Petschnig et al., 1998; Wilk et al., 1994). Much has been published regarding high intensity lower extremity functional tests developed to assess readiness for activity after injury and subsequent rehabilitation(Augustsson et al., 2004; Barber-Westin et al., 1999; Eastlack et al., 1999; Fitzgerald et al., 2001; Greenberger & Paterno, 1995; Juris et al., 1997; F R Noyes & Barber-Westin, 1997; O'Donnell et al., 2006; Petschnig et al., 1998; Wilk et al., 1994). Likewise, functional testing of older adults related to fall risk has been studied. Tests used for this population are designed for those subjects who may have lower tolerance of activities that stress the joints of the lower extremities and spine(Dite et al., 2007; Dite & Temple, 2002; Guralnik et al., 1995; Steffen et al., 2002; Whitney et al., 2007).

It is important to establish performance levels that correlate with decline in activity and function so that preventative measures can be implemented to delay the onset of activity or participation limitations. Older adults are the most likely to suffer injury related to decreased activity, strength and functional ability, and this population has been studied with regard to clinical functional test performance(Bellew, Click Fenter, Moore, Chelette, & Lorenzo, 2004; Dite & Temple, 2002; Guralnik et al., 1995; Newton, 2001; Sherrington & Lord, 2005). Many of the tests used with this older population have a ceiling effect when applied to more active and able people which may limit their use with this population. Thus, it is important to identify clinical functional tools that discriminate well within each population to which they are applied. It is also important to identify characteristics of the middle aged population that may assist in predicting future decline and possible injury later in life. Clinical functional testing of middle aged adults has been limited and correlations of these tests with activity levels and muscle fitness do not presently exist. Self-reported activity and fitness levels represent data that are easy to obtain and may yield information that correlates with performance on clinical functional tests.

## **Purposes and Research Hypotheses**

With the above in mind, the purposes of this study were to: 1) determine if the star excursion balance test (SEBT), four square step test (FSST) and Biering-Sorensen trunk extensor muscle endurance test (BS) correlate to the fitness performance levels of subjects 30-60 years old as determined by performance on a series of muscle fitness tests. (Hypothesis: Better performance on each test will correspond to the highest one-third and poorer performance will correspond to the lowest one-third of neuromotor fitness level demonstrated.) and 2) determine if any set of demographic information, functional test performances, or self-reported activity levels exists that distinguish the highest from the lowest one-third of participants in neuromotor fitness performance. (Hypothesis: Subjects who report the highest levels of activity and exercise and who perform at the highest levels on the clinical functional tests will demonstrate higher levels of fitness.)

## **Methodology**

### *Subjects*

A total of 101 subjects volunteered to participate in the study. Each one signed a University of Kentucky IRB approved consent form prior to beginning the study. Subjects were recruited as described in earlier chapters and all subjects met the study criteria and were scheduled for a testing date. Testing was completed for this portion of the study on one day for each subject. Subject characteristics are displayed in Table 4.1. As a precaution all subjects' blood pressure and heart rate were recorded prior to testing and any medications taken for cardiac or metabolic conditions were documented. Recruitment information included descriptions of exclusion criteria to increase the likelihood that all subjects who volunteered were able to complete the study.

Table 4.1. Descriptive statistics of the general demographic characteristics (N = 101)

	Minimum	Maximum	Mean	Std. Deviation	
	Statistic	Statistic	Stat.	Std. Error	
Age	30	60	44.12	.85	8.39
Height (cm)	146.5	191.0	168.6	.85	8.41
Leg length (cm)	77.00	101.00	87.23	.52	5.15
Weight (kg)	47.00	128.00	73.89	1.66	16.46
BMI (kg/height in meters squared)	17.82	45.89	25.87	.50	4.99

### Procedures

After subject recruitment as described above and in previous chapters, preliminary data were collected on each subject to include height, weight, and leg length. Body mass index (BMI) was calculated for each subject as described in Chapter Three. Testing procedures for the FSST, SEBT and Biering-Sorensen trunk extensor muscle endurance test were followed as outlined in Chapter Two. Reliability of these measurements with this population is adequate and was reported in Chapter Two. For this portion of the study, subjects also performed three tests of muscle fitness to include curl-ups (or partial sit-ups), push-ups and a sit and reach flexibility test. The order in which all tests were administered was determined by identifying the testing station available at the time the subject was ready to be tested. Each subject walked five to ten minutes from the parking structure or nearby offices so this was used as a warm-up. Between each testing station, subjects were given as much time as they needed to rest prior to beginning the next test.

Curl-ups were done in a supine hooklying position with finger tips at the start position marked by a white stripe. Two other white stripes were placed beyond the starting stripe at a distance of eight and 12 cm respectively.(Figure 4.1) According to the procedure outlined in the ACSM manual(*ACSM's Guidelines for Exercise Testing and Prescription*, 2000), subjects under the age of 45 were to curl up and reach toward their heels a distance of at least 12 cm for the repetition to count. Subjects 45 and over were required to reach at least eight cm for the repetition to count. When the subject was positioned correctly, the examiner started a metronome at a count of 40 beats per

minute. The subject curled up to the point required on one beat and down to the starting position on the next beat. The head was not required to touch the mat. This movement continued until the subject quit or could no longer reach the target stripe. If in the course of performing the activity the subject did not reach the target, he or she was informed that the particular repetition did not count. The test was stopped if three attempts in a row did not reach the target, the subject quit, or a maximum of 75 curl ups were performed. The number of successful curl-ups performed was recorded.

Figure 4.1. Curl-ups (note the tape marks at 8 and 12 cm from starting position)



The push-up activity was completed differently for men and women. Men performed the push-up with hands near, but lateral to the shoulders and supporting the lower body on the toes. While performing the push-up, male subjects were instructed to maintain a stable, straight body and to lower the body touching the chin or nose to the mat. Women followed the same procedure, but supported the lower body on the knees.(Figures 4.2 and 4.3) Each subject performed as many push-ups as possible using the appropriate form above until they could no longer perform them correctly or they stopped the test. The number of successful push-ups performed was recorded.

Figure 4.2. Push-ups (modified, from knees for all women)



Figure 4.3. Push-ups (men performed a standard push-up)



The sit and reach activity is a measure of posterior leg and trunk flexibility. Subjects completed this test while sitting on a floor mat with feet in neutral dorsiflexion, with the plantar surfaces of the feet against a sit and reach board. Subjects were given one practice attempt and then three trials to place the hands together and reach forward along the top of the sit and reach board. On the top of the board, a tape measure was secured and the farthest distance reached was marked with each trial. The reach of the greatest length was recorded for data analysis. See figure 4.4.

Figure 4.4. Sit and reach with feet dorsiflexed to neutral and knees straight.



Upon completion of the fitness testing, the performances on the three fitness tests were reduced to one score called the fitness composite score. The fitness composite score utilized in this study is based on the established performances of sample populations for each fitness test at the 50<sup>th</sup> percentile by age and sex. If the sample population had scores comparable to the published norms, the fitness scores on the individual components of the fitness test would equal one. By adding these individual component scores together, the composite score would then approximate three. For example, in men 30-39 years old, the normative value at the 50<sup>th</sup> percentile was 31 for the curl-up test. The mean for our sample of men in this age group was 21.5. The mean of 21.5 divided by 31 yields a score of 0.69 for curl-ups in the sample of men 30-39 years old. This process was repeated for each test in each group studied.

