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AC INJURY PREVENTION PARTICIPATION AMONGST COLLEGIATE FEMALE ATHLETES

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ACL INJURY PREVENTION PARTICIPATION AMONGST

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To Coach Lauren Glenn who has encouraged me to be a better athlete, leader, student each and every day and has inspired me to help other athletes just like myself to do the same

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ABSTRACT

Background: A common injury for athletes is a tear in the anterior cruciate ligament, with a disproportionally higher rate of injury among female athletes rather than male athletes due to many anatomical and physiological differences. One of the proposed causes of increased injury is the difference in hormone levels during the phases of the menstrual cycle. While ACL injury prevention programs have been used to help reduce the number of injuries among athletes, it is not yet well known if changing hormone levels throughout the menstrual cycle is predictive of ACL injury risk among athletes that engage in injury prevention programs and those that do not. Here, we use the Lower Extremity Scoring System (LESS) as a way to evaluate an athlete's risk of sustaining an ACL injury for athletes that have and have not participated in ACL injury prevention and correlate those scores with phases of the menstrual cycle.

Methods: 122 female collegiate athletes were tested using the LESS model and a questionnaire on the injury prevention and menstrual cycle history of the athlete. The average LESS scores were compared in order to determine significant differences between athletes who had participated in injury prevention, and those who had not, as well as athletes in different phases of the menstrual cycle.

Results: One out of the eight teams had been actively participating in ACL injury prevention and had the lowest average LESS score of 5.43. The menstrual phases all had similar averages of LESS scores ranging from 7-8.

Conclusion: The results of the study concluded ACL injury prevention had lowered the risk of an ACL injury among female collegiate athletes However, fewer athletes were participating in ACL injury prevention than expected. The hypothesis for the menstrual cycle was rejected due to the follicular phase having the lowest average LESS score.

INTRODUCTION

The occurrence of anterior cruciate ligament (ACL) injuries, an injury common in sports consisting of several cutting and jumping movements, has increased nine times in the last 30 years according to a study by Hewett, Myer & Ford (2006) cited in (Adachi, Nawata, Maeta, & Kurozawa, 2008). There are four to eight times the amount of these injuries occurring in female athletes than in male athletes (Agel, Barshardsky, & Ardent, 2006). Heitz & Eisenman (1999), along with other studies, report the differences between male and female athletes and why there are more injuries occurring in the female athletes. These differences include muscular, biomechanical, hormonal, and structural features in male and female bodies. Several of these studies search to declare one aspect as the primary cause of an ACL tear, but these studies have concluded that it is important to not just focus on one primary cause, especially in the case of injury prevention programs (Park, Stefanyshyn, Loitz-Ramage, Hart, & Ronsky, 2009).

The ACL injury includes a long recovery process that can affect the individual long after it has been repaired (Willadsen, Zahn, & Durall, 2019). Because of this, many studies have been conducted to test different types of ACL injury prevention programs among athletes in order to decrease the risk of injury occurrences (Marcordes, 2018). There are several different types of programs developing within recent years that have shown fewer occurrences in ACL injuries among groups that participate in these strengthening programs (Paszkewicz, Webb, Waters, McCarthy, & Van Lunen, 2012). These studies have used different methodologies to calculate the differences before and after an athlete has gone through an injury prevention program such as the use of a Lower Extremity Scoring System (LESS) (Marcodes, 2018), and the use of a measuring device such as a KT-1000 arthrometer (Paszkewicz, Webb, Waters, McCarthy, & Van Lunen, 2012). The LESS model in particular has rarely been tested among different teams who

have and who have not participated in ACL injury prevention program, especially for use in comparing the knee laxity with the menstrual cycle of female athletes. The same hormones that play a major role in the menstrual cycle are also located in the ACL. These hormones have been linked to knee laxity at different points of the menstrual cycle, which is the reasoning behind including the following topic in this particular study. The purpose of the following study, therefore, was twofold: to compare the LESS scores of collegiate female athletes who have and have not participated in ACL injury prevention programs; secondly to compare these scores to the menstrual cycle phase of each athlete for trends in knee laxity. The purpose of comparing the scores of the LESS to the menstrual cycle was to see whether or not the LESS could be an effective scoring system to also predict knee laxity for menstrual phases.

