The Effectiveness of Functional Movement Screening Testing in Prevention of Anterior Cruciate Ligament Injuries in Women's Collegiate Soccer

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THE EFFECTIVENESS OF FUNCTIONAL MOVEMENT SCREENING TESTING IN PREVENTION OF ANTERIOR CRUCIATE LIGAMENT INJURIES IN WOMEN'S COLLEGIATE SOCCER

by

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Abstract

The Functional Movement Screen (FMS), invented in 1995, has been adopted among Division One sports programs across the country. Being a women's soccer player at the University of Central Florida (UCF), this particular topic had been of interest for years. The FMS is a series of seven tests evaluated at the beginning and end of each season. The UCF team's preventative rehabilitation was based upon the measurements from the FMS testing. The team engaged in preventative rehabilitation three times a week. Each year of my membership, the team of 28 to 30 players had no less than two anterior cruciate ligament tears each season. This research explored the effectiveness of the Functional Movement Screening, and its' predictive ability regarding injury to possibly prevent future injuries. The purpose of this study was to review literature of multiple studies exploring the Functional Movement Screen, the anterior cruciate ligament, and, specifically, the recent spike in women's collegiate soccer injuries. This study also examined and included findings from five years of FMS scoring data from the UCF women's soccer team. The study consisted of 43 participants, 29 in the control group and 14 in the test group (those who suffered and ACL tear). They were females, ages 18-23, and of fit manner. Multivariate analysis, independent and dependent T-Tests, and Leven's test ran these data. This study also investigated the reliability of the Functional Movement Screen and analyzed data about anterior cruciate ligament injuries among women's collegiate soccer players. Recommendations for future protocols and implications for coaches, trainers, and women soccer players are provided.

Dedication

To Mom and Dad, thank you for pushing me to step out of my comfort zone and pursue my intellectual abilities alongside my athletic abilities. Thank you for sticking with me even though producing this took longer than expected. Thank you for constantly pushing me to be the best me I can be. This is for you.

Acknowledgements

Thank you to Dr. Thomas Fisher for chairing my thesis and helping me push through the past year and a half to finish this strong. Thank you for teaching me to question everything and making me a better student, researcher and person. I am forever indebted to you. Thank you to Dr. Sherron Killingsworth-Roberts for your patience and persistence with me. Thank you for being a shoulder to lean on and always understanding. You go above and beyond for your students and I am beyond grateful to have worked with you. Thank you to Dr. Anna Valdes for being on my committee and assisting me in my time at UCF. Thank you to the Burnett Honors College for the opportunity to participate in undergraduate research and allowing me to better myself as a student. Lastly, thank you to Samantha Visco. Thank you for treating me as more than a student-athlete, for your assistance in my research, and for your constant commitment to go above and beyond for your job. You are appreciated.

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Chapter One: Introduction

The Functional Movement Screen[1] (FMS) invented in 1995 (Garrison, Westrick, Johnson, & Benenson, 2015), is a collective series of pre-participation tests that can be used as a screening tool to identify compensatory movements in athletes. It was developed to help predict the likelihood of an injury, and enhance performance by repairing these compensations. The Functional Movement Screen was developed as a tool to provide better communication between athletic trainers, physical therapists, and strength and conditioning coaches. It was originally intended to serve as objective data for statistical analysis, but evolved to the analysis of human performance and injury prevention (Garrison, Westrick, Johnson, & Benenson, 2015). FMS testing is a series of seven tests, each of which explore different movement deficiencies around the entire body. The tests include; deep squat, hurdle step, in-line lunge, active straight leg raise, trunk stability push-up, shoulder mobility, and rotary stability. Each test is graded on a scale of 0 to 3 relative to completion of certain movements in the specific exercise. To receive a 3, the athlete is able to perform the movement without aid or compensation. To receive a 2, the athlete is able to perform the movement, but must utilize poor mechanics and/or compensatory patterns to accomplish movement. To receive a 1, the athlete is not able to perform the movement, even with compensation. A zero is only given if the individual has accompanying pain. Although there are seven tests, this research is based solely on the lower extremity exercises and how indicative they can be in relation to anterior cruciate ligament injuries (Garrison, Westrick, Johnson, and Benenson, 2015).

