THE RELATIONSHIP BETWEEN THE FUNCTIONAL MOVEMENT SCREEN AND STAR EXCURSION BALANCE TEST

A THESIS

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INTRODUCTION

Balance and functional movements are essential elements for improving athletic ability and decreasing risk of injuries.[1-6] Athletic performance and activities of daily living both rely on the ability to move and move in such a way that maintaining stability is vital.[2] In this way, observation of balance and functional movement in athletes is important for injury prevention and performance enhancement. Current research has suggested that tests assessing multiple domains of function, such as balance, strength, and range of motion, may improve the accuracy of identifying athletes at risk for injury.[7,8] Thus, clinicians should realize assessment of functional movement and balance as a possible means of injury prevention is equally as important as evaluating and treating injuries.[4]

Balance is the single most important element dictating movement strategies within the closed kinetic chain and is essential in athletic and sport-related activities.[5,6,9,10] Visual, vestibular and somatosensory inputs, along with movements at the ankle, knee, and hip joints, are vital for fluid sport-related movement.[5] According to two studies performed by Hrysomallis and Zech et al[11,12], balance ability is significantly related to a number of performance measures in sports such as rifle shooting accuracy, archery shooting accuracy, ice hockey maximum skating speed and simulated luge start speed. Additionally, sport specific skills may be improved by balance training. Hrysomallis[11] found that increased balance ability improved vertical jump, agility, shuttle run times, and downhill slalom skiing.

Functional balance can be measured in numerous ways including the Star Excursion Balance Test (SEBT). The SEBT is a functional and dynamic unilateral balance test that integrates a single-leg stance on one leg and a maximum reach of the opposite leg in eight directions at 45° increments from the center point.[11,13-16] Previous research has demonstrated that reliability of the SEBT is strong for intratester and intertester reliability.[10,14] Reported Intraclass Correlation Coefficient (ICC) for intratester reliability have been .78-.96 on day one and .82-.96 on day two; ICCs for intertester reliability have been .35-.84 on day one and .81-.93 on day two. The SEBT can be used to demonstrate that the neuromuscular control mechanism works properly in an individual, which is an important mechanism for balance.[16] Earl and Hertel[16] found that the SEBT can also be used during rehabilitation as a closed-kinetic chain exercise to regenerate neuromuscular control after an injury.[16] Comparing functional balance to functional movement could provide further insight into an athlete's overall neuromuscular behavior.

Functional movement is defined as the ability to produce and maintain a balance between mobility and stability through the kinetic chain while performing fundamental patterns with accuracy and efficiency.[17] Functional movement can be effected by a lack of proprioception and postural control.[5] Research has shown that improving proprioception after an injury can enhance the sensation of movement and cognitive awareness of the joint relative to the movement.[18,19] According to Hoffman and Payne[20], proprioceptive training produces a significant decrease in postural sway and increase in postural control, thus benefitting human movement and ultimately athletic performance.

Functional movement has been successfully measured by an evaluation tool called the Functional Movement Screen (FMS). The FMS is an assessment tool that identifies fundamental movement-pattern limitations and asymmetry quantitatively with a series of seven movement tests.[1] The seven fundamental movement patterns or tests require a balance of mobility and stability and include the Deep Squat (DS), Hurdle Step (HS), Inline Lunge (IL), Shoulder

Mobility (SM), Active Straight-Leg Raise (ASLR), Trunk Stability Pushup (TSP), Rotary Stability (RS), and three clearing tests: Impingement Clearing Test (IC), Press-Up Clearing Test (PC), and Posterior Rocking Clearing Test (PRC). [1,3,4] The clearing tests check for pain and end-range of spinal flexion and extension pain.[8] The seven movement tests overall use a variety of positions and movements which places the individual in positions where weaknesses and imbalances become noticeable.[3] These tests provide observable performance of basic locomotor, manipulative, and stabilizing movements.[3] Previous research done by Minick et al[8] suggested that the inter-rater reliability of the FMS is high among trained individuals. Using the weighted kappa statistic, inter-rater reliability between the novice FMS raters has demonstrated excellent or substantial agreement on 82% of the tests, and the expert FMS raters demonstrated the same agreement on 76% of the tests.[8] When the novice FMS raters were compared to the expert FMS raters, all seven tests demonstrated excellent or substantial agreement. According to Kiesel et al[21], there is a positive relationship between an athlete's functional movement, as measured by the FMS, and injury risk in professional football. Athletes who scored lower on the FMS were more likely to suffer an injury than those with a higher composite FMS score.

Evaluating functional movements, whole body movements, and balance is important in order to optimize an athlete's performance and prevent injury. The goal of a functional movement screen is to identify athletes at high risk for an injury so appropriate actions can be taken to correct presented muscular dysfunctions.[16] Since there are multiple screenings available to a certified athletic trainer, it may be difficult to choose one test over another. The information from this study may help allied health professionals in general to determine which battery of tests can fully and accurately screen an athlete. There were no research studies found which compared functional movement as measured by the FMS to balance as measured by the SEBT at the time of research. Thus, the purpose of this study was to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test.

METHODS

The purpose of this study was to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test. If there is a relationship, the FMS might be adequate in assessing overall balance as measured by the SEBT. To this date, the author has not found literature comparing the FMS and the SEBT. This section will include the following subsections: research design, subjects, instruments, procedures, hypotheses, and data analysis.

Research Design

This descriptive correlational study examined the relationship between functional movement as tested by the FMS and functional balance as tested by the SEBT, where the FMS could potentially predict overall balance as measured by the SEBT. A limitation to this study is the inability to generalize the results beyond NCAA Division II male soccer athletes.

Subjects

Healthy NCAA Division II male soccer athletes (n~20) who were eighteen years of age or older from California University of Pennsylvania were asked to participate in this study. Subjects volunteered to participate with no coercion from coaches or faculty after the researcher had explained its purpose. Any subjects who suffered from any visual, vestibular, balance disorder, severe lower/upper extremity injury, and/or a concussion within the last six months were excluded from volunteering as these conditions may interfere with accurate functional balance and functional movement assessment.

Prior to the study, subjects read and signed the Informed Consent Form (Appendix C1). A Test Score Sheet (Appendix C2) was used to report the subject's results from the FMS and the SEBT. In order to protect subjects' identity, a number was used instead of their names in the study; this also assisted in blinding the researcher when checking the data collection sheet.

Preliminary Research

Preliminary research was designed to familiarize the researcher with the FMS, SEBT, and for a determination of the time necessary to test each subject. The procedure for each test was based on previous valid research.[8,14,15] Both tests were conducted on three adult volunteers within the age range of athletes who were studying or working at California University of Pennsylvania. Preliminary research helped to determine adequate practice times for the SEBT. It was determined that three practice trials of SEBT were adequate for subjects to become familiar with the SEBT and sufficiently minimize learning effects. Preliminary research validated previous scoring of the SEBT by using the maximum distance for each of the eight reaches per leg in eight directions (distance in centimeters). The average of the distances from each leg was then calculated for each leg, and then averaged for both legs and used as a composite score. The scoring of the FMS used the composite score from seven tests (Deep Squat, Hurdle Step, In-Line Lunge, Shoulder Mobility, Active Straight Leg Raise, Trunk Stability Push-Up, and Rotary Stability) according to previous research.[8]

Instruments

The instruments that were used in this study were test score sheets, the FMS kit (measuring device, hurdle with elastic band, and measuring dowel), and the SEBT with star grid. The practice test score sheet results were not used in the analysis.

FMS

The FMS (Appendix C4) is comprised of seven fundamental movement tests used to categorize functional movement patterns which each have a high inter-rater reliability among trained individuals.[8] The seven tests are the Deep Squat (DS), Hurdle Step (HS), Inline Lunge (IL), Shoulder Mobility (SM), Active Straight-Leg Raise (ASLR), Trunk Stability Pushup (TSP), and Rotary Stability (RS). Three clearing tests, the Impingement Clearing Test (IC), Press-Up Clearing Test (PC), and Posterior Rocking Clearing Test (PRC) are not scored but are used to observe any pain response. The clearing tests were not graded with a 3,2,1 or 0, but were reported as positive (painful) or negative (non-painful). A positive sign for pain in the IC, PC, and PRC tests will result in a score of a zero for only the associated SM, TSP and RS tests respectively.[1,3,4]

The FMS is scored on a 0-3 scale. A score of 3 represents the subject's ability to perform the functional movement as described, a score of a two represents the ability to perform a functional movement pattern but with some compensation, a score of 1 represents the inability to perform or complete the movement pattern. A score of zero represents pain with the movement pattern. There was a raw score and a final score noted for each test.[1] The raw score was used to denote right and left side scoring. The right and left sides were scored in five of the seven tests (HS, IL, SM, ASLR, and RS). The lowest score of the raw score (left and right sides) was carried over to give a final score for the test. For example, a person who received a raw score of a three on the right side and a two on the left side received a score of a two for the final score for that test. The final score was used to denote the overall score for the test.[1,3,4,] The sum of the final scores of each test was used as the composite score (0-21).

SEBT

The SEBT (Appendix C4) is a functional test of dynamic balance that has high intertester and intratester reliability while having the participant maintain a base of support on one leg and maximally reaching in eight different directions with the opposite leg.[14,15] The ICCs for intratester reliability have ranged from .78-.96. The SEBT used taped lines on a floor in a star pattern with eight lines extending at 45° increments from the center of the grid (star). Further hash marks were marked in 5cm increments from the center of the grid in all eight directions: anterolateral (AL), anterior (A), anteromedial (AM), medial (M), posteromedial (PM), posterior (P), posterolateral (PL), and lateral (L), according to the stance leg in relation to the direction of reach and in accordance with other research.[13,14] The labeling of the grid was different from the right and left stance legs (Appendix C4). Subjects' leg length was measured before the test to allow for normalizing of excursion distance data between subjects.[14,15] There were three test trials following the three practice reaches in each of the eight directions for both legs.[14,15] The distance between the center of the grid and the touch on the line from the subject's most distal aspect of the reach leg was recorded in centimeters. Each reached distance was marked along the line and the researcher manually measured the distance in centimeters from the center of the grid to the mark with a tape measure. The maximum distance for each of the eight excursions per leg in eight directions (distance in centimeters) was recorded. The maximum distances were then normalized to leg length and each the left and right normalized scores were totaled. The average of the left and right totals was then used as a composite score. A higher score in centimeters indicates better functional balance.

Procedures

The study was approved by the California University of Pennsylvania Institutional Review Board (IRB) (Appendix C3). Prior to the start of the study, the researcher met with the selection of volunteers to explain the study and offer the Informed Consent Form so that each subject understood the requirements and risks of the study.

Before the tests were administered, qualifications were presented to the subject again. Once the subjects understood and approved, they signed the Informed Consent Form (Appendix C1) and completed the subject information sheet on the Test Score Sheet (Appendix C2). The first day was a familiarization day for the SEBT and FMS tests. The second day was the test day. The SEBT and the FMS were randomized in order for each subject. Prior to each test, the researcher explained the test procedures and methods. The results were recorded on the practice test score sheet but were not used in the analysis. Further photographs and instructions for each test is presented in Appendix C4, and outlined below.

FMS

Subjects completed the seven tests used in the FMS in the following order: Deep Squat (DS), Hurdle Step (HS), Inline Lunge (IL), Shoulder Mobility (SM), Active Straight-Leg Raise (ASLR), Trunk Stability Pushup (TSP), and Rotary Stability (RS), and three clearing tests: Impingement Clearing Test (IC), Press-Up Clearing Test (PC), and Posterior Rocking Clearing Test (PRC). Each of these tests was performed for a maximum of three attempts. If one repetition is completed successfully, there was no reason to perform the test again.

For the DS, the subject assumed the starting position by placing feet shoulder width apart with both feet pointing forward. The subject rested the dowel on top of the head and adjusted the hand position so the elbows were at 90°. The subject then pressed the dowel overhead to fully extend the elbows. The subject then slowly assumed the deepest squat possible keeping the heels on the floor, head and chest facing forward, and the dowel maximally pressed overhead. The knees should be aligned over the feet with no valgus collapse. If these conditions were met, the subject received a score of a 3. If the subject could not meet the conditions for a score of a 3 on the DS, then the movement was performed again with the FMS kit board placed under the heels for a score of a 2. If requirements listed for a score of 2 were not achieved, then the subject received a score of a 1. If there was pain with the movement, a final score of a zero was given for the DS test.

For the HS, the height of the tibia was measured from the floor using the tibial tuberosity as a reliable landmark and the dowel as the measuring device. The hurdle's marking cord was adjusted to the tibial tuberosity. The dowel was positioned across the shoulders behind the neck. The subjects stepped over the hurdle with one leg and touched their heel to the floor while maintaining the stance leg in an extended position and then returned the moving leg to the starting position. The same was repeated with the other leg. A score of 3 was given on the HS if the subject's hips, knees, and ankles remained aligned in the sagittal plane, there was minimal to no lumbar movement and the dowel and hurdle remain parallel. If any of the criteria was not achieved for a score of a 3, then a score of 2 was given, and if the criteria for a score of 2 could not be achieved, then a score of 1 was given. If there was pain with the movement, a final score of a zero was given for the HS test.

For the IL, the subjects placed one foot at the start line on the kit with the toe behind the line and the other heel directly in front of them on the marked lines on the kit. The heel was placed at the height of the tibial tuberosity mark on the kit. The dowel was placed behind the back touching the head, thoracic spine, and sacrum. The hand opposite to the front foot was the hand that held dowel at the cervical spine while the other hand held the dowel at the lumbar spine with the shoulder internally rotated. The dowel had to maintain the three contacts during the entire movement. The subject then lowered the back knee to touch the board behind the heel of the front foot and returned to the starting position. A score of 3 was given on the IL if there was minimal to no torso movement; feet remained aligned in sagittal plane, knee touched behind the heel of front foot. If any of the criteria was not achieved for a score of a 3, then a score of 2 was given, and if the criteria for a score of 2 could not be achieved, then a score of 1 was given. If there was pain with the movement, a final score of a zero was given for the IL test.

