ABSTRACT

INTERRATER RELIABILITY BETWEEN THE NOVICE AND EXPERT FUNCTIONAL MOVEMENT SCREEN RATERS

By

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January 2015

This study compared the level of agreement and interrater reliability between novice and expert FMS evaluators from observing only the deep squat test. Sixty healthy subjects (36 females and 24 males) between the ages of 18-35 years performed the deep squat test and were scored by 20 FMS raters (experience levels ranging from 5 months to 5 years). All subjects who scored a 0 were eliminated from this study. Each of the subjects was video taped from the sagittal and frontal view. Data was determined using a Chi square test ($p \leq 0.05$) and a Kappa statistic. The interrater reliability was considered less than chance agreement with a Kappa value = -0.009. The Chi-Square value resulted in a p-value = 0.865, which is greater than the probability of $p = 0.05$. Results showed that there were no significant differences between the novice and expert FMS raters on the ability to agree 50% or more of the time on the deep squat test. The interrater reliability for the deep squat test resulted to be poor reliability within the two groups of FMS raters.

INTERRATER RELIABILITY BETWEEN THE NOVICE AND EXPERT FUNCTIONAL MOVEMENT SCREEN RATERS

A THESIS

Presented to the Department of Kinesiology

California State University, Long Beach

In Partial Fulfillment

of the Requirements for the Degree

Master of Science of Kinesiology

Option in Exercise Science

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January 2015

ACKNOWLEDGEMENTS

I am honored and privileged to receive support and guidance from my committee members throughout the course of this thesis and degree. I would like to express my gratitude to Dr. Ralph Rozenek, Dr. Jill Crussemeyer, and Leslie Musser. Dr. Ralph Rozenek, thank you for all your assistance and knowledge throughout every step of this process. What can I say, your research background and expertise has been an exponentially beneficial for allowing myself to finish this thesis. There are not enough words to describe how much your attention to detail and advice has excelled my work ethic and ability to finish this task. Dr. Jill Crussemeyer, it has been an excellent experience on taking all your courses and learning about research studies from you. Without your thorough and meticulous expertise, my completion of this thesis would not be possible. Leslie Musser, it was a pleasure having you as a fellow classmate and committee member. I appreciate all your help and support on observing and reviewing my thesis. You were also a key ingredient to my success on completing this research. Finally, I would like to send out a special thanks to my entire family; my Mom for her support, guidance, and inspiration on anything I do, my Dad for his love and advice, and Jane for her dreams and unconditional encouragement to every attempt of entrepreneurship I thrive to achieve. Lastly, I would like to send a special thanks to my best friends and Chariesse Turner who have always been there by side and believing in my accomplishments.

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CHAPTER 1

INTRODUCTION

Between 1988 and 2004, the National Collegiate Athletic Association (NCAA) Injury Surveillance System reported approximately 182,000 injuries within collegiate athletes (Hootman, Randall, & Agel, 2007). In the United States alone, an estimated seven million sports-related injuries require medical attention annually (Butler, Kiesel, & Plisky, 2012). American football has the greatest incidence of injury of any sports with a reported 500,000 each year (Kiesel, Plisky, & Voight, 2007). However athletes are not the only individuals suffering musculoskeletal injuries. Individuals in highly skilled occupations, such as police officers, firefighters, and military soldiers have also experienced musculoskeletal injuries (Larsson, Larsson, Osterberg, & Ringdahl, 2008; O'Connor, Davis, Deuster, Knapik, & Pappas, 2011).

The most prominent risk factors for musculoskeletal injury in highly skilled occupations and athletes have been related to overuse and the complexity of any previous injury (Kiesel, Plisky, & Butler, 2009; Smith & Peterson, 2007). In addition, there are other factors that can be the cause of injury, such as elevated body mass index and body fat percentage, level of experience in the sport, shoe design, type of playing surface, amount of joint flexibility, degree of ligamentous laxity, and poor biomechanics (Kiesel et al., 2007). Most recently, research has shown that core instability, contralateral muscular imbalances, and altered kinematics can lead to dysfunctional neuromuscular control which can increase the chances of musculoskeletal injuries (Chorba, Chorba

Bouillon, Landis, & Overmyer, 2010; Teyhan et al., 2014).

Sports medicine physicians and specialists (physical therapists, chiropractors, strength and conditioning coaches) have been attempting to improve the technology to detect and identify musculoskeletal injuries. Over the past 10 years, many of these sports medicine specialists have dedicated their time to creating more accurate assessment tools to diagnose and treat injuries via MRIs (Magnetic Resonance Imaging), CT (Computed Topography), X-rays, and other computer-based modalities. Simpler screening tests such as the Preparticipation Physical Evaluation (PPE) and the orthopedic screening examination have also been developed (Bernhardt & Roberts, 2010).

The current history questionnaire, recent history form, and musculoskeletal screening examination from the PPE were designed to provide an expedient, generic, and historical screening tool for all sports participants (Garrick, 2004). The main reasons for using the PPE were: (1) to determine general health; (2) to disclose existing medical problems that may limit participation; (3) to detect conditions that may predispose the athlete to injury; (4) to determine optimal level of performance; (5) to classify the athlete according to individual qualification; (6) to evaluate the athlete's size and level of maturity; (7) to improve the athlete's fitness and performance; and (8) to provide opportunities for patients who suffer either physiologic or pathologic health conditions that may preclude blanket approval to compete (Sanders, Blackburn, & Boucher, 2013; Table 10). The primary purpose of the PPE has been to screen for any conditions that may predispose an individual to injury or illness that may be detrimental to the person's health and life-threatening or disabling to their conditions (Onate et al., 2012; Sanders et al., 2013). Also, the PPE has been used in an attempt to facilitate optimal musculoskeletal health and performance of an athlete and to identify potential risk factors for injury (Maffey & Emery, 2006; Sanders et al., 2013). Physicians have used the PPE model for promoting health and safety for their clients.

In addition to using the PPE, sports medicine specialists have also used orthopedic screening examinations. The orthopedic screening examination was the musculoskeletal screening section of the PPE. The orthopedic screening examination has been designed to address the following purposes: (1) to fulfill the institution's legal and insurance requirements; (2) to assure coaches that their players would start the season with a common level of health and fitness; (3) to inform the medical staff that there are treatable conditions that might be a disturbance during any athletic participation; (4) to aid in predicting and preventing future injuries; and (5) to serve as a commonly applicable exam that is appropriate to all the sports (Garrick, 2004). The orthopedic screening examination main objective is to determine the client's strength and range of motion and their ability to play the sport (Garrick, 2004).

Currently there does not appear to be enough evidence-based literature to suggest that the PPE and orthopedic screening examination can successfully predict injury or enhance an individual's performance (Garrett, 2004; Maffey & Emery, 2006). A primary limitation of both PPE and orthopedic screening examination is they do not directly assess the functional movement of multiple areas on the body either independently or simultaneously, nor do they provide information pertaining to the quality of movement patterns. Other limitations to both the PPE and orthopedic screening examination are the lack of consensus regarding the threshold of abnormality, the lack of data indicating the predictive value of specific physical abnormalities for injury, and the insufficient amount of evidence that corrective interventions alter outcome (Maffey & Emery, 2006). Some type of assessment tool that can provide this information has been in demand.

Recently, the Functional Movement Screen (FMS), created by Cook, Burton, and Hoogenboom (2006) has been used as an assessment tool to determine movement pattern quality with a grading system that focuses on limitations and asymmetries with respect to basic human movement patterns. The screen uses movements that incorporate a combination of muscle strength, flexibility, range of motion, coordination, balance, and proprioception (Cook, 2004; Cook et al., 2006). According to its developers the FMS was designed to challenge the interactions of kinetic chain mobility and stability necessary for performance of fundamental, functional movement patterns, and to predict those at highest risk for musculoskeletal conditions and injuries (Chorba et al., 2010; Teyhen et al., 2012).

The FMS examination consists of deep squat, shoulder mobility, rotary stability, hurdle step, in-line lunge, active straight leg raise, and trunk stability push-up tests. These tests were developed to assess individuals using more complex movement patterns requiring balance of mobility and stability as opposed to typical movements used in daily activities (Cook, Burton, Kiesel, Rose, & Bryant, 2010).

History of Overhead Squat Test

Using the information from the overhead squat test, Cook (2004) was able to create a screening tool called the deep squat (DS) test for the FMS. The test requires an individual to hold the arms extended above the head (180° shoulder flexion) holding a wooden dowel while attempting a full squat. It is thought that this movement takes into account flexibility, strength, and nervous system coordination (Cook et al., 2006; Hirth, 2007). Sports medicine professionals have used the overhead squat test to determine individuals' performance levels, and have used this information to create proper rehabilitation/exercise programs for improving functional movement patterns (Hirth, 2007). Areas of the body involved in the movement include the pelvis, hip, core musculature, and lower extremities. These areas of the body listed above must have complete range of motion and sufficient core strength in order for a deep squat to be completed. The anatomical definition of the core is a box with the abdominals as the front, paraspinals and gluteals as the back, diaphragm as the roof, and pelvic region and hip girdle musculature as the bottom (Hibbs, Thompson, French, Wrigley, & Spears, 2008). Core stability is important to study during stabilization of the torso, hip, and spine (focusing mainly on the thoracic region), thus allowing optimal production, transfer, and control of force and motion to the terminal segment within the deep squat motion (Okada, Huxel, & Nesser, 2011). The primary difference between the overhead squat test and the deep squat test has been the use of both arms holding a dowel over the person's head.

Description of Deep Squat Test:

The DS movement consists of an individual holding a dowel or a stick balanced on the top of the head, right above the middle portion of the cranium. The DS screen test has been used to determine the individual's lifting movements by challenging the total body mechanics of the lower extremities (quadriceps, hamstrings, gastrocnemius, gluteus maximus), and the core musculature (abdominals and spinal erectors), as well as the mobility of the upper extremities (deltoid, supraspinatus, infraspinatus). In the closed kinematic chain during the DS movement, the ankle is the foundation; if the mobility and stability is compromised or limited, the DS test would result in a low score. The knee serves as the primary modulator of the lower extremity motion during the DS, as the quadriceps becomes the primary agonistic muscle group during the knee extension movement (Hemmerich, Brown, Smith, Marthandam, & Wyss, 2006). The main role of the hip joint is to act as a coupler between the lower extremity and upper extremity, as the hip provides maintenance of the upper extremity alignment as the lower extremity flexed and extended during the DS movement (Butler, Kiesel, Plisky, Scoma, & Southers, 2010).