The topic of ACL injuries has always been fascination because of personal experience with FMS testing. As a UCF women's soccer player, the team worked closely with Functional Movement Screening, and base preventative rehabilitation on the scores from the tests. Yet, each year spent playing at UCF, the season ended with multiple ACL injuries. Questions developed from these experiences to explore the effectiveness of the FMS in terms of its predictive nature. This research will include a literature review of the effectiveness of the Functional Movement Screen in the prevention of ACL injuries. This study will also examine 5 years of data from the UCF women's soccer team FMS scoring. Multivariate analysis, independent and dependent T-Tests and Leven's test ran this data. This study also investigated the reliability of the Functional Movement Screen and analyzed data about anterior cruciate ligament injuries among women's collegiate soccer players at a large public university in southeastern United States.

Chapter Two: Definitions

[16]**Anterior tibial displacement-** complete rupture of the anterior cruciate ligament can sometimes result in an anterior subluxation of the tibia up to 7mm in relevance to the femur (Garrison, Westrick, Johnson, & Benenson, 2015).

[12]**ASIS-** anterior superior iliac spine of the innominate bone (Garrison, Westrick, Johnson, & Benenson, 2015).

[2]**Bilateral symmetrical mobility**- a basic body plan in which the left and right sides of the body can be divided into approximate mirror images of each other along the midline. Mobility is the flexibility of each limb in the assigned plane of motion (Mohamed, Useh, & Mtshali, 2012).

[6]**Calcaneus-** the scientific name for the heel (Garrison, Westrick, Johnson, & Benenson, 2015).

[5]**Closed kinetic chain-** are physical exercises performed where the hand (for arm movement) or foot (for leg movement) is fixed in space and cannot move. The extremity remains in constant contact with the immobile surface, usually the ground or the base of a machine (Huston, & Wojtys, 1996).

[10]**Dorsiflexion-** the backward flexion of the hand or foot (dorsi=upper/superior) (Garrison, Westrick, Johnson, & Benenson, 2015)

[1]**Functional Movement Screen-** The Functional Movement Screen[1] (FMS) invented in 1995, is a collective series of pre-participation tests that can be used as a screening tool to identify compensatory movements in athletes, to help further predict the likelihood of an injury, and enhance performance by fixing these compensations (Garrison, Westrick, Johnson, & Benenson, 2015).

[3]**Latissimus dorsi-** either of a pair of large, roughly triangular muscles covering the lower part of the back, extending from the sacral, lumbar, and lower thoracic vertebrae to the armpits (Mohamed, Useh, & Mtshali, 2012).

[11]**Malleous-** a bony projection on either side of the ankle (Arendt, Egel, & Dick, 2012)

[9]**Open kinetic chain**- are exercises that are performed where the hand or foot is free to move (Garrison, Westrick, Johnson, & Benenson, 2015)

[4]**Pelvic rhythm-** occurs when one bends forward, a combined movement of the pelvis and lumbar spine occurs. This motion when done correctly and efficiently can help increase the value of the pelvic rhythm (Mohamed, Useh, & Mtshali, 2012).

[7]**Pronated-** turn or hold (a hand, foot, or limb) so that the palm or sole is facing downward or inward (Mohamed, Useh, & Mtshali, 2012).

[8]**Rectus femoris-** the biggest of the quadriceps family, located most anterior (Arendt, Egel, & Dick, 2012).

[13]**Title IX Law-** No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving federal financial assistance (Fulstone, Chandran, Barron, & DiPietro, 2016).

[17]**Torque-** is the force applied by the muscles through a moment arm of a given length, at a given angle to the joint (Mohamed, Useh, & Mtshali, 2012).

[15]**Valgus-** a deformity involving oblique displacement of part of a limb away from the midline (Mohamed, Useh, & Mtshali, 2012).

[14]**Vastus medialis-** the most medial of the quadriceps muscles (Arendt, Egel, & Dick, 2012).

Chapter Three: Review of Related Research

The Functional Movement Screen is comprised of seven tests, but only four were used for this research. The following section explains each individual test: the deep overhead squat, the in-line lunge, the hurdle step, and the active straight leg-raise.