For the SM, the subject's hand length was measured with the dowel from the distal wrist crease to the tip of the longest digit. The subject stood with the feet together and made a fist with each hand, thumbs inside of the fingers. One fist reached as far as possible behind the neck and the other hand reached as far as possible behind the back simultaneously keeping the clenched fists. Using the dowel, the distance between the two closest bony prominences was measured. For a score of a 3 on the SM, the fist placement had to be within subjects' one hand length apart. For a score of a 2, the fist placement fell between one and a half hand lengths, and a score of a 1 was received if the fist placement was greater than one and half hand lengths apart. If there was pain with the movement, final score of a zero was given for the SM test.

The IC test was performed after the SM test with the subjects' palm on their opposite shoulder while lifting the elbow as high as possible. If there was pain from performing this clearing exam, a positive was recorded and a score of a zero was given to the SM test.

For the ASLR, the subject would lay supine with the arms by the sides, palms up and forehead flat on the floor. The FMS kit board was placed under the knees with the subject's feet in a neutral position and soles of the feet perpendicular to the floor. The dowel was placed at the point halfway between the anterior superior iliac spine (ASIS) and the joint line of the knee. The subject then lifted the test limb with a dorsiflexed ankle and extended knee until end range position is achieved. A score of 3 was given on the ASLR if the ankle passed the dowel placement in the description of the test. If the ankle did not pass the dowel placement for a score of a 3, then the dowel was moved halfway between the mid-thigh and knee for a score of a 2. If the ankle did not move past the dowel for the requirements for a score of a 2, then the subject received a score of a 1. If there was pain with the movement, a final score of a zero was given for the ASLR test.

For the TSP, the subject was prone with the arms extended overhead and feet together. The knees were extended and the ankle was dorsiflexed. Male athletes are to begin this test with their thumbs at the top of the forehead and moved them shoulder width apart at that level. Subjects then performed one pushup in that position. During this movement, the body must raise as one unit. A score of 3 was given on the TSP if males performed a pushup with the thumbs just above the forehead and raised the body as one unit. If the requirements for a score of a 3 were not met, the men moved the thumbs in line with the chin and performed the push-up again. If the requirements for a score of a 2 were not met, then a score of a 1 was given. If there was pain with the movement, a final score of a zero was given for the TSP test.

The PC test was performed after the TSP in a prone position. The subject pressed up to extend the elbows while keeping the hips on the ground (hyperextension of the back). If there was pain from performing this clearing exam, a positive was recorded and a score of a zero was given to the TSP.

For the RS, the subject was in a quadruped position with shoulders and hips at 90° relative to the torso with the FMS kit parallel to the spine in between the hands and the knees. The ankles were in a dorsiflexed position. The subject then flexed the shoulder while extending the same-side hip and knee. And then the subject slowly brought the elbow to the same-side knee while remaining in line over the board. For a score of a 3 on the RS, the subject performed the task correctly using the same-side leg and arm while keeping the torso parallel to the FMS kit board and keeping the elbow and knee in line with the FMS kit board. A score of a 2 was given, if the subject performed a diagonal pattern using the opposite shoulder and hip in the same manner as for a score of a 3. The knee and opposite elbow must make contact over the FMS kit board. If the requirements for a score of a 2 were not met, then a score of a 1 was given. If there was pain with the movement, a final score of a zero was given for the RS test.

The PRC test was performed after the RS test in a quadruped position. While in a quadruped position, the subject rocked back and touched the buttocks to the heels and the chest to the thighs. The hands remained in front of the body, reaching out as far as possible. If there was pain from performing this clearing exam, a positive was recorded and a score of a zero was given to the TSP.

The sum of the final scores of each test was used as the composite score (0-21). The clearing tests were not graded numerically, but were reported as positive (painful) or negative (non-painful).

SEBT

Procedures for the SEBT were based on those described by Hertel.[14] The subject's leg length was measured bilaterally in centimeters between the ASIS and medial malleolus. The subject placed the heel on the center of the star and stood on that one leg while the opposite leg reached as far as possible along the chosen line. After touching down, the subject returned the reaching leg back to the center, while maintaining the single-leg stance with the other leg.[6] Hands were held on the waist, and the subject was allowed to move their torso, or lean, during the reach while making a light touch with the most distal part of the lower limb on the chosen line. The distance was marked on the line and the researcher measured the distance manually in centimeters with a tape measure after the subject returned to the center position. The test was repeated if the reach foot touched the ground before returning to the start position, if the stance leg was lifted from the center of the grid, or if equilibrium was lost at any point in the trial.[14,15]

The subject performed three test trials the second day following the three practice reaches in each of the eight directions. The practice trials were performed to minimize any learning effect.[14,15] There was 15 seconds of rest time in between each trial. The order for the tests were AL, A, AM, M, PM, P, PL, and L. After the initial stance leg excursions were performed, the same protocol was repeated on the opposite stance leg. The maximum distance for each of the eight excursions per leg in eight directions (distance in centimeters) was recorded. The maximum distances were then normalized to leg length and each the left and right normalized scores were totaled. The average of the left and right totals was then used as a composite score.[15]

Hypothesis

The following hypothesis was based upon the review of literature and the researcher's intuition:

There will be a positive correlation between the Functional Movement Screen composite score and Star Excursion Balance Test composite score indicating that functional movement is positively related to functional balance.

Data Analysis

A Pearson Product Moment Correlation coefficient was used to determine the relationship between functional movement as measured by the FMS and functional balance as measured by SEBT. The data was analyzed by SPSS version 18.0 statistical software package at an alpha level of $\leq .05$.

RESULTS

The purpose of this study was to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test. Subjects were tested using the FMS and SEBT. The FMS was used to measure functional movement and the SEBT was used to measure functional balance.

Demographic Information

A total of 16 male subjects ages 18-23 years old (20.4±1.6) participated in and completed this study. All subjects were volunteers and were NCAA Division II male soccer athletes at California University of Pennsylvania.

Hypothesis Testing

Hypothesis testing was performed by using data from the 16 subjects who completed all the tests at an alpha level ≤ 0.05. Descriptive statistics for the FMS and SEBT are shown in Table 1. The possible scoring range for the FMS composite score is from 0 to 21. The SEBT composite score was measured in centimeters.

Table 1. Descriptive statistics for FMS and SEBT

Test	Mean	SD	Minimum	Maximum	N
FMS	16.4	2.6	11	20	16
SEBT(cm)	841.9	82.2	748.6	977.2	16

Hypothesis: There will be a positive correlation between the Functional Movement Screen composite score and Star Excursion Balance Test composite score indicating that functional movement is positively related to functional balance. A Pearson Product Moment Correlation coefficient was calculated to examine the linear relationship between the variables. Prior to calculating the correlation, additional analyses were performed. Each variable was reduced to one total score using the composite score from the seven FMS tests and normalized excursions from all directions for both right and left legs during the SEBT.

A Pearson Product Moment Correlation coefficient was calculated for the relationship between subjects' composite FMS and SEBT score using a one-tailed test. A moderate positive correlation was found ($r = .478$, $P = .031$), indicating a significant linear relationship between the two variables.

Conclusion: A significant moderate positive correlation between functional movement (FMS) and functional balance (SEBT) ability was present (r = .478, *P* = .031).(Table 2). The results indicate that better functional movement is positively related to better functional balance.

Table 2. Correlations between FMS and SEBT

Test		**FMS**	**SEBT**
FMS	Pearson Correlation Sig. (1-tailed)	1	.478* .031
SEBT	Pearson Correlation Sig. (1-tailed)	.478* .031	1

*. Correlation is significant at the 0.05 level (1-tailed)

Additional Findings

An additional Pearson Product Moment Correlation was preformed to examine the relationship among right and left leg side performance using the sum of the left and right normalized reaches for the SEBT, the left and right hurdle step (HS) test, right and left inline lunge (IL), and left and right rotary stability (RS). A significant strong correlation between left and right sums of the SEBT normalized reaches was present (r = .993, *P* = .000). These results indicate lower extremity symmetry among DII male soccer athletes. A significant moderate correlation between left sums of the SEBT normalized reaches and the right HS test was present (r = .527, *P* = .036) (Table 3). The significance of comparing the left sums of the SEBT reaches and the right HS test is that both are the plant leg which is used to balance. The plant leg for both the left SEBT reaches and right HS test is the left leg. These results indicate that a higher score on the right HS test is positively related to a higher score on the SEBT.

Table 3. Correlations among individual FMS tests and SEBT

Test		**R SEBT Reaches**	**L SEBT Reaches**
L SEBT Excursions	Pearson Correlation	.933**	1
	Sig. (2-tailed)	.000	
R SEBT Excursions	Pearson Correlation	1	.933**
	Sig. (2-tailed)	.031	.000
R Hurdle Step Test	Pearson Correlation	.354	.527*
	Sig. (2-tailed)	.178	.036

*. Correlation is significant at the 0.05 level (2-tailed)
**. Correlation is significant at the 0.01 level (2-tailed)

DISCUSSION

Discussion of Results

The main finding was that functional movement, as measured by the FMS was positively correlated to functional balance as measured by the SEBT. As there are currently no studies directly comparing the FMS and SEBT, these results are original. However, previous research has demonstrated that reliability of the SEBT and FMS is strong for interrater reliability.[8,10,14] The procedures for measuring functional balance as measured by SEBT and functional movement as measured by the FMS were based on those described by Hertel and Minick respectively.[8,14,15]

Evaluating functional movements, whole body movements, and balance is important in order to optimize an athlete’s performance and prevent injury. Screenings such as the FMS and the SEBT can be used as an evaluative tool to prevent injury or optimize performance by identifying athletes at high risk for an injury.[1,16,18,30] These tests can be easily tested clinically and may be used to predict injury.[7,21,22] The FMS is an assessment tool that identifies fundamental movement-pattern limitations and asymmetry quantitatively with a series of seven movement tests.[1] The seven movement tests use a variety of positions and movements which places the individual in positions where weaknesses and imbalances become noticeable.[3] These tests provide observable performance of basic locomotor, manipulative, and stabilizing movements.[3] The SEBT is a functional and dynamic unilateral balance test that integrates a single-leg stance on one leg and a maximum reach of the opposite leg,[11,13-16] and as such, determines that the neuromuscular control mechanism is working properly.[16] Balance is essential in athletic and sport-related activities because balance is the single most important element dictating movement strategies within the closed kinetic chain.[5,6,9,10]

It is important to point out that the mean score for the FMS among the subjects was 16.4±2.6. These results are similar to a previous study by Kiesel et al[21] examining professional football players. The mean score in Kiesel's study was 16.9±3. The authors suggested that players with a composite score of less than 14 were eleven times more likely to suffer a serious injury than those who had a composite score above 14. The cut-point determination of 14 was determined in Kiesel's study[21] by creating a receiver-operator characteristic (ROC) curve. Kiesel et al[22] also has reported that an off-season training program could significantly improve scores on the FMS. Pre and post-intervention FMS scores were taken on 62 subjects who completed the 7-week off season intervention program.[22] This information may be beneficial for sports medicine professionals implementing injury prevention protocols.

Another important aspect of efficient athletic performance is symmetry. We found a significant strong correlation between the left and right sums of the SEBT normalized reaches, indicating lower extremity symmetry among these DII soccer athletes. As symmetry and muscle balance is important for athletic performance, the FMS can be used as an assessment tool to identify muscle imbalances and asymmetry quantitatively.[1,3] Asymmetries create limitations in movement and compromise motor control.[1] These asymmetries and muscle imbalances may ultimately lead to an injury.[23-27] Results also showed a significant moderate correlation between left sums of SEBT normalized reaches and right HS test. The HS test and SEBT are both considered a single leg stance test in which the plant leg is used to balance. The plant leg for both the right HS test and left SEBT reach is the left leg. For the right HS test, the subject moved the right leg over the hurdle while balancing on the left leg. For the SEBT, the left heel was on the center of the star while the reaching leg was the right limb. These results indicate that a higher composite score on the left SEBT is positively related to a higher score on the right HS test, and may suggest that performing the HS test has the same outcome as performing the eight directions on the SEBT.

The HS test, along with other single leg stance tests such as the SEBT; test the mobility and stability essential for stepping, running and climing.[1] These movements are the foundation for which an athlete moves in their sport and are demonstrated with single leg stance tests such as the HS test or SEBT. A poor score on the HS tests may suggest a lack of reflex stabilization or type of compensation when going from a double to single leg stance. During the HS test, the patient is in the single leg stance position long enough to see a compensation or lack of reflex stabilization.[1] In this way, the HS test is similar to the single leg stance during the SEBT. As stated earlier, we found that the left SEBT and right HS test are positively related, which may suggest that performing the HS test has the same outcome as performing the eight directions on the SEBT.

Conclusion

Functional balance and functional movement appear to be moderately related in healthy Division II soccer athletes. This relationship indicates that better functional movement can be associated with functional balance. Additionally, lower extremity symmetry for functional movement and functional balance in DII soccer athletes was significantly apparent with scores indicating that the FMS hurdle test may be used to determine functional balance as well. This was reflected as a higher score on the right HS test was moderately positively related to a higher score on the left SEBT. Overall, the sports medicine and strength and conditioning professionals may choose to perform one test over another based on the functional performance desired to be tested, and that such tests may be used as screening tools for potential injury.