Delimitations

Delimitations involved in this study consist of:

1. Subjects were between the ages of 18 and 35 years.
2. Subjects had no orthopedic surgeries (skeletal, muscular, ligament, tendon, labrum, etc.) within the past year at the beginning of the study.
3. Subjects were free from any injury that would limit upper or lower extremity movement.
4. There were no age restrictions on the FMS testers.
5. All FMS testers were randomly selected throughout the United States from flyers and word of mouth.
6. The warm-up and practice protocols were given 24 hours before the test was administered.
7. There was a pre-screening questionnaire that eliminated all subjects who had scored a 0 on the FMS DS test.
8. All the tests were performed in a controlled environment.

Limitations

All FMS raters provided a restricted scoring range of 1-3, since all subjects who scored a 0 were eliminated. The FMS raters only scored one FMS screen test, the deep squat test. Only 20 FMS raters ranging from five months to five years certification participated.

Although the use of FMS has gained popularity, there is little research currently available to support its reliability or validity on predicting those at high risk for musculoskeletal conditions and injuries or to improve performance after a prescribed rehabilitation program. In this study, the focus was on interrater reliability using only the DS test from the FMS. The overall purpose of this study was to investigate the level of agreement and interrater reliability between novice and experienced FMS evaluators. The null hypothesis of the study was that there would not be a significant difference in scoring the deep squat test between the experienced and inexperienced evaluators. Alternatively it was hypothesized that there would be significant differences in scoring on the deep squat test between experienced and inexperienced evaluators.

CHAPTER 2

LITERATURE REVIEW

Screening Tools Used Prior to the FMS

Screening tools for sports often involve evaluation of gait pattern, balance, jump-landing mechanics, flexibility, neuromuscular stability, strength, orthopedic screening examination, and the PPE (Onate et al., 2012). Other tests commonly used are sit-ups, push-ups, endurance runs, sprints, and agility activities. The PPE is an examination consisting of questionnaires, standard neuro-musculoskeletal examinations, and some form of functional testing. The purpose of the PPE is to identify potentially modifiable risk factors of injury and assuming the patient's improvement of performance (Maffey & Emery, 2006). The PPE consists of medical examination, musculoskeletal examination (focusing on functional specificity for flexibility, posture, gait, and strength), performance testing (speed, agility, power, endurance, and balance), body composition, and maturity assessment (Sanders et al., 2013). There are different formats of the PPE (which all have the same content overall but presented it in contrasting formats), and one example of a preparticipation assessment is included in Appendix A.

Previous research has shown that the PPE has been used as a screening tool to identify risk factors for injury (Maffey & Emery, 2006). However the PPE and orthopedic screening examination have high operating costs and extensive time requirements in order to make assessments. In addition to the time constraints, PPE also has had reliability issues concerning multiple examinations performed by various sports-specific professionals from different disciplines (athletic trainers, sports physical therapists, physiotherapists, chiropractors, or medical doctors), either on the same athlete or by different examiners on different athletes (Kiesel, Plisky, & Butler, 2011). One example is when an NFL defensive player can play the game competitively while he lacks 10 degrees of wrist extension from a previous hand injury; but the NBA player cannot be able to compete at the appropriate level with the same injury. Besides the PPE, other assessment tools have been used to evaluate injury potential (Parchmann & McBride, 2011).

A study performed by Smith and Peterson (2007) investigated the benefits of using a musculoskeletal screening examination, consisting of 10 functional movements including a squat test (similar to but not exactly the same as a DS test), for initiating or discharging soldiers. In order to continue military training, the soldiers had to pass all 10 functional movements without any pain. Of the 105 soldiers participating, only 29 had no physical restrictions and were cleared to return to duty; the remainder of them had certain specific physical restrictions limiting their duty time. The 76 injured soldiers were able to receive appropriate aid and medical intervention. Smith and Peterson found that 92% of the 76 were able to complete their training and graduate on time. This study demonstrated that a brief screening tool such as the musculoskeletal screening examination could identify injured soldiers early in the training cycle. And the usage of this screening tool provided information for its necessity in the military environment to minimize the potential risks of further injury (Smith & Peterson, 2007).

In another study, Larsson et al. performed screening tests to detect knee pain (2008). According to the Smith and Peterson (2007) and Larsson et al. (2008) studies, the musculoskeletal examination proved to be effective on identifying orthopedic injuries through the feeling of pain but did not identify musculoskeletal injuries or lower injury rates. Overall the musculoskeletal exam proved to be useful mainly for detecting pain, and the reliability as a screening tool was not established in either case.

FMS Used to Identify Injuries

A study was conducted on 62 National Football League (NFL) players, where each player was evaluated with the FMS before and after a 7-week intervention consisting of traditional strength and conditioning activities along with corrective exercises (Kiesel et al., 2009). The results revealed that the players' mean pre-test scores compared to the mean post-test scores showed an improvement in their FMS scores. The improved FMS scores allowed these football players to have a score above the injury threshold and a higher percentage of players were free from asymmetry before the intervention (Kiesel et al., 2009). This study demonstrated the importance of improving FMS scores above the score of 14 via a specific off-season training program, but there was no data showing any relationship between the FMS scores and incidence of injury. But there was no evidence showing if this intervention could work in other active populations.

Peate, Bates, Lunda, Francis, and Bellamy (2007) performed a study on 433 active-duty firefighters to identify who was at a high risk of injury. The focus of this study had a group of occupational medicine physicians, therapists, and fire department health and safety officers to create a unique method of injury prediction and prevention for firefighters via the FMS. Firefighters have the highest injury rates in all occupations due to comprised trunk stability and ergonomically hazardous conditions; especially when their FMS scores were less than 16, this caused them to be subject to injury-prone situations (Peate et al., 2007).

All 433 firefighters performed the seven FMS tests, which revealed certain subjects who scored greater than 16 had reduced injuries, and as each firefighter used a specific intervention, he or she improved in flexibility and strength in core muscle groups. The intervention reduced lost time due to injuries by 62% and the number of injuries by 42% within a 1-year period when compared to a historical control group. However, no description of the historical control group was provided in this study (Peate et al., 2007). Overall, this study provided additional evidence to suggest that the FMS may be useful in evaluating risk for injury similar to the Kiesel et al. (2009) NFL study. Additionally, a study by Chorba et al. (2010) found similar results by observing the compensatory movement patterns of predisposed collegiate female soccer athletes by using the FMS to predict injuries within the course of one competitive season.

FMS and its Reliability

Due to rapid increases in sports participation, sports physicians and specialists have focused on finding new screening tools to decrease the chances of musculoskeletal injuries and increase participants' strength, speed, agility, and flexibility. A key underlining component to any screening tool is its reliability. "Reliability" is a measure of a test to produce similar results when measured under different conditions (Field, 2009). Several studies have investigated interrater reliability of the FMS assessment tool.

In a study by Schneiders, Davidsson, Horman, and Sullivan (2011), the normative values for the FMS were shown within a healthy, active population. The secondary aim, evaluated the real time interrater reliability between two FMS raters. There were 209 subjects, with almost a 50/50 split in the female-to-male ratio. Two FMS raters evaluated each of the subjects, where each FMS rater was equal in terms of clinical experience and previous usage of the FMS. It was found that there was no significant difference in the FMS scores between male and female subjects. This meant that female and male subjects were nearly equal with their functional movement patterns, so gender was not a main factor on determining the difference of FMS scores. The real time interrater reliability between the FMS raters had an intraclass correlation coefficient (ICC) score of 0.971, which indicated excellent reliability. Additionally, the level of agreement for the DS test was 100% between two FMS raters with a high Kappa score. The Kappa statistic was used to determine the interrater reliability measurement of each FMS tests; and Kappa scores above 80% represented excellent agreement, above 60% had substantial agreement, 40-60% had moderate agreement, and below 40% had poor to fair agreement. A major limitation of the study was that only two testers were used to evaluate the subjects.

Onate et al. (2012) investigated intersession and interrater reliability in all tests except the Hurdle Step. The study consisted of 19 healthy active subjects who had no orthopedic surgeries in the past year and no upper or lower extremity injuries within the last 6 months. There was one expert certified FMS evaluator who had 4 years experience as a Certified Athletic Training (ATC) and Certified Strength and Conditioning Specialist (CSCS). The second evaluator had 3 years of CSCS with no FMS course training, but had read the FMS manual one time before scoring the individuals. Onate et al. used both an ICC for the intersession reliability and a weighted Cohen's Kappa to determine the interrater reliability. The results showed real time reliability of the FMS ranks from fair to high reliability across the intersession and interrater assessments. A high interrater reliability during real time assessment between a novice and expert FMS rater were evaluated. The limitation to Onate et al. study was that one of the seven FMS examinations (the hurdle step) tested with poor interrater reliability that might lead to a failure to recognize and address functional limitations. Another limitation was the use of only two FMS raters evaluating the subjects.

In another study, Minick et al. (2010) used 40 subjects and four raters (two experts, which was defined as having 10 years of experience with the FMS, and two novices, who had completed the FMS training course and used the FMS for fewer than 4 years) to test the interrater reliability of the FMS. The authors used the term "regional interdependence" to explain why dysfunction in one body region affected another region by causing weakness, tightness, or pain (Minick et al., 2010). In the results, the two expert raters had a total of excellent (Kappa scores ≥ 0.80) to substantial (Kappa scores between 0.60 – 0.79) agreement on 13 of the 17 test components, and the two novice experts had a total of excellent to substantial agreement on 14 of 17 test components. When the novice and expert raters were paired together, the results showed 14 of the 17 tests had excellent agreement. Focusing on just the DS test, the expert raters had substantial agreement with a Kappa score of 0.64 as opposed to the novice raters who had a Kappa score of 0.80. Overall, the FMS showed a high interrater reliability in this study. But there were noticeable differences between the two groups of raters and between the different tests due to the experience of the raters and testing protocols. The limitation in this study involved the two-dimensional video setup, where the transverse plane was difficult to accurately assess due to time, equipment deficiency, and cost. Another limitation was the use of only four FMS raters.