I. **The Deep Overhead Squat**

The deep overhead squat assesses bilateral, symmetrical mobility[2] of the shoulders and spine. To achieve symmetrical mobility of the spine, the subject must be flexible in their joints, and latissimus dorsi[3]. The squat also tests pelvic rhythm. Pelvic rhythm[4] occurs when bending forward and a combined movement of the pelvis and lumbar spine occurs (Garrison, Westrick, Johnson, & Benenson, 2015). This motion, when performed correctly and efficiently, can help increase the score of the overhead squat. The squat also tests flexion (bending) of the knee and hip joints, and the closed kinetic-chain dorsiflexion of the ankles (See Figure 1-A, page 16). Closed kinetic-chain[5] exercises occur when the extremity (leg) is in a fixed space and cannot move. The feet remain in constant contact with the floor, which acts as the immobile surface. The deep overhead squat is assessed on a scale of 0-3. A bar is held above the head with the calcaneus[6] (heel) placed on a wooden bar. The bar helps shift the weight and creates a mechanical advantage to increase core stability. If the feet are pronated[7] (facing outwards), or a spine tilt is present, a point is deducted. The objective is to achieve 90 degrees parallel, with the spine erect and the shoulders locked-out during the entire movement. This test can measure deficiencies in hip flexibility, coordination, and pelvic rhythm (Letafatkar, Hadadnezhad, Shojaedin, & Mohamadi, 2014).

II. The In-Line Lunge

The in-line lunge targets movements that will focus on rotational, decelerating and lateral abilities. When scoring, the tester's body trunk is challenged to resist rotation. The torso, knee, ankle, and hip stability are all tested, along with rectus femoris[8] (quadriceps) flexibility, and dorsiflexion[9] (bending of the foot) of the ankle. The objective of this test is to balance through a complete lunge, while holding a stick behind the back. The purpose of the stick is to align the spine, while preventing rotation of the hips. Points are deducted if rotation is present in the torso, or if the knee extends over the foot in the lunge position (Garrison, Westrick, Johnson, & Benenson, 2015).

III. The Hurdle Step

The hurdle step also tests balance, coordination, and stability in the hips and torso. A bar is placed 12 inches above the ground. The athlete is instructed to step over it with no rotation, and have the ability to bring their foot straight over the bar. This test assesses maximal open kinetic chain, [9] step-leg-dorsiflexion[10] of the ankle. An open kinetic chain exists when either the upper or the lower extremities are free to move. The hurdle step assesses stability of the knee and ankle**.** The athlete receives a score of three when the hips, knees, and ankles remain aligned in the sagittal plane (divides the body in to left and right). The dowel and hurdle must also remain parallel, with limited to no movement in the lumbar (lower) back. To receive a two, there is movement in the lumbar spine, the alignment is lost between the hips, knees and ankles, and the dowel does not remain parallel (Letafatkar, Hadadnezhad, Shojaedin, & Mohamadi, 2014).

IV. The Active Straight Leg Raise

The last test, active straight leg raise, disassociates the lower extremity while maintaining stability in the torso. The straight leg-raise assesses the hamstring, gastrocnemius (calf), and soleus flexibility, while maintaining a stable pelvis, and active extension (straightening) of the opposite leg. To receive a score of three on this test, a vertical line of the malleolus[11] (bony prominence on each side of the ankle) must reside between mid-thigh and ASIS[12] (anterior superior iliac spine on the innominate bone). The non-moving limb must remain in neutral position. Once the elevated leg begins to drop below the joint line, points are deducted (Letafatkar, Hadadnezhad, Shojaedin, & Mohamadi, 2014).

Many of the ligaments, tendons, and muscles associated with the knee are placed under a great deal of stress during soccer activities. In particular, the anterior cruciate ligament (ACL) is one of the most commonly torn ligaments of the knee. (See Figure 2, page 16). The ACL is one of the four main ligaments in the leg that connect the femur to the tibia. Located anteriorly, the ACL is responsible for stabilizing the knee, while also preventing hyperextension. Since the 1970s and the arrival of the Title IX law[13], there has been a dramatic increase in women's participation in athletics, and in turn, the number of ACL injuries in female athletes has increased as well (Fulstone, Chandran, Barron, & DiPietro, 2016).