In addition to the three muscle fitness tests and the clinical functional tests, each subject completed three self-report instruments concerning activity level and exercise habits. The short form of the International Physical Activity Questionnaire was completed to help identify the number of days and amount of time spent in the previous one week period in vigorous, moderate, walking and sitting activities. A score was generated by multiplying the number of days a type of activity was reported by the number of minutes spent per day by the number of metabolic equivalents (METS)

required for various levels of activity. Vigorous activities were valued at eight METs, moderate activities were valued at four METs, and walking activities were valued at 3.3 METs. For example, if a subject reported vigorous activity three days per week for 30 minutes per day the amount of MET-minutes/week for vigorous activity would be:

$$8 \text{ (METs)} \times 3 \text{ (days)} \times 30 \text{ (minutes)} = \text{for a total of 720 MET-minutes per week}$$

This calculation was repeated with the appropriate values for vigorous, moderate and walking activities and the calculated totals were summed to give the researchers a total weekly activity value. According to the IPAQ scoring system, each subject was then classified as having a low, moderate or high activity level (Craig et al., 2003). The activity level and each value were placed in the data base for analysis. See Table 4.2 for the activity level classifications. The short form of the IPAQ is displayed in Appendix C.

Table 4.2. Scoring criteria for the International Physical Activity Questionnaire.

	Vigorous Activity	Moderate Activity	Walking Activity
Category 1	Does not meet Levels for Categories 2 or 3		
Category 2	3 or more days of 20 Minutes per day OR ->	5 or more days of 30 Minutes per day OR ->	5 or more days of any combination of walking, vigorous or moderate activity totaling 600 MET-min/week
Category 3	3 or more days at least 1500 MET-min/week OR ->		7 days of any combination of walking, vigorous or moderate activity totaling 3000 MET-min/week or more

Marcus and colleagues (Marcus et al., 1992) developed a tool that identifies a person's stage of readiness for behavior change based on the Transtheoretical Model of change of behavior first used by DiClemente, Prochaska and others (DiClemente & Prochaska, 1982; DiClemente et al., 1991; Prochaska & Velicer, 1997). Sarkin and associates (Sarkin, Johnson, Prochaska, & Prochaska, 2001) utilized a similar tool when applying the Transtheoretical Model to exercise in an overweight population. In using the stages of change of exercise tool, the researcher simply asks each subject to identify

which of six statements represents their current exercise status. Exercise in this tool is defined as regular exercise occurring three or more times per week for 20 or more minutes each time. Each statement represents one of five stages of behavior change in the model. An additional category is included for those who have exercised regularly in the past but are not currently doing so. The stages and definitions are listed in Table 4.3. The tool used with the statements included is displayed in Appendix D.

Table 4.3. Stages of change in exercise behavior and corresponding descriptions

Stage of Change of Exercise Behavior	Description of the stage
Precontemplation	I currently do not exercise, and I do not intend to start exercising in the next 6 months.
Contemplation	I currently do not exercise, but I am thinking about starting to exercise in the next 6 months.
Preparation	I currently exercise some, but not regularly.
Action	I currently exercise regularly, but I have only begun doing so within the last 6 months.
Maintenance	I currently exercise regularly, and have done so for longer than 6 months.
Relapse	I have exercised regularly in the past, but I am not doing so currently.

Self-efficacy theory states that the level of confidence one has that she is able to carry out an activity is strongly and positively related to actually performing the activity (Bandura, 1977; Marcus et al., 1992). It has been shown that the self-efficacy score is strongly related to stages of behavior change and to behaviors such as exercise. For this reason, a self-efficacy and exercise survey was used. This tool is displayed in Appendix E and is based on the work by Marcus and colleagues (Marcus et al., 1994; Marcus et al., 1992). The tool is a series of statements related to the confidence one has to participate in regular exercise as defined above. There are nine statements and each is scored on a numerical scale from 0-10 with 0 being not confident at all and 10 being very confident. The individual scores are summed to produce a self-efficacy score which was recorded in the data base.



### *Data Analysis*

Data were analyzed using SPSS version 15.0 (Chicago) software. Descriptive statistics for the whole sample group including means, standard deviations, ranges and standard errors were analyzed. Prior to answering either research purpose, a bivariate correlation analysis (Pearson's Product Moment Correlation) was completed among all variables to identify which variables showed the greatest correlation to the neuromotor fitness composite score. The variables with the highest correlations to neuromotor fitness were selected for further analysis. A multiple linear regression with collinearity analysis was run to determine variables that represented redundant information. When analyzing the data related to the fitness composite normalized score, collinearity must be considered in order to identify variables that are highly correlated to each other and may bias any regression model. Variance inflation factors of 10 or more are indicative of collinearity (Field, 2005; Portney & Watkins, 2000). A much more conservative variance inflation factor of four or more was used in this study to be sure that collinearity did not influence the results. Variables initially considered included all demographic data, all scores related to the SEBT, FSST, Biering-Sorensen test, IPAQ total, IPAQ moderate, IPAQ vigorous, IPAQ walking, IPAQMETS-min total, Stage of Change, self-efficacy and BMI. Any variable with a variance inflation factor (VIF) of four or over was considered to have significant collinearity and only one of these similar variables was chosen for analysis with all other variables of interest. Variables removed from regression analysis because of multicollinearity included: all individual reach data from the SEBT, the IPAQ total, IPAQ vigorous, IPTQ walking, IPAQMETS-min total height, weight and leg length.

In order to answer the first aim of this study it was necessary to determine the relationships among the variables of interest. Bivariate correlation analyses were completed using the Pearson's Product Moment Correlation for all fitness and activity related data (fitness composite score, IPAQ moderate score, stage of change of behavior and self efficacy score), all clinical functional test performances (SEBT total, FSST and Biering-Sorensen), and then for all these data together. A one way analysis of variance with post hoc analysis using the Bonferroni adjustment was then completed to determine if any of the activity report scores or clinical functional tests could identify which subjects scored in the top and bottom third of the sample population.

To answer the second aim, a stepwise multiple linear regression was used to determine the model of variables that best predicted the level of muscle fitness achieved

by the subjects according to the scores generated using the battery of muscle fitness tests. The model was chosen after stratifying the study group into those who scored in the highest, middle and lowest thirds of the entire group on the fitness composite score generated by the data gathered from the individual fitness tests.

## Results

It was noted that three of the 101 subjects reported levels of vigorous activity over the past seven day period that were over three standard deviations beyond the mean, so these three subjects were omitted from the data analyzed leaving a total of 98 subjects. Descriptive statistics, means, and standard deviations for each of the clinical tests have been described in previous chapters. Descriptive statistics for the fitness tests, fitness composite score, self report activity and exercise tools are displayed in Table 4.4.

Table 4.4. Descriptive data for all self-report activity and fitness tools

Variable	Range	Mean	Standard Deviation
Curl-ups	0-75	28	20.4
Push-ups	0-41	17	11.3
Sit & Reach (cm)	0-47	29	8.3
Fitness Composite (normalized to 50 <sup>th</sup> percentile)	0.33-9.71	3.9	1.9
IPAQ category	1-3	2.2	0.7
IPAQ vigorous (MET-min/week)	0-4800	1122.6	992.7
IPAQ moderate (MET-min/week)	0-2880	429.1	443.6
IPAQ walking (MET-min/week)	0-5544	762.1	1006.3
IPAQ total (MET-min/week)	0-9864	2310.4	1588.6
Stage of Change	2-6	4.3	1.1
Self- Efficacy	26-90	65.6	15.6

Correlation analyses

identified slight to moderate correlations among all fitness, activity and functional test variables. All correlations are displayed in Table 4.5. Moderate, statistically significant correlations were identified as follows: 1) between BMI and the Biering Sorensen test, fitness composite score and stage of change of behavior levels, 2) between SEBT total and the FSST, and 3) between stage of change of behavior and the self-efficacy score.