Recommendations

These findings suggest that functional balance and functional movement appear to be moderately related in healthy Division II soccer athletes. Therefore, if a sports medicine and/or strength and conditioning professional wishes to look at functional balance alone, the SEBT is a good test to perform. However, if functional movement is to be isolated, the use of FMS for functional movement is appropriate. Future studies may benefit from comparing functional testing of other populations such as high school athletes to college athletes for the purposes of comparisons or differences in an injury prevention protocol. It is important that allied health professionals realize assessment of functional movement and balance as a possible means of injury prevention is equally as important as evaluating and treating injuries.[4]

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APPENDICES

APPENDIX A

Review of Literature

REVIEW OF THE LITERATURE

Balance and functional movements are essential elements for improving athletic ability and decreasing risk of injuries.[1-6] Athletic performance and activities of daily living both rely on the ability to move and move in such a way that maintaining stability is vital.[2] In this way, observation of balance and functional movement in athletes is important for injury prevention and performance enhancement. Tests assessing multiple domains of function, such as balance, strength, and range of motion, may improve the accuracy of identifying athletes at risk for injury.[7,8] Functional balance can be measured in numerous ways including the Star Excursion Balance Test (SEBT). The SEBT is a functional test of dynamic balance that integrates a single-leg stance of one leg and a maximum reach of the opposite leg. The SEBT measures maximum single leg reach in 8 directions at 45° increments from the center point to make a star formation.[9-13] Functional movement is another important aspect to consider when evaluating athletes. Functional movement can be measured by an evaluation tool called the Functional Movement Screen (FMS). The FMS is an assessment tool that identifies fundamental movement-pattern limitations and asymmetry quantitatively with a series of seven movement tests.[1] Evaluating functional movements, whole body movements, and balance is important in order to optimize an athletes' performance and prevent injury. Thus, the purpose of this Review of Literature is to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test. The main topic that will be discussed is functional performance including functional balance and functional movement as well as the measurement tools associated with each.

Balance and Balance Testing

Balance is defined as the process of maintaining the center of gravity (COG) within the body's base of support.[5,6,14] Balance is both a dynamic and static process. Balance or "postural equilibrium" is the single most important element when it comes to movement strategies within the closed kinetic chain.[5,6] It is necessary for everyday activities and is essential in sports activities.[5,6,14,15]

There are different classifications of balance. Static balance is when the COG is maintained over a fixed base of support while standing on a stable surface. Dynamic balance is the maintenance of the COG within the limits of stability (LOS) over a moving base of support, usually while on a stable surface.[5,6,15] Functional balance is very similar to dynamic balance but involves balance in sport-specific tasks.

Mechanisms of Balance

Maintenance of balance requires the complex processes in the postural control system, which includes both sensory and motor components.[5] Both of these components include sensory detection of body motions, sensorimotor information from the central nervous system (CNS), and appropriate musculoskeletal responses. The body relies on a feedback control circuit to maintain these components, thus achieving balance.

The sensory component or sensory organization relies on the information obtained from the vestibular, visual and somatosensory (proprioceptive) inputs.[5,6,14,15] The vestibular input supplies information from the gravitational, linear, and angular acceleration of the head in relation to inertial space.[5] The visual input supplies information from the orientation of the eyes and head in relation to surrounding objects. Somatosensory is a specialized variation of the sensory modality of touch that encompasses the sensation of joint movement (kinesthesia) and joint position (proprioception).[5,6] The motor component in the postural control system is the process of preparatory or reactive contractile activity in the legs and trunk to maintain balance.[5,6]

Neuromuscular Considerations

Along with balance, neuromuscular control is also important in physical activity.[5,14] Neuromuscular control can be defined as changing the afferent (sensory) information to the efferent (motor) response or physical energy.[5] Some of the CNS components to balance also contribute the neuromuscular control such as proprioception and kinesthesia. Neuromuscular control relies on the feed-forward process and feedback process. The feed-forward (Preparatory) process regulates planning movements based on sensory information from past experiences. The feedback (reactive) process regulates muscle activity through reflex pathways. Neuromuscular control is important in activity because balance and stretch-shortening exercises both require the preparatory and reactive muscle activity through the feed-forward and feedback systems within neuromuscular control.[5] Neuromuscular control is also important to understand for rehabilitation. When there is an injury to articular structures, it not only results in a mechanical disturbance, but also in a loss of joint sensation.[5] Knowing this is important for the rehabilitation process for returning an athlete back to functional stability, thus return to participation.

Balance and Performance

Balance is essential in sports activities.[5,6,14,15] Visual, vestibular and somatosensory inputs along with movements at the ankle, knee, and hip joints are all processes that are vital for fluid sports-related movements.[5]

Hrysomallis[9] stated that balance ability is significantly related to a number of performance measures in sports. In his systematic review, he stated that balance ability, specifically dynamic balance, showed a significant relationship with ice hockey players and maximum skating speed. Hrysomallis also found that balance training increased rectus femoris activation during jump landing. Balance training may improve vertical jump, agility, shuttle run and downhill slalom skiing, however resistance training produced superior results to increases in those areas.[27]

Another systematic review by Zech et al[16] investigated balance training and performance. Balance training is effective for improving static postural sway and dynamic balance in both athletes and non-athletes. Sport specific skills may be improved by balance, but other training methods may be equally or more effective. Balance training may specifically improve knee muscle strength in non-athletes.

Balance is important to investigate in terms of performance and sport ability. Knowledge in mechanisms of balance, neuromuscular considerations, and balance in performance helps the clinician create an optimal rehabilitation or training program for an athlete.

Star Excursion Balance Test

There are several methods for assessing balance including the Biodex Balance system, Romberg test, Star Excursion Balance Test (SEBT) and Balance Error Scoring System (BESS).[5,6,8-16] The Romberg test is commonly used clinically, but has been criticized for its lack of sensitivity and objectivity.[5,6] The BESS is recommended to use over the Romberg test, however is it only for static balance ability. The SEBT is a functional and dynamic unilateral balance test that integrates a single-leg stance of one leg and a maximum reach of the opposite leg.[6,8-15] The SEBT uses 8 tape measurements on the floor at 45°

increments from the center point.[6,10] The subject places their foot in the middle of the star and maximally reaches with the opposite leg. The tape is marked by 5cm increments. The eight lines represent the reaches labeled anterior (A), anteromedial (AM), medial (M), posteromedial (PM), posterior (P), posterolateral (PL), lateral (L), and anterolateral (AL) and change in relation to the stance leg.[6,17]

The SEBT reliability has been proven to be strong for intratester and intertester reliability.[11,15] Kinzey and Armstrong[15] performed a study on 20 subjects who completed two testing sessions one week apart to measure the reliability of the SEBT. The results were that the SEBT had ICCs for intratester reliability range from .78-.96.[15] Hertel et al[11] performed a study investigating the intratester and intertester reliability. The study involved sixteen subjects with no history of balance disorders. The subjects performed two bouts of the eight directions on the SEBT on each leg and on two different days. The ICCs for the intratester reliability were .78-.96 on the first day and .82-.96 on the second day. The ICCs for the intertester reliability were .35-84 on the first day and .81-.93 on the second day. The authors suggested there be a practice trial prior to taking recorded measurements.[11]

Gribble and Hertel[12] performed a study to examine the role of foot type, leg length, and range of motion (ROM) measurements on excursion distances measured by the SEBT. The authors also wanted to determine the need for normalizing the SEBT. There were 30 subjects for this study and they each performed three trials in each of the eight SEBT directions. There were no significant relations between foot type or ROM measurements. However, there were significant correlations between height and excursion distance and leg length and excursion distance. The authors concluded stating that the measured excursion distances should be normalized to leg length to allow for a more accurate comparison of performance among participants.[12]

In terms of rehabilitation, the SEBT may be used as a closed-kinetic chain exercise. Earl and Hertel[13] performed a study to investigate the muscle activity during the eight SEBT. Earl and Hertel used ten subjects for this study and measured the EMG activity of the vastus medialis oblique (VMO), vastus lateralis (VL), medial hamstring (MH), biceps femoris (BF), anterior tibialis (AT), and gastrocnemius. There were significant differences in EMG activity among the different SEBT directions in all muscles.[13] VM activity was the greatest during the anterior excursion. VL activity was the lowest during lateral excursion direction and MH activity was highest during the anterolateral excursion direction. The BF activity was highest during the posterior, posterolateral, and lateral excursion directions. AT activity was highest during the posteromedial, posterior, posterolateral, and lateral excursion directions. There were significant differences in ROM at the ankle and knee during the different directions. The highest knee flexion occurred during the anteromedial direction. Ankle dorsiflexion was greatest during the anterior, anteromedial, and medial directions. The authors stated that the SEBT demonstrates that the neuromuscular control mechanism works properly in the individual.[13] For rehabilitation purposes, this study supported research that advocates the use of closed-kinetic chain (CKC) exercises to regenerate neuromuscular control after an injury. The authors suggested that the SEBT could be used as part of a rehabilitation program. For example, if an athlete were recovering from a quadriceps strain, the SEBT could inform the clinician which direction not to make the athlete reach. The athlete should not reach in the lateral direction to avoid overloading the quadriceps but still working on proprioception. Using the SEBT as a CKC exercise can be beneficial as part of a rehabilitation program for athletes suffering from patellofemoral pain. The SEBT could also be used as a tool for ACL rehabilitation. The posterior excursion directions can safely be performed early on in the rehabilitation program and then progress to the anterior and lateral excursion directions. While a number of assessments can be used to measure balance, the SEBT may be the most valid tool for athletes as it measures dynamic posureal control, which is important for physical activity.[5,6,14,15]

Functional Performance and Movement

Functional movement can be defined as the ability to produce and maintain a balance between mobility and stability along the kinetic chain while performing fundamental patterns with accuracy and efficiency.[18] How a person moves functionally can determine how well they perform. It is important to inspect and understand common fundamental or functional aspects of human movement realizing that similar movements occur throughout many athletic activities and applications.[3] Proprioception and postural control can effect that movement, thus effecting overall performance.

Proprioception

Proprioception plays an important role in human movement and they both influence each other.[1] After an injury, if the proprioceptive input is left untreated, it can result in mobility, stability and asymmetry problems. This ultimately leads to a negative effect on movement patterns.[1,3] Lephart et al[19] investigated the role of proprioception in the management and rehabilitation of athletic injuries. This study examined the role of proprioception in the ankle, knee and shoulder. Ultimately, proprioception should be rehabilitated after an injury to retrain the altered afferent pathways, thus enhancing the sensation of movement.[19] There are three levels of motor activation within the CNS when the rehabilitation program involves proprioceptively mediated neuromuscular control of joints.[19] The first level involves a reflex joint stabilization when there is an abnormal stress to the joint. Exercises that incorporate dynamic joint stabilization may improve the neuromuscular mechanism at this level. The second level involves the brainstem receiving input from the joint mechanoreceptors, vestibular centers, and the vision to maintain posture and balance. Exercises that incorporate reactive neuromuscular activities may improve the brainstem function for this level. The third and highest level involves cognitive awareness of body position and movement. Exercises that incorporate kinesthetic and proprioception training may improve the cognitive awareness for this level. The authors concluded that proprioception in rehabilitation is important for practitioners to incorporate into rehabilitation programs. Borsa et al.[20] also investigated proprioception in shoulder rehabilitation. The authors reviewed the importance of proprioception in other rehabilitation programs and concluded that the objective of proprioception in rehabilitation is to enhance cognitive awareness of the joint relative to the movement. Proprioception can also enhance the muscular stabilization of the joint if the joint is lacking ligamentous structures. Šalaj et al[21] performed an experimental study looking at the effects of proprioceptive training on jumping and agility performance. The subjects of this study included 75 physically active men. The subjects in the experimental group underwent a proprioceptive training program that lasted ten weeks (sixty minutes three times a week). The exercises performed were one-leg and double-leg static and dynamic balance drills. The tests used to evaluate explosive jumping were the double-leg vertical jump test, the single-leg vertical jump test, and the single leg- right and left jumps tests. The horizontal jump was measured using the horizontal jump-landing surface with measured markings. The agility performance was measured by using the 20-yard tests, side steps, and side jumps over the bench during ten seconds test. The results showed that for vertical jumping performance, there was a minor improvement following the proprioceptive training. For horizontal jumping performance, no changes occurred after proprioceptive training. For agility, there were improvements in the tests except for the side steps. The authors concluded that the proprioceptive program could be of possible value to sports preparation. Lastly, Fatma et al[22] investigated the effect of an eight-week proprioception training program on dynamic postural control in taekwondo athletes. This study consisted of 42 male and female taekwondo athletes. The athletes in the experimental group trained for thirty minutes, three times a week for eight weeks performing various proprioceptive exercises on a wobble board. The authors of this study concluded that the proprioception training program improved female and male taekwondo athletes' dynamic postural control.

Postural Control

Postural control can also effect functional movement and performance. Hoffman and Payne[23] investigated the effects of proprioceptive ankle disk training on healthy subjects. This study examined the importance of proprioception and postural control. This study[23] included 28 male and female high school athletes. The training program consisted of various progressions on the Biomechanical Ankle Platform System for ten minutes, three times a week for ten weeks. The authors concluded that proprioceptive training produces a significant decrease in postural sway, increase in postural control, thus benefitting human movement. Mckeon and Hertel[24] performed a systematic review of postural control and lateral ankle instability. They concluded that various studies support that poor postural control is most likely associated with an increased risk of acute ankle sprains. This also supports the importance of postural control in injuries, thus effecting performance.

Functional movement is important in the outcome of the performance. Examining things that effect functional movement is crucial for rehabilitation programs. Proprioception and postural control effect functional movement and performance. Thus, these things should be included in a rehabilitation program.