ACL Injuries

Injury Occurrence

The ACL injury is most often classified as a noncontact injury or a single-plane injury as stated by Agel, Bershardsky, and Ardent (2006) and Heitz and Eisenman (1999), most commonly occurring when the foot is in a fixed position and the lower leg is rotated at the same time. The ACL is considered to be in its highest state of vulnerability specifically when the tibia bone is externally rotated with the knee in a valgus position and the flexion of the leg (Heitz, & Eisenman, 1999). This also can occur because of leg dominance within a physical activity, which has significantly more of the valgus knee angles in the female athlete than the nondominant leg (Ford, Myer, & Hewett, 2003). Adachi et. al. (2008) conducted a study that found that 9 of the 18 subjects who had torn their ACL had torn it while landing after a jump, while the other nine subjects tore the ACL by twisting, pivoting, or during deceleration. The study also showed that 59% of the ACL injuries occurred during competition. Another study showed that the majority of

these injuries were also done during competition and also reported that 64% of the injuries happened within the first few minutes of play (Wojtys, Huston, Lindenfeld, Hewett, & Greenfield (1998).

Adachi et. al. (2008) also looked at what sports had the most occurrences of ACL injuries. The study showed that the most injuries had occurred in basketball (39%) and volleyball (28%), with the other injuries occurring across multiple other sports. Ford et. al. (2003) also reported that the majority of the ACL injuries among female athletes were caused by rebounding a basketball. Another study looked at the occurrences of ACL and ankle ligament injuries in basketball and soccer athletes across three seasons for 209 NCAA schools. There was a statistically significantly higher number of injuries among the basketball athletes than there were among soccer athletes (Ford et. al., 2003).

Differences Between Men & Women

With ACL injuries being four to eight times more likely to occur in women (Adachi et. al., 2008), it is important to look at the reasons why this is occurring. Ford et. al. (2003) conducted a study to look at the differences in the valgus knee motion during the landing of both female and male basketball players and determined that the main differences were multifactorial. These factors included anatomical, biomechanical, and hormonal differences. The anatomical differences were due to the fact that women had an increased Q-angle in their pelvis for childbirth, a narrower femoral notch within the pelvis, and an increased hypermobility (laxity) in the female knee. The biomechanical differences included the idea that females are more ligament, leg, and quad dominant meaning females rely more on their quadricep muscles, whereas men rely more on their hamstring muscles. The study, along with another study by Benjaminse, Otten, Gokeler, Diercks, and Lemmink (2015), showed that females had a higher

hypermobility in the knee and were more reliant on their quadriceps and ligaments within landing movement patterns, which in turn would allow them to be more susceptible to an injury of the ACL. Moreover, the researchers saw that the female subjects were also more ligament dominant than the male subjects. The studies mentioned above provide a strong foundation for some of the risk factors associated with an ACL injury for a female.

A pivotal difference between male and female athletes were the natural muscle and joint movements of female athletes. The motor learning strategies were tested among 47 female and 34 male basketball players all of high school age. The valgus knee motion and angle were calculated during a simple jumping maneuver, and the female athletes recorded a higher quantity of both when compared to the male athletes (Ford et. al., 2003). Because of the lower dynamic knee joint stability, there is a higher chance of females to tear their ACL because the ACL is more vulnerable during the movements that would normally cause the injury. Park et. al. (2009) also looked at knee laxity and stiffness among healthy female athletes that did not experience an ACL or other knee injury. The study discovered that the female subjects had experienced delayed muscle reflexes, decreased joint proprioception, and greater knee adduction during moments where they were cutting and landing. This later affects the protective mechanism of the knee during external loads, which is not as common among males (Park et. al., 2009). The differences have also been looked at among recreational activities such as skiing, where women skiers were more likely to sustain an ACL injury than men (Ruedl et. al., 2012).

ACL Injury Prevention

Types of Programs

As stated earlier, injuring the ACL requires a long recovery process for the individual (Willadsen, Zahn, & Durall, 2019). Because of this process, many athletes and coaches strive to

find ways to prevent an ACL injury from happening within their teams. There are several different strategies to ACL prevention, and other studies show the benefits of the specific types. Benjaminse et. al. (2015) looked at learning strategies for male and female basketball players when learning different motor skills. Many of the previous programs had used internal focus, but this specific study used external focus using video feedback as a visual for the subjects. The results showed males responding better to the visual feedback that was given, whereas females did not respond as well. The study later suggests females would respond to a different type of feedback such as that with an internal focus, and that programs should be sex-specific because females and males respond differently to different types of feedback.