Table 4.5. Pearson Product Moment Correlations among all final variables.

	BMI	SEBT	FSST	BS	Fitness	IPAQ moderate	SOC	SE
BMI	1	-.38*	.27*	-.48*	-.45*	-.13	-.40*	-.35*
SEBT	-.38*	1	-.57*	.34*	.36*	.22*	.28*	.10
FSST	.27*	-.57*	1	-.28*	-.35*	-.20*	-.31*	-.11
BS	-.48*	.34*	-.28*	1	.34*	.03	.13	.15
Fitness	-.45*	.36*	-.35*	.34*	1	.23*	.27*	.21*
IPAQ Moderate	-.13	.22*	-.20*	.03	.23*	1	.19	.15
Stage of Change	-.40*	.28*	.31*	.13	.27*	.19	1	.47*
Self-efficacy	-.35*	.10	.11	.15	.21*	.15	.46*	1

(\* indicates statistically significant at the  $p \leq 0.05$  level)

The bivariate correlation analysis also identified the following variables as having a statistically significant low to moderate correlation to the fitness composite score: weight, BMI, Right posterior medial reach, Left anterior medial reach, SEBT total, FSST, BS, IPAQ moderate activity, SOC, and Self-Efficacy. The first multiple linear regression included all variables studied and collinearity was evident in the five variables associated with the SEBT and the IPAQ and the four variables used to describe the sample population (height, weight, leg length and body mass index). For this reason, the SEBT total summation of all four reaches, the moderate activity score on the IPAQ and the body mass index were selected for use in the final regression model. These were the variables that had the strongest correlations to the fitness composite when compared to similar variables. Table 4.6 displays each variable chosen and the corresponding variance inflation factors after removal of variables producing potentially redundant data.

Table 4.6. Variables selected for analysis in the regression model with VIFs

Variable	Variance Inflation Factor (VIF)
BMI	1.64
SEBT total	1.66
FSST	1.60
BS Trunk	1.40
IPAQ moderate	1.09
Stage of Change	1.51
Self Efficacy	1.35

After stratifying the sample into thirds based on fitness composite scores, the one way ANOVA with Bonferroni adjustment demonstrated all showed significant differences between the subjects who performed at the highest third and lowest third levels. Table 4.7 provides evidence that each of the variables selected distinguishes between subjects whose fitness was determined to be in the highest versus the lowest third of the sample.

Table 4.7. Results of the one-way ANOVA with Bonferroni adjustment.

Variable	Mean Difference	Standard Error	Significance	95% Confidence Interval
BMI (kg/m <sup>2</sup> )	5.8	1.05	p<.001	3.27-8.41
SEBT total (cm)	-31.6	8.3	p=.001	-51.8- -11.3
FSST (sec.)	1.02	.25	p<.001	.41-1.63
BS (sec.)	-49.2	12.9	p=.001	-80.7- -17.6
IPAQ moderate (MET-min/week)	-362	103.4	p=.002	-614- -110
Self-Efficacy (scale 0-90)	-9.3	3.8	p=.05	-18.6- .06
Stage of Change	-.76	.26	p=.01	-1.4- -.12

The participants in the highest one third on the fitness score had a lower BMI, performed faster on the FSST, held position in the Biering Sorenson trunk extension test

longer, reported more confidence in their exercise habits, reached further in the SEBT, and reported greater activity levels.

The data were then analyzed in an attempt to identify a model that would best correlate with performance on the fitness tests. The primary goal was to establish which clinical functional tests, self report activity scales and physical characteristics may give clinicians insight into how these measures are related to muscle fitness. A stepwise multiple linear regression demonstrated that the best fit model of the BMI and four square step test together were able to predict 25% of the variance in fitness composite score at a significance level of  $p < .01$ . A multiple linear regression with all final variables entered was shown to predict 29% of the variance at a significance level of  $p < .01$ . Simple linear regressions with each of the seven variables showed BMI to predict 20%, FSST 12%, SEBT 13%, BST, 12%, SOC , SE, IPAQ moderate of the variance in fitness composite score. Table 4.8 displays this statistical data.

Table 4.8. Regression model statistics for each individual variable, the all variable model and model of best fit with regard to fitness composite score prediction. (\* indicates a statistically significant difference)

Model	R	R Square	F statistic	Significance
BMI	.45	.20	24.2	<.01
FSST	.35	.12	13.0	<.01
SEBT	.36	.13	14.33	<.01
BS test	.34	.12	12.88	<.01
SOC	.27	.07	7.42	<.01
SE	.21	.04	7.42	.04
IPAQ moderate	.23	.05	4.21	.02
BMI, FSST, SEBT, BS, SOC, SE, IPAQ mod	0.54	0.29	5.18	$p < .001^*$
BMI, FSST	0.50	0.25	16.02	$p < .001^*$

## Discussion

It was hypothesized that the performance on the functional tests studied would correlate strongly with performance on the fitness tests. Each of the functional tests identified the highest and lowest thirds of the fitness composite performance in the sample population. SEBT total showed a mean difference of 386.7 cm for the highest third compared to 355.1 cm for the lowest ( $p < .01$ ). FSST also showed a significant

difference ( $p < .01$ ) with the highest third performing faster at 4.55 seconds compared to 5.57 sec for the lowest third. Finally the Biering-Sorensen test of trunk extension endurance showed a significant mean difference of 49.2 seconds ( $p < .01$ ). These findings demonstrate that better muscle fitness as defined in this study can be identified by performance on clinical functional tests of postural stability, trunk endurance, balance, and coordinated stepping.

An important clinical note may be that findings showing poorer performance on the functional tests may indicate a need to address overall muscle fitness in addition to balance or postural stability. This is an especially important finding with this population. If fitness levels diminish as we age and people continue to engage in physically challenging activities on an infrequent basis, injuries may be observed in greater numbers. Injury in the middle years of life may lead to decreased activity levels. Once an individual decreases their activity level, the spiral of decreased fitness, decreased activity and increased frequency of injury may lead to future functional limitations and morbidity. This knowledge may lead to minimizing decline through the middle years.

A best fit model to predict fitness level was hypothesized at the outset of this study as well. It was hypothesized that the model would include the clinical functional tests and at least one self-report activity scale. When all key variables were entered into a multiple linear regression model, together these variables were able to predict about 29% of the variance in the fitness composite score. When a stepwise regression was run, a model was identified that was able to predict 25% of the variance in fitness composite score. The model includes the body mass index (BMI) and the FSST. It was surprising that the SEBT and the Biering-Sorensen test were not included in the best fit model. However, neither of these tests have quite as strong a relationship to muscle fitness as defined in this study as the BMI. BMI was significantly correlated with almost all other variables, and was the highest correlated with fitness composite score. The only variables that did not have significant correlations with the BMI were the various IPAQ scores.