Muscle Imbalance and Injuries

Muscle imbalance can be defined as a modification of the strength balance between the agonist and antagonist muscles.[25] Certain muscle groups are more apt to imbalance than others. The hamstring/quadriceps group is the most frequently injured due to imbalances. Croisier[25], in a prospective study, concluded that muscle imbalances could contribute to injury. Nadler et al[26] performed a prospective study on the relationship between hip muscle imbalance and occurrence of low back pain (LBP). The researchers tested 63 females and 100 males for hip muscle strength. Five of the sixty-three female athletes had LBP and three of the five had a previous history of LBP. These authors concluded that hip extensor strength imbalance might be associated with LBP in females.[26]

Devan et al[27] also conducted a study on lower limb muscle imbalances, specifically the hamstring/quadriceps ratios (H:Q). These authors found that during this prospective study, the athletes who had overuse knee injuries also had H:Q ratios of “less than normal”.[27] It is suggested that hamstring muscle imbalances be identified and corrected before sport participation to prevent overuse knee injuries.[27]

Other muscle groups in the shoulder that can be imbalanced are the rotator cuff muscles and scapulothoracic muscle group. Page[28] reviewed the muscle imbalances associated with the shoulder and stated these imbalances are present in patients with subacromial impingement. He concluded that shoulder impingement might be associated with muscle imbalance; therefore this should be taken into consideration during rehabilitation.[28]

Muscle strength, or lack there of, can play a role in injury as well. Tyler et al[29] studied hip strength and flexibility and it’s role in adductor and hip flexor strains. The authors used 47 National Hockey League ice hockey team players. During this study, there were eight players who experienced 11 adductor muscle strains. The results showed that adduction strength was 95% of abduction strength in the uninjured players and 78% of abduction strength in the injured players. From the results, the authors concluded that a hockey player was 17 times more likely to sustain an adductor muscle strain if their adductor strength was less than 80% of abduction strength. The authors also indicated that testing hip strength during the preseason could identify players at risk for developing adductor muscle strains.

Muscle imbalance can have a significant effect on sports performance. Therefore, this is one of the areas that should be focused upon to improve performance.

Functional Movement Screen

Functional movement can be measured by an evaluation tool called the Functional Movement Screen (FMS). The Functional Movement Screen (FMS) is an easy and simple screen that was first introduced in 1998 by Gray Cook and colleagues.[1] The creators wanted to invent a screen that could standardize and quantify movement in a non-diagnostic way. The FMS was first introduced in screening workshops, and then gradually gained more exposure in the National Athletic Trainer's Association (NATA) and the National Strength and Conditioning Association (NSCA).

The Functional Movement Screen is an assessment tool that identifies fundamental movement-pattern limitations and asymmetry quantitatively. The FMS allows for ranking and grading of activity-specific movement patterns.[1] The definition of a movement-pattern problem is the basic deficiencies in mobility and stability causing limitation and asymmetries in one or more basic movement pattern or patterns.[1] The FMS consists of seven movement tests as well as three clearing tests. The seven tests are Deep Squat, Hurdle Step, Inline Lunge, Shoulder Mobility, Active Straight-Leg Raise, Trunk Stability Pushup, and Rotary Stability. The three clearing tests are the Impingement Clearing Test, the Prone Press-Up Clearing Test, and the Posterior Rocking Clearing Test.[1] The clearing tests are similar to pain provocation tests and their purpose is to rule out pain with shoulder internal rotation/flexion, end range spinal flexion and end range spinal extension.[7] The Impingement clearing test is performed after the Shoulder Mobility, the Prone Press-Up clearing test is performed after the Trunk Stability Pushup, and the Posterior Rocking clearing test is performed after Rotatory Stability.

Reliability of FMS. Checking the reliability of tests and screenings is important so it can be used confidently in a clinic setting. Minick et al[7] looked at the inter-rater reliability of the FMS using two expert raters and two novice raters. These raters looked at videotapes of forty healthy subjects performing the FMS tests. The results showed a significant agreement among the raters. The data may suggest that the FMS can be conducted by trained individuals at different training levels and still confidently assess the movement patterns from the FMS screen.[7]

The Deep Squat from the FMS is similar to the Overhead Squat Test. The observations for the two movement patterns are similar with both of them looking at excessive forward lean, arms falling too far forward, knee valgus, foot toe out, or foot pronation.[1,7] Hirth and Padua[2] studied the reliability of the Overhead Squat Test looking at photographs of 20 subjects in the anterior, posterior, and lateral views from two separate testing sessions. The authors had a certified athletic trainer (ATC) with no experience with the Overhead Squat Test score these subjects by looking at the photographs. The ATC looked for the following characteristics in the photographs: Toe-out, inward knee movement, excessive forward trunk lean, arm fall-forward, and medial longitudinal arch flattening. The results suggested that the test a reliable tool for assessing movement patterns within the squat.

Noda and Verscheure[30] did, however, look specifically at the FMS Deep Squat in their research. They observed seventy-one collegiate, Division I athletes from varying sports perform the FMS Deep Squat. The purpose of this study was to look at the correlation between the observations from the Deep Squat and goniometric measurements made with individual joints such as ankle dorsiflexion, hip extension, hip internal rotation, and hip external rotation.[4] The authors of this study concluded that the results support the theories of the National Academy of Sports Medicine experts and the developer of the FMS, Gray Cook. The reliability of any test is important so it can be used confidently clinically and in a research study. Since many studies support the reliability of the FMS, it can be used with confidence in future research studies.

Uses of FMS. The FMS has been studied in a variety of settings and people. It has been studied on football players and firefighters. It has also been introduced in a pre-participation screening and can be used as a tool to create intervention programs.

Kiesel et al[31] examined the relationship between professional football players' score on the FMS and serious injury. The authors studied one team of 46 professional football players. The football players were tested using the FMS prior to the start of the season and data was collected during the season for serious injuries. The authors defined a serious injury as an athlete on the injured reserve for at least 3 weeks. The results showed that a composite score of 14 (out of 21) or less on the FMS was positive to predict serious injury. These results suggest that the FMS is an identifiable risk factor for injury in professional football players and those scoring lower on the FMS are more likely to suffer an injury than those with a higher composite FMS score. Kiesel performed another study examining professional football players. This study[32] investigated if an off-season intervention program was effective in improving FMS scores in professional football players. There were 62 football players who completed a seven-week intervention program during their off-season. The intervention program consisted of self and partner stretching and self-administered trigger point treatment using The Stick on muscles that were contributing to the dysfunctional movement patterns. Various corrective exercises from FMS were also performed on individual athletes. The results were that 41 players were free of asymmetry post-intervention as compared with the 31 at the pre-testing. There was also an increase in the number of athletes with a composite FMS score of above 14 out of 21. The authors suggested that fundamental movement characteristics do change with an intervention.

The FMS has been used on other individuals that engage in rigorous physical activity. Peate et al[17] examined the performance of the FMS on firefighters. The authors performed a study on 433 firefighters. The firefighters were first tested with the FMS and then went through a training program. The FMS test scores were correlated with a history of prior musculoskeletal injuries from the fire department database. For the training program, the firefighters finished twenty-one training sessions each one three hours long. During theses sessions, the firefighters were instructed on exercises and tips to make the ergonomically challenging tasks easier. They also performed various core and spine stabilizing exercises related to firefighting. The intervention reduced the time lost due to injures by 62% and the overall number of injuries decreased by 42% when compared to the historical group.[17] There was also a correlation between past musculoskeletal injury and FMS score. A history of an injury lowered the firefighter score by 3.44.[17] The authors suggested, based on the results, that core strength and function movement enhancement programs should be incorporated into jobs where there are many ergonomically incorrect positions.

Cook et al[4] provided a clinical commentary on a complete description of the FMS tests. The purpose of this commentary was to instruct clinicians to recognize the need for the assessment of fundamental movements, and promote the need for evidence related to assessment of fundamental movements and the ability to predict and reduce injury. The authors also noted that these screenings could be used to fill the void between pre-participation screening and performance tests. The authors concluded saying the FMS can identify at risk individuals and prevention strategies can be developed from those scores. Functional training can decrease injury through improved performance efficiency to improve overall wellness.[3,4]

The FMS can also be used to focus an intervention program. Butler et al[33] investigated the peak sagittal plane joint angle and joint movements of the lower extremity during the FMS deep squat test. This study had 28 subjects and they were split into three groups. Groups one, two and three represented subjects who scored a one, two or three respectively on the DS. The results showed that group three revealed greater dorsiflexion compared to group one. Group three had greater peak knee flexion than group two. Group two showed greater peak knee flexion than group one. Group three exhibited greater peak knee extension moment compared to group one. Groups three and two had greater peak hip flexion and peak hip extension moment compared to group one. These results may suggest that individuals have different mechanics with different scores on the FMS deep squat test. Using the information from the mechanics may be useful to individualize an intervention program for an athlete. The authors also stated that quadriceps activation and hamstring tone and length could be an area to improve in the intervention to improve the score on the FMS deep squat test.[33]

Summary

Balance and functional movements are essential for improving athletic performance and decreasing risk of injuries. [1-6] Athletic performance and activities of daily living both rely on the ability to move and move in such a way that maintaining stability is vital.[2] Measuring functional balance and functional movement may improve the accuracy of identifying athletes at risk for injury.[7,8] Functional balance, as measured by the SEBT, and functional movement, as measured by the FMS, are two evaluative tools that can be used to identify athletes with specific movement deficits.[1,8,18]

The SEBT is a functional test of dynamic balance that integrates a single-leg stance of one leg and a maximum reach of the opposite leg. The SEBT measures maximum single leg reach in 8 directions at 45° increments from the center point to make a star formation.[9-13] The SEBT reliability has been proven to be strong for intratester and intertester reliability.[11,15] The ICCs for the intratester reliability were .78-.96 on day one and .82-.96 on day two. The ICCs for intertester reliability were .35-.84 on day one and .81-.93 on day two. The SEBT can be used to demonstrate that the neuromuscular control mechanism works properly in the individual, which is an important mechanism for balance.[13] Earl and Hertel[13] found that SEBT can also be used during rehabilitation as a closed-kinetic chain exercise to regenerate neuromuscular control after an injury.[13] Balance as measured by the SEBT is important to consider when evaluating athletes. Functional movement is another important aspect to consider.

Functional movement can be measured by an evaluation tool called the Functional Movement Screen (FMS). The FMS is an assessment tool that identifies fundamental movement-pattern limitations and asymmetry quantitatively with a series of seven movement tests.[1] The seven fundamental movement patterns or tests require a balance of mobility and stability.[1,3,4] Previous research done by Minick et al[7] suggested that the inter-rater reliability of the FMS is high among trained individuals. According to Kiesel et al[31], there is a positive relationship between an athlete’s functional movement, as measured by the FMS, and injury risk in professional football. Kiesel et al[31] also stated that those individuals scoring lower on the FMS are more likely to suffer an injury than those with a higher composite FMS score.

Emphasis on whole body movements, and balance is important in order to maximizing performance. The goal of a screen for functional movement is to identify athletes at high risk for an injury, so appropriate actions can be taken to correct presented problems.[10] Since there are multiple screenings available to an athletic trainer, it may be difficult to choose one test over another. The information from this study may help allied health professionals in determining which battery of tests can fully and accurately screen an athlete, helping prevent injury and maximizing performance.

APPENDIX B

The Problem

STATEMENT OF THE PROBLEM

There are different types of screenings performed on athletes to measure or predict performance. These screens may also be used as injury prevention as they can identify imbalances within the body, which may lead to injury.[1] Also, since there are many types of screenings, choosing one may be difficult. If two screenings have a high correlation, then one battery of tests may be sufficient for both screens. The purpose of this study was to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test.

Definition of Terms

The following terms are defined for this study:

1) Athlete – a person who currently participates in an NCAA Division II Collegiate sport team.
2) Movement – The act of a functioning body as it changes position under its own power.[1]
3) Functional movement - the ability to produce and maintain a balance between mobility and stability along the kinetic chain while performing fundamental patterns with accuracy and efficiency.[18]
4) Motion – the available range of flexibility within a single body segment or group of segments.[1]

5) Movement-pattern problem - the basic deficiencies in mobility and stability causing limitation and asymmetries in one or more basic movement pattern or patterns.[1]

6) Functional Movement Screen - an assessment tool that identifies fundamental movement-pattern limitations and asymmetry quantitatively.[1]

7) Balance – the process of maintaining the center of gravity (COG) within the body's base of support.[23]

8) Dynamic Balance – the maintenance of the COG within the limits of stability (LOS) over a moving base of support, usually while on a stable surface.[5]

9) Functional Balance - the maintenance of the COG within the LOS over a moving base of support with the inclusion of sport-specific tasks.[5]

10) Proprioception – specialized variation of the sensory modality of touch that encompasses the sensation of joint movement and joint position.[19]

11) Star Excursion Balance Test - functional, unilateral balance test that integrates a single-leg stance of 1 leg with maximum reach of the opposite leg.[14]

Basic Assumptions

The following are basic assumptions of this study:

1) All participants will fully understand the instructions provided and give a maximum effort during testing.
2) The subjects are honest in completing the demographic form.
3) Testing instruments (FMS and SEBT) are valid and reliable tools for measuring the variables.
4) All subjects will volunteer with no coercion from coaches or faculty.
5) Researcher will be consistent in evaluating subjective measures.

Limitations of the Study

Test results can be generalized for only the NCAA Division II collegiate soccer athletes. Since the testing was done in a laboratory setting, the results could represent assumptive functional measures of balance.

Significance of the Study

The scope of this study was to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test. Screenings such as the

Functional Movement Screen and the Star Excursion Balance Test can be used as an evaluative tool to prevent injury or optimize performance by way of determining the specific needs of an athlete.[1,18,30] Evaluating functional movements, whole body movements, and balance is important in order to optimize an athletes' performance. This can be done by reducing the injury time, improving functional movement and balance, or preventing an injury before it happens.

The goal of a screen is to identify athletes at high risk for an injury so appropriate actions can be taken to correct problems.[18] Also, since there are multiple screenings available to an athletic trainer, then it may be difficult to choose one test over another. The information from this study may help allied health professionals in determining which battery of tests can fully and accurately screen an athlete, helping prevent injury and maximizing performance.

APPENDIX C

Additional Methods

APPENDIX C1

Informed Consent Form

California University of Pennsylvania

Informed Consent Form

1. Sarah Beaulieu, who is a Graduate Athletic Training Student at California University of Pennsylvania, has requested my participation in a research study at California University of Pennsylvania. The title of the research is *The Relationship between the Functional Movement Screen and Star Excursion Balance Test*.