According to Dr. Elizabeth A. Arendt (2012), "Women soccer players were two times more likely than their male counterparts to have an ACL injury as the result of player contact and three times more likely to obtain such an injury through noncontact mechanisms (p. 534)." The ACL has become one of the most common injuries in soccer. Specifically in females, 58.3% of the athlete's ACL injuries were noncontact (Agel, Arendt, & Bershadsky, 2016). Questions have arisen as to the extent this injury can be prevented. FMS testing has become a common resource to help in the prevention process.

In a study published by *International Journal of Sports Physical Therapy*, one hundred physically active athletes between the ages of 18 and 25 performed FMS testing and were evaluated on the correlation between their scores and how prone the subjects were to injury. Letafatkar, Hadadnezhad, Shojaedin, & Mohamadi, (2014) found that of the 100 subjects, 35 suffered an acute lower extremity (ankle = 20, knee = 15) injury in practice or competition. An odds ratio was calculated at 4.70, meaning that an athlete had an approximately 4.7 times greater chance of suffering a lower extremity injury during a regular competitive season if they scored less than 17 on the FMS (p. 1).

If athletes are 4.7 more times likely to experience a lower extremity injury based upon the predictive score from FMS, a preventative rehabilitation program must be created. For example, if the athlete received a score of two on the deep overhead squat, the preventative program would focus on vastus medialis[14] (superior medially to the patella) strengthening, hip mobility, and overall leg flexibility (Letafatkar, Hadadnezhad, Shojaedin, & Mohamadi, 2014). These exercises such as gluteus bridges, hamstring stretching, and proper landing technique exercises may be performed through proper static stretching every day. Each stretch of the hamstring, gluteus and quadriceps will be held for approximately 15 to 20 seconds, and focus primarily on achieving full range of motion. For vastus medialis strengthening, weighted quadriceps extensions, together with lateral lunges, can be beneficial. If the athlete scores below a three on the in-line lunge, attention shifts to hip stability along with and thoracic spine mobility.

Regarding lower extremity injuries, tears of the ACL have become the most common. One study by Voskanian in 2013 explored ACL injuries among post-pubescent female collegiate athletes. Voskanian found, “Females have a higher tendency to have risky landing patterns that are associated with ACL injury. The majority of ACL injuries occur during landing from a jump or sudden deceleration. The ACL has been shown to be under higher degrees of stress when the knee is in extension or only minimally flexed (such as 5–20 degrees as opposed to 60 degrees) and when it is under valgus[15] stress (knee internal rotation) which are common mechanisms in female athletes who have injured their ACL” (Shimokochi & Shultz, 2008). Females tend to land from a jump in a more erect position than males (insufficient knee and hip flexion). They also have greater hip internal rotation and hip adduction when decelerating or landing (Barber-Westin, Noyes, Smith, & Campbell, 2009). Their movements involve more internal rotation of the hip along with external rotation at the tibia than males, leading to increased knee valgus (Huston, & Wojtys, 1996). Together, these tendencies increase forces on the knee and are associated with greater risk for ACL injury. The combination of riskier landing patterns and insufficient neuromuscular adaptations leads to greater ACL stress **(**Renstrom, Ljungqvist, Arendt, Beynnon, Fukubayashi, Garrett, & Engebretsen, 2008**)**. Adequate musculature strength, along with appropriate muscle recruitment and timing, are important aspects of knee stability. The hamstrings are instrumental in ACL prevention. As the main knee flexor, they provide an opposing force to anterior tibial displacement[16] (Renstrom, Ljungqvist, Arendt, Beynnon, Fukubayashi, Garrett, & Engebretsen, 2008). However, muscle strength is only one factor. Muscle preference and recruitment are also important for knee stability. Studies have shown that females take longer to generate maximum hamstring torque[17], and have more quadriceps than hamstring activation than their male counterparts, predisposing them to ACL injury **(**Malinzak, Colby, Kirkendall, Yu, & Garrett, 2001).

Female athletes were examined by the *Internal Journal of Sports Medicine* to evaluate the reason for their injury. They compared the results among all male and female collegiate soccer players. Table 1 (page 17) refers to a study done by the NCAA Injury Surveillance System (Fulstone, Chandran, Barron, & DiPietro, 2016). This NCAA study illustrated past years of NCAA athletes who have had ACL injuries, how they happened, the setting, and the competition level. All are important factors when determining the probability of tearing the ACL. The Functional Movement Screen has attempted to prevent the likelihood of an ACL tear. As stated by Voskanian (2013), hamstring strength is key to ACL tear prevention protocol. From the Functional Movement Screen, hamstring deficits detected from the active straight leg raise (scores of 0-2) can then be strengthened in a preventative program.