The FSST is a test of quickness and speed that may be more reflected in the muscle fitness tests chosen. The curl-ups and push-ups test muscle strength, endurance and trunk stability which are all a part of the FSST. Curl-ups test strength and endurance in the global trunk flexors and push-ups test a combination of upper body strength and endurance with a secondary and less direct test of trunk postural muscles. The Biering-Sorensen test measures trunk extensor muscle endurance and this was not

directly tested with the chosen fitness tests. The Biering-Sorensen test more directly addresses the global and local trunk extensor muscles and may not contribute as much to the fitness composite score used in this study.

Self-report activity data did not contribute to the best fit model to predict neuromotor fitness. Individually, the fitness composite score had small but significant correlations with the IPAQ moderate activity score (( $r = 0.26$ ,  $p = .037$ ), the stage of change in exercise rating ( $r = .316$ ,  $p = .01$ ) and the self-efficacy rating ( $r = .243$ ,  $p = .05$ ). These correlations are very low, but definitely support a relationship between the variables. However, when these were included in the regression model to help predict the outcome, they were omitted from the model due to their low correlations and predictive value. This may have significant implications when considering self-report activity scales and fitness. Certainly, the fitness tests should test components of fitness that are consistent with those used in the self-report scales. However, it is also important to remember that self report tools may yield information that is less than accurate because it is based on an individual's perception of vigorous activity and time. Tools used in this study have been determined to be adequately reliable. Criterion validity of the tools was also assessed using data from accelerometers and determined to be acceptable (Craig et al., 2003; Marcus et al., 1994; Marcus et al., 1992). The low agreement found may be acceptable when comparing to other self-report tools, but this low agreement may be reflected in the self-report tools not being included in the model of prediction for the fitness score.

Fitness is complex to define. In this study, a series of simple tests of muscle strength, endurance, and flexibility were used as one definition of muscle fitness. These muscle characteristics play an important role in function and, as people grow older, muscle fitness and function decline (Krems et al., 2004; Nitz & Choy, 2004; Pober et al., 2002). The findings in this study will help clinicians assess clients quickly to determine functional levels with respect to balance and postural stability as well as obtain insight into muscle fitness levels. The model which includes the body mass index and the FSST can be assessed in a short period of time with minimal equipment making this combination valuable in a busy clinic. Although the model only predicts 25% of the variance possible in the fitness composite score, the additional variables only added 4% more predictive ability and take more time to assess. It has been established that slow performance of the FSST is related to a higher risk of falls in older adults (Dite & Temple, 2002; Whitney et al., 2007). The findings in this study show there is a relationship

between overall muscle and total body fitness and function in middle aged adults. This may indicate that addressing overall fitness with patients in the middle age years while also addressing the primary complaint, will help them continue to function at a higher level as they age and possibly diminish the chances they have of suffering a fall related injury in later life.

Previous research with fitness test performance has established normative values for large samples of healthy subjects. The current sample of 98 subjects demonstrated a fitness composite mean score of 3.85 which is greater than the 50<sup>th</sup> percentile of previous larger samples represented by a score of 3.0(ACSM's *Guidelines for Exercise Testing and Prescription*, 2000). See Table 4.9 for sample scores on each individual test and the composite score. The population of 30 year olds is representative of the larger sample reported in the ACSM publication. The 40 and 50 year old men and women scored better on the individual tests as well as the composite score. This difference appears to be a significant one and may pose a limitation to this study.

Table 4.9. Fitness test scores compared to the 50th percentile of ACSM norms

	Men 30-39 (n=15) Score/nor m	Men 40-49 (n=9) Score/nor m	Men 50-60 (n=13) Score/nor m	Women 30-40 (n=20) Score/nor m	Women 40-49 (n=16) Score/nor m	Women 50-60 (n=25) Score/nor m
Curl-up	21.53/31	41.44/39	30.54/27	24.90/21	32.63/25	25.52/9
Push-up	22.13/19	21.67/13	19.92/10	16.15/14	19.25/12	10.4/9
Sit & Reach	29.75/29	26.89/25	22.47/25	30.54/33	31.41/31	29.04/30
Fitness Composite	2.89/3	3.79/3	4.07/3	3.27/3	3.92/3	4.91/3

According to Craig and colleagues,(Craig et al., 2003) the CDC and ACSM guideline of 150 MET-min/week is considered a minimum amount of moderate level activity per week to maintain a healthy lifestyle. In this study, 70 of the 98 subjects (71%) whose data were analyzed had moderate activity levels of 150 or more. This compares to 82% of subjects in the study by Craig and colleagues. The average total MET-



min/week in Craig's sample was 2514. In the current study, the average was 2310 MET-min/week for all 98 subjects demonstrating that the total activity reported is comparable between samples.

It is interesting that of the clinical functional tests only the SEBT and FSST showed significant, but low correlations to the IPAQ moderate activity level. Additionally, the fitness composite was also significantly correlated at a level of  $p < .01$ . It was hypothesized that fitness, performance on all the clinical tests, and self report of activity would all correlate with each other. Muscle strength and endurance in the trunk and upper body are important for healthy functional activities that require lifting and other total body activities. IPAQ moderate activities are operationally defined as activities "that make one breathe somewhat harder than normal like carrying light loads, biking at a regular pace or doubles tennis", may or may not correlate significantly to performance in a dynamic balance or trunk extensor endurance test. (IPAQ instrument, [www.ipaq.ki.se](http://www.ipaq.ki.se)) In this case, it appears the fitness level assessment, FSST (test of coordination and balance), and the SEBT (test of postural stability that requires the type of muscle fitness measured) are the only final variables that relate to the self reported moderate activity in the IPAQ.

When studying all the self-reports of activity level and their ability to identify subjects scoring in the highest and lowest thirds with respect to the muscle fitness composite score, it is interesting to note that the IPAQ moderate activity ( $p=.002$ ), self-efficacy score ( $p = .05$ ) and stage of change of behavior in exercise ( $p = .01$ ) were all able to identify the fitness levels of the sample. Although the mean differences were small, there were definite differences noted between the highest and lowest performers on the fitness composite. These data may indicate that the self-report exercise behavior pattern tools and the report of moderate activity using the IPAQ have value in identifying neuromotor fitness levels as defined in this study.

It was expected that all component parts of the self-report of activity would correlate strongly and significantly with fitness composite scores. However, only the IPAQ moderate activity level showed a significant relationship. The individual components of the IPAQ require subjects to recall activities in the previous seven days and all components may not be representative of fitness levels or the exercise habits needed to maintain fitness levels. On the stage of change tool, it would be expected that a subject who reports that he/she has exercised regularly for over six months would have a higher fitness score. The low levels of correlation may indicate that the types of

exercise done by the subjects are not strongly related to the fitness tests chosen or that the activity reported in a short seven day period does not reflect the activity duration or level of intensity needed to improve and maintain fitness levels.

It will be important to continue studying this population to establish normative values of performance. Other studies should begin to address these clinical functional tests with various patient populations in this age group. Studying the middle aged injured population may give us valuable insight into their ability to perform functionally in an injured state, after injury, and compared to the uninjured state. Injuries of various types occur throughout the life continuum. Understanding how functional ability is impacted by injury will enhance our understanding of the aging process and functional performance.