The majority of FMS research recommended that sports medicine professionals use the 21-point FMS test for screening purposes and creating intervention programs. Instead of the 21-point test, Butler et al. developed the 100-point FMS test, a more precise version of the FMS (2012). Increasing the precision of the FMS test improved the development of targeting intervention techniques and pointed out the weakest muscle group of the weakest movement. Two expert raters (each trained and certified in FMS but given no other details) evaluated 30 middle-aged students (who were all free of musculoskeletal injuries and active in their physical education classes) through videotaped sessions. According to the results, the 100-point test showed an interrater reliability scale of 0.91 and 1.00 and a composite ICC score of 0.99 (Butler et al., 2012). The primary limitation of this study was that only two raters were used.

Research performed by Teyhen et al. (2012) looked to determine the interrater and intrarater reliability of the FMS component and composite scores from 64 young active individuals when scored by eight novice FMS testers in real time. After examining all seven FMS tests on each subject, researchers showed a wide range of weighted kappa (K_w) scores from moderate (40%-59.9%) to excellent (≥ 80%) interrater agreement, while the DS test showed substantial (60%-79.9%) interrater agreement with a K_w score of 0.68. The overall ICC score of 0.76 showed a good (1.00 - 0.75) reliability for the FMS (Teyhen et al., 2012). These results showed a similar level of agreement with the prior publication of Minick et al. (2012). There were various limitations in this study, including no test-retest reliability, FMS testers only assessing the component scores, and only two out of the eight novice raters having FMS certification.

Unlike the previous research, there was a study performed by Shultz, Anderson, Matheson, Marcello, and Besier (2013) looking to assess the test-retest of the FMS and to determine the interrater reliability among six raters (one undergraduate student, one physical therapist, two athletic trainers, and two strength and conditioning coaches, each of whom ranged from 1 month to four years of experience in using the FMS). The authors also compared each rater's score between a live session and a videotaped session. There were 39 subjects (21 women and 18 men, all of whom were NCAA division 1A athletes) and each subject attended two sessions separated by a week, while completing the FMS protocol. The results showed both the reliability of the test-retest and live-versus-video session to range from good to excellent, with a high ICC score of 0.99. The results for the entire FMS examination had a low Krippendorff (K) α score of 0.38, illustration of a poor interrater reliability. The DS test also showed a low K α score of 0.41, reflective of a poor interrater reliability. One major limitation to this study was the range of experience and professions amongst evaluators; and this showed that the level of experience or training was a huge influence on determining the interrater reliability. The other limitation was the use of only six FMS raters.

Screening tools such as the PPE and the musculoskeletal examination used prior to the FMS showed lack of evidence on identifying injuries and improving physical performance. Majority of FMS research had focused on identifying risk for injuries within the athletic community and highly trained individuals, but there were few studies performed on normal active or sedentary populations. In the previous studies mentioned above, authors such as (Minick et al., 2010; Schneiders et al., 2011; Shultz et al., 2013; Teyhan et al., 2012) investigated the interrater reliability between novice and expert raters; and they showed a range of poor to excellent interrater reliability within the DS test. Based upon the results of these studies, there were limitations ranging from lack of the number of FMS raters used in each research and the experience of each rater scoring the FMS.

Based upon previous research there appears to be a greater need for more information pertaining to the reliability of the FMS test. Therefore, the purpose of this study was to evaluate the interrater reliability and the level of agreement between novice and expert FMS raters using only one of the FMS exams, the DS test.

CHAPTER 3

METHODOLOGY

Experimental Approach to the Problem

Twenty FMS specialists were recruited throughout the United States via personal networks, emails, and snowball sampling. Any individual affiliated with the fitness and health field can be certified in FMS: either by attending an FMS-sponsored seminar and passing the FMS Certification Exam or by studying the take-home study course and passing the FMS Certification Exam. The expert group consisted of individuals who were certified and had practiced FMS for 2.5-5 years, and the novice group consisted of individuals who were certified and had practiced for 5 months-2 years. Also, these two groups were separated by the amount of FMS clients they see per year; the novice group used the FMS on fewer than 25 people per year, and the expert group used it on more than 50 per year. Each specialist from both groups evaluated all 60 subjects.

There were five different levels of agreement with level 1 = >90%; level 2 = 80-89.9%; level 3 = 70-79.9%; level 4 = 60-69.9%; and level 5 = 50-59.9% (Appendices J, Table 1). In this study, the level of percentage agreement represents the number of cases where testers were in agreement. Greater than 90% means that the specialists agreed in over 90% of cases, giving the same score to an individual; 80 to 89.9% means that the specialists agreed in 80% to 89.9% of cases, giving the same score to an individual; 70 to 79.9% means that the specialists agreed in 70% to 79.9% of cases, giving the same score to an individual; 60 to 69.9% means that the specialists agreed in 60% to 69.9% of cases, giving the same score to an individual; and 50 to 59.9% means that the specialists agreed in 50% to 59.9% of cases, giving the same score to an individual.

Subjects and Selection Criteria

All subjects signed an informed consent prior to participating in the study. The experimental protocol for the study was approved by the university institutional review board for protection of subjects. Thirty-six females and 24 males, all healthy individuals between the ages of 18-35 years (average Standard Deviation [*SD*] age of 23 ± 4.23 years, average *SD* height of 1.68 ± 0.09 m, average *SD* weight of 68.04 ± 14.67 kg, average *SD* Body Mass Index [BMI] of 24.14 ± 4.28 kg/m^2) were recruited by email flyers (Appendix B) and posted flyers at the California State University of Long Beach (CSULB) campus, and BeLean Fitness gym (Appendices J, Table 2). In order to have the greatest potential range for scoring, all participants were accepted, ranging from limited range of motion to full range of motion in all three joints of the hip, knee, and ankle. Each of the participants was free of orthopedic surgeries (skeletal, muscular, ligament, tendon, labrum, etc.) and injuries involving the upper and lower extremities. Subjects who participated had to follow these directions in order:

1. Complete physical activity readiness questionnaire form (ParQ) (Appendix C).
2. Complete a video release form (Appendix D).
3. Complete an informed consent form (Appendix E).
4. Must answer “yes” to the four prescreened questions (Appendix F).
5. Watch a video on the warm-up stretches and DS movement 24 hours before the test day.
6. Perform the warm-up stretches and practice the DS three times and then perform

the DS twice while being recorded.

Procedures

Subjects were recorded and then evaluated by the FMS evaluators. A total of 60 subjects were each evaluated by the 20 FMS evaluators (12 inexperienced; 8 experienced). All subjects performed the DS while being recorded from two views, anterior (frontal) and lateral (sagittal). On testing day, all 60 subjects performed the warm-up protocol for 12 minutes (Appendix G), and then practiced the DS three times. All subjects were recorded on two iPhone 4S cameras (Apple INC Model A1387) in high definition, and each video was edited on the software iMovie (Apple INC). There were no scores of 0 (showed that the individual experienced pain while performing the movement or could not continue) for the subjects during the DS study. Each subject was scored on a 1-3 scale with 1 representing a person could not perform the complete DS movement; 2 representing a person completed the DS movement with compensations; and 3 representing a person completed the DS movement with no asymmetries or dysfunctional alignments (Appendices J, Table 3). A score of 1 was given when the tibia and upper torso were not parallel, the femur was not below horizontal, the knees were aligned past the feet and toes, and lumbar flexion was observed (Cook et al., 2010). A score of 2 was given if the upper torso was parallel to the tibia or toward vertical, the femur was below horizontal, the knees were aligned over the feet but not past the toes, and the dowel was aligned over the feet while the heels were elevated on a 2X6" piece of wood (Cook et al., 2010). A score of 3 was given if the individual performed the squat with the upper torso parallel to the tibia or toward vertical, femur below horizontal, knees aligned over the feet but not past the toes, and the dowel aligned over the feet (Cook et al., 2010). The subjects were instructed to (a) stand tall with feet within shoulder width apart and toes pointing forward; (b) grab the dowel in both hands and place it horizontally on top of the head so shoulders and elbows are 90 degrees; (c) press the dowel so it is directly above your head while maintaining the upper body in an upright position; (d) keep the heels and dowel in position; and (e) descend as deep as possible and hold the descend position for a count of one, then return to the starting position (Clark, Corn, & Lucett, 2005; Cook, 2004). In addition there should be no knee valgus (knees are pointing inward) and the knee should be aligned directly above the toes (Clark et al., 2005; Cook, 2004).

Each edited video of the 60 subjects performing the DS was emailed out to all 20 FMS raters. Every FMS rater had one week to evaluate each of the subjects and score them. Once the FMS raters had scored each subject on the video, they completed the score sheet and returned it back by email.

Once all of the evaluations were completed, the number of times a 1, 2, or 3 score was reported and tallied for each subject. These values were then divided by the number of evaluators in the respective group ($n = 12$ inexperienced, $n = 8$ experienced) to give the percentage of 1's, 2's, or 3's given to a subject by each group. The percentages were then tallied to determine out of the 60 observations how many times or what level of agreement (% agreement) was achieved.

Statistical Analysis

A Chi square test was performed to determine if there was a significant difference in the percent level of agreement between the experienced and inexperienced groups and within each of the two groups (Appendices J, Table 1). A Chi square test was used to compare the two categorical variables forming an associated contingency table (Field, 2009). The Kappa statistic was performed to establish the interrater reliability measurement between the experienced and inexperienced FMS raters on the DS test. A Kappa statistic was reported as the precision (reliability) pertaining to the interobserver agreement (agreement between observers; Viera & Garrett, 2005). A Kappa value from 0.81-1.00 represents high agreement; 0.61-0.80 represents substantial agreement; 0.41-0.60 represents moderate agreement; 0.21-0.40 represents fair agreement; 0.01-0.20 represents slight agreement; and <0 represents less than chance agreement (Viera & Garrett, 2005; Appendices J, Table 4). The latest version of Statistical Package for the Social Sciences (SPSS 22) was used to perform all these calculations and tables. A p-value ≤ 0.05 was used to determine statistical significance.