2. I have been informed that the purpose of this study is to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test. I understand that I must be 18 years of age or older to participate. I understand that I have been asked to participate along with other members of the soccer teams at California University of Pennsylvania. I have no visual, vestibular, balance disorder, severe lower/upper extremity injury, and/or a concussion within the last six months nor do I have any neurovascular disorders which could interfere with balance.

3. I have been invited to participate in this research project. My participation is voluntary and I can choose to discontinue my participation at any time without penalty or loss of benefits. My participation will involve a familiarization day and a testing day. The familiarization day will include reviewing the testing procedures, signing the informed consent, and practice trials for the FMS and SEBT. The testing day will record my results from the SEBT and the FMS. On the testing day, I will perform the seven tests from the FMS, the three clearing tests for the FMS, and then perform the SEBT.

4. I understand there are foreseeable risks or discomforts to me if I agree to participate in the study. With participation in a research program such as this there is always the potential for unforeseeable risks as well. The possible risks and/or discomforts are very minimal and include falling during the SEBT and the FMS tests. In both the SEBT and FMS, the researcher will further minimize my risk of falling by acting as a spotter. No tests are physically invasive and involve no more physical effort than my participation level in DII soccer.

5. I understand that, in case of injury, I can expect to receive follow-up treatment or care in Hamer Hall's Athletic Training Facility. This treatment will be provided by the researcher, Sarah Beaulieu, under the supervision of the CalU athletic training faculty, all of which who can administer emergency care. Additional services needed for prolonged care will be referred to the attending staff at the Downey Garofola Health Services located on campus.

6. There are no feasible alternative procedures available for this study.

7. I understand that the possible benefits of my participation in the research are contribution to existing research and may aid in enhancing injury prevention programs and/or rehabilitation programs for injuries by identifying overall ability of functional movement and functional balance.

(i.e. to help determine the effects of cryotherapy over the lateral ankle on static and dynamic balance. This study can help athletic trainers decide how and when to use cryotherapy and if it causes a decrease in balance after application which could lead to a decrease in performance.)

8. I understand that the results of the research study may be published but my name or identity will not be revealed. Only aggregate data will be reported. In order to maintain confidentially of my records, Sarah Beaulieu will maintain all documents in a secure location on campus and password protect all electronic files so that only the student researcher and research advisor can access the data. Each subject will be given a specific subject number to represent his or her name so as to protect the anonymity of each subject.

9. I have been informed that I will not be compensated for my participation.

10. I have been informed that any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by:

Sarah Beaulieu, ATC
GRADUATE STUDENT/PRIMARY RESEARCHER
BEA9001@calu.edu
207-754-3823

Rebecca Hess, Ph.D.
RESEARCH ADVISOR
Hess_ra@calu.edu
724-938-4350

11. I understand that written responses may be used in quotations for publication but my identity will remain anonymous.

12. I have read the above information and am electing to participate in this study. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me upon request.

13. This study has been approved by the California University of Pennsylvania Institutional Review Board.

14. The IRB approval dates for this project are from: NN/NN/NN to MM/MM/MM.

Subject's signature:___________________________________

Date:____________________

Witness signature:___________________________________

Date:____________________

Appendix C2

Test Score Sheets

SEBT Practice Record Sheet Date:___________ Subject’s #_______

Leg Length:R:________cm L:________cm

Stance Leg/Direction	Px 1	Px 2	Px 3
L / AL			
L / A			
L / AM			
L / M			
L / PM			
L / P			
L / PL			
L / L			
R / AL			
R / A			
R / AM			
R / M			
R / PM			
R / P			
R / PL			
R / L			

SEBT Record Sheet Date:___________ Subject's #_______

Leg Length:R:________cm L:________cm

Stance Leg/Direction	Trial 1 (cm)	Trial 2 (cm)	Trial 3 (cm)	Highest Test Score(cm)
L / AL				
L / A				
L / AM				
L / M				
L / PM				
L / P				
L / PL				
L / L				
R / AL				
R / A				
R / AM				
R / M				
R / PM				
R / P				
R / PL				
R / L				

Normalize Score Formula:

$$\frac{\text{Highest Test Score}}{\text{L leg length}} * 100 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

$$\frac{\text{Highest Test Score}}{\text{R leg length}} * 100 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

L Sum of Normalized Excursions: ________________

R Sum of Normalized Excursions:_________________

Average of Normalized Excursions: _______________

FMS Practice Test Score Sheet

Date: ___________ Subject's #:__________

Test		**Raw Score**	**Final Score**
Deep Squat			
Hurdle Step	L		
	R		
Inline Lunge	L		
	R		
Shoulder Mobility	L		
	R		
Impingement Clearing Test	L		
	R		
Active Straight Leg Raise	L		
	R		
Trunk Stability Push-Up			
Press-Up Clearing Test			
Rotary Stability	L		
	R		
Posterior Rocking Clearing Test			
Total			

FMS Test Score Sheet

Date: ___________   Subject's #:__________

Test		Raw Score	Final Score
Deep Squat			
Hurdle Step	L		
	R		
Inline Lunge	L		
	R		
Shoulder Mobility	L		
	R		
Impingement Clearing Test	L		
	R		
Active Straight Leg Raise	L		
	R		
Trunk Stability Push-Up			
Press-Up Clearing Test			
Rotary Stability	L		
	R		
Posterior Rocking Clearing Test			
Total			

Appendix C3

Institutional Review Board –

California University of Pennsylvania

California University of Pennsylvania

Proposal Number
Date Received

PROTOCOL for Research Involving Human Subjects

Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects

(Reference IRB Policies and Procedures for clarification)

Project Title ***The relationtionship between the Functional Movement Screen and Star Excursion Balance Test***

Researcher/Project Director ***Sarah Beaulieu***

Phone # ***207-754-3823*** ***E-mail Address*** ***bea9001@calu.edu***

Faculty Sponsor (if required) ***Dr. Rebecca Hess***

Department ***Health Science***

Project Dates ***January 1, 2012*** ***to*** ***December 1, 2012***

Sponsoring Agent (if applicable) ***N/A***

Project to be Conducted at *CalU*

Project Purpose: ☒ ***Thesis*** ☐ ***Research*** ☐ ***Class Project*** ☐ ***Other***

Keep a copy of this form for your records.

<u>Please attach a typed, detailed summary of your project AND complete items 2 through 6.</u>

1. *Provide an overview of your project-proposal describing what you plan to do and how you will go about doing it. Include any hypothesis(ses)or research questions that might be involved and explain how the information you gather will be analyzed. For a complete list of what should be included in your summary, please refer to Appendix B of the IRB Policies and Procedures Manual.*

The purpose of this research study is to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test. Healthy National Collegiate Athletic Association (NCAA) Division II collegiate athletes from California University of Pennsylvania are expected to participate in this study (N~30). Any subject who is currently participating and competing could potentially volunteer as a participant in this study. Each subject who signs the informed consent (attached) will have two measures of performance measured. These include a functional movement test using the Functional Movement Screening (FMS) and a functional balance test using the Star Excursion Balance Test (SEBT). Each subject will perform practice trials for each test as recommended in the literature to become familiar with the test as well as to minimize the learning effect. Pictures of the test are attached (Appendix C4).

Subjects will complete the seven tests used in the FMS in the following order: Deep Squat (DS), Hurdle Step (HS), Inline Lunge (IL), Shoulder Mobility (SM), Active Straight-Leg Raise (ASLR), Trunk Stability Pushup (TSP), and Rotary Stability (RS); and three clearing tests: Impingement Clearing Test (IC), Press-Up Clearing Test (PC), and Posterior Rocking Clearing Test (PRC) will be used to determine pain. Each of these seven tests is performed for a maximum of three attempts. If one repetition is completed successfully for a maximum score of 3, no further trial will be administerd and that score will be recored.

For the DS, the subject assumes the starting position by placing feet shoulder width apart with both feet pointing forward. The subject rests the dowel on top of the head and adjusts the hand position so the elbows are at 90°. The subject then presses the dowel overhead to fully extend the elbows. The subject then slowly assumes the deepest squat possible keeping the heels on the floor, head and chest facing forward, and the dowel maximally pressed overhead. The knees should be aligned over the feet with no valgus collapse. If these conditions are met, the subject receives a score of a 3. If the subject cannot meet the conditions for a score of a 3 on the DS, then the movement will be performed again with the FMS kit board placed under the heels for a score of a 2. If requirements listed for a score of 2 are not achieved, then the subject will receive a score of a 1. If there is pain with the movement, final score of a zero will be given for the DS test.

For the HS, the height of the tibia is measured using the tibial tuberosity as a reliable landmark and the dowel as the measuring device. The hurdle's marking cord is adjusted to the tibial tuberosity. The dowel is positioned across the shoulders below the neck. The subjects will step over the hurdle with one leg and touch their heel to the floor while maintaining the stance leg in an extended position and then return the moving leg to the starting position. The same is repeated with the other leg. A score of 3 will be given on the HS if the subject's hips, knees, and ankles remain aligned in the sagittal plane, there is minimal to no lumbar movement and the dowel and hurdle remain parallel. If any of the criteria is not achieved for a score of a 3, then a score of 2 will be given, and if the criteria for a score of 2 cannot be achieved, then a score of 1 will be given. If there is pain with the movement, final score of a zero will be given for the HS test.

For the IL, the subjects will place one foot at the start line on the kit with the toe behind the line and the other heel will be directly in front of them on the marked lines on the kit. The heel will be placed at the height of the tibial tuberosity mark on the kit. The dowel is placed behind the back touching the head, thoracic spine, and sacrum. The hand opposite to the front foot will be the hand holding the dowel at the cervical spine while the other hand holds the dowel at the lumbar spine with the shoulder internally rotated. The dowel must maintain the three contacts during the entire movement. The subject will then lowers the back knee to touch the board behind the heel of the front foot and will return to the starting position. A score of 3 is given on the IL if there is minimal to no torso movement; feet remain aligned in sagittal plane, knee touches behind the heel of front foot. If any of the criteria is not achieved for a score of a 3, then a score of 2 will be given, and if the criteria for a score of 2 cannot be achieved, then a score of 1 will be given. If there is pain with the movement, final score of a zero will be given for the IL test.

For the SM, the subject's hand length will be measured with the dowel from the distal wrist crease to the tip of the longest digit. The subject will stand with the feet together making a fist with each hand, thumbs inside the fingers. One fist will reach as far as possible behind the neck and the other hand will reach as far as possible behind the back simultaneously keeping the clenched fists. Using the dowel, the distance between the two closest bony prominences will be measured. For a score of a 3 on the SM, the fist placement must be within one hand length apart. For a score of a 2, the fist placement falls between one and a half hand lengths, and a score of a 1 is received is the fist placement is greater than one and half hand lengths apart. If there is pain with the movement, final score of a zero will be given for the SM test.

The IC test will be performed after the SM test with the palm on the opposite shoulder while lifting the elbow as high as possible. If there is pain from performing this clearing exam, a positive is recorded and a score of a zero is given to the SM test.

For the ASLR, the subject will lie supine with the arms by the sides, palms up and head flat on the floor. The FMS kit board will be placed under the knees with the subject's feet in a neutral position and soles of the feet perpendicular to the floor. The dowel is placed at the point halfway between the anterior superior iliac spine (ASIS) and the joint line of the knee. The subject will then lift the test limb with a dorsiflexed ankle and extended knee until end range position is achieved. A score of 3 is given on the ASLR if the ankle passes the dowel placement in the description of the test. If the ankle does not pass the dowel placement for a score of a 3, then the dowel is moved halfway between the mid-thigh and patella joint line for a score of a 2. If the ankle does not move past the dowel for the requirements for a score of a 2, then the subject receives a score of a 1. If there is pain with the movement, final score of a zero will be given for the ASLR test.

For the TSP, the subject will be prone with the arms extended overhead and feet together. The knees will be extended and the ankle will be dorsiflexed. The men will begin with their thumbs at the top of the forehead and moved then shoulder width apart at that level. The women will begin with their thumbs at chin level and then moved shoulder width apart at that level. The subject will then perform one pushup in that position. During this movement, the body must raise as one unit. A score of 3 is given on the TSP if the males perform a pushup with the thumbs just above the forehead and the females with the thumbs in line with the chin and raising the body as one unit. If the requirements for a score of a 3 are not met, the men move the thumbs in line with the chin and the females move the thumbs in line with the clavicle and perform the push-up again. If the requirements for a score of a 2 are not met, then a score of a 1 is given. If there is pain with the movement, final score of a zero will be given for the TSP test.

The PC test will be performed after the TSP in a prone position. The subject will then press up to extend the elbows while keeping the hips on the ground. If there is pain from performing this clearing exam, a positive is recorded and a score of a zero is given to the TSP.

For the RS, the subject will be in a quadruped position with shoulders and hips at 90° relative to the torso with the FMS kit parallel to the spine in between the hands and the knees. The ankles will be in a dorsiflexed position. The subject will then flex the shoulder while extending the same-side hip and knee, and then slowly bring the elbow to the same-side knee while remaining in line over the board. For a score of a 3 on the RS, the subject must perform the task correctly using the same-side leg and arm while keeping the torso parallel to the FMS kit board and keeping the elbow and knee in line with the FMS kit board. A score of a 2 is given, the subject performs a diagonal pattern using the opposite shoulder and hip in the same manner as for a score of a 3. The knee and opposite elbow must make contact over the FMS kit board. If the requirements for a score of a 2 are not met, then a score of a 1 is given. If there is pain with the movement, final score of a zero will be given for the RS test.

The PRC test will be performed after the RS test in a quadruped position and then rocking back and touching the buttocks to the heels and the chest to the thighs. The hands will remain in front of the body, reaching out as far as possible.

The sum of the final scores of each test is used as the composite score (0-21). The clearing tests are not graded with a 3,2,1 or 0. The clearing tests will be reported as a positive (painful) or negative (non-painful). A positive sign for the IC, PC, and PRC will result in a score of a zero for only the SM, TSP and RS tests respectively.