### **Study Limitations**

This study has several limitations that may affect the findings. The subject pool used in the study may not be representative of the typical population of middle aged adults. The fitness composite shows that the 40 and 50 year olds in the study were above the 50<sup>th</sup> percentile in performance on the fitness tests. This may also indicate their performances in the functional tests may be higher than expected. The investigators attempted to recruit a variety of subjects, but those volunteering may have been people who were interested to see how their exercise programs have prepared them in fitness compared to others. There were not many subjects who reported they did not exercise at all. Another limitation is the fitness test battery chosen. Although the battery used gives a measure of fitness, it may not be a measure comparable to the activities reported and the manner in which people exercise. It is well known that aerobic exercise is commonly chosen as a primary type of exercise. This study did not test aerobic capacity and so may not have discerned fitness related to the types of activities chosen by this population.

### **Conclusions**

The FSST, SEBT, and Biering-Sorensen clinical functional tests correlate with muscle fitness levels based on the fitness test battery used in this study. A model of body mass index and FSST was identified that best identifies those who will be a high and low performer in muscle fitness tests. Self-reported activity tools identified high and low performers in muscle fitness tests but only the IPAQ moderate activity correlated with muscle fitness individually. Further studies are needed to establish normative

values for performance and whether these functional tools may be useful as outcome measures in patient populations.

## CHAPTER FIVE: SUMMARY

### Overview

The relationships among clinical functional tests, physical fitness and reported activity levels are complex. Clinical functional tests are utilized in physical therapy in a range of age groups and with patients who present with multiple diagnoses (Augustsson et al., 2004; Barber-Westin et al., 1999; Dite & Temple, 2002; Eastlack et al., 1999; Fitzgerald et al., 2001; Greenberger & Paterno, 1995; Guralnik et al., 1995; Juris et al., 1997; F R Noyes & Barber-Westin, 1997; O'Donnell et al., 2006; Petschnig et al., 1998; Steffen et al., 2002; Whitney et al., 2007; Wilk et al., 1994). These diagnoses include musculoskeletal and neuromuscular conditions which vary greatly in their ultimate impact on function. Unlike the older and younger populations, the middle aged population has not been studied significantly with regard to clinical functional tests. This has created a void in data that may be helpful in progressing interventions and in decision making with regards to return to work and activity for this population. Studies of high impact hopping and jumping tests have been appropriately limited to subjects who are younger and more athletic (Augustsson et al., 2004; Barber-Westin et al., 1999; Eastlack et al., 1999; Fitzgerald et al., 2001; Greenberger & Paterno, 1995; Juris et al., 1997; F R Noyes & Barber-Westin, 1997; O'Donnell et al., 2006; Petschnig et al., 1998; Wilk et al., 1994). Clinical functional tests used with older adults are able to yield information that is very helpful in identifying people more likely to fall or experience other age related injuries (Dite & Temple, 2002; Guralnik et al., 1995; Steffen et al., 2002; Whitney et al., 2007). The present research was an attempt to provide data on functional performance for middle aged people by examining many characteristics that may be related to functional performance and activity levels and their relationship with physical fitness characteristics.

### Primary Purposes and Data Summary

The primary purposes of this study were to:

1. Determine if the star excursion balance test (SEBT), four square step test (FSST), and Biering-Sorensen trunk extensor muscle endurance test (BS) correspond to the fitness performance levels of subjects (30-60 years old) as determined by performance on a series of muscle fitness tests.

2. Determine if any set of demographic information, functional test performances, or self reported activity levels exists that distinguishes the highest from the lowest one-third of participants in fitness level performance.
3. Determine a set of expected values in the performance of the two lower extremity functional tests (SEBT and FSST) and the trunk extensor muscle endurance test (Biering-Sorensen) for subjects in ten-year age groupings within the sample population.
4. Demonstrate the reliability of the two lower extremity functional tests (star excursion balance test (SEBT) and four square step test (FSST)) and the Biering-Sorensen trunk extensor muscle endurance test (BS) in a population of subjects ranging in age from 30-60 years old.

The first two purposes are related as the highest and lowest performers on muscle fitness tests were studied at two different levels. First, an attempt was made to discern if any of the variables studied were successful in identifying the high and low performers in fitness level. Within the context of the second purpose, identification of a model of variables that best predicted muscle fitness as defined here was completed. In each case, it was found that each clinical functional test and the activity report tools identified the high and low performers without exception. (Table 4.7) Based on the findings it was possible to identify a model of best fit that predicted 25% of the variance in muscle fitness which included body mass index and the four square step test (FSST). Predicting 25% of the variance indicates there are other factors that contribute to muscle fitness, but this model gives clinicians a combination of tests with statistically significant predictive ability. This knowledge may allow clinicians to quickly assess a client's height, weight and FSST performance and have a general idea of their overall muscle fitness level. It has been reported that people who have higher fitness and activity levels are healthier in general (Arraiz et al., 1992). Understanding the client's level of fitness gives the clinician added information regarding the type of intervention to develop and can help make that intervention more efficient and effective.

Reliability of the clinical functional tests has been established in previous research with sample populations that differed from the current sample. FSST reliability and validity have been established with adults 65 years old and older (Dite & Temple, 2002; Whitney et al., 2007). The SEBT has been shown to be a reliable and valid test in several studies with subjects 18-35 years old and in subjects over 59 years old (Hertel et al., 2000; Kinzey & Armstrong, 1998; Stockert & Barakatt, 2005). The Biering-Sorensen test has also shown acceptable reliability, but with a much broader sample of

individuals(Alaranta et al., 1994; Hyytiainen, Salminen, Suvitie, Wickstrom, & Pentti, 1991; Keller et al., 2001). In the current study, reliability was established with the sample population that is comparable to the previous studies of varying sample populations. Table 5.1 displays reliability data from this investigation with the reliability ranges found in previous studies for each test.

Table 5.1. Comparison of reliability between studies for each clinical functional test

	SEBT	FSST	Biering-Sorensen
English (2008)	.76-.97	.88	.64
Dite (2002)	---	.98	---
Whitney (2006)	----	.93	---
Alaranta (1994)	---	---	.63
Keller (2001)	---	---	.80-.98
Hyytiainen (1991)	---	---	.74
Hertel (2000)	.89-.96	---	---
KInzey (1998)	.67-.87	---	---
Stockert (2005)	.91-.95	---	---

For clinical functional tests to have the greatest value, comparison to a standard or expected performance is optimal. Many clinical functional tests use comparison to the uninvolved extremity and standard percentages of performance when using this comparison(Itoh et al., 1998; Mattacola & Dwyer, 2002; F.R. Noyes et al., 1991). In the case of the functional tests chosen for this study, comparison to uninvolved limbs is inappropriate and comparison to performance by other age groups previously tested may be misleading. Younger populations have been previously tested with the SEBT and older ones with the FSST, but there are no available comparable samples that have been tested in the middle aged population. Although this study did not have an adequate number of subjects to establish normative performance values, it is reasonable to use the data as expected performance values for the purpose of comparing the performance of clients in the clinic with what is expected for their age and sex. The Biering-Sorensen test has normative values established and the values found in this study approximate those values(Alaranta et al., 1994). The sample used in this study performed this test at a higher level possibly due to a greater level of fitness. Expected performance values are displayed by gender and age in previous chapters.