CHAPTER 4

RESULTS

The data analyzed in this research was collected on 60 subjects performing the DS test, and 20 FMS specialists evaluated 36 females and 24 males of healthy individuals between the ages of 18-35 years. There were no subjects who received a score of 0; all the scores ranged from 1-3. The interrater reliability was considered less than chance agreement (poor agreement) with a Kappa value = -0.009 (Appendices J, Table 4). The Chi-Square value (Appendices J, Table 5) resulted in a p-value = 0.865. The results fail to reject the null hypothesis that no differences would exist between experienced and inexperienced testers. The data presented no significant difference ($p \leq 0.05$) between the less experienced and more experienced observers on the ability to agree 50% or more of the time.

According to appendices J, table 6 and 7, the raw scores from the novice (n=12) and experienced groups (n=8) on each of the 60 subjects were obtained, and then added up how many times a 1, 2, or 3 were scored by each rater. After the sum of the raw scores for each subject were added up, then the percentage for each FMS assessment level (1, 2, or 3) were calculated for the novice and experienced groups (Appendices J, Table 8 & 9). Taking the summed raw score and dividing by the total number of reported scores determined the percentages for each FMS assessment level.

Looking at appendices J, table 1, it showed the novice and experienced groups total count number of percentages for each FMS assessment level ranging from 50%-100%.

Although the total count number for both groups was 180, there were 113 (novice group = 48 plus experienced group = 65) accounted for, because anything less than 50% agreement was not counted. The novice group had only one occurrence out of 60 cases with a 100% level of agreement and the experience group had only 10 occurrences out of 60 cases (Appendices J, Table 6 & 7). Only 5 occurrences out of 60 cases where there was ≥ 90% agreement in the novice group, and 10 occurrences out of 60 cases where there was ≥ 90% agreement in the experienced group (Appendices J, Table 1). Looking at the percentage of occurrences out of 60 cases for the ≥ 90%, the experience group only had a 0.17% (10/60 cases) compared to the novice group with 0.08% (5/60 cases). The interrater reliability (Kappa value = -0.009) for the DS test was considered to be poor or less than chance agreement (Appendices J, Table 4).

CHAPTER 5

DISCUSSION

This study focused on interrater reliability of the FMS DS test. Based upon the results of this study, it appears that there was a poor level of agreement between the novice and expert groups in observing 60 young, healthy males and females. The novice group had the highest agreement level between 60%-69.99% and the expert group had the highest agreement level between 50%-59.99% out of the 60 cases. The final scores from the FMS testers showed a large discrepancy among agreement levels, allowing the DS test to be labeled as a subjective tool due to the dependency on the tester's experience and educated belief. Although the FMS raters used playback on the video to carefully decide on their scores, this option did not appear to be helpful in the overall evaluation process. Few studies have performed the reliability testing on the DS test, and due to the poor agreement levels and interrater reliability this resulted in a weak validity as well.

In previous research, these results are inconsistent with prior publication on FMS interrater reliability and agreement levels. The DS test showed results ranging from poor to excellent interrater reliability between two to eight FMS specialists ranging in experience. One component of reliability testing is interrater and the other is intrarater, which is how well a tester can repeat their measurements and obtain the same results. Previous researches done by (Kiesel, Plisky, & Butler, 2011; Peate et al., 2007; Smith & Peterson, 2007) exhibited the evidence on creating rehabilitation programs for different types of athletes to improve their functional movement patterns in order to prevent any future injuries. The limitations to these studies were the small number of FMS specialists used. Shultz et al. (2013) study showed a poor interrater reliability between the six raters on both the DS test and the FMS as a whole examination. The problem with the FMS was the subjective scoring system incurred, which allowed the interrater reliability to be low between different experienced raters. There was no criterion to judge between these two groups of raters. In order for this system to be consistent in the exercise science field, the interrater reliability needs to be high or maintain high levels of agreement between all the FMS evaluators. In order to achieve a high validity test, there needs to be a high reliability test on the DS test.

The DS study had several limitations: (1) all FMS testers provided a restricted scoring range of 1-3 and all subjects with a score of 0 were disqualified, (2) FMS testers only scored one out of seven FMS screen tests, the deep squat test, (3) only 12 novice testers with 5 months – 2 years of experience; and only 8 expert testers with 2.5 years – 5 years of experience were included, and (4) only 20 FMS testers ranging from 5 months to 5 years certification participated.

In summary, the overall purpose for this research was to evaluate the level of agreement and reliability between novice and expert FMS raters using only one of the FMS exams, the DS test. Previous screening tools, such as PPE by Onate et al. (2012) and musculoskeletal screening examination by Smith et al. (2007), were used to identify risk factors of injury. Kiesel et al. (2011) was able to establish risk factors of injury and create intervention programs to improve their FMS scores. Authors such as (Kiesel et al., 2007; Minick et al., 2010; Schneiders et al., 2011; Teyhan et al., 2012) investigated the interrater reliability between novice and expert raters; and they showed a range of poor to excellent interrater reliability within the DS test. Based upon the results from these authors above, there was no consistency between the FMS raters on the agreement levels and reliability of the DS test.

In retrospect, future research needs to focus on the interrater reliability among the FMS creators', Cook, Burton, and Hoogenboom's scores compared to 20 randomized FMS raters' scores ranging in experience levels. The experiment would use only one subject for each score of a 1,2, and 3 with the deep squat (total of 3 subjects). The FMS creators' three scores of the three subjects would be compared to the group of novice and expert raters' scores.

Another study design should be sports physicians or specialists measuring an objective joint motion angle of the hip, knee, and ankle during the deep squat; with this data, a standard chart is created showing the exact range of motions of the joints during the deep squat. For example, a score of 3 would equal the shoulder range of motion (ROM) between 180-160 degrees flexion, the hip ROM between 160-140 degrees flexion, the knee ROM between 130-110 degrees flexion, and the ankle ROM between 20-15 degrees dorsiflexion. Using this chart, there would be an exact range of motion for the shoulder, hip, knee, and ankle for each subject scoring a 3, 2, or 1. Knowing these facts, FMS evaluators would have a better understanding with an objective score to compare with the measurements of the four joints. The use of these two options is recommended to further validate the FMS as an accurate screening tool that can be used in the future for recreational, occupational, and professional individuals.

APPENDICES

APPENDIX A

OFFICE OF UNIVERSITY RESEARCH

California State University, Long Beach

Institutional Review Board for the Protection of Human Subjects

Know all people by these presents that

Michael Yi

has completed the

Protection of Human Subjects

of Research

Orientation Program

and upon satisfactory evaluation of diagnostic work submitted will be certified for eligibility for external funding of research involving human subjects. In witness whereof this certificate is authorized and issued.

__Albert Russo______

Director for Research Compliance,Office of University Research
California State University, Long Beach

APPENDIX B

FLYERS FOR SUBJECTS AND FMS RATERS

Deep Squat Test from the Functional Movement System Study

SUBJECTS:
Come join and be a part of a unique exercise study. For all subjects who are willing to participate, they have to answer these questions listed below.

- *Are you between the ages of 18-35 years?*
- *Do you not have any history of orthopedic (muscles, tendons, ligaments, bones, joints) surgeries in the past year?*
- *Are you currently able to exercise with no recent extremity injuries?*
- *Are you not playing any professional sports?*

If you answer, "yes" to all the questions above, then you are eligible to participate in this study. If you answer, "no" to any one of the questions, then automatically you are disqualified to participate in this study.

The purpose of this study is to investigate the relationship between novice and expert Functional Movement Screen (FMS) specialists' subjective scores from the deep squat test. During the deep squat motion, a person holds a stick with both hands above their head while performing a squat, and the FMS expert will give a score between 0-3 on the performance. The FMS examination introduces a person's weaknesses and imbalances while placed in extreme positions, where the person's functional limitations and asymmetries are exposed. The FMS scoring system provides individuals to improve their body mechanics and to use efficient movement patterns during their activities; therefore, preventing any inefficient movement patterns to lead to injuries or loss of balance. This study will focus on individuals of all different sizes, who are non-professional athletes or highly trained individuals.

The benefits involve information of proper body mechanics when performing squats, improved functional movement, and a description of what muscle groups are weak and tight, and improving core stability/strength. Your body will not be jeopardized or put in harms way during this study; and no medication will be given or taken during this study.

There is no monetary compensation or any other gifts provided for participating in this study. All subjects are responsible for any medical bills and expenses, if there is any injury that occurs before, during, or after this study.

Please Call/text **Michael Yi** at 310-882-9594 or email me at SavvyNerd@aol.com.

Deep Squat Test from the Functional Movement System Study

SPECIALISTS:
Come join and be a part of a unique exercise study. For all the testers willing to participate, they must answer to the following questions listed below.

- Are you currently working in the fitness/health industry?
- Are you currently certified in FMS?

If you answer, "yes" to all the questions above, then you are eligible to participate in this study. If you answer, "no" to any one of the questions, then automatically you are disqualified to participate in this study.

If the tester agrees to participate, he/she will receive an email which will include further details on what they will have to grade. Each tester will receive
a specific time, day, and location on where he/she will be watching the randomized edit video of the subjects. At the specific date chosen by the FMS specialists, they will review one of the three videos and provide their scores on a FMS Score Sheet, without knowing any of the subject's range of motion measurements during the deep squat test. Each certified FMS trainer must turn in a FMS score sheet with their scores in order to complete their task for participating.