Other similar studies have shown the same improvement in landing kinematics as the studies conducted among collegiate athletes. The different prevention techniques included exercises such as balancing on one leg, heel touches, wall squats, single leg bridges, lunges, broad jumps, and several others. The target of these exercises is to help the athlete work on proper landing form in a jump, as well as strengthening the hamstring muscles so that the quadricep muscles are not doing most of the work during a landing. Ultimately, as mentioned previously, the quadricep dominant individuals have been shown to tear their ACL more frequently than those who are more hamstring dominant (Olsen, Mykelbust, Holme & Bahr, 2005).

Many studies stressed the importance of strengthening neuromuscular control when considering what to include in a prevention program. Ford et. al. (2003) showed that implementing dynamic neuromuscular control to strengthen the hamstrings would decrease the incidences of ACL injuries in male and female basketball players. Paszkewicz et. al. (2012) noted that programs in the preseason and during the season involving strengthening exercises,

plyometrics, and balance would help reduce ACL injuries. The programs also would be more successful if there was emphasis on planting, cutting, and jumping exercises. The participation rates would also be higher if there was an entire team involvement rather than the individual athlete. Willadsen et. al. (2019) noted also the plyometric training and core stability helped overall motor coordination and knee flexion during landing movements. Often programs involving these types of exercises last at least four weeks with two to three sessions per week for optimal success (Willadsen et. al., 2019).

Prevention Success

Prevention is not as common throughout all sports because coaches can be hesitant to include it in their daily practices. In particular, coaches tend not to have much interest in prevention during the sports season. The goal of the ACL prevention is to find long-term effects in the athlete's performance, which will then continue into actual competition where injuries are most common (Benjaminse et. al., 2015). Ford et. al. (2003) showed that for female athletes, prevention five times equal to male prevention allowed thousands of female athletes to reduce ACL injuries. This is not only for collegiate athletes but in high school athletes as well because there are about 7,000 ACL injuries occurring in high school female basketball players each year. One study completed by Marcodes (2018) tested the effects of a four-week prevention program of a collegiate women's soccer team. The study involved different exercises including types of jumps that would strengthen the hamstrings and other muscles around the knee. The subjects were tested in their landing form using a modified Lower Extremity Scoring System (LESS) before and after the program to see if any improvement in scores appeared in the athletes who had completed the entirety of the program. This was supported at the end of the study by improvement among individuals who had participated.

Olsen, Myklebust, Engebretsen, Holme, and Bahr (2005) looked at implementing prevention in youth sports. The intervention groups showed significantly fewer injuries not only to the ACL but also to acute knee and ankle injuries. Paszkewicz et. al. (2012) showed a significant reduction in ACL injuries among groups who underwent programs including a warm-up, stretching, strengthening exercises, plyometric exercises, and sport-specific agility. These sport-specific activities also helped the individual to not only prevent an injury but also become more skilled within the sport. Overall team injury rates were also reduced when these programs were implemented. Myklebust et al. in 2006 looked at how prevention affected the occurrence of noncontact ACL injuries in both adolescent and elite female handball athletes. These athletes were assessed over three seasons in order to see if the prevention had any affect over time. Overall, the number of ACL injuries decreased among these athletes the longer they had been participating in prevention, which was similar at both the adolescent and elite levels. This study, along with the other studies mention, show the benefit of implementing ACL prevention into the training seasons of an athlete.

These injuries affect the academic performance as well as athletic performance in the individual. They can affect how an individual goes about daily life because of the long recovery and return-to-play process (Ford et. al., 2003). Not only the injury can be career-ending, many collegiate athletes lost potential scholarships because they were not able to return. This in turn also costs the athlete more as surgical interventions and rehabilitation can cost large sums of money (Olsen et. al., 2005). Even though there are several studies that test the effectiveness of ACL prevention among these athletes, few studies have been conducted that examine the differences in prevention across different sports. One proposed way to evaluate the effects of prevention on landing kinematics is through the Lower Extremity Scoring System.

The Lower Extremity Scoring System

The LESS is a system that evaluates several aspects of landing kinematics. The LESS is used to provide a score for different aspects within a subject's landing kinematics. Traditionally, the LESS evaluates 17 total points of the landing. Subjects stand on a box of a given length and are told to jump and land at a distance about half of their height. Immediately after this landing, the athlete jumps again straight up in the air landing again. For each subject, the jumps are videoed in the frontal and sagittal view. Using both videos, the jumps are then scored based off of the criteria of 17 given points. The major points that the LESS looks at specifically for the knee is flexion, medial position, and knee-flexion displacement. Several studies have used this method as an accurate way to measure landing kinematics (Dressendorfer, & Callanen, 2017, and Bird, & Markwick, 2016).