### **Value of the Clinical Tests Considering the Aging Population**

Clinical functional tests should be reliable, valid, and easy to use if they are to be valued in the clinic. Reliability must be assessed with the sample populations with which the tests are used. In the case of the clinical tests in this study, the FSST has been shown to be reliable with older adults (Dite & Temple, 2002; Whitney et al., 2007). SEBT has been shown to be reliable with younger and older subjects (18-35 and > 59 years old) and the Biering-Sorensen test is reliable with a variety of subjects (Alaranta et al., 1994; Hertel et al., 2000; Hyytiainen et al., 1991; Keller et al., 2001; Kinzey & Armstrong, 1998; Stockert & Barakatt, 2005). In each of the above cases, the tests were shown to be reliable with specific ages and specific impairments. This study has tried to establish acceptable reliability with subjects in a particular age range who are asymptomatic. This is a first step in establishing the value of these tests with a wider range of people. Using these tests with a sample of similarly aged subjects who have impairments will be appropriate for future studies. At this time, clinicians can begin using these tests with confidence that they can be reliably applied to people in the 30-60 year old age range.

Portability and ease of use are also critical to consider when establishing the value of clinical tests. A clinical test that is time consuming or that requires extensive equipment that limits its use may not be used in a fast paced clinic that must maximize efficiency. All three of the clinical tests used in this study are very easy to perform, require minimal and portable equipment and take little time to complete. All these characteristics make the tests more likely to be used in the clinics. Coupled with their strong reliability and established expected performance values, clinicians have testing procedures they can use efficiently with confidence.

Having an understanding of how performance on clinical tests correlates to fitness and activity levels gives a clinician valuable information with regard to a client's level of general function and function as it relates to the specific test. It was demonstrated that performance on the clinical functional tests was moderately, but significantly correlated to level of muscle fitness. All three functional tests target muscle endurance and to a lesser extent strength. It is not surprising that moderate correlations are reported since the muscle fitness tests chosen target endurance, strength, and flexibility of the trunk and upper body. The functional tests used in this study target the trunk and lower extremities more than upper extremities so the correlations are understandably lower than anticipated. Knowing that tests of lower extremity and balance functions are related to trunk strength and overall muscle fitness can guide

physical therapists in intervention planning and give support to decisions for the use of broad programs including strength, endurance, flexibility and stability exercises.

Stated activity levels also correlated significantly to level of fitness, but only at a slight to moderate level of correlation. It is known that as people age, their levels of activity decline in intensity and they begin to decline in areas that contribute to function such as muscle strength, lean body mass and flexibility (Brach & VanSwearingen, 2002; Gehlsen & Whaley, 1990; Menz, Morris, & Lord, 2006). The combination of the fitness tests used relates well to the body mass index. Muscle strength, flexibility, and lean body mass are fitness parameters assessed and these characteristics give the researchers insight into the levels of fitness demonstrated by typical middle aged people, how they perform in several clinical functional tests and their self-reported activity levels. Physical therapists can be more efficient when assessing function while relating functional ability to overall fitness and activity tendencies. Understanding muscle fitness and self-reported activity levels allows physical therapists to educate clients based on expected performance levels reported in order to encourage activity and exercise for the whole body in the middle aged years in hopes of minimizing some of the functional losses commonly associated with aging. As healthcare professionals across the world recognize the impact of internal and environmental factors on function as highlighted in the International Classification of Function tool, addressing internal factors such as fitness, strength and flexibility may lead to higher levels of function for the aging population in a variety of environments.

The Biering-Sorensen test reliability was unexpected. Reliability for this trunk extension muscle endurance test was only  $r = .64$ . This moderate reliability is acceptable, and comparable to some previously reported data but much lower than the reliability of the other two clinical tests studied (Alaranta et al., 1994; Hyytiainen et al., 1991; Keller et al., 2001). It appears that this difference in test-retest performance may be related to knowledge of results from the first day testing. As subjects completed testing on Day One, they were given a summary sheet of their performance data for blood pressure, heart rate, all fitness tests and the Biering-Sorensen test. Their performance was compared to established norms. So when they left Day One testing, each subject had some knowledge of how their fitness performance and vital signs compared to others of their sex and age. The Biering-Sorensen test done with asymptomatic subjects has been shown to be stopped by the subjects for a variety of reasons including leg fatigue and pain, back fatigue and lack of motivation (Ropponen et



al., 2005). This knowledge may indicate the presence of a ceiling effect with asymptomatic subjects using the Biering-Sorensen test. Since motivation is one of the identified reasons for stopping the test, it is likely that knowledge of Day One results may have motivated the subjects to sustain the position longer on Day Two. Knowledge of results was also given for the FSST and SEBT, but these tests seem to depend less on motivation and more on physical performance than the Biering-Sorensen test.

Upon data analysis, it was determined that the key variables in the study, after omitting variables that demonstrated collinearity, included the body mass index, SEBT summed total reach normalized to leg length, fitness composite score normalized to the 50<sup>th</sup> percentile of performance based on age and sex, FSST time, Biering-Sorensen test time, IPAQ moderate activity report, self efficacy score and the reported stage of change of behavior in exercise. Body mass index (BMI) is an easily calculated figure that considers height and weight with established standards identifying people in the normal, underweight and overweight categories. It was expected that those with a lower BMI would perform better on the fitness and functional tests and be more active. This indeed was the case. It was also hypothesized that lower BMI, faster FSST, greater reach in the SEBT, longer hold times in the Biering-Sorensen test and greater reported activity and exercise frequency would all correspond to higher fitness levels. We did find that all these variables correlated favorably with fitness, but when a model was calculated to determine the best fit for prediction of fitness, only the BMI and FSST were selected to be most significant. Table 5.2 displays the Pearson product moment correlations for the key variables related to the fitness composite score.

Table 5.2. Correlations between key variables and all fitness composite scores

Test	Correlation Coefficient	Significance
BMI	-.45	p <.01
SEBT total	.36	p <.01
FSST	-.35	p <.01
IPAQ moderate Activity	.23	p =.02
Stage of Change	.27	p =.01
Self efficacy	.21	p =.04

Each of the variables correlated in a statistically significant manner with fitness, but the correlations ranged from low to moderate. This lack of a strong relationship between any of the variables and the fitness score may explain why only the BMI and FSST variables were represented in the regression model of best fit. When placed in a regression model together, all the variables contributed to a model that predicted 29% of the variance in fitness scores. This was only slightly better than the model with only two variables. This indicates that although these factors may correlate with muscle fitness, there are other factors not studied which influence fitness levels. The positive relationship between each of the variables and the fitness score highlights the importance of remaining active and fit through the lifespan on functional ability. This key information should be used by physical therapists and other health care practitioners to encourage lifelong exercise and fitness activities as a potential method of minimizing functional decline and promoting functional independence for as long as possible.

### Concluding Comments

In addition to establishing that several clinical functional tests can help identify people with higher and lower muscle fitness levels and that the FSST and the body mass index together can assist in identifying high and low fitness performance, other clinically relevant findings have resulted from this research. First, the clinical functional tests studied are reliable with a healthy population of men and women ages 30-60. These tests are used to measure important functional abilities and the FSST and SEBT have not previously been tested for reliability in this population. Knowing the reliability of

clinically relevant tests gives health care practitioners confidence the procedures they use will be repeatable.

Secondly, the findings are a beginning in developing expected performance values for the FSST and SEBT in the age groups tested. It is important to know expected performance values on examination procedures used in clinical settings. When working with middle aged clients that have trunk or lower extremity dysfunction, it is helpful to be able to assess their ability compared to established values and educate them accordingly. Many more subjects are needed to establish accepted norms for these procedures, but the 101 subjects used in this study represent an initial effort in the development of norms and can be used preliminarily as a gauge of the levels of performance among patient populations in this age group.