The purpose of this study is to investigate the relationship between the novice and expert Functional Movement Screen (FMS) specialists' subjective scores from the deep squat test. During the deep squat motion, a person holds a stick with both hands above their head while performing a squat, and the FMS expert will give a score between 0-3 on the performance. The FMS examination introduces a person's weaknesses and imbalances while placed in extreme positions, where the person's functional limitations and asymmetries are exposed. The FMS scoring system provides individuals to improve their body mechanics and to use efficient movement patterns during their activities; therefore, preventing any inefficient movement patterns to lead to injuries or loss of balance. This study will focus on individuals of all different sizes, who are non-professional athletes or highly trained individuals.

The benefits in this study include: practice observing movement and scoring clients with the FMS examinations, may increase their skills on comparing FMS performance and scores, and improve on finding the body's weaknesses and strengths of each individual. Each specialist may provide a better understanding of their subjective scores matching the quantitative range of motions of the squat movement.

There is no monetary compensation or any other gifts provided for participating in this study. All subjects are responsible for any medical bills and expenses, if there is any injury that occurs before, during, or after this study.

Please Call/text **Michael Yi** at 310-882-9594 or email me at SavvyNerd@aol.com.

APPENDIX C

INFORMED CONSENT FOR SUBJECTS AND FMS RATERS

Consent to Participate in Research

SUBJECTS:

The relationship between subjective and quantitative scores from certified Functional Movement Screen (FMS) trainers.

You are asked to participate in a research study conducted by Michael Yi for a graduate thesis in the Kinesiology department at California State University, Long Beach. You were selected as a possible participant in this study, because you are between the ages of 18-35 years, have no current injuries, no orthopedic surgeries in the past year, and do not play in any professional sports.

Purpose of the Study:

The purpose of this study is to see the relationship between Functional Movement System (FMS) specialists' subjective scores and the actual joint measurements of the shoulder, hip, knee, and ankle from the deep squat test. This study will focus on using FMS non-professional individuals to improve functional movement and prevent further injuries.

Procedures:

If you volunteer to participate, you are asked to read and sign this Informed Consent and a Video Consent and complete a physical activity readiness questionnaire (Par Q). The researcher will schedule an appointment 24 hours before the test date at a particular location. The researcher will provide instructions to you involving: a 5-minute warm-up stretch, demonstration of the deep squat movement, an explanation of where the markers will be put on the body, and how they will be recorded on a video camera.

The 5-minute warm-up protocol will include:
1. Hamstring stretch
2. Quadricep stretch
3. Calf stretch
4. Low Back stretch, Single knee to chest while laying on the ground
5. Three trials of the deep squat

These stretches will be performed 3 times for 30 seconds on the left and right leg.
At the day of the testing, you will be given 5-minutes to perform the warm-up protocol, and when you have completed that, the researcher will put markers on your shoulder, hip, knee, and ankle joints. The researcher will provide an explanation for the markers and how these markers are relevant to the video recording. There will be a FMS specialist assisting the researcher and scoring you. You will follow the directions given by the researcher and perform three consecutive deep squats while being recorded on camera. After you perform three deep squats, you will have the option to obtain your FMS and range of motion scores, or you can choose to leave. This whole process will take about 15-20 minutes to perform in this study.

After the recording, playback of the video will be provided to you. Your face will be blurred out, in order to keep your identity confidential. If you chose to see the video, it will be available for you at the end of the recording. The researcher will have a computer connected to the camera and playback will be available for you to review. The researcher will also explain the editing process of blurring out your face and recording the best trial of the three.

Potential Risks and Discomforts:

There are no potential risks or any extreme changes to your heart rate, lung performance, blood pressure, dizziness, fainting, stroke, or brain function during this study. Video analysis may be accompanied by feeling of discomfort by you. It would be prevented by the fact that you will know when you are being videotaped, and you can opt out of participating at any time. There can be potential body injury involving, but not limited to, the muscles, bones, ligaments, tendons, or joints. A small potential fall can occur during the test with injury to any structure of the body. The risk for any psychological well-being/comfort for you will be minimizing to none, after the test. In order for this to happen, you will be the only one to see/review your scores. All scores will be kept confidential between the researcher and you; and you will not have access to any other subject's scores and data. There is the potential of the researcher losing your scores, forms, and confidentiality.

There will be personal trainers and/or physical therapists, certified in FMS and CPR; and they will have the medical background of taking all precautions into effect. The researcher and FMS specialists will take appropriate measures and proper supervision of you performing in order to prevent any injuries to occur. You are responsible to understand all the instructions, rules, and test protocols without having any past upper/lower extremity injuries within one year. There will also be safety pads placed behind and in front of you during the test. Should an injury occur during the test, the standard protocol will be followed. Campus police will be contacted and you may be transported to Student Health Center depending on the nature of the injury. You will be responsible for any costs associated with medical treatment.

Potential Benefits to Subjects and/or to Society:

The possible benefits are involving FMS specialists and researcher providing important information of proper body mechanics and functional movement for you. You can choose to obtain your scores or not, and a description of what muscle groups could improve in strength and flexibility. You have the option to receive information on how to perform proper squats, increasing core stability/strength, and preventing future injuries from occurring. Your results may benefit a better understanding of your body and how it should move without jeopardizing other body parts.

Payment for Participation:

If you choose to participate in this study, you will not receive any payment or gifts.

Confidentiality:

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law.
You will be videotaped with a video camera, and the recorded material will only be used specifically for this study. You will be able to review their own trials of the video recordings and the edited recordings, at any time. The researcher and advisor will only be the ones with access to the data, videos, and consent forms. All data, videos, and consent forms will be kept for 3 years, from the date the study is completed. After 3 years from the date of completion, all data, videos and consent forms will be deleted and terminated.

Participation and Withdrawal:

You may choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which in the opinion of the researcher warrant doing so.

Identification of Investigators:

If you have any questions or concerns about the research, please feel free to contact the principal investigator, Michael Yi, at 310-882-9594 or the advisor, Professor Ralph Rozenek, at 562-985-4083.

Rights of Research Subjects:

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact the Office of University Research, CSU Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840; Telephone: (562) 985-5314 or email to research@csulb.edu.

SIGNATURE OF RESEARCH SUBJECT:

I understand the procedures and conditions of my participation described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.
Name of Subject:____
Signature of Subject:____
Date:_______________

Statement and Signature of Investigator

In my judgment the subject is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.
Signature of Investigator:____
Date:____

Consent to Participate in Research

SPECIALISTS:

The relationship between subjective and quantitative scores from certified Functional Movement Screen (FMS) trainers.

You are asked to participate in a research study conducted by Michael Yi for a graduate thesis in the Kinesiology department at California State University, Long Beach. You were selected as a possible tester in this study, because you are licensed and experienced as a Functional Movement System specialist.

Purpose of the Study:

The purpose of this study is to see the relationship between Functional Movement System (FMS) specialists' subjective scores and the actual joint measurements of the shoulder, hip, knee, and ankle from the deep squat test. This study will focus on using FMS non-professional individuals to improve functional movement and prevent further injuries.

Procedures:

If you volunteer to participate, you are asked to read and sign this Informed Consent Form. At an agreed upon date, you will be asked to review one of three videos and provide your evaluations of the movement. At the end of the video, you will turn in a FMS score sheet and leave the facility. The researcher will edit three different randomized videos of all the individuals participating in order for the FMS experts not to share scores among each other. All subjects' faces will be blurred out, so their identity is kept confidential. In addition, your identity will be kept confidential. The researcher will follow up with a video analysis and actual quantitative measurements of the body segment displacement, which will be compared to the scores of the FMS experts. The whole process of participating will take thirty minutes.

Potential Risks and Discomforts:

The potential risks for you are:

- Fear of loss of confidentiality
- May lose confidence on grading future FMS clients

Potential Benefits to Testers and/or to Society:

The possible benefits for you are:

- Practice observing movement and scoring clients with the FMS examinations
- Increase skills on comparing FMS performance and scores
- Improve on the ability to find the body's weaknesses and strengths
- Better understanding of the subjective scroes with the quantitative range of motions of the squat movement

Payment for Participation:

If you participate in this study, you will not receive any payment or gifts.

Confidentiality:

Any information that is obtained in connection with this study and that can be identified with you will remain confidential, and will be disclosed only with your permission or as required by law. The researcher and advisor will only be the ones with access to the data, videos, and consent forms, which will all be in a locked file cabinet inside the research advisor's office for 3 years. No personal scores from you will be released in this study; all information will be provided as a whole not as individualists, in order to protect your identity. All data, videos, and consent forms will be kept for 3 years, from the date the study is completed. After 3 years from the date of completion, all data, videos and consent forms will be deleted and terminated.

Participation and Withdrawal:

You may choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which in the opinion of the researcher warrant doing so.

Identification of Investigators:

If you have any questions or concerns about the research, please feel free to contact the principal investigator, Michael Yi, at 310-882-9594, or the advisor, Professor Ralph Rozenek, at 562-985-4083.

Rights of Research Testers:

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact the Office of University Research, CSU Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840; Telephone: (562) 985-5314 or email to research@csulb.edu.

SIGNATURE OF TESTER:

I understand the procedures and conditions of my participation described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.
Name of Specialist:____
Signature of Specialist:____

Date:______________

Statement and Signature of Investigator

In my judgment the subject is voluntarily and knowingly giving informed consent and possesses the legal capacity to give informed consent to participate in this research study.
Signature of Investigator:____
Date:____

APPENDIX D

NASM PAR-Q

NASM PAR-Q

Data Collection Sheet

NAME:____ DATE:_________________
HEIGHT:_________in. WEIGHT:___________lbs. AGE:__________
PHYSICIANS NAME:_____________________________ PHONE:_____________

PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Questions Yes No
1 Has your doctor ever said that you have a heart condition and that you should only perform physical activity recommended by a doctor?
2 Do you feel pain in your chest when you perform physical activity?
3 In the past month, have you had chest pain when you were not performing any physical activity?
4 Do you lose your balance because of dizziness or do you ever lose consciousness?
5 Do you have a bone or joint problem that could be made worse by a change in your physical activity?
6 Is your doctor currently prescribing any medication for your blood pressure or for a heart condition?
7 Do you know of any other reason why you should not engage in physical activity?