A study completed in 2015 by Padua et al. evaluated LESS scores as a screening method for and ACL injury prevention program in youth soccer athletes. The study evaluated over 800 young athletes and used the scores as a predictor of ACL injuries. Their results showed that athletes who scored an overall score of 5 or more during their preseason training had more instances of ACL injury during their soccer season than those athletes who scored lower than a 5 on the LESS. Even though this study targeted a similar population to the current study, all of the evaluated athletes were only soccer players. The current study compares the LESS scores of those athletes that have participated in ACL prevention and the athletes that have not participated in ACL prevention in order to determine if there are any significant differences between the scores of the two groups.

The Female Menstrual Cycle

Phases of the Cycle

The menstrual cycle is a coordination that occurs through the hormones within the endocrine system of a female: the coordination is between the hypothalamus, pituitary gland, and the ovaries (Wojtys et. al. 1998). Heitz and Eisenman (1999) looked at the hormonal changes throughout the menstrual cycle among seven active females. In the study, the menstrual cycle was stated to range from 24 to 35 days with an average of 28 days. Within the cycle are three phases: menstrual (days 1-5), follicular (days 6-13), and luteal (days 15-28). The luteal phase however, is usually the time between ovulation and the next menses. After ovulation, the luteinizing hormone (LH) will cause the development of the corpus luteum. The corpus luteum then secretes several of the hormones that are used for pregnancy. Hormone levels are continuously changing throughout these phases and continue to change through menarche, conception, pregnancy, postpartum period and menopause (Constantini, Dubnoc, & Lebrun, 2005). These hormonal changes can then cause many changes in the female herself.

Effects on the Female

In a review of literature by Constantini et. al. (2005), the focus was on the menstrual cycle and sports performance on the female athlete. The review stated that for the female, the cardiovascular system, brain, thermoregulation, substrate metabolism, ventilation, and choice of fuel storage usage can be affected during the menstrual cycle. In the times of the cycle when estrogen is low, the cardiovascular system responses to stress are elicited more easily than when there are higher levels of estrogen. Progesterone, another hormone associated with the menstrual cycle, can cause an increase of strain and excitability within the cardiovascular system. This can

further affect females with asthma as those effects can be aggravated while under more stress (Constantini et. al., 2005).

The subjects in the study by Adachi et. al. (2008) also reported to have experienced several premenstrual symptoms such as mood swings, breast tenderness, low back pain, and irritability. Another study showed 20 of the 28 subjects to have undergone similar premenstrual symptoms, which was reported to have affected them in their physical activity during this time (Wojtys et. al., 1998). Even though many of them experienced these symptoms, the subjects might not have all experienced them to the same degree. Park et. al. (2009) noted that while studying knee laxity and stiffness in 26 females, not all of the subjects underwent the considered normal hormonal changes, nor do they experience all of the symptoms before and during the menstrual cycle. The study instead saw that each cycle is still unique to the individual and has to be seen that way when trying to study any aspect of the menstrual cycle in females.

The Relationship to ACL Injuries

The female menstrual cycle is known to have several different effects on the female's body including fatigue, sickness, and an impact on a female's mood and focus (Constantini, Dubnoc, & Lenrun, 2005). One of the main reasons for all of these effects is the changing of hormone levels within the different phases of the menstrual cycle (Park et al., 2009). The menstrual cycle can be broken down into three phases: the menstrual, the follicular, and the luteal phases. Different studies have been conducted to analyze the differing hormone levels throughout these three phases. The findings have shown estrogen and progesterone as the two main hormones affected by this cycle, both of which are also present in the ACL ligament itself (Agel et. al., 2006). When these hormones are detected within the ACL, they can affect the laxity of the ligament. This, in turn, can make the ACL more susceptible to tears or sprains because the

ACL is more vulnerable at these states. Heitz & Eisenman (1999) conducted a study to look at knee laxity under the influence of different levels of menstrual cycle hormones. Knee laxity was measured using a KT 2000 arthrometer during the different phases of the cycle to test the differences. The study concluded that knee laxity, which causes a higher risk of ACL injuries, was highest when estrogen was at its peak level. This peak level is during the later follicular phase of the menstrual cycle, which is also when progesterone is at a lower level. All of these studies were done on athletes, but they were done at the collegiate level and not at the high school level.