Another finding directs practitioners and researchers to look at additional practice trials when using the FSST to account for the learning effect. Further studies should also include an additional fitness test that targets lower extremity muscle fitness such as a single leg squat or step down procedure and studies with a patient population to assess people with an identified dysfunction and how they compare with the expected performance values reported.

Appendix A. Recruitment Flyer

# Middle-Aged Volunteers Needed for Fitness Study

Researchers at the University of Kentucky College of Health Sciences are conducting a research study to determine if there is a relationship between activity level, fitness and performance. It is known that as people age, their activity level and ability to function independently declines. This study is to help researchers determine if activity and fitness levels in middle-aged people are related to performance on tests commonly used in physical therapy clinics.

**You may be able to participate if you are:**

- between 30-60 years old
- have had no current heart condition or back, leg or foot pain in the past month that limits your ability to walk

If you qualify for this study, you will be compensated for your participation. You will also receive an assessment of your fitness level in comparison to others in your age group. For more information, contact Robert A. (Tony) English, investigator and research coordinator, at (859) 323-1100 ext. 80834 or [tenglish@uky.edu](mailto:tenglish@uky.edu).

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REHAB-012\_flyer#

## Appendix B. Consent to Participate in the Research Study

### Consent to Participate in a Research Study

Functional Limitation: Correlation of Trunk Strength, Dynamic Balance and Perceived Functional Ability in People Aged 30-60.

#### **WHY ARE YOU BEING INVITED TO TAKE PART IN THIS RESEARCH?**

You are being invited to take part in a research study about the relationships among clinical functional tests and activity and fitness. We are also studying the reliability of tests of postural control and dynamic balance between periods of time. You are being invited to take part in this research study because you are between 30 and 60 years old. If you volunteer to take part in this study, you will be one of about 70 people to do so at the University of Kentucky.

#### **WHO IS DOING THE STUDY?**

The person in charge of this study is Robert A. (Tony) English (PI) of the University of Kentucky. He is being guided in this research by Terry R. Malone, PT, ATC, EdD and Tim L. Uhl, PT, ATC, PhD. There may be other people on the research team assisting at different times during the study.

#### **WHAT IS THE PURPOSE OF THIS STUDY?**

We are trying to determine if there is a relationship between activity level and fitness and performance on 3 clinical functional tests commonly used in physical therapy clinics with young and old patients. We are also trying to determine typical performance levels for these tests in the population and studying whether the tests are reliable from one test day to another when used in people between the ages of 30-60. For example when testing a person between the ages of 30-60, we want to know if the information obtained is the same the next time that the person is tested and if any of the tests are able to predict performance on other tests for this age group. This will give us information about the tests' reliability and accuracy in testing dynamic postural control.

#### **WHERE IS THE STUDY GOING TO TAKE PLACE AND HOW LONG WILL IT LAST?**

The research procedures will be conducted at the University of Kentucky, College of Health Sciences Musculoskeletal laboratory. You will need to come to the Charles T. Wethington, Jr. Building's Musculoskeletal Lab (room 222) 1-2 times during the study. The first of those visits will take about 60 minutes. If you agree to a second visit, it should be shorter and the total amount of time you will be asked to volunteer for this study will be less than 100 minutes over the next year.

#### **WHAT WILL YOU BE ASKED TO DO?**

As a test subject you will come in to the lab one-two times in comfortable athletic clothing and shoes. When you arrive we will measure your leg length using a tape measure. We will then measure height and weight on a standard physician scale and

have you completed 3 health and activity surveys. Then you will complete a short physical fitness test to include curl-ups (a partial sit-up), push ups and a flexibility test. We will then have you stand on one leg at a time and reach as far as you can in 4 directions, this is called the star excursion balance test. We will also test your back muscle strength by having you lift up off a mat and hold the position as long as you can. The final test is called the four square step test where you will step over small diameter pipes lying on the floor as fast as you can. Prior to all tests you will be given a chance to practice and become familiar with the testing procedures. Each of the tests is done in Physical Therapy clinics to test strength, agility and balance. There is nothing invasive or potentially harmful in this study. If you are selected to be tested twice, testing will be done on two separate days at least 1 week apart. When you return for the second time, all the clinical tests will be repeated. If you are selected to be tested only once, testing will be over after the first session. When you come for testing, you will be tested in a randomly selected order. One time we may test on the star excursion balance test first and the next time on the four square step test. This is to avoid any testing error.

### **ARE THERE REASONS WHY YOU SHOULD NOT TAKE PART IN THIS STUDY?**

You should not take part in this study if you are not 30-60 years old or have any known foot, ankle, hip or back injuries (in the last 3 months) on either leg that currently limit your walking, or if you have any balance disorders. You should also not participate if you have a current heart condition or other condition that limits your ability to perform minimal to moderate exercise, uninterrupted, for more than 5 minutes.

### **WHAT ARE THE POSSIBLE RISKS AND DISCOMFORTS?**

The risks are rare and minimal. It is rare, but you may be slightly sore after testing or may fall during testing. We will be guarding you as you perform the tests to protect you from losing balance.

There is always a chance that any physical fitness procedure can cause harm, and the procedures in this study are no different. We will do everything we can to keep you from being harmed. In addition to the risks listed above, you may experience a previously unknown risk or side effect.

<b>Possible Risk/Side Effect</b>	<b>How often has it occurred?</b>	<b>How serious is it?</b>	<b>Can it be corrected?</b>
Muscle soreness	It is uncommon	It will not impact your health	Yes, it will go away in just a few days

You will not get any personal benefit from taking part in this study other than knowledge of your performance compared to already published typical performance of others in your age group.

### **DO YOU HAVE TO TAKE PART IN THE STUDY?**

If you decide to participate in the study, it should be because you really want to volunteer. You can stop at any time during the study.

## **IF YOU DON'T WANT TO TAKE PART IN THE STUDY, ARE THERE OTHER CHOICES?**

If you do not want to be in the study, there are no other choices except not to take part in the study.

## **WHAT WILL IT COST YOU TO PARTICIPATE?**

The only costs should be your time and cost of transportation. Parking will be available in the Kentucky Clinic Parking Structure. The cost for parking is \$0.75 per hour and the physical therapy division will cover this cost.

## **WHO WILL SEE THE INFORMATION THAT YOU GIVE?**

We will keep private all research records that identify anyone to the extent allowed by law. Once we get information we will change all names to an identification number and only we will have the master list of information and names.

All information will be combined with information from other people taking part in the study. When we write about the study to share it with other researchers, we will write about the combined information we have gathered. No one will be identified in these written materials. We may publish the results of this study; however, we will keep all names and other identifying information private.

We will make every effort to prevent anyone who is not on the research team from knowing that information was given to us, or what that information is. For example, all names will be kept separate from the information given, and these two things will be stored in different places under lock and key. You should know, however, that there are some circumstances in which we may have to show your information to other people. Someone from the University of Kentucky may look at or copy pertinent portions of records that identify you.

## **CAN YOUR TAKING PART IN THE STUDY END EARLY?**

If you decide to take part in the study you still have the right to decide at any time that you no longer want to continue. You will not be treated differently if you decide to stop taking part in the study.