Before the SEBT, each subject's leg length will be measured bilaterally in centimeters as the distance between the anterior superior iliac crests and the medial malleolus to normalize the SEBT score. The SEBT uses a star on the floor with eight lines extending at 45° increments from the center of the grid. The subject will stand on one leg with the heel on the center of the star and hold the hands at the hip. Then the subject will reach with the opposite leg to touch as far as possible along the chosen line. The subject will touch the farthest point possible on the line with the most distal part of their reach foot. The subject will then return to a bilateral stance while maintaining equilibrium. The reached distance is marked along the line and the researcher will manually measure the distance in centimeters from the center of the grid to the mark with a tape measure. The subject will perform six bouts of practice trials followed by three test trials in each of the eight directions with each leg. If a subject loses his/her balance during a trial, they will be asked to repeat the trial. There will be 15 seconds of rest time in between each trial. The order for the tests will be AL, A, AM, M, PM, P, PL, and L. For the lateral and posterolateral lines, the subject must reach behind the stance leg. After the initial stance leg excursions are performed, the same protocol will be repeated on the opposite stance leg. The maximum distance for each of the eight excursions per leg in eight directions (distance in centimeters) will be recorded. Means for the three test trials in each leg is calculated for each of the eight excursions. Then, the mean of the three test trials will be divided by a subject's leg length to normalize the score.

The data will be analyzed using a Pearson product moment correlation coefficient provided by SPSS 18.0. It is hypothesized that there will be a positive correlation between the Functional Movement Screen composite score and Star Excursion Balance Test composite score indicating better functional movement is positively related to functional balance.

2. *Section 46.11 of the Federal Regulations state that research proposals involving human subjects must satisfy certain requirements before the IRB can grant approval. You should describe in detail how the following requirements will be satisfied. Be sure to address each area separately.*

   a. *How will you insure that any risks to subjects are minimized? If there are potential risks, describe what will be done to minimize these risks. If there are risks, describe why the risks to participants are reasonable in relation to the anticipated benefits.*

   The possible risks and/or discomforts are very minimal and include falling during the SEBT and the FMS tests. In both the SEBT and FMS, the researcher will further minimize the risk of falling by acting as a spotter. No tests are physically invasive. The subjects will perform tasks in both tests that are similar to the training for their sport. If an injury was to occur, the researcher will provide care of the subjects under the supervision of a certified athletic trainer in the Athletic Training Room at the Phillipsburg stadium on the upper campus of CalU.

   b. *How will you insure that the selection of subjects is equitable? Take into account your purpose(s). Be sure you address research problems involving vulnerable populations such as children, prisoners, pregnant women, mentally disabled persons, and economically or educationally disadvantaged persons. If this is an in-class project describe how you will minimize the possibility that students will feel coerced.*

   All subjects will be volunteers who are eighteen years or older and are NCAA Division II collegiate athletes at California University of Pennsylvania. Prior to the study, an informational meeting will be held with the potential subjects to explain the concept of the study in the absence of the coach. Any subject who is currently participating and competing could potentially volunteer as a participant in this study. This exclusion due to these medical conditions will be performed by the supervising Certified Athletic Trainer while maintaining patient confidentiality.

balance and functional movement assessment. This exclusion due to these medical conditions will be performed by the supervising Certified Athletic Trainer while maintaining patient confidentiality.

c. *How will you obtain informed consent from each participant or the subject's legally authorized representative and ensure that all consent forms are appropriately documented? Be sure to attach a copy of your consent form to the project summary.*

An informed consent form (Attached Appendix C1) will be completed and signed by all subjects before participating in this study at the day of the testing. Each signed form will be kept by the researcher.

d. *Show that the research plan makes provisions to monitor the data collected to insure the safety of all subjects. This includes the privacy of subjects' responses and provisions for maintaining the security and confidentiality of the data.*

Data will be collected during the spring semester of 2012. All subjects will come in for two separate times. One day will be a familiarization day for the SEBT and the FMS tests to minimize learning effect and the other day will be the data collection day for both tests.

3. *Check the appropriate box(es) that describe the subjects you plan to use.*

☒ *Adult volunteers*	☐ *Mentally Disabled People*
☒ *CAL University Students*	☐ *Economically Disadvantaged People*
☐ *Other Students*	☐ *Educationally Disadvantaged People*
☐ *Prisoners*	☐ *Fetuses or fetal material*
☐ *Pregnant Women*	☐ *Children Under 18*
☐ *Physically Handicapped People*	☐ *Neonates*

4. *Is remuneration involved in your project?* ☐ *Yes or* ☒ *No. If yes, Explain here.*

5. *Is this project part of a grant?* ☐ *Yes or* ☒ *No* *If yes, provide the following information:*

   Title of the Grant Proposal _____

   Name of the Funding Agency _____

   Dates of the Project Period _____

6. *Does your project involve the debriefing of those who participated?* ☐ *Yes or* ☒ *No*

   If Yes, explain the debriefing process here.

7. *If your project involves a questionnaire interview, ensure that it meets the requirements of Appendix___in the Policies and Procedures Manual.*

California University of Pennsylvania Institutional Review Board
Survey/Interview/Questionnaire Consent Checklist (v021209)

This form MUST accompany all IRB review requests

Does your research involve ONLY a survey, interview or questionnaire?

☐ **YES**—Complete this form

☒ **NO**—You MUST complete the "Informed Consent Checklist"—skip the remainder of this form

Does your survey/interview/questionnaire cover letter or explanatory statement include:

☐ (1) Statement about the general nature of the survey and how the data will be used?

☐ (2) Statement as to who the primary researcher is, including name, phone, and email address?

☐ (3) FOR ALL STUDENTS: Is the faculty advisor's name and contact information provided?

☐ (4) Statement that participation is voluntary?

☐ (5) Statement that participation may be discontinued at any time without penalty and all data discarded?

☐ (6) Statement that the results are confidential?

☐ (7) Statement that results are anonymous?

☐ (8) Statement as to level of risk anticipated or that minimal risk is anticipated? (NOTE: If more than minimal risk is anticipated, a full consent form is required—and the Informed Consent Checklist must be completed)

☐ (9) Statement that returning the survey is an indication of consent to use the data?

☐ (10) Who to contact regarding the project and how to contact this person?

☐ (11) Statement as to where the results will be housed and how maintained? (unless otherwise approved by the IRB, must be a secure location on University premises)

☐ (12) Is there text equivalent to: "Approved by the California University of Pennsylvania Institutional Review Board. This approval is effective nn/nn/nn and expires mm/mm/mm"? (the actual dates will be specified in the approval notice from the IRB)?

☐ (13) FOR ELECTRONIC/WEBSITE SURVEYS: Does the text of the cover letter or explanatory statement appear before any data is requested from the participant?

☐ (14) FOR ELECTONIC/WEBSITE SURVEYS: Can the participant discontinue participation at any point in the process and all data is immediately discarded?

California University of Pennsylvania Institutional Review Board
Informed Consent Checklist (v021209)

This form MUST accompany all IRB review requests

Does your research involve ONLY a survey, interview, or questionnaire?
☐ **YES**—DO NOT complete this form. You MUST complete the "Survey/Interview/Questionnaire Consent Checklist" instead.
☒ **NO**—Complete the remainder of this form.

1. **Introduction** (check each)
   ☒ (1.1) Is there a statement that the study involves research?
   ☒ (1.2) Is there an explanation of the purpose of the research?

2. **Is the participant.** (check each)
   ☒ (2.1) Given an invitation to participate?
   ☒ (2.2) Told why he/she was selected.
   ☒ (2.3) Told the expected duration of the participation.
   ☒ (2.4) Informed that participation is voluntary?
   ☒ (2.5) Informed that all records are confidential?
   ☒ (2.6) Told that he/she may withdraw from the research at any time without penalty or loss of benefits?
   ☒ (2.7) 18 years of age or older? (if not, see Section #9, Special Considerations below)

3. **Procedures** (check each).
   ☒ (3.1) Are the procedures identified and explained?
   ☒ (3.2) Are the procedures that are being investigated clearly identified?
   ☒ (3.3) Are treatment conditions identified?

4. **Risks and discomforts**. (check each)
   ☒ (4.1) Are foreseeable risks or discomforts identified?
   ☒ (4.2) Is the likelihood of any risks or discomforts identified?
   ☒ (4.3) Is there a description of the steps that will be taken to minimize any risks or discomforts?
   ☒ (4.4) Is there an acknowledgement of potentially unforeseeable risks?
   ☒ (4.5) Is the participant informed about what treatment or follow up courses of action are available should there be some physical, emotional, or psychological harm?
   ☒ (4.6) Is there a description of the benefits, if any, to the participant or to others that may be reasonably expected from the research and an estimate of the likelihood of these benefits?
   ☒ (4.7) Is there a disclosure of any appropriate alternative procedures or courses of treatment that might be advantageous to the participant?

5. **Records and documentation**. (check each)
   ☒ (5.1) Is there a statement describing how records will be kept confidential?
   ☒ (5.2) Is there a statement as to where the records will be kept and that this is a secure location?
   ☒ (5.3) Is there a statement as to who will have access to the records?

6. For research involving more than minimal risk (check each),

☒ (6.1) Is there an explanation and description of any compensation and other medical or counseling treatments that are available if the participants are injured through participation?

☒ (6.2) Is there a statement where further information can be obtained regarding the treatments?

☒ (6.3) Is there information regarding who to contact in the event of research-related injury?

7. Contacts.(check each)

☒ (7.1) Is the participant given a list of contacts for answers to questions about the research and the participant's rights?

☒ (7.2) Is the principal researcher identified with name and phone number and email address?

☒ (7.3) FOR ALL STUDENTS: Is the faculty advisor's name and contact information provided?

8. General Considerations (check each)

☒ (8.1) Is there a statement indicating that the participant is making a decision whether or not to participate, and that his/her signature indicates that he/she has decided to participate having read and discussed the information in the informed consent?

☒ (8.2) Are all technical terms fully explained to the participant?

☒ (8.3) Is the informed consent written at a level that the participant can understand?

☒ (8.4) Is there text equivalent to: "Approved by the California University of Pennsylvania Institutional Review Board. This approval is effective nn/nn/nn and expires mm/mm/mm"? (the actual dates will be specified in the approval notice from the IRB)

9. Specific Considerations (check as appropriate)

☐ (9.1) If the participant is or may become pregnant is there a statement that the particular treatment or procedure may involve risks, foreseeable or currently unforeseeable, to the participant or to the embryo or fetus?

☐ (9.2) Is there a statement specifying the circumstances in which the participation may be terminated by the investigator without the participant's consent?

☐ (9.3) Are any costs to the participant clearly spelled out?

☒ (9.4) If the participant desires to withdraw from the research, are procedures for orderly termination spelled out?

☐ (9.5) Is there a statement that the Principal Investigator will inform the participant or any significant new findings developed during the research that may affect them and influence their willingness to continue participation?

☐ (9.6) Is the participant is less than 18 years of age? If so, a parent or guardian must sign the consent form and assent must be obtained from the child

- ☐ Is the consent form written in such a manner that it is clear that the parent/guardian is giving permission for their child to participate?
- ☐ Is a child assent form being used?
- ☐ Does the assent form (if used) clearly indicate that the child can freely refuse to participate or discontinue participation at any time without penalty or coercion?

☒ (9.7) Are all consent and assent forms written at a level that the intended participant can understand? (generally, 8th grade level for adults, age-appropriate for children)

California University of Pennsylvania Institutional Review Board
Review Request Checklist (v021209)

This form MUST accompany all IRB review requests.
Unless otherwise specified, ALL items must be present in your review request.

Have you:

☒ (1.0) FOR ALL STUDIES: Completed ALL items on the Review Request Form?
Pay particular attention to:

☒ (1.1) Names and email addresses of all investigators

☒ (1.1.1) FOR ALL STUDENTS: use only your CalU email address)

☒ (1.1.2) FOR ALL STUDENTS: Name and email address of your faculty research advisor

☒ (1.2) Project dates (must be in the future—no studies will be approved which have already begun or scheduled to begin before final IRB approval—NO EXCEPTIONS)

☒ (1.3) Answered completely and in detail, the questions in items 2a through 2d?

☐ 2a: NOTE: No studies can have zero risk, the lowest risk is "minimal risk". If more than minimal risk is involved you MUST:

☐ i. Delineate all anticipated risks in detail;

☐ ii. Explain in detail how these risks will be minimized;

☐ iii. Detail the procedures for dealing with adverse outcomes due to these risks.

☐ iv. Cite peer reviewed references in support of your explanation.

☒ 2b. Complete all items.

☒ 2c. Describe informed consent procedures in detail.

☒ 2d. NOTE: to maintain security and confidentiality of data, all study records must be housed in a secure (locked) location ON UNIVERSITY PREMISES. The actual location (department, office, etc.) must be specified in your explanation and be listed on any consent forms or cover letters.

☐ (1.4) Checked all appropriate boxes in Section 3? If participants under the age of 18 years are to be included (regardless of what the study involves) you MUST:

☐ (1.4.1) Obtain informed consent from the parent or guardian—consent forms must be written so that it is clear that the parent/guardian is giving permission for their child to participate.

☐ (1.4.2) Document how you will obtain assent from the child—This must be done in an age-appropriate manner. Regardless of whether the parent/guardian has given permission, a child is completely free to refuse to participate, so the investigator must document how the child indicated agreement to participate ("assent").

☐ (1.5) Included all grant information in section 5?

☒ (1.6) Included ALL signatures?

☒ (2.0) FOR STUDIES INVOLVING MORE THAN JUST SURVEYS, INTERVIEWS, OR QUESTIONNAIRES:

☒ (2.1) Attached a copy of all consent form(s)?