The University of Central Florida women's soccer team requires exercises such as gluteus bridges, hamstring curls; Romanian deadlift (RDL), eccentrics, and proper landing technique are incorporated in to a thirty-minute program performed twice a week. For example, Player A scored a 2 on the deep overhead squat, 2.5 on the in- line lunge, 3 on the hurdle step, and 3 on the active straight leg raise. Player A was 5’6” and weighed 128 pounds. She has a history of one ACL tear in her pre-collegiate career. Player A has torn her ACL twice since participating in FMS testing along with three years of collegiate Division I soccer. She tore her ACL twenty games in to the season, due to a non-contact injury. Although player A had a history of knee injury, her FMS scores appear unreliable. Her preventative rehabilitation did not work, as she was predisposed to ACL injury.

Player B scored a 2 on the deep overhead squat, 3 on the in-line lunge, 2 on the hurdle step, and 3 on the active straight leg raise. Player B was 5’6” and weighed 140 pounds. She had no prior history of injury, and fully participated in preventative rehabilitation. She suffered an ACL tear, seventeen games in to the season from a noncontact injury.

Player C scored a 3 on the deep overhead squat, 2 on the in- line lunge, 2 on the hurdle step, and 2 on the active straight leg raise. Player C was 5’4” and weighed 120lbs. She has a history of one ACL tear from her pre-collegiate career. Player C has suffered two ACL tears in one and half years with no actual collegiate playing time. She was medically “red-shirted” during her freshman year after suffering both ACL injuries in practice contact.

These three players actively participated in preventative rehabilitation exercises consisting of: hip mobility exercises, side lying hip abduction, iliotibial tract stretches, supine ball pull-ins, single leg RDL’s, single leg squats, clock lunges, planks, and single leg squats. Their scores averaged on the deep overhead squat 2.3, 2.5 on the in-line lunge, 2.3 on the hurdle step, and 2.6 on the straight leg raise. “The overall incidence rate of a second ACL injury within 24 months after ACLR and RTS (1.39/1000 AEs) was nearly 6 times greater (IRR, 5.71; 95% CI, 2.0-22.7; P = .0003) than that in healthy control participants (0.24/1000 AEs). The rate of injury within 24 months of RTS for female athletes in the ACLR group was almost five times greater (IRR, 4.51; 95% CI, 1.5-18.2; P = .0004) than that for female controls (Paterno, Rauh, Schmitt, Ford, & Hewitt, 2014). Two of the three subjects tore an ACL within the 24-month period even with an FMS score that was indicative of little to no imbalances. This suggested that the FMS testing should scrutinized in conjunction with other baseline tests.

Chapter Four: Methodology and Research Design

To examine the Functional Movement Screen and its relevance in prevention of ACL injuries, an interdisciplinary, multi-phase literature review was conducted. First, the Functional Movement Screen lower extremity tests were examined. Articles and studies were drawn from journals, books, and databases in the field of Exercise Science, Athletic Training, and Medicine. Once this research was analyzed, further review of anterior cruciate ligament tears in women collegiate soccer was conducted. This study also examined 5 years of FMS scoring of the women's soccer team from the University of Central Florida. The study consisted of 43 participants, 29 in the control group and 14 in the test group (those who suffered and ACL tear). They were females, ages 18-23, and of fit manner. Those who were in the control group were acknowledged with the condition of '0.' Those in the test group were acknowledged with the condition of '1.'

I. Measurement Instrumentation

Multivariate analysis, independent and dependent T-Tests and Leven's test were conducted. The analyses revealed correlations between vastus medialis deficiencies and ACL tears, the lack of proper prevention techniques and ACL tears, and the greater number of women affected and ACL tears. Literature tables were used to organize and graphically represent correlations (See Table 2, page 20). As discussed, four tests specifically apply to lower body injuries. These scores, assessed by one athletic trainer, may lack validity. The Functional

Movement Screen was not predictive for this small population of female collegiate athletes. It has been used a preventative measure in many different environments. This study will further examine the effectiveness of the Functional Movement Screen in women’s collegiate soccer players. The study will examine the likelihood of ACL injury in specific populations, risk factors contributing to ACL injury, and attempt to answer the question of the validity and reliability of the FMS test.