Studies have looked at these different hormone cycles and there have been attempts to determine if more injuries occurred during a specific phase of the cycle. Many of these studies, however, have had very small sample sizes and have conflicting results among each other (Wojtys et al., 1998). The sample sizes from these studies ranged from a minimum of 7 subjects to a maximum of 21 subjects. For this current study, the aim will be to have a larger sample size among the collegiate population. This sample size range would be at least 40 athletes from both the group participating in prevention and another 40 athletes who have not participated in prevention. Many of the above studies were also done using methods of various blood samples for discovering hormone levels (Park et. al., 2009). For finding knee laxity, the methods used were a KT-2000 arthrometer or different reflective markers using a computer software to mimic knee angles during movements (Shafiei et al., 2015 & Shultz et al., 2011). These studies as mentioned, determined that more knee laxity was shown during the follicular phase when estrogen was at a peak level. No study has been recorded by using a Lower Extremity Scoring System in order to correlate those scores in landing kinematics with the different phases of the menstrual cycle.

METHODS

Participants

There were 122 female athletes from a small NAIA school that participated in this study. The sports ranged in a wide variety including basketball, volleyball, softball, cross country, soccer, swim, track throws (shot put, hammer throw, javelin, etc.), and track jumpers (long jump, high jump, pole vault, etc.). All of the participants ranged from the ages 18-22 years old. Each participant had signed a written informed consent, which was improved by the university's Institutional Review Board before the testing was completed. For this study, the inclusion criteria with the ACL injury prevention test required that each athlete was actively participating in an organized JV or Varsity sport at the university. For the menstrual cycle testing, the inclusion criteria also required for the athletes to have a regular menstrual cycle within the parameters of the questionnaire that was given.

Questionnaire

A modified questionnaire based off of a previous study by Wojtys et al. (1998) was given to each athlete to be filled out. The questionnaire consisted of basic demographic information, sport/injury history, participation in previous prevention, and their basic menstrual history including length of cycles and date of last period. The menstrual cycle information questions were taken from the previous researched questionnaires, while the rest of the questionnaire was developed to be personalized in this study. The main purpose of the questionnaire was used to determine which athletes were actively participating in ACL injury prevention with their teams.

Procedure

The day before the scheduled testing date, each athlete had been given the questionnaire and consent form which were brought to the next session. The athletes had the entire testing

process explained and each team completed their testing before they had started any practice activity in order minimize the number of variables that would affect the outcome of the scores. The athletes were each assigned an identification number based off of their questionnaires in order to compare their questionnaires to their jump videos later on in the data analysis. After taking a measurement of the athlete's heights, each athlete then performed two of the vertical drop jumps based off of the LESS parameters. No jump was performed without first having a visual demonstration given beforehand. Videos of each jump from the frontal and side view totaling in about 4 videos for each athlete to be analyzed. During the collection of the questionnaires and videos, the athletes were then placed in a menstrual phase based off of the menstrual history provided in the questionnaire. These three phases for a standard 28-day cycle were distributed as follows: the menstrual phase lasting days 1-5, the follicular phase lasting days 6-14, and the luteal phase lasting days 16-28. Adjustments were made in accordance to the length of the cycle that the athlete provided.

LESS Scoring and Analysis

The videos were analyzed and scored according to the 19-point LESS scale in order to test whether or not the entire LESS is an accurate way to score athletes in comparison to ACL injury prevention and the menstrual cycle in female athletes (Dressendorfer, & Callanen, 2017, and Bird, & Markwick, 2016). Each athlete had two jump scores that were averaged to give that athlete an overall LESS score. The team's average LESS scores were compared to one another on the basis of whether or not these teams were participating in ACL injury prevention training. Any athletes who had a history of previous ACL injuries were not included in the final analysis. The average LESS scores of the athletes were also divided among the three menstrual cycle phases. The averages of each phase were then analyzed in order to determine any significant

difference between the scores. Athletes that had reported as having inconsistent cycles were not included in the final data analysis.