☐ (2.2) FOR STUDIES INVOLVING INDIVIDUALS LESS THAN 18 YEARS OF AGE: attached a copy of all assent forms (if such a form is used)?

☒ (2.3) Completed and attached a copy of the Consent Form Checklist? (as appropriate—see that checklist for instructions)

☐ (3.0) FOR STUDIES INVOLVING ONLY SURVEYS, INTERVIEWS, OR QUESTIONNAIRES:

☐ (3.1) Attached a copy of the cover letter/information sheet?

☐ (3.2) Completed and attached a copy of the Survey/Interview/Questionnaire Consent Checklist? (see that checklist for instructions)

☐ (3.3) Attached a copy of the actual survey, interview, or questionnaire questions in their final form?

☒ (4.0) FOR ALL STUDENTS: Has your faculty research advisor:

☒ (4.1) Thoroughly reviewed and approved your study?

☒ (4.2) Thoroughly reviewed and approved your IRB paperwork? including:

☒ (4.2.1) Review request form,

☒ (4.2.2) All consent forms, (if used)

☐ (4.2.3) All assent forms (if used)

☐ (4.2.4) All Survey/Interview/Questionnaire cover letters (if used)

☒ (4.2.5) All checklists

☒ (4.3) IMPORTANT NOTE: Your advisor's signature on the review request form indicates that they have thoroughly reviewed your proposal and verified that it meets all IRB and University requirements.

☒ (5.0) Have you retained a copy of all submitted documentation for your records?

Project Director's Certification

Program Involving HUMAN SUBJECTS

The proposed investigation involves the use of human subjects and I am submitting the complete application form and project description to the Institutional Review Board for Research Involving Human Subjects.

I understand that Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects. If the Board grants approval of this application, I agree to:

1. Abide by any conditions or changes in the project required by the Board.
2. Report to the Board any change in the research plan that affects the method of using human subjects before such change is instituted.
3. Report to the Board any problems that arise in connection with the use of human subjects.
4. Seek advice of the Board whenever I believe such advice is necessary or would be helpful.
5. Secure the informed, written consent of all human subjects participating in the project.
6. Cooperate with the Board in its effort to provide a continuing review after investigations have been initiated.

I have reviewed the Federal and State regulations concerning the use of human subjects in research and training programs and the guidelines. I agree to abide by the regulations and guidelines aforementioned and will adhere to policies and procedures described in my application. I understand that changes to the research must be approved by the IRB before they are implemented.

Professional Research

Project Director's Signature

Department Chairperson's Signature

Student or Class Research

Student Researcher's Signature

Supervising Faculty Member's Signature if required

Department Chairperson's Signature

ACTION OF REVIEW BOARD (IRB use only)

The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved.
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm.

☐ Approved[ ] ☐ Disapproved

Chairperson, Institutional Review Board

Date

Approved, September 12, 2005 / (updated 02-09-09)

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Sarah Beaulieu** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 12/01/2011

Certification Number: 813010

Institutional Review Board
California University of Pennsylvania
Morgan Hall, Room 310
250 University Avenue
California, PA 15419
instreviewboard@calu.edu
Robert Skwarecki, Ph.D., CCC-SLP,Chair

Dear Sarah Beaulieu:

Please consider this email as official notification that your proposal titled "The relationship between Functional Movement Screen and Star Excursion Balance Test" (Proposal #11-028) has been approved by the California University of Pennsylvania Institutional Review Board as amended.
The effective date of the approval is 2-28-2012 and the expiration date is 2-27-2013. These dates must appear on the consent form .
Please note that Federal Policy requires that you notify the IRB promptly regarding any of the following:

(1) Any additions or changes in procedures you might wish for your study (additions or changes must be approved by the IRB before they are implemented)

(2) Any events that affect the safety or well-being of subjects

(3) Any modifications of your study or other responses that are necessitated by any events reported in (2).

(4) To continue your research beyond the approval expiration date of 2-27-2013 you must file additional information to be considered for continuing review. Please contact instreviewboard@calu.edu

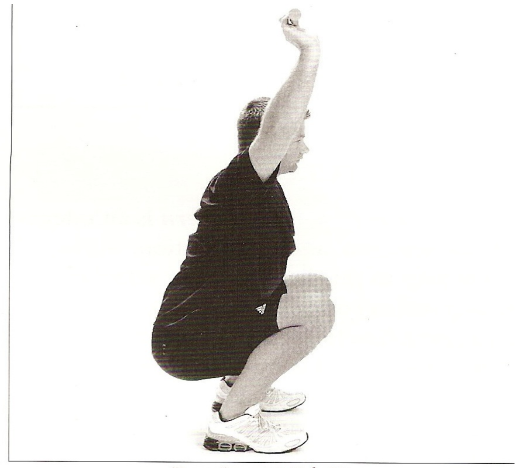
Please notify the Board when data collection is complete.
Regards,
Robert Skwarecki, Ph.D., CCC-SLP
Chair, Institutional Review Board

Appendix C4

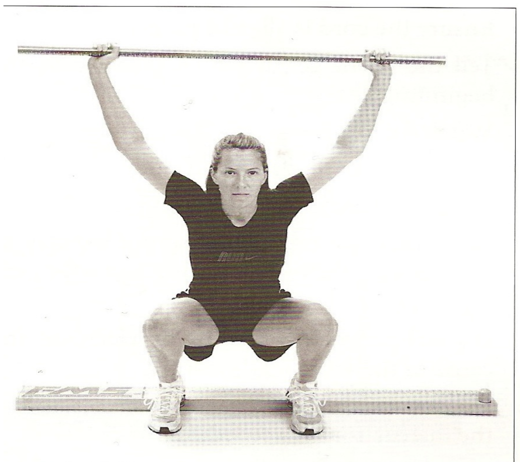
Pictures and Instructions for FMS and SEBT

Functional Movement Screen

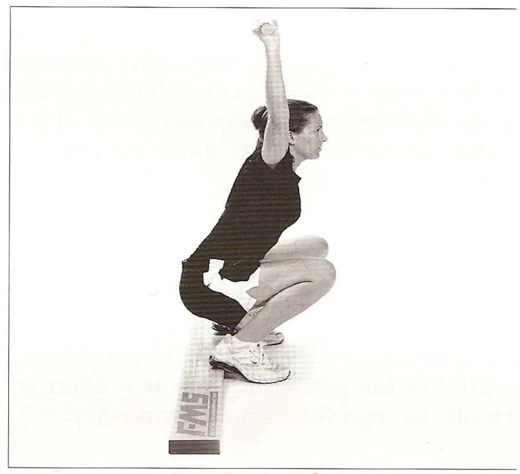
Deep Squat 3 Front View



Deep Squat 3 Side View



Deep Squat 2 Front View

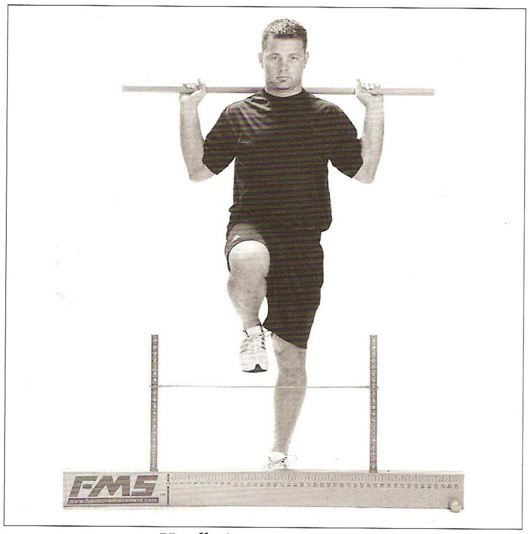


Deep Squat 2 Side View

Deep Squat 1 Front View

Deep Squat 1 Side View

Movement: Functional Movement Systems—Screening, Assessment, Corrective Strategies
Copyright © 2010 Gray Cook.