Chapter Five: Figures/Tables

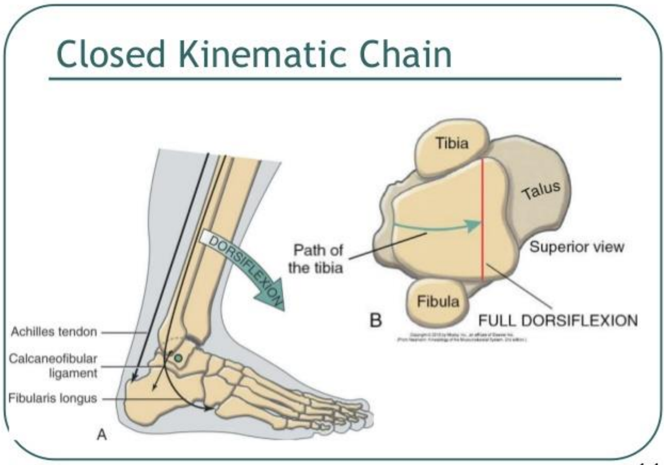

Figure 1-A. Saurab Sharma, Assistant Professor, Kathmandu University School of Medical Sciences Follow. (2015, June 22). 1. Biomechanics of ankle joint subtalar joint and foot. Retrieved February 13, 2018, from https://www.slideshare.net/saurabsharma/1-ankle-joint-biomechanics-2015-saurab

Figure 1-B. What is the MCL? (n.d.). Retrieved February 13, 2018, from http://www.theknee.com/mcl-medial-collateral-ligament/what-is-the-mcl-medial-collateral-ligament/

Table 1 Frequency of soccer-related knee injuries: NCAA ISS 2004–2009.

	Women	Men
Origin		
New	554 (89%)	417 (90%)
Recurrent	69 (11%)	49 (10%)
Contact		
Yes	412 (63%)	311 (65%)
No	239 (37%)	165 (35%)
Setting		
Game	335 (51%)	233 (49%)
Practice	327 (49%)	247 (51%)
Competition level		
Division I	332 (50%)	213 (44%)
Division II/III	330 (50%)	267 (56%)

Table 1. Received from Fulstone, D., Chandran, A., Barron, M., & DiPietro, L. (2016). Continued Sex-Differences in the Rate and Severity of Knee Injuries among Collegiate Soccer Players: The NCAA Injury Surveillance System, 2004–2009. *International Journal of Sports Medicine, 37*(14), 1150-1153

Chapter Six: Results and Findings

The purpose of this study was to further knowledge on the correlations between FMS testing and ACL tears and solve why it became an epidemic for UCF women's soccer team. Five years of FMS data was collected from the women's soccer team at the University of Central Florida. 43 participants participated in this study. Every evaluation and test was performed in the same location, by the same examiner. With the help of Dr. Clark, the data were subjected to multivariate analysis, independent and dependent T-Tests, and Leven's test. An independent samples t-test was conducted to determine if the mean control group differed from the ACL tears group. The assumption of normality was tested using box plots and histograms. The boxplots and histograms suggested none of the distributions were normal. However, this was anticipated due to the small sample size.

According to Levene's test, the homogeneity of variance was satisfied for two dependent variables (the in-line lunge at .035 and the hurdle step at .047), but not for all (See table 3, page 20). Table 2, page 20 shows descriptive statistics: sample size, means, and standard deviations. The independent t-test indicated that the ACL tear group means were not significantly different than the control group. The effect size calculator using Cohen D (calculated using the standard deviation) showed a moderate distribution. A large distribution would be significant, but this data falls inconclusive using the effect size calculator. The only significant result recorded was that women who had an ACL tear tend to have a higher score on the in-line lunge.