RESULTS

Out of the eight tested sports teams, basketball was the only sport that had reported actively participating in an ACL injury prevention program with their respective team. There were 5 athletes that were excluded from this data because they had sustained ACL injuries in their athletic history. The average LESS score of each team was assessed with basketball having the lowest average score of 5.43 out of the 19 possible pointed scale system. This specific score would be in a lower risk category for sustaining an ACL injury. The next closest sport was track (jumps) with an average score of 6.38. The next three sports were volleyball, soccer and track (throws) with average scores of 8.49, 8.68 and 8.75 respectively. Cross country had the highest average score of 10.05 out of the 19-point scale (Figure 1).

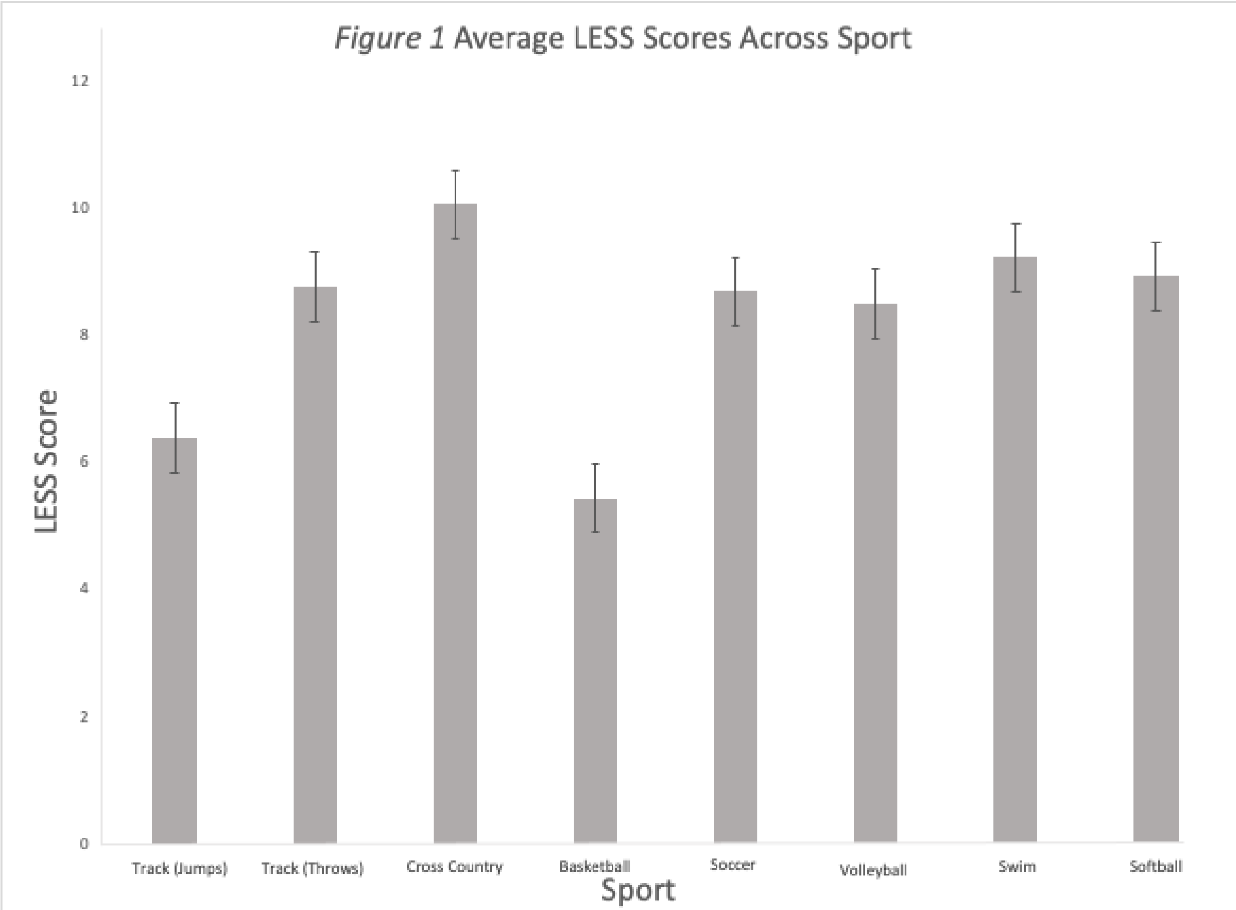

Figure 1. Teams with ACL injury prevention programs displayed lower LESS scores. The average scores of Track-Jumps (n=9), Track-Throws (n=6), Cross Country (n=9), Basketball (n=14), Soccer (n=20), Volleyball (n=21), Swim (n=25), and Softball (n=13) were all displayed above. Basketball had the lowest average of 5.43, and Cross Country had the largest with 10.05.

For the menstrual cycle analysis, 84 athletes were eligible to be included with a reported regular menstrual cycle. Most athletes were in the luteal phase with 43 athletes, 26 athletes in the menstrual phase, and 15 in the follicular phase. The lowest LESS score was for the follicular phase with an average score of 7.53, while the other two phases (menstrual and luteal, were slightly higher with average scores of 8.46 for the menstrual phase and 8.86 for the luteal phase (Figure 2).

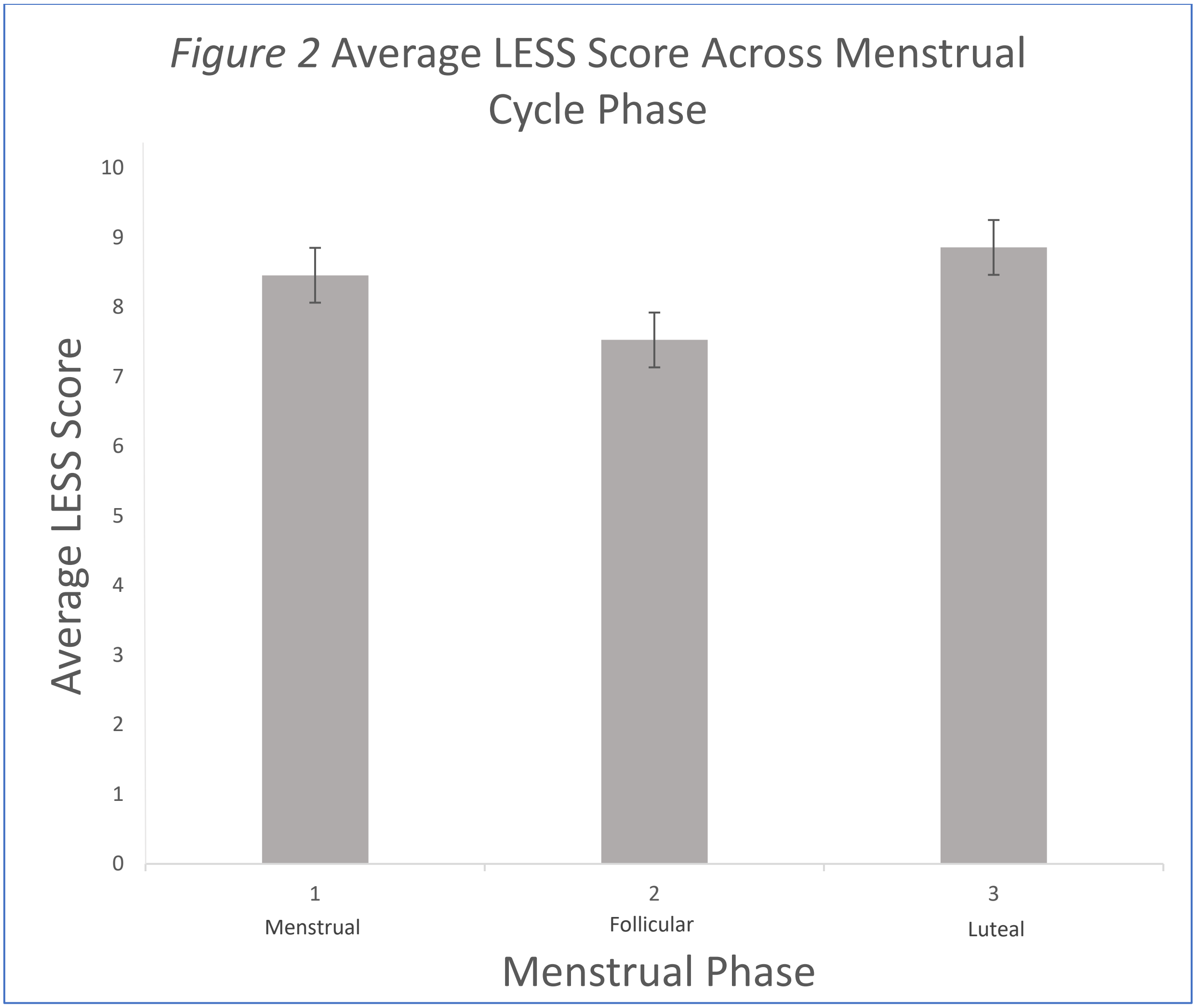

Figure 2. LESS scores were not meaningfully different during different phases of the menstrual cycle. The average scores of the LESS scores for each phase were shown with the different athletes that reported being in those respective phases. Menstrual (n=26), follicular (n=15), and luteal (n=43) were the three phases used in this study. The athletes in the follicular phase had the lowest average of 7.53, while also having the smallest number of athletes in that category.

DISCUSSION

ACL Injury Prevention

The main finding of this particular study showed that there were fewer teams that had been actively participating in ACL injury prevention at the collegiate level when compared to

other studies that conducted similar testing (Benjaminse et al., 2015). There was only one team out of the entire female athletic program that had been doing this injury prevention, which would potentially mean that the other athletic teams would be at a higher risk for ACL injuries than the one team that had been participating. This had been shown in previous studies by athletic programs who did and did not participate in ACL injury prevention (Myklebust, et al., 2006). The teams were shown to have a lower risk of sustaining an ACL injury after they had participated. However, it is important to note, that some regular training exercises that would also be used in ACL injury prevention, are already being used in an athletes regular training without the coach's or athlete's knowledge (Olsen, et al., 2005). For example, an athlete that is a part of the track team as a jumper would be training the same muscles and completing the same exercises that any other athlete would be doing in an ACL injury prevention program.

In terms of the LESS as being a reliable source for determining this same conclusion, the data from the LESS showed the single team (basketball) that had participated in ACL injury prevention training had the lowest average of LESS scores. All other sports had shown higher averages of their LESS scores, and those teams had not been actively participating like the single basketball team had. The track (jumps) group had been the next closest, which would be understandable considering the idea that their everyday training involves similar movements to that of ACL injury prevention. Cross country, having the highest average of LESS scores would therefore be considered to be at the highest risk of sustaining an ACL injury. However, cross country is a sport that does not involve as many jumping and cutting movements as the other listed sports. Therefore, it would be logical to assume that their scores would be naturally higher than the others. In the above analysis, the LESS showed to be a reliable assessment of the given data.

Based on the above data, it would be suggested that all female athletes at the collegiate level would begin participating in some sort of ACL injury prevention training with their respected teams. Many other studies have been completed to show the impact of these programs on the individual, with similar results as the ones displayed in this study (Padua, et al., 2015). These programs have been adapted and grown more popular among the athletic community, but many coaches still are not fully informed on what these programs consist of and their benefits to athletes. It is important that coaches are encouraged to implement this training in order to save their athletes from career-altering injuries.

The Menstrual Cycle

The menstrual cycle data showed that the lower LESS scores were during the follicular phase, which was the opposite of the hypothesis. There were many reasons why this could have been the outcome of the study. The method of using the LESS to display a difference between the three phases had not been a common method used in past studies. Many studies like those completed by Park et al. in 2009 used methods such as blood and laxity tests to show the differences in the hormone levels of the individuals. Even though there was a slight difference between average LESS scores of the three phases, there was not enough evidence to conclude this difference to be anything more than minimal. Using the LESS as the methodology was a novel choice because most studies have used other methods such as the KT 2000 arthrometer. However, based on the results of this study, replication would need to take place in order to determine whether or not this methodology is a viable tool for other studies of this nature relating to the menstrual cycle. One of the main drawbacks of this method was the number of subjects that qualified for this analysis. There were 38 athletes who were not included in this analysis for having inconsistent menstrual cycles. This meant that there was a sample size of 84 athletes

involved in the study, and each phase did not have the same number of athletes who fell into those categories. It is suggested that this same study should be replicated among multiple collegiate athletic programs in order to determine whether or not the LESS would be an accurate screening tool for female athletes and their ACL injury susceptibility during different phases of their menstrual cycle.

CONCLUSION

In this study, there were a limited number of athletes participating in ACL injury prevention. Those athletes that had participated scored a lower average LESS, which means that they were at a lower risk of sustaining an ACL injury. The results indicate that there is a great importance on ACL injury prevention among athletes at all levels in order to help reduce the number of injury occurrences. Further research would still need to be completed, however, in order to see the reliability of the LESS with different phases of the menstrual cycle. It is also suggested that this study be replicated among younger and older athletes in order to ensure that this testing is an equalized method at all levels. This study can be used as a tool to encourage coaches to stress the importance of ACL injury prevention training within their athletic circles.

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