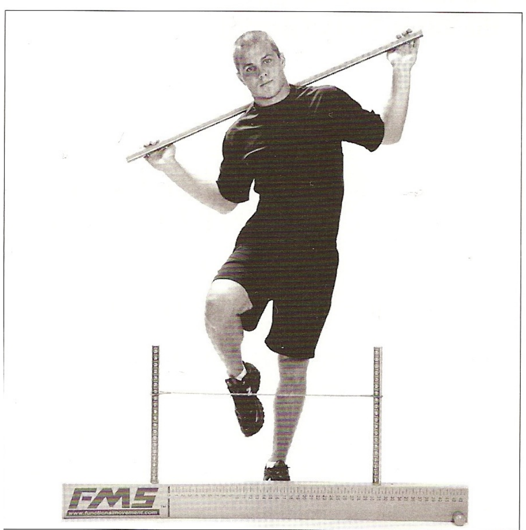


Hurdle Step 3 Front View

Hurdle Step 3 Side View

Hurdle Step 2 Front View

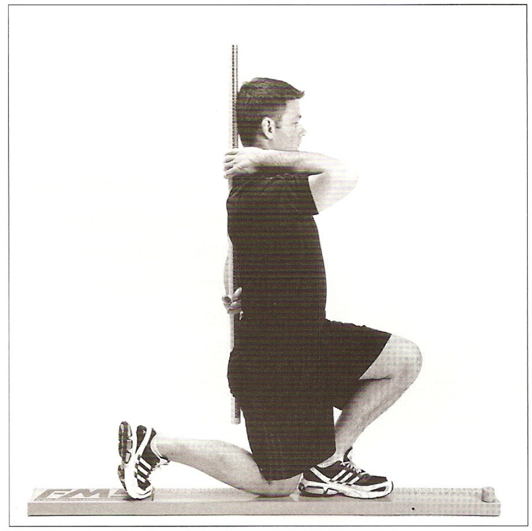
Hurdle Step 2 Side View



Hurdle Step 1 Front View

Hurdle Step 1 Side View

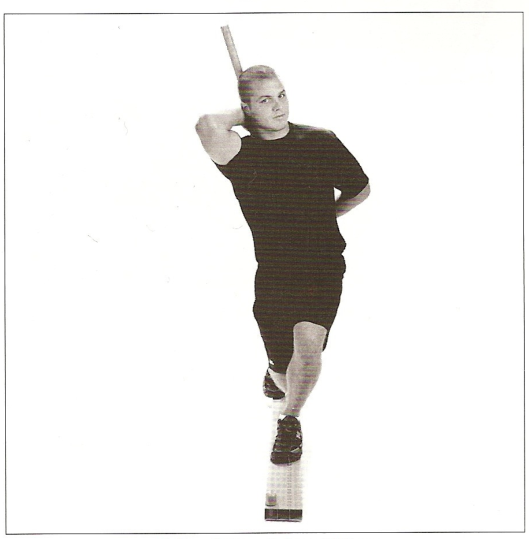
Inline Lunge 3 Front View



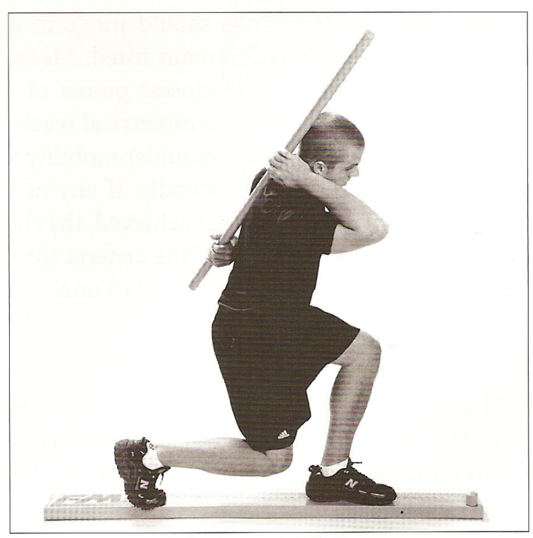
Inline Lunge 3 Side View

Inline Lunge 2 Front View

Inline Lunge 2 Side View



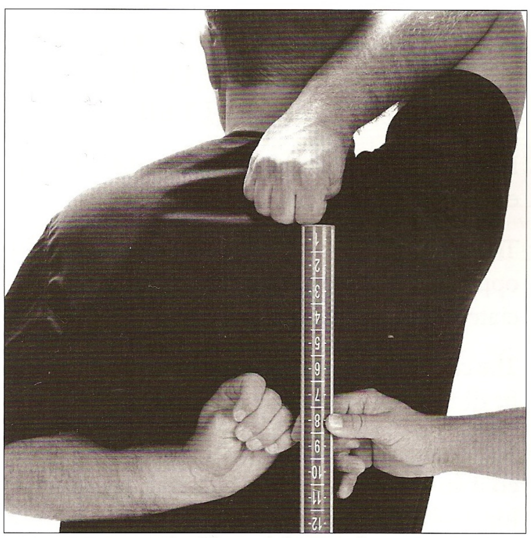
Inline Lunge 1 Front View



Inline Lunge 1 Side View

Shoulder Mobility 3 Right

Shoulder Mobility 1 Right



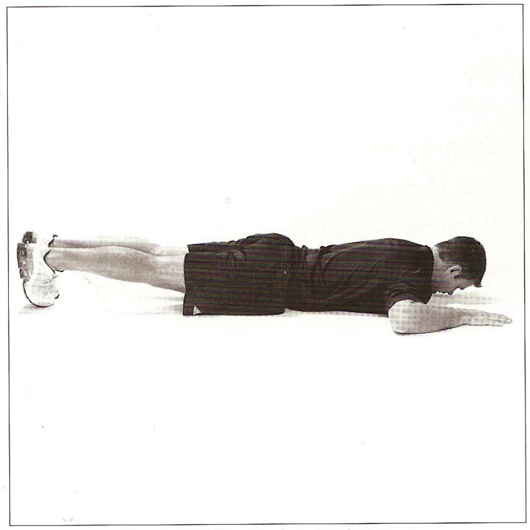
Shoulder Mobility 2 Right

Shoulder Pain Provocation Test

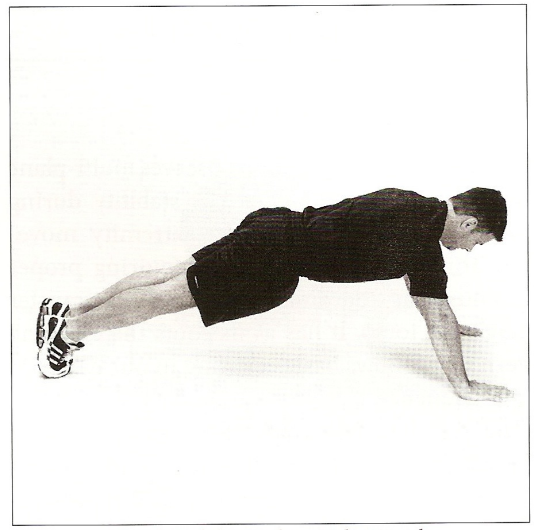
Active Straight-Leg Raise 3

Active Straight-Leg Raise 2

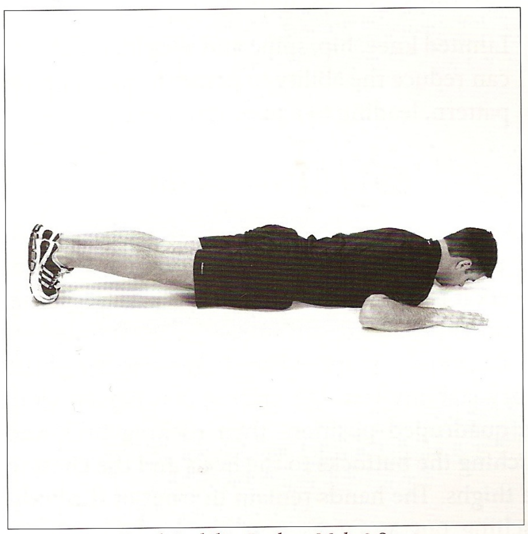
Active Straight-Leg Raise 1



Trunk Stability Pushup Male 3 Start



Trunk Stability Pushup Male 3 Finish

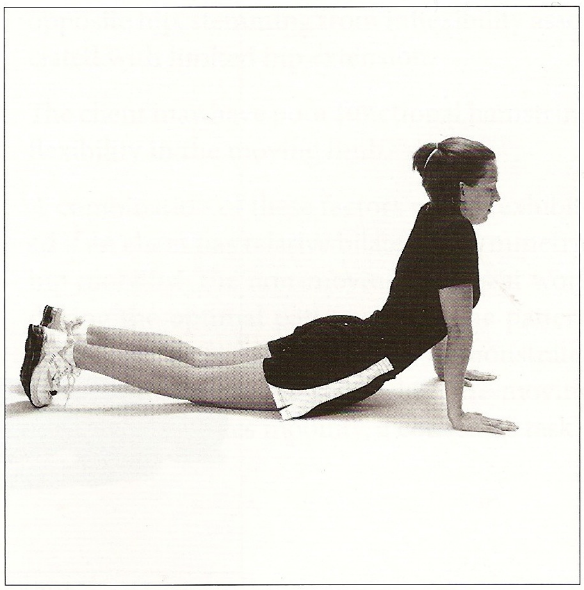


Trunk Stability Pushup Male 2 Start

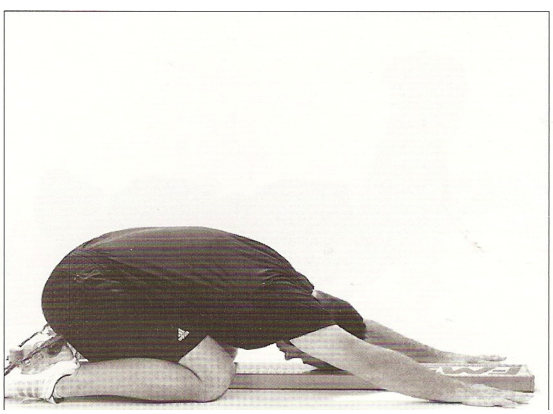
Trunk Stability Pushup 2 Female Finish

Trunk Stability Pushup 2 and 1 Female Start

Trunk Stability Pushup 1 Female Finish

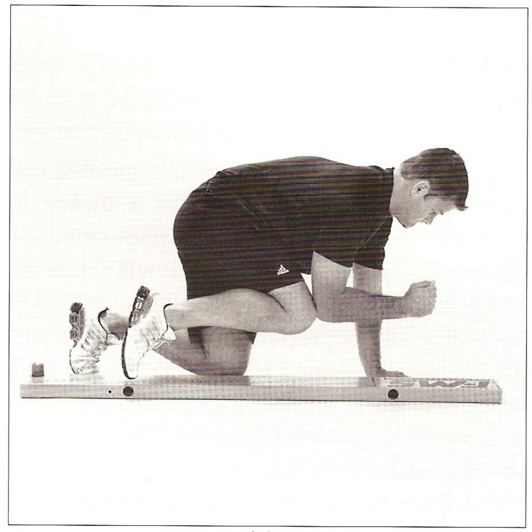


Trunk Stability Press-up Extension Test



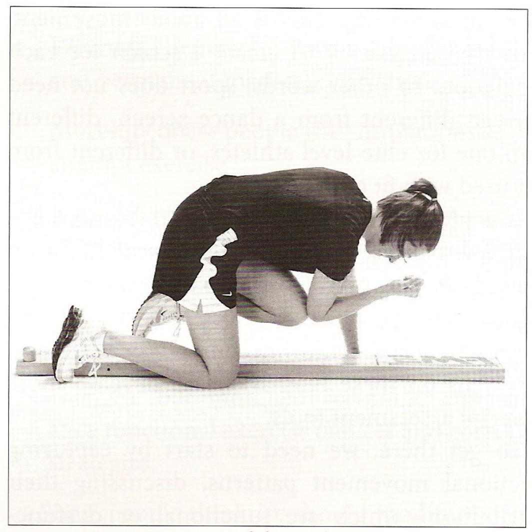
Posterior Rocking Clearing Test

Rotary Stability 3 Extension

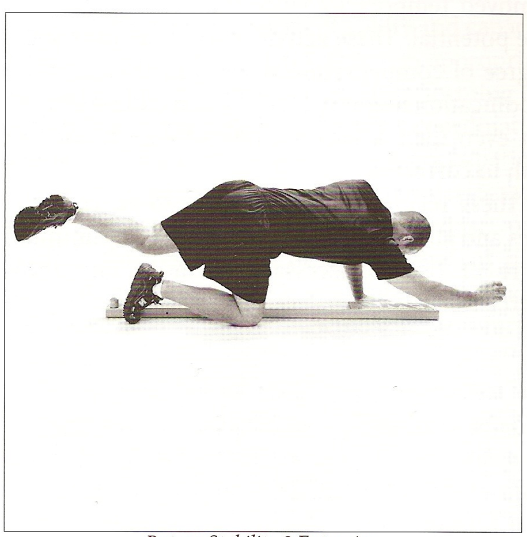


Rotary Stability 3 Flexion

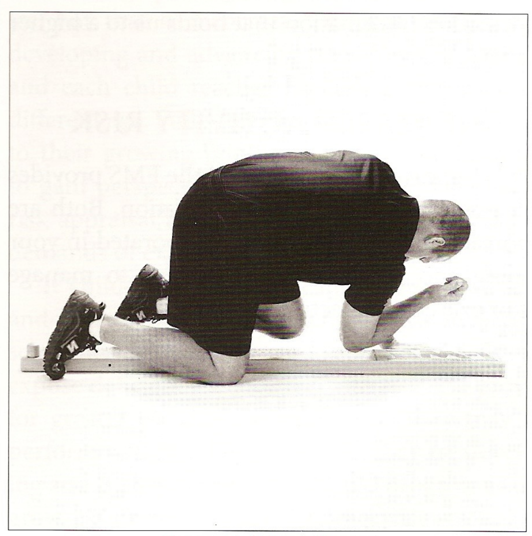
Rotary Stability 2 Extension



Rotary Stability 2 Flexion

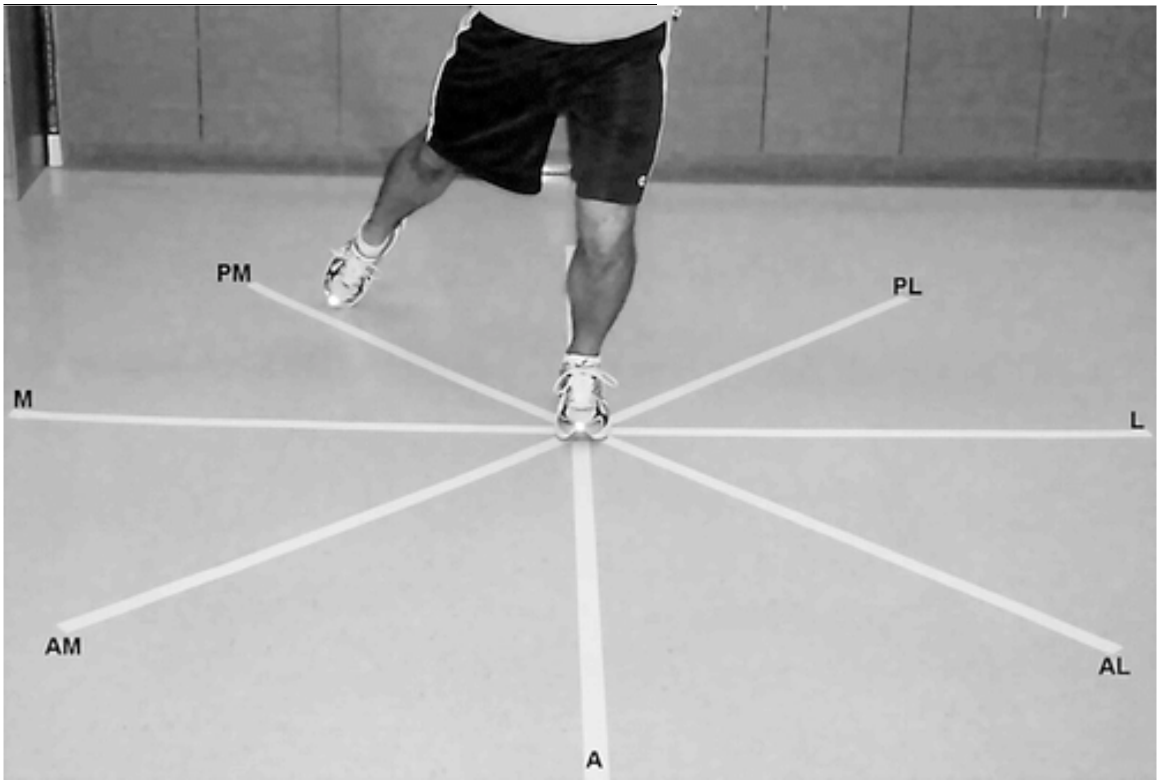


Rotary Stability 2 Extension



Rotary Stability 1 Flexion

Star Excursion Balance Test (SEBT)



http://www.bmsi.ru/doc/3007bf2e-9a55-4e6f-9254-0b9b727770a6

VERBAL INSTRUCTIONS FOR
THE FUNCTIONAL MOVEMENT SCREEN

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

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

Deep Squat

Equipment needed: Dowel

Instructions

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

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

FMS

Hurdle Step

Equipment needed: Dowel, Hurdle

Instructions

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

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

Inline Lunge

Equipment needed: Dowel, 2x6

Instructions

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

behind your left heel.
- **Return to the starting position.**
- **Do you understand these instructions?**

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

Shoulder Mobility

Equipment needed: Measuring device

Instructions

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

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

Active Scapular Stability (shoulder clearing)

Instructions

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

Repeat the test on the other side.

FMS

Active Straight-Leg Raise

Equipment needed: Dowel, measuring device, 2x6

Instructions

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

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

Trunk Stability Pushup

Equipment needed: None

Instructions

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

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

Spinal Extension Clearing

Instructions

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

Rotary Stability

Equipment needed: 2 x 6

Instructions

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

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

Spinal Flexion Clearing

Instructions

• Get on all fours, and rock your hips toward your heels.
• Lower your chest to your knees, and reach your hands in front of your body as far as possible.
• Do you understand these instructions?
• Do you feel any pain?

Excerpted from the book, Movement: Functional Movement Systems—Screening, Assessment, Corrective Strategies
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ABSTRACT

Title: THE RELATIONSHIP BETWEEN THE FUNCTIONAL MOVEMENT SCREEN AND STAR EXCURSION BALANCE TEST

Researcher: Sarah Beaulieu

Advisor: Dr. Rebecca Hess

Date: May 2012

Research Type: Master's Thesis

Context: There were no research studies found which compared functional movement as measured by the FMS to balance as measured by the SEBT at the time of research.

Objective: The purpose of this study was to examine the relationship between the Functional Movement Screening and the Star Excursion Balance Test.

Design: This descriptive correlational study examined the relationship between functional movement as tested by the FMS and functional balance as tested by the SEBT.

Setting: The testing was performed in a controlled laboratory setting by the researcher.

Participants: Sixteen male Division II collegiate athletes volunteered for this study.

Interventions: Each subject was tested on two days. All subjects were tested by using the Functional Movement Screen (FMS) and the Star Excursion Balance Test (SEBT). The FMS was used to measure functional movement and the SEBT was used to measure functional balance.

Main Outcome Measures:

FMS score and SEBT score were computed from all test trials correlation was examined between the two variables.

Results: A significant moderate positive correlation between functional movement (FMS) and functional balance (SEBT) ability was present ($r = .478$, $P = .031$).

Conclusion: Functional balance and functional movement appear to be moderately related in healthy Division II soccer athletes. This relationship indicates that better functional movement can be associated with functional balance.

Overall, the sports medicine and strength and conditioning professionals may choose to perform one test over another based on the functional performance desired to be tested, and that such tests may be used as screening tools for potential injury.