I. Limitations

With only five years of data collected from one women's soccer team, it is hard to infer a predictive equation with such little data. If this study was over ten years, with multiple teams and a higher number in the test group, further conclusions could have probably been drawn. However, informal examinations of three players with ACL injuries (Players A, B and C) were an exception barring the 24-month likelihood of an ACL re-tear. The rate of injury within 24 months of RTS for female athletes in the ACLR group was almost five times greater (IRR, 4.51; 95% CI, 1.5-18.2; P = .0004) than that for female controls (Paterno, Rauh, Schmitt, Ford, & Hewitt, 2014). Two of the three subjects tore an ACL within the 24-month period even with an FMS score that was indicative of little to no imbalances. This suggested that the FMS testing should scrutinized in conjunction with other baseline tests. This study looked at FMS at the sole criteria for ACL tears when it is well documented that it is multi-factorial.

II. Data and Finding Tables

Table 2

Group Statistics

	Condition	N	Mean	Std. Deviation	Std. Error Mean
In Line Lunge	1	11	2.818	.2523	.0761
	0	24	2.646	.4032	.0823
Deep Squat	1	14	2.357	.4569	.1221
	0	30	2.367	.5074	.0926
Straight Leg Raise	1	14	2.857	.3056	.0817
	0	30	2.817	.3592	.0656
Hurdle Step	1	11	2.591	.3754	.1132
	0	24	2.604	.4658	.0951

Table 3

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
In Line Lunge	Equal variances assumed	4.831	.035	1.300	33	.203	.1723	.1326	-.0974	.4421
	Equal variances not assumed			1.538	29.528	.135	.1723	.1121	-.0567	.4014
Deep Squat	Equal variances assumed	.220	.641	-.060	42	.953	-.0095	.1594	-.3311	.3121
	Equal variances not assumed			-.062	28.096	.951	-.0095	.1533	-.3235	.3044
Straight Leg Raise	Equal variances assumed	.684	.413	.364	42	.718	.0405	.1112	-.1839	.2649
	Equal variances not assumed			.386	29.641	.702	.0405	.1048	-.1736	.2545
Hurdle Step	Equal variances assumed	4.241	.047	-.083	33	.935	-.0133	.1603	-.3395	.3129
	Equal variances not assumed			-.090	23.915	.929	-.0133	.1478	-.3184	.2919

Chapter Seven: Final Conclusions, Recommendations and Future Research

This study matters to the major because ACL tears are prominent among women collegiate soccer players. Not only in collegiate soccer, but it matters all across sports from youth to professional. This study's intent was to further the knowledge of coaches, athletic trainers, and strength and conditioning coaches of all ages. Agel, Arendt, & Bershadsky stated, "Women soccer players were two times more likely than their male counterparts to have an ACL injury as the result of player contact and 3 times more likely to obtain such an injury through non-contact mechanisms (p. 534)." The ACL has become one of the most common injuries in soccer. Specifically in females, 58.3% of the athlete's ACL injuries were noncontact (Agel, Arendt, and Bershadsky, 2016). For future study, this work could be replicated with more data. Results could be more conclusive if the data was taken over a longer period of time. This study concluded: an independent samples t-test was conducted to determine if the mean control group differed from the ACL tears group. The assumption of normality was tested using box plots and histograms. The boxplots and histograms suggested none of the distributions were normal. Due to the small sample, this was anticipated. According to Levene's test, the homogeneity of variance was satisfied for two dependent variables (the in-line lunge at .035 and the hurdle step at .047), but not for all. Shown in table 1 (page 17) are descriptive statistics: sample size, means, and standard deviations. The independent t-test indicated that the ACL tear group means were not significantly different than the control group. The effect size calculator using Cohen D (calculated using the standard deviation) showed a moderate distribution. A large distribution would be significant, but this data falls inconclusive using the effect size calculator. The only significant data recorded was that women who had an ACL tear tend to have a higher score on the in-line lunge. The intent of this study was to look at the relationship between FMS scoring and ACL tears. Now that there is an initial database of findings, it is known that a larger sample size or a larger period of time is needed. With this larger sample size there could be more conclusive findings and it is the hope that a relationship would exist between FMS testing and ACL tears. This could give athletic trainers and coaches possible information on where to focus their prevention. This study provided many avenues for future research to perhaps engage other baseline tests, other universities, and collect and gather data together in hope to find a solution to the never-ending ACL tear epidemic.

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