If you have answered "Yes" to one or more of the above questions, consult your physician before
engaging in physical activity. Tell your physician which questions you answered "Yes" to. After a
medical evaluation, seek advice from your physician on what type of activity is suitable for your
current condition.

GENERAL & MEDICAL QUESTIONNAIRE

Occupational Questions Yes No

1 What is your current occupation?

____

2 Does your occupation require extended periods of sitting?

3 Does your occupation require extended periods of repetitive movements? (If yes, please explain.)

____

4 Does your occupation require you to wear shoes with a heel (dress shoes)?

5 Does your occupation cause you anxiety (mental stress)?

Recreational Questions Yes No

6 Do you partake in any recreational activities (golf, tennis, skiing, etc.)? (If yes, please explain.)

____

____

7 Do you have any hobbies (reading, gardening, working on cars, exploring the Internet, etc.)? (If yes, please explain.)

____

____

Medical Questions Yes No

8 Have you ever had any pain or injuries (ankle, knee, hip, back, shoulder, etc.)? (If yes, please explain.)

____

____

9 Have you ever had any surgeries? (If yes, please explain.)

____

____

10 Has a medical doctor ever diagnosed you with a chronic disease, such as coronary heart disease, coronary artery disease, hypertension (high blood pressure), high cholesterol or diabetes? (If yes, please explain.)

____

____

11 Are you currently taking any medication? (If yes, please list.)

____

____

____

APPENDIX E

VIDEO RECORDING RELEASE FORM

VIDEO RECORDING RELEASE FORM

The relationship of the deep squat test, Functional Movement System, subjective scores from FMS professional testers and the young adolescent's joint angle measurements of the shoulder, hip, knee, and ankle.

Principal Investigator: Michael Yi

Video recordings will be taken with three trials of the deep squat motion as part of your participation in this research study. Your consent for this study is not optional; and if you choose to refuse to be recorded then you are no longer able to participate in this study.

Please indicate if you are willing to be recorded on video by signing your name at the bottom of this form.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential, and will be disclosed only with your permission or as required by law.
You will be videotaped with a video camera, and the recorded material will only be used specifically for this study. You will be able to review your own trials of the video recordings and the edited recordings, at any time. The researcher and advisor will only be the ones with access to the data, videos, and consent forms. All data, videos, and consent forms will be kept for 3 years from the date the study is completed. After 3 years from the date of completion, all data, videos and consent forms will be deleted and terminated.

I have read the above description and give my consent for the use of the video as indicated by my signature below.

Name ____
(Print)

Name _____________________________________ _________________________
(Signature) (Date)

APPENDIX F

PRE-SCREEN QUESTIONNAIRE

PRE-SCREEN QUESTIONNAIRE

1. Are you between the ages of 18-35 years?

2. Do you not have any history of orthopedic (muscle, skeletal, ligament, tendon) surgeries in the past year?

3. Are you currently able to exercise without any extremity injuries?

4. Are you not playing any professional or collegiate sports?

APPENDIX G

WARM-UP PROTOCOL

WARM-UP PROTOCOL

1. Hamstring stretch

2. Quadricep stretch

3. Calf stretch

4. Low Back stretch, single knee to chest while lying on the ground

5. Three trials of the deep squat

These stretches will be performed three times for 30 seconds on the left and right leg.

APPENDIX H

FMS TESTER BLANK SCORE SHEET

FMS SCORESHEET			
NAME	MONTHS/YEARS CERTIFIED	DATE	
TEST	SUBJECTS #	RAW SCORE	COMMENTS
DEEP SQUAT	1		
	2		
	3		
	4		
	5		
	6		
	7		
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	10		
	11		
	12		
	13		
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APPENDIX I

PPE BLANK FORMS

APPENDIX A
PRE-PARTICIPATION PHYSIOTHERAPY ASSESSMENT

Athlete to please fill out the following: **Date:**______________

Name:________________________________ **Address:**____

Phone No:___________**Age:** ________ **Physician:**_____________________**Physician Phone No:**________

Sport:________________________________ **Level of Completion:** ______________________________

Distance:________________________ **Number of Years Completing:**____________________________

Coach(s) Name : ______________________________**Coach(s) Phone No:** ________________________

Past Medical History: (list injury, date and percentage of recovery)

Fractures:____

Surgery(s):____

Sprains/Strains:____

Car Accidents:____

Illness / Hospitalization:____

Other:____

Past Treatment: **(list injury, date treated, name of practitioner & also indicate if treatment ongoing)**

Physiotherapy:____

Chiropractor:____

Acupuncture:____

Athletic Therapy:____

Massage:____

Other (medical tests such as blood work, x-rays, ect): ________________________________

Present Injury(s) & Present Treatment:

_____________________________________ _____________________________________

_____________________________________ _____________________________________

_____________________________________ _____________________________________

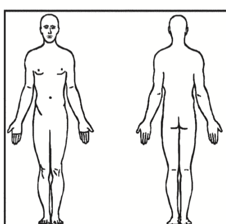
Medications / Supplements:

_____________________________________ _____________________________________

_____________________________________ _____________________________________

Braces / Orthotics / Splints Usage:

_____________________________________ _____________________________________



Map of Symptoms (grade pain 0-10/10)

///=pain
xxx=paraethesia

PT Initial:___ Page 1/4

Physical Examination

Name:___________________________

Posture:

Functional Tests:

Sit-stand-sit:	Stairs: Step Up: Step Down:
Sit-lie-sit:	Heel raise: double: single:
¼ squat: double: single:	Vert. jumping: double: single:
full squat: double: single:	Tuck jumping: single:
Walk: Run:	Lift Floor to Waist: Lift Waist to Overhead:
Balance Test:	Lunge: right fwd left fwd
Other Sport Specific Test:	

Palpation Findings:

Tender O
Painful ●
Stiff X
Spasm ∿∿
Tightness III

_1_
_2_
_3_
_4_
_5_
_6_
_7_
__o __1__ o___
__o __2__ o___
__o __3__ o___
__o __4__ o___
__o __5__ o___
__o __6__ o___
__o __7__ o___
__o __8__ o___
__o __9__ o___
__o __10__o___
_11_
_12_
__1__
__2__
__3__
__4__
__5__

Range of Motion

TMJ

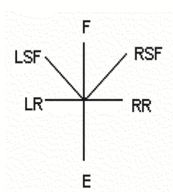
PPM:

PAM:
Compression:
Stress Tests:
Inferior:
Posterior:
Anterior:

Ribs

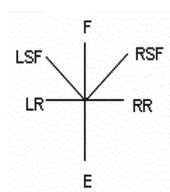
AROM:
PAM:
CTJ Stress Tests:
Anterior:
Inferior:
Other:

Csp



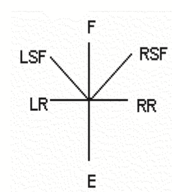
PPIVM:
PAIVM:
Stress Tests:
Passive / Dynamic
Ant:
Post:
Lat:
Rot:
Comp:
Traction:
Alar:
VA tests:
MRecruit: (rep's/qual/dur/measurement)
DNF Supine:
Other:

Tsp



PPIVM:
PAIVM:
Stress Tests:
Passive / Dynamic
Ant:
Post:
Lat:
Rot:
Comp:
Traction:
MRecruit:
Scapular Control:
Other:

Lsp



PPIVM:
PAIVM:
Stress Tests:
Passive / Dynamic
Ant:
Post:
Lat:
Rot:
Comp:
Distract:
Traction:
MRecruit:
Crookly hip flex:
Prone hip exten:
Sidely hip exten:
Other:

SIJ

Gillet's:
Stance leg:
Nonstance leg:
Hip Ext: Standing: Prone:
Fwd / Bwd Bend:
ASLR:
Form closure:
Force Closure –TA
– Mult
– Lat
– Glut

PPM/PAM:
Stress Tests:
Passive / Dynamic
Pub Symp:
Posterior Gap SIJ:
Anterior Gap SIJ:
Ant Shear:
Post Shear:
Vertical Shear: Sup:
Inf:

Neuro Meningeal:

ULTT 1:
2:
3:

Slump:___ ° R CV flex: DF: Other:
Slump:___ ° L CV flex: DF: Other:
SLR:___ ° R CV flex: DF: Other:
SLR:___ ° L CV flex: DF: Other:
Mod PKB:___ ° R CV flex: DF: Other:
Mod PKB:___ ° R CV flex: DF: Other:
Other:

Neuro Conductivity: upper / lower quadrant

Dermatomes: Light Touch
Sharp / Dull
Temperature:

Myotomes: Repeated Tests:
LMN Reflexes:

Clonus: Babinski: Cranial Nerves:

Pulses:

PT Initial:____ Page 2/4

Peripheral Joints

Name:________________________

Shoulder:

AROM:	PROM:	Resisted:
F:		
E:		
Ab:		
Ad:		
IR: 0^{0}: 90^{0}:		
ER: 0^{0}: 90^{0}:		
Combined: Quadrants: HBB: HBH: Horz Add:		

Observation and Palpation:

Stress Tests:

PAM:

Special Tests:

Muscle Recruitment:
(rep's/quality/duration/measurement)

Elbow:

AROM:	PROM:	Resisted:
F:		
E:		
Pron:		
Sup:		
Combined: Quadrants:		

Observation and Palpation:

Stress Tests:

PAM:

Special Tests:

Muscle Recruitment:
(rep's/quality/duration/measurement)

Wrist/Fingers:

AROM:	PROM:	Resisted:
Wrist F:		
Wrist E:		
Wrist Rad Dev:		
Wrist Ulnar Dev:		
Wrist Combined:		
Finger F:		
Finger E:		
Finger Rad Dev:		
Finger Ulnar Dev:		

Observation and Palpation:

Stress Tests:

PAM:

Special Tests:

Muscle Recruitment:
(rep's/quality/duration/measurement)

Hip:

AROM:	PROM:	Resisted:
F:		
E:		
Ab:		
Ad:		
IR: 0^{0}: 90^{0}:		
ER: 0^{0}: 90^{0}:		
Quadrants: FADIR's Patrick's Other:	Right:	Left:

Observation and Palpation:

Stress Tests:

PAM:

Special Tests:

Muscle Recruitment:
(rep's/quality/duration/measurement)

Thomas Test:

Ham's Tripod:

Knee:

AROM:	PROM:	Resisted:
F:		
E:		
IR:		
ER:		
Combined:		

Observation and Palpation:

Stress Tests:

PAM:

Special Tests:

Muscle Recruitment:
(rep's/quality/duration/measurement)

Ankle & Foot:

AROM:	PROM:	Resisted:
DF:		
PF:		
Pro:		
Sup:		
Combined:		
Toe F:		
Toe E:		
Toe Abd*:		
Toe Add*:		

*reference the second digit

Observation and Palpation:

Stress Tests:

PAM:

Special Tests:

Muscle Recruitment:
(rep's/quality/duration/measurement)

PT Initial:___

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Name:________________________
Date:_________________________

Digital and Video Analysis / Comments:

Clinical Impression / Key Points Identified:

Suggestions for Coach / Strength Trainer:

Contraindications to treatment:

Rationale for possible pathology given to patient
Rationale for treatment given to patient
Patient gave consent for assessment, future assessment and treatment

Treatment Given:

Treatment Plan:

Consent for sharing information with coaches, trainers, team medical personnel on file: Yes__ No__

Therapist__________________________________

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Primary Objectives

- Screen for conditions that may be life-threatening or disabling.
- Screen for conditions that may predispose to injury or illness.

