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Low Back Pain or Injury Before Collegiate Athletics, a Potential Risk Factor for Noncontact Athletic Injuries

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Context: Surrounding the predictive value of clinical measurements and assessments for future athletic injury, most researchers have not differentiated between contact and noncontact injuries.

Objectives: We assessed the association between clinical measures and questionnaire data collected before sport participation and the incidence of noncontact lower extremity (LE) injuries among Division III collegiate athletes.

Design: Prospective cohort study.

Setting: University setting, National Collegiate Athletic Association Division III.

Patients or Other Participants: Here, 488 Division III freshmen athletes were recruited to participate in the study during their preseason physical examinations.

Main Outcome Measure(s): Prospective incidence of noncontact LE injury. Athletes completed questionnaires to collect demographics and musculoskeletal pain history. Clinical tests, performed by trained examiners, included hip provocative tests, visual appraisal of a single-leg squat to identify dynamic knee valgus, and hip range of motion. Injury surveillance for each athlete's collegiate career was performed. The athletic training department documented each athlete-reported new onset injury and documented the injury location, type, and outcome (days lost, surgery performed). Univariable generalized estimating equation models were used to analyze the relationship between each clinical measure and the first occurrence of noncontact LE injury. An exchangeable correlation structure was used to account for repeated measurements within athletes (right and left limbs).

Results: Of the 488 athletes, 369 athletes (75%) were included in the final analysis. Sixty-nine noncontact LE injuries were reported. Responding *yes* to, "Have you ever had pain or an injury to your low back?" was associated with an increased risk of noncontact LE, odds ratio = 1.59 (95% confidence interval = 1.03, 2.45; $P = .04$). No other clinical measures were associated with an increased injury risk.

Conclusions: A history of prior low back pain or injury was associated with an increased risk of sustaining a noncontact LE injury while participating in National Collegiate Athletic Association Division III athletics.

Key Words: noncontact injury, injury risk, injury prediction

Key Points

- A history of low back pain or low back injury is associated with an increased risk of future noncontact lower extremity injury in National Collegiate Athletic Association Division III athletes.
- No other clinical measurements, including provocative hip testing, hip range of motion, presence of dynamic knee valgus during a single leg squat, or previous lower body injury, were associated with an increased risk of injury.

Primary prevention of athletic injury presents a promising means of reducing overall health care costs and injury burden while potentially extending athlete careers through multiple developmental levels. Primary prevention by clinicians and other sports medicine providers can involve the modification of both extrinsic and intrinsic risk factors to the athlete.[1] Modification of extrinsic factors, such as athlete-to-athlete contact, can be achieved through the use of protective equipment and adequate enforcement of competition rules designed to ensure player safety.[1] In contrast, modification of intrinsic risk factors involves understanding which intrinsic factors (such as prior injury history,[2,3] dynamic knee valgus [DKV],[4] and joint range of motion [ROM][5]) may be related to future injury rates.

In much of the current literature surrounding intrinsic risk factors for future injury, the relationship between prior injury and future injury rates has been examined. In these cases, the initial injury is known as the *index injury*, and a future injury to the same location is known as a *recurrent injury*, while an injury to an adjacent location or tissue is known as a *subsequent injury*.[2,6] While in the literature causal relationships are not clear, it is generally understood that index injuries increase the risk of both recurrent and subsequent injuries.[2,3,7] With regard to the lower extremity (LE) specifically, intrinsic factors that have been proposed to increase athlete risk of future injury include movement impairments, specifically DKV displayed during sporting tasks or tests,[4] and hip joint ROM,[5] among others. The use of hip provocative tests as screening tests has also gained recent interest.[8]

Authors assessing LE injuries do not often clearly differentiate between contact and noncontