[Athletic Training]

Analyses of Landing Mechanics in Division I Athletes Using the Landing Error Scoring System

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Background: Injury to the anterior cruciate ligament (ACL) can be detrimental to any athlete, having both short- and long-term health consequences. Examining preseason screening landing mechanics can indicate the likelihood of injury during the season. Furthermore, previous injury is also commonly referred as a predisposing factor for reinjury.

Hypothesis: Players with a history of lower extremity injury would have higher Landing Error Scoring System (LESS) scores than those with no previous injury, and healthy soccer athletes who sustained an injury during the 2014 season would have higher LESS scores than those who remained uninjured.

Study Design: Prospective cohort study.

Level of Evidence: Level 3.

Methods: Thirty-four Division I male and female soccer athletes (19 men, 15 women; mean age, 19.6 ± 1.2 years; mean height, 172.4 ± 8.7 cm; mean weight, 70.8 ± 9.1 kg). An a priori sample size estimation for a power of 0.80 (80%) and an alpha error of 0.05 with an estimated effect size of 0.6 for a sample of 30 participants was attained. Participants performed a drop-landing task and were scored on their landing mechanics using the LESS. Lower extremity injuries were tracked during the season. LESS scores between those with and without a history of injury and those who were injured and uninjured during the season were compared using 2 separate 1-way analyses of variance.

Results: No statistically significant differences ($F_{1,33}$ = 0.47, P = 0.50) existed between LESS scores in athletes who had a previous injury history compared with those with no injury history. No statistically significant differences ($F_{1,20}$ = 0.05, P = 0.83) existed between LESS scores in healthy athletes who were injured during the 2014 season compared with those healthy athletes who were uninjured.

Conclusion: No differences were present between athletes with and without a history of lower extremity injury. The majority of healthy participants who were injured during the season had similar LESS scores to those who remained uninjured, suggesting that the LESS may not be able to identify atypical landing mechanics in this group of athletes.

Keywords: clinical tools; injury; athletes; landing

Injuries to the lower extremity are common in sports, with the anterior cruciate ligament (ACL) being the most commonly injured ligament of the lower extremity.[1] Approximately 250,000 ACL injuries occur each year in individuals between the ages of 15 and 25 years.[11,36] ACL tears and respective reconstruction have a detrimental impact on any athlete, including knee pain, increased knee instability, and prolonged absence from sport.[12,34] Long-term health consequences include decreased function and early onset osteoarthritis.[31]

Up to 70% of ACL injuries are noncontact in nature and occur as a result of a jump-landing, which creates a valgus force on the lower extremity with the knee in close to full extension.[14,22] These injuries typically occur when there is an anterior tibial force with the knee in close to full extension associated with a

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valgus moment, such as when the athlete is landing from a jump, cutting, or pivoting.[17,25,33] The biomechanical risk factors of these movements have been reproduced clinically with the use of a drop-landing task.[7,11,21,25,28,30] Hewett et al[14] reported that individuals who perform a drop jump–landing task and display increased knee valgus angle along with increased external valgus moments are at increased risk of sustaining an ACL injury. Furthermore, individuals with a history of ACL reconstruction are at an increased risk of future lower extremity injury or ACL reinjury.[9,26]

A laboratory-based motion analysis system is often the primary instrument used to identify those at increased risk of lower extremity injury.[25] Motion analysis makes it difficult to screen large populations of athletes given it is costly, time consuming, and requires specific video equipment and specialized programming software with countless hours for analysis.[3,25] Several screening tests have been developed to clinically assess those performing a drop-landing task.[3,18,25] The Landing Error Scoring System (LESS) was developed as an inexpensive clinical assessment tool to identify those who have high-risk movement patterns during a drop-landing task.[25] The LESS is performed with 2-dimensional video camera assessment and is based on a 17-question video analysis in which an investigator evaluates the participants performing a drop-landing task.[25] The LESS has shown to be valid when compared with 3-dimensional motion analysis systems[23,25] and has good inter- and intrarater reliability.[22,23] A higher LESS score may be indicative of poor landing mechanics, which may suggest an increased knee valgus but it is not an indication of it. Increased knee valgus has been proposed as a predictor of noncontact ACL injuries.[13,17,22,25,33] Researchers found that participants who had lower LESS scores were more susceptible to an ACL injury.[24]

Clinical assessment tools have been used in the past to identify weaknesses that athletes may possess, especially after a lower extremity musculoskeletal injury.[5] The Balance Error Scoring System (BESS) was shown to be a reliable tool when evaluating postural stability; however, this test does not address specific dynamic movements associated with lower extremity injury in sport.[29] Another popular clinical assessment tool, the Star Excursion Balance Test (SEBT), may be a reliable functional test of dynamic balance.[15] The SEBT, much like the BESS, does not address specific movement patterns associated with the biomechanical risk factors of lower extremity injury. A specific algorithm to identify female athletes who have high knee abduction moments requires specialized software programs for analysis.[18] A simpler iLESS analyzes a single jump from the frontal plane.[3] Although the iLESS showed a high level of agreement in ACL injury–identifying risk factors, it does not evaluate the sagittal plane (knee extension) on landing, which may be a risk factor for ACL injury.[17,25,33] At baseline prefatigue, individuals with ACL reconstruction had higher LESS scores than healthy individuals, suggesting that individuals who have undergone ACL reconstruction may not have good landing mechanics.[8]

The primary purpose of this study was to compare LESS scores of Division I soccer players who had a history of lower extremity injury with those who had no history of injury at preseason. Our hypothesis was that athletes who had a previous history of injury would have higher LESS scores than those without a previous history of lower extremity injury. Our secondary purpose was to compare LESS scores of healthy Division I soccer athletes who sustained a lower extremity injury during the 2014 season with athletes who remained uninjured during the season. We hypothesized that healthy athletes who sustained injury would have higher LESS scores than those who remained uninjured during the 2014 season.

METHODS

Participants

All study protocols were approved by the university institutional review board, and all participants signed an informed consent form prior to participation. A convenience sample of 34 (19 men, 15 women) NCAA Division I athletes participated in the study (Table 1). The group with a history of lower extremity injury had a previous lower extremity injury or surgery, including but not limited to ACL reconstrution; had no symptoms limiting participation in soccer at the time of testing; and was cleared for competition by a team phyisician at the time of testing.[27] The healthy group had no previous history of lower extremity injury and no current symptoms limiting their participation in soccer at the time of testing.[4,23] Previous history of injury was self-reported by the participants and consisted of sprains, strains, contusions, tendonitis, and injuries resuting in surgery. Lower extremity injury was defined as any injury that caused the participant to miss 1 or more practice or game (mean, 6 practices missed [range, 1-25]; mean, 6 games missed [range, 1-7]).[10,26]

Experimental Procedure

Athletes were recruited at the beginning of the fall 2014 season. All participants performed a drop-landing task while being videotaped with 2 standard video cameras (Sony HDR CX380) in the frontal and sagittal planes using complete LESS protocols.[4,22,25,33] Previous research has shown that the LESS is a valid and reliable clincial assessment tool.[22-25] Participants performed 3 practice trials for task familiarization. Participants were instructed to drop forward using both feet and to then immediately jump straight into the air as if going up for a header.[25] Participants were given no more instruction or feedback unless they were performing the task incorrectly. A successful jump used 2 feet, was forward and not vertical, and was in 1 fluid motion.[25] Once the participants practiced the drop-jump task, they performed 3 test jumps and were given a 1-minute break between trials.

Statistical Analysis

An a priori sample size estimation for a power of 0.80 (80%), an alpha error of 0.05, and an estimated effect size of 0.6 for a sample of 30 participants was attained. Interrater reliablity between a novice and expert rater was established after a

Table 1. Participant anthropometric information

	Hypothesis 1[a]		Hypothesis 2[a]	
	History of Injury (n = 13)	No History of Injury (n = 21)	Injured (n = 10)	Uninjured (n = 11)
Age, y	19.7 ± 1.2	19.6 ± 1.3	19.6 ± 1.2	19.6 ± 1.4
Height, cm	169.7 ± 5.7	174.0 ± 9.9	174.8 ± 11.0	173.3 ± 9.3
Weight, kg	69.6 ± 5.9	71.5 ± 10.7	72.4 ± 12.0	70.7 ± 9.8

[a]Hypothesis 1: Participants who had a previous history of injury compared with those who reported no history of previous injury. Hypothesis 2: Healthy participants who were injured during the 2014 soccer season compared with those who were uninjured.

60-minute training session.[22] The scoring researcher (J.J.) underwent a successful 60-minute training session on evaluating video using the LESS. A single researcher analyzed all videos using the LESS with a between-day reliability of 0.95. One-way analysis of variance (ANOVA) was performed comparing LESS scores between participants who had a previous history of lower extremity injury and those who did not. A separate 1-way ANOVA was used to compare LESS scores of healthy participants who sustained an injury during the 2014 season with those who remained uninjured. All analyses were conducted using SPSS (v23), and an alpha level of 0.05 was set a priori.

RESULTS

The overall LESS score for all 34 participants was 5.4, with a range between 2 and 13.3. The LESS score mode for all participants was 4.7.

There were no statistically significant differences in LESS scores between participants who had a previous injury (n = 13) compared with participants who did not have a previous injury (n = 21) ($F_{1,33}$ = 0.47, P = 0.50). The mean LESS score for those who reported a previous history of injury was 4.9 ± 2.4, whereas for those who were uninjured prior to testing, the mean LESS was 5.6 ± 2.9.

From the 21 participants who did not report a history of lower extremity injury prior to testing, 10 participants sustained a lower extremity injury during the 2014 season, whereas 11 participants remained uninjured (Figure 1). There were no statistically significant differences in LESS scores at preseason between those participants who sustained an injury and those who were uninjured during the season ($F_{1,20}$ = 0.05, P = 0.83). The mean LESS score of participants who were injured during the season was 5.5 ± 2.5, while those who were uninjured during the season had a mean LESS score of 5.8 ± 3.4.

DISCUSSION

The need to quickly and efficiently identify those at increased risk of ACL injury is apparent. Athletes who have a previous history of ACL injury resulting in surgery are 15 times more likely to reinjure their ACL.[26]

LESS scoring can be divided into 4 quartiles: excellent (≤4), good (>4 to ≤5), moderate (>5 to ≤6), and poor (>6).[25] Participants reporting a history of lower extremity injury had a mean LESS score of 4.9, indicating a good LESS score[25] and potentially decreased biomechanical risk of lower extremity injury.[8] Rehabilitation programs can be similar to the neuromuscular prevention programs that have been successful in decreasing the risk of ACL injury.[13,16,19,20,32] Neuromuscular training can reduce the risk for ACL injury[12,19] and the valgus moment in the lower extremity.[19] In the ankle, decreased stability may be present for up to 2 years after lower extremity injury.[2] Our results show that after a rehabilitation program, there are decreased biomechanical risk factors in athletes returning to sport. An LESS score of less than 5 may indicate that an athlete is at a decreased risk of lower extremity injury and has good to excellent landing mechanics.[24,25]

The average LESS score for those who were injured was 5.5, and those who were uninjured had an average LESS score of 5.8. Most studies involving the LESS are done to identify those with high-risk movement patterns, leaving athletes more vulnerable to lower extremity injury.[25] These results are consistent[33]: although reliable at identifying those with biomechanical risk factors of ACL injury, the LESS could not predict ACL injury.

Both our male and female soccer athletes participate in a strength and conditioning program at least twice a week during their fall season. In addition, prior to practices and games, each team engaged in a dynamic warm-up to prepare them for competition. It is noteworthy that our results contrast those from previous studies that reported that individuals with a history of ACL reconstruction have movement patterns associated with increased risk for another ACL injury.[8] Both groups had LESS scores in the moderate range, suggesting they have limited biomechanical risk factors of lower extremity injury.[25] A majority of our participants scored 4.7 on the LESS. LESS scores of 5 or greater may place athletes at increased risk of lower extremity

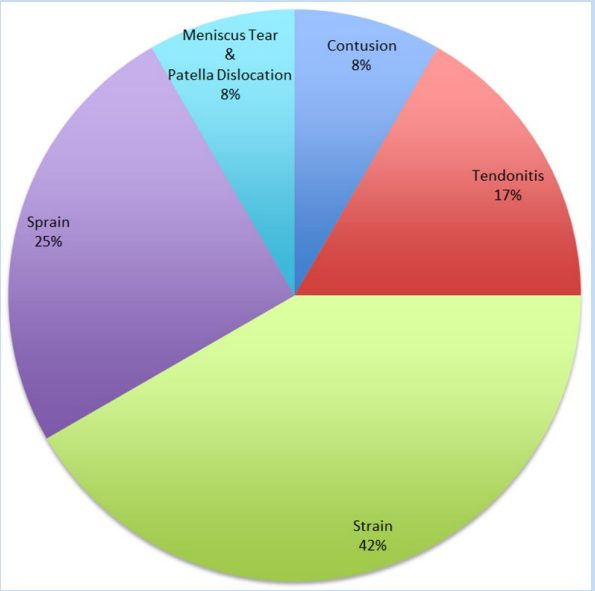

Figure 1. Types of injuries sustained during the 2014 Division I soccer season. These include knee, foot, quadriceps contusions, knee tendonitis, foot and ankle strains, and knee surgeries.

injury.[24] These results indicate that a majority of our participants already had good landing mechanics[25] and were at decreased risk of lower extremity injury.[24]

We acknowledge the following study limitations. Our study utilized a small sample size and only a single season worth of injury tracking. Participants' self-reported their previous history of lower extremity injury on a medical questionnaire and was not based on medical records. Prior research has shown that when asked to recall injuries 12 months after the injury occurred, only 61% of participants were able to accurately self-report the injury.[6,35] Also, using a smaller time frame than 8 years may have resulted in more accurate self-reported injury recall.

CONCLUSION

The LESS did not identify atypical landing mechanics in this sample; both groups had similar landing mechanics as screened by the LESS. A majority of healthy participants injured during the season had similar LESS scores to those who remained uninjured. The lack of differences between groups may indicate that the LESS may not provide additional screening value in athletes who have already been cleared to return to play by the medical team. This study found that the LESS could not identify atypical landing mechanics between individuals who had an injury during the season and those who did not.

Clinical Recommendations

SORT: Strength of Recommendation Taxonomy
A: consistent, good-quality patient-oriented evidence
B: inconsistent or limited-quality patient-oriented evidence
C: consensus, disease-oriented evidence, usual practice, expert opinion, or case series

Clinical Recommendation	SORT Evidence Rating
Athletes, regardless of injury status, should be screened for biomechanical patterns that may increase their risk of injury or reinjury.	C
Neuromuscular training and strength and conditioning programs can improve landing mechanics even after injury.	C

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