Secondary Objectives

- Determine general health.
- Serve as an entry point to the health care system for adolescents.
- Provide an opportunity to initiate discussion on health-related topics.

Stations for the PPE

- Check-in
- History
- Vital Signs
- Medical examination
- Musculoskeletal examination
    - Function specific – flexibility, posture, gait, strength
    - Regional – spine, upper extremity, lower extremity
- Performance testing
    - Speed, agility, power, endurance, balance
- Body composition
- Maturity assessment
- Sport-specific considerations
- Review, assessment, check-out

Performance Assessment Tests	
Endurance	12 minute run 1.5 mile run Bench step test Submaximal bicycle ergometry test
Speed	40 yard dash 100 yard dash
Sustained speed	440 yard run
Power	Vertical jump Stair climb test
Agility	Shuttle run Cariocas Sidestep test Figure of eights
Balance	One leg standing test (stork test)
Dynamic Balance	Commercial testing devices Beam walking test
Strength	Bench press/leg press Sit-ups Push-ups Pull-ups
Body Composition	BMI calculation Skin folds Hydrostatic weighing Circumferential measures Skin impedance

APPENDIX J

TABLES

Table 1 - Agreement Level Cross Tabulation

Agreement Level Cross Tabulation		**Agreement Level**					
Level		**5**	**4**	**3**	**2**	**1**	
Group		**50-59%**	**60-69%**	**70-79%**	**80-89%**	**≥90%**	**Total**
0-2.5 yrs	**Count**	**12**	**13**	**10**	**8**	**5**	**48**
	Expected Count	**12.7**	**11.9**	**8.5**	**8.5**	**6.4**	**48**
	% within Group	**25.00%**	**27.10%**	**20.80%**	**16.70%**	**10.40%**	**100.00%**
	% within Agreement_Level	**40.00%**	**46.40%**	**50.00%**	**40.00%**	**33.30%**	**42.50%**
	% of Total	**10.60%**	**11.50%**	**8.80%**	**7.10%**	**4.40%**	**42.50%**
≥2.5 yrs	**Count**	**18**	**15**	**10**	**12**	**10**	**65**
	Expected Count	**17.3**	**16.1**	**11.5**	**11.5**	**8.6**	**65**
	% within Group	**27.70%**	**23.10%**	**15.40%**	**18.50%**	**15.40%**	**100.00%**
	% within Agreement_Level	**60.00%**	**53.60%**	**50.00%**	**60.00%**	**66.70%**	**57.50$**
	% of Total	**15.90%**	**13.30%**	**8.80%**	**10.60%**	**8.80%**	**57.50%**
Total	**Count**	**30**	**28**	**20**	**20**	**15**	**113**
	Expected Count	**30**	**28**	**20**	**20**	**15**	**113**

	% within Group	**26.50%**	**24.80%**	**17.70%**	**17.70%**	**13.30%**	**100.00%**
	% within Agreement_Level	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**
	% of Total	**26.50%**	**24.80%**	**17.70%**	**17.70%**	**13.30%**	**100.00%**

Table 2 – Standard Deviation Subject's Age/Height/Weight/BMI (average)

Subjects (36 females, 24 males) who participated				
Average Standard Deviation (SD)	Average SD Age (years)	Average SD Height (meters [m])	Average SD Weight (kilograms [kg])	Average SD BMI (kilograms per meters squared [kg/m^2])
Total Subjects (60)	23 ± 4.23 years	1.68 ± 0.09 m	68.04 ± 14.67 kg	24.14 ± 4.28 kg/m^2

TABLE 3 – FMS Rater's Criteria on Scoring DS Test

RATING	CRITERIA
0	- During the testing he/she has pain anywhere in the body, & If pain occurs, a score of zero is given and the painful area is noted
1	- Tibia and upper torso are not parallel - Femur is not below horizontal - Knees are not aligned over feet - Lumbar flexion is noted
2	- Upper torso is parallel with tibia or toward vertical - Femur is below horizontal - Knees are aligned over feet - Dowel is aligned over feet - Heels are elevated
3	- Upper torso is parallel with tibia or toward vertical - Femur below horizontal - Knees are aligned over feet - Dowel aligned over feet

(Cook, 2004; Clark et al., 2007)

TABLE 4 – Interpretation of Kappa Statistic Scores

Interpretation of Kappa	
KAPPA	AGREEMENT
< 0	Less than chance agreement
0.01–0.20	Slight agreement
0.21– 0.40	Fair agreement
0.41–0.60	Moderate agreement
0.61–0.80	Substantial agreement
0.81–0.99	Almost perfect agreement

(Vierra & Garrett, 2005)

TABLE 5 – Chi-Square Analysis and The Kappa Statistic Measures

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.281[a]	4	.865
Likelihood Ratio	1.288	4	.863
Linear-by-Linear Association	.154	1	.695
N of Valid Cases	113		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.37.

The Kappa Statistic

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Measure of Agreement	Kappa	-.009	.030	-.301	.764
N of Valid Cases		113			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

TABLE 6 – Raw Scores of Inexperience Raters

Subject #	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
1	1	2	2	2	1	2	1	1	1	1	2	2
2	1	1	1	1	1	2	1	2	2	2	2	1
3	2	2	2	3	2	2	3	2	3	2	3	2
4	1	1	2	1	1	2	1	1	1	1	1	1
5	1	2	1	2	1	2	1	1	1	1	1	2
6	1	1	1	1	1	3	1	2	1	2	2	2
7	1	1	1	1	1	2	1	1	1	1	2	1
8	1	2	2	1	1	2	2	2	2	2	2	1
9	1	2	2	2	1	1	1	1	2	1	1	1
10	1	2	2	2	1	2	1	1	2	1	1	1
11	1	1	1	2	1	2	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	3	2	1	3	1	2	2
14	1	1	1	1	1	3	2	1	2	1	1	1
15	1	2	2	2	1	2	2	1	2	1	1	1
16	2	2	2	2	1	3	2	2	3	2	2	2
17	1	2	2	2	1	1	1	1	1	1	1	1
18	2	2	2	2	1	2	1	2	1	1	2	2
19	1	3	3	3	1	2	3	2	3	3	2	2
20	1	1	1	1	1	1	1	1	2	1	1	2
21	1	1	2	2	1	2	2	1	2	1	2	1
22	1	1	1	1	1	2	2	1	2	1	3	2
23	2	2	2	3	1	3	3	1	2	1	3	2
24	1	1	2	1	1	3	1	1	2	2	3	2
25	1	1	2	1	1	2	2	2	3	1	3	3
26	2	3	3	2	1	3	2	2	3	2	3	2
27	1	2	2	1	1	2	1	2	2	1	2	2
28	1	1	2	1	1	3	3	2	2	2	2	2
29	1	1	1	1	2	2	2	2	3	2	2	2
30	1	1	2	1	1	2	2	2	2	2	2	2
31	1	2	2	1	1	2	2	1	1	1	1	1
32	1	2	2	2	1	2	3	1	2	2	2	2
33	2	2	2	2	1	2	2	2	2	2	2	2

34	3	2	3	2	1	3	2	3	3	3	3	3
35	1	2	2	2	1	1	1	1	1	1	1	1
36	2	2	2	3	1	3	2	2	3	2	2	2
37	2	2	2	2	1	2	1	1	1	1	2	2
38	2	2	2	2	1	2	1	2	2	1	1	2
39	1	2	2	1	1	1	1	1	1	1	1	1
40	2	2	2	2	1	2	1	1	1	1	2	1
41	2	2	1	1	1	2	1	2	2	1	2	2
42	1	1	1	1	1	2	1	1	1	1	2	1
43	1	1	2	2	1	2	2	1	1	1	2	1
44	1	2	2	2	1	2	2	2	2	1	2	2
45	3	3	3	3	1	3	2	3	3	3	3	3
46	2	1	1	1	1	1	1	1	1	1	2	2
47	2	1	1	1	1	1	1	1	1	1	1	1
48	1	1	1	1	1	2	1	1	1	1	1	1
49	1	1	1	1	1	1	2	1	1	1	1	1
50	1	1	1	1	1	2	2	1	1	1	1	2
51	1	2	2	2	1	2	2	2	2	2	1	2
52	2	2	2	2	1	2	2	1	1	1	1	1
53	2	2	2	2	1	3	2	1	3	2	2	3
54	2	2	2	3	1	2	3	2	2	2	2	2
55	2	2	2	2	1	2	1	1	2	2	2	1
56	2	1	1	2	1	2	1	1	2	1	2	2
57	1	1	1	1	1	2	2	1	1	1	2	2
58	1	1	1	1	1	2	1	1	1	1	2	1
59	1	1	1	1	1	2	1	1	1	1	2	2
60	2	2	2	2	1	2	2	1	1	2	1	1