The individuals conducting the study may need to withdraw you from the study. This may occur if you are not able to follow the directions given or if they find that being in the study is more risk than benefit to you.

## **WHAT HAPPENS IF YOU GET HURT OR SICK DURING THE STUDY?**

If you believe you are hurt or if you get sick because of something that is done during the study, you should call Robert A. English at 859 323-1100 extension 80834 immediately. It is important for you to understand that the University of Kentucky will not pay for the cost of any care or treatment that might be necessary because you get hurt or sick while taking part in this study. That cost will be your responsibility. Also, the University of Kentucky will not pay for any wages you may lose if you are harmed by this study.

Medical costs that result from research-related harm can not be included as regular medical costs. The University of Kentucky may not be allowed to bill your insurance

company for such costs. You should ask your insurer if you have any questions about your insurer's willingness to pay under these circumstances. Therefore, the costs related to your care and treatment because of something that is done during this study of balance and strength will be your responsibility

**WILL YOU RECEIVE ANY REWARDS FOR TAKING PART IN THIS STUDY?**

You will receive a small payment for taking part in the study.

**WHAT IF YOU HAVE QUESTIONS, SUGGESTIONS, CONCERNS, OR COMPLAINTS?**

Before you decide whether to accept this invitation to take part in the study, please ask any questions that might come to mind now. Later, if you have questions, suggestions, concerns, or complaints about the study, you can contact the investigator, Robert A. English at 859 323-1100 extension 80834. If you have any questions about your rights as a volunteer in this research, contact the staff in the Office of Research Integrity at the University of Kentucky at 859-257-9428 or toll free at 1-866-400-9428. We will give you a signed copy of this consent form to take with you.

**WHAT ELSE DO YOU NEED TO KNOW?**

Taking a part in a research project can be very rewarding.

You will be told if any new information is learned which may affect your condition or influence your willingness to continue taking part in this study.

\_\_\_\_\_  
Signature of person agreeing to take part in the study

\_\_\_\_\_  
Date

\_\_\_\_\_  
Printed name of person agreeing to take part in the study

\_\_\_\_\_  
Name of [authorized] person obtaining informed consent

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature of Investigator



## Appendix C. International Physical Activity Questionnaire- Short Form

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

### INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

\_\_\_\_\_ **days per week**

No vigorous physical activities **Skip to question 3**

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis?

Do not include walking.

\_\_\_\_\_ **days per week**

No moderate physical activities **Skip to question 5**

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

\_\_\_\_\_ **days per week**

No walking ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

\_\_\_\_\_ **hours per day**

\_\_\_\_\_ **minutes per day**

Don't know/Not sure

**This is the end of the questionnaire, thank you for participating.**

## Appendix D. Stages of Change of Behavior in Exercise Tool

### Regular Exercise Survey

Regular moderate exercise is defined as any planned physical activity such as fast walking, aerobics, jogging, tennis, easy bicycling, volleyball, badminton, swimming, alpine skiing, dancing, etc., performed to increase physical fitness. Regular exercise means the activity is done 4-7 days per week for at least 20-40 minutes per day. Moderate exercise does not have to be painful or exhausting to be effective, but should result in an increased rate of breathing and you should break into a light sweat.

Please select the one option below which best matches your intention to engage in a regular moderate exercise program according to the definitions above.

1. I currently do not exercise, and I do not intend to start exercising in the next 6 months.
2. I currently do not exercise, but I am thinking about starting to exercise in the next 6 months.
3. I currently exercise some, but not regularly
4. I currently exercise regularly, but I have only begun doing so within the last 6 months.
5. I currently exercise regularly, and have done so for longer than 6 months.
6. I have exercised regularly in the past, but I am not doing so currently.

## Appendix E. Self-Efficacy and Exercise Tool

### Confidence in Exercise

How confident are you right now that you could exercise at least 3 times per week for 20 minutes if:

	Not Confident					Very Confident					
1. the weather was bothering you	0	1	2	3	4	5	6	7	8	9	10
2. you were bored by the program or activity	0	1	2	3	4	5	6	7	8	9	10
3. you felt pain while exercising	0	1	2	3	4	5	6	7	8	9	10
4. you had to exercise alone	0	1	2	3	4	5	6	7	8	9	10
5. you did not enjoy it	0	1	2	3	4	5	6	7	8	9	10
6. you were too busy with other activities	0	1	2	3	4	5	6	7	8	9	10
7. you felt tired	0	1	2	3	4	5	6	7	8	9	10
8. you felt stressed	0	1	2	3	4	5	6	7	8	9	10
9. you felt depressed	0	1	2	3	4	5	6	7	8	9	10

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## VITA

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**Date and Place of Birth:** January 16, 1956, Victoria, Texas

#### **Educational Institutions Attended:**

<u>Year</u>	<u>Degree</u>	<u>Major-Subspecialty</u>	<u>Institution</u>
1974	none	Pre-physical therapy	The Victoria College
1978	B.S.	Physical Therapy	University of Texas
1990	M.S.	Education	University of Kentucky
Enrolled 2002 Candidate status	Ph.D.	Rehabilitation Sciences	University of Kentucky

#### **Professional Positions Held:**

1978-1981	Staff Physical Therapist	Presbyterian Hospital of Dallas
1981-1982	Assistant Director of Physical Therapy	Presbyterian Hospital of Dallas
1982-1987	Co-director and Co-owner	English Physical Therapy Refugio Cnty Mem Hospital
1987-1990	Staff Physical Therapist	Humana Hospital Lexington, Ky
1990-1991	Asst. Director of Rehabilitation Services	Humana Hospital Lexington, Ky
1991-1992	Director of Rehabilitation Services	Humana Hospital Lexington, Ky
1992-1998	Assistant Professor	University of Kentucky
1998- present	Associate Professor	University of Kentucky

#### **Scholastic and Professional Honors:**

1978	Outstanding Graduate, School of Allied Health Sciences (SAHS) University of Texas Medical Branch at Galveston (UTMB)
1978	Outstanding Physical Therapy Student, SAHS, UTMB

- 1996 Nominated for University of Kentucky Alumni Association Great Teachers Award by PT class of 1997.
- 1996 Inducted into the University of Kentucky Chapter of Alpha Eta Society
- 1997 Nominated for Kingston Award for Teaching Excellence in the CAHP, UK
- 1997 Kingston Award for Teaching Excellence in the CAHP, UK
- 1998 Promotion to Associate Professor with Tenure, CAHP, UK
- 2005 Kentucky Physical Therapy Association Outstanding Physical Therapist of the Year.

### **Professional Publications:**

Malone TR, English T. Monograph: Home study course on Patellar Tendonitis. August, 1994.

Book Chapter in Malone, TR, McPoil T, Nitz AJ. Orthopedic and Sports Physical Therapy. English T, Wheeler E, Hettinga D. *Inflammatory Response of Synovial Joint Structures*. 1996.

English T, Harrison A, Hart A. A Distance Learning Model in a Physical Therapy Curriculum. *Journal of Allied Health*, December 1998.

Hart AL, Malone TR, English T. Shoulder Function and Rehabilitation Implications for the Wheelchair Racing Athlete. *Topics in Spinal Cord Rehabilitation*. Winter issue, 1998

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English RA, Banks A, Uhl TL. Correlation and reliability of trunk strength, dynamic balance, and perceived functional ability in young people. *JOSPT*. 2008;38(1): A49.

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