[redacted]

Reported Raw Scores by 0-2.5 yr Inexperience Group (n=12)

TABLE 7 – Raw Scores of Experience Raters

SUBJECT #	T1	T2	T3	T4	T5	T6	T7	T8
1	1	1	2	2	2	1	1	1
2	2	2	2	2	2	1	2	1
3	2	2	2	3	3	1	2	1
4	1	1	1	2	1	1	1	1
5	2	1	1	2	2	1	1	1
6	2	2	2	3	2	1	3	1
7	1	1	1	1	2	1	1	1
8	2	1	1	2	2	1	2	1
9	1	1	1	1	1	1	1	2
10	1	1	2	1	2	1	1	1
11	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1
13	1	1	3	1	2	1	1	1
14	1	1	1	1	2	1	1	1
15	2	1	1	1	2	1	1	1
16	2	2	2	2	3	1	2	1
17	1	1	1	1	1	1	1	1
18	2	1	2	2	1	1	2	2
19	3	3	2	3	3	1	3	1
20	2	2	1	2	2	1	1	1
21	2	2	1	2	2	1	1	1
22	2	2	2	2	2	1	2	1
23	2	1	2	2	2	1	1	1
24	2	1	2	2	3	1	1	1
25	2	2	2	3	3	1	2	1
26	3	2	3	3	3	1	3	3
27	2	2	2	2	2	1	1	1
28	2	2	2	2	3	1	2	1
29	2	2	2	3	3	1	2	1
30	2	3	2	2	3	1	2	1
31	1	1	1	1	1	1	1	1
32	2	1	2	2	2	1	1	1
33	2	1	2	2	2	1	2	2

34	3	3	2	3	3	1	1	1
35	1	1	1	1	1	1	1	2
36	2	2	2	2	2	1	2	3
37	1	1	1	1	1	1	1	2
38	2	1	1	2	2	1	1	1
39	1	1	1	1	1	1	1	1
40	1	1	2	1	1	1	1	1
41	2	1	2	1	2	1	1	1
42	1	1	1	1	2	1	1	1
43	1	1	1	1	1	1	1	1
44	2	2	2	2	2	1	1	2
45	3	3	3	3	3	1	3	3
46	1	1	2	1	2	1	1	1
47	2	1	1	1	1	1	1	1
48	1	1	1	1	1	1	1	1
49	1	1	1	1	1	1	1	1
50	1	1	1	1	1	1	1	1
51	2	2	1	2	2	1	2	1
52	1	1	1	1	1	1	1	1
53	2	2	2	2	3	1	3	1
54	2	2	2	2	2	1	1	1
55	2	1	2	2	2	1	2	1
56	1	1	2	2	2	1	1	1
57	1	1	2	1	1	1	1	1
58	1	1	2	1	2	1	1	1
59	1	1	2	1	1	1	1	1
60	2	1	2	1	2	1	1	1

Reported Raw Scores by >2.5 yr Experience Group (n=8)

TABLE 8 – Percentage of Each FMS Assessment Level 1-3 for Inexperience Raters

	Sum			Percentage		
Subject #	1's	2's	3's	1's	2's	3's
1	6	6	0	50.0	50.0	0.0
2	7	5	0	58.3	41.7	0.0
3	0	8	4	0.0	66.7	33.3
4	10	2	0	83.3	16.7	0.0
5	8	4	0	66.7	33.3	0.0
6	7	4	1	58.3	33.3	8.3
7	10	2	0	83.3	16.7	0.0
8	4	8	0	33.3	66.7	0.0
9	8	4	0	66.7	33.3	0.0
10	7	5	0	58.3	41.7	0.0
11	10	2	0	83.3	16.7	0.0
12	12	0	0	100.0	0.0	0.0
13	7	3	2	58.3	25.0	16.7
14	9	2	1	75.0	16.7	8.3
15	6	6	0	50.0	50.0	0.0
16	1	9	2	8.3	75.0	16.7
17	9	3	0	75.0	25.0	0.0
18	8	4	0	66.7	33.3	0.0
19	2	4	6	16.7	33.3	50.0
20	10	2	0	83.3	16.7	0.0
21	6	6	0	50.0	50.0	0.0
22	7	4	1	58.3	33.3	8.3
23	3	5	4	25.0	41.7	33.3
24	6	4	2	50.0	33.3	16.7
25	5	4	3	41.7	33.3	25.0
26	1	6	5	8.3	50.0	41.7
27	5	7	0	41.7	58.3	0.0
28	4	6	2	33.3	50.0	16.7
29	4	7	1	33.3	58.3	8.3
30	4	8	0	33.3	66.7	0.0
31	8	4	0	66.7	33.3	0.0

32	3	8	1	25.0	66.7	8.3
33	1	11	0	8.3	91.7	0.0
34	1	3	8	8.3	25.0	66.7
35	9	3	0	75.0	25.0	0.0
36	1	8	3	8.3	66.7	25.0
37	5	7	0	41.7	58.3	0.0
38	4	8	0	33.3	66.7	0.0
39	10	2	0	83.3	16.7	0.0
40	6	6	0	50.0	50.0	0.0
41	5	7	0	41.7	58.3	0.0
42	10	2	0	83.3	16.7	0.0
43	7	5	0	58.3	41.7	0.0
44	3	9	0	25.0	75.0	0.0
45	1	1	10	8.3	8.3	83.3
46	9	3	0	75.0	25.0	0.0
47	11	1	0	91.7	8.3	0.0
48	11	1	0	91.7	8.3	0.0
49	11	1	0	91.7	8.3	0.0
50	9	3	0	75.0	25.0	0.0
51	3	9	0	25.0	75.0	0.0
52	6	6	0	50.0	50.0	0.0
53	2	7	3	16.7	58.3	25.0
54	1	9	2	8.3	75.0	16.7
55	4	8	0	33.3	66.7	0.0
56	6	6	0	50.0	50.0	0.0
57	8	4	0	66.7	33.3	0.0
58	10	2	0	83.3	16.7	0.0
59	9	3	0	75.0	25.0	0.0
60	5	7	0	41.7	58.3	0.0

Summed raw score for each subject and the percentage for each FMS assessment level (1,2, or 3) for the 0-2.5 yr Inexperience Group (n=12)

Percentages determined by taking the summed raw score and dividing by the total number of reported scores.

TABLE 9 - Percentage of Each FMS Assessment Level 1-3 for Experience Raters

	Sum			Percentage		
Subject #	1's	2's	3's	1's	2's	3's
1	5	3	0	62.5	37.5	0.0
2	2	6	0	25.0	75.0	0.0
3	2	4	2	25.0	50.0	25.0
4	7	1	0	87.5	12.5	0.0
5	5	3	0	62.5	37.5	0.0
6	2	4	2	25.0	50.0	25.0
7	7	1	0	87.5	12.5	0.0
8	4	4	0	50.0	50.0	0.0
9	7	1	0	87.5	12.5	0.0
10	6	2	0	75.0	25.0	0.0
11	8	0	0	100.0	0.0	0.0
12	8	0	0	100.0	0.0	0.0
13	6	1	1	75.0	12.5	12.5
14	7	1	0	87.5	12.5	0.0
15	5	2	0	62.5	25.0	0.0
16	2	5	1	25.0	62.5	12.5
17	8	0	0	100.0	0.0	0.0
18	3	5	0	37.5	62.5	0.0
19	2	1	5	25.0	12.5	62.5
20	4	4	0	50.0	50.0	0.0
21	4	4	0	50.0	50.0	0.0
22	2	6	0	25.0	75.0	0.0
23	4	4	0	50.0	50.0	0.0
24	4	3	1	50.0	37.5	12.5
25	2	4	2	25.0	50.0	25.0
26	1	1	6	12.5	12.5	75.0
27	3	5	0	37.5	62.5	0.0
28	2	5	1	25.0	62.5	12.5
29	2	4	2	25.0	50.0	25.0
30	2	4	2	25.0	50.0	25.0
31	8	0	0	100.0	0.0	0.0

32	4	4	0	50.0	50.0	0.0
33	2	6	0	25.0	75.0	0.0
34	3	1	4	37.5	12.5	50.0
35	7	1	0	87.5	12.5	0.0
36	1	6	1	12.5	75.0	12.5
37	7	1	0	87.5	12.5	0.0
38	5	3	0	62.5	37.5	0.0
39	8	0	0	100.0	0.0	0.0
40	7	1	0	87.5	12.5	0.0
41	5	3	0	62.5	37.5	0.0
42	7	1	0	87.5	12.5	0.0
43	8	0	0	100.0	0.0	0.0
44	2	6	0	25.0	75.0	0.0
45	1	0	7	12.5	0.0	87.5
46	6	2	0	75.0	25.0	0.0
47	7	1	0	87.5	12.5	0.0
48	8	0	0	100.0	0.0	0.0
49	8	0	0	100.0	0.0	0.0
50	8	0	0	100.0	0.0	0.0
51	3	5	0	37.5	62.5	0.0
52	8	0	0	100.0	0.0	0.0
53	2	4	2	25.0	50.0	25.0
54	3	5	0	37.5	62.5	0.0
55	3	5	0	37.5	62.5	0.0
56	5	3	0	62.5	37.5	0.0
57	7	1	0	87.5	12.5	0.0
58	6	2	0	75.0	25.0	0.0
59	7	1	0	87.5	12.5	0.0
60	5	3	0	62.5	37.5	0.0

Summed raw score for each subject and the percentage for each FMS assessment level (1,2, or 3) for the >2.5 yr Experience Group (n=8)

Percentages determined by taking the summed raw score and dividing by the total number of reported scores.

Table 10 – Sample of PPE Form

Station Examination	
Stations for PPE	
Check-In	
History	
Vital Signs	
Medical Examination	
Musculoskeletal Examination	Function specific – flexibility, posture, gait, strength Regional – spine, upper extremity, lower extremity
Performance Testing	Speed, agility, power, endurance, balance
Body Compositions	
Maturity Assessment	
Sport-Specific Considerations	
Review, Assessment, Check-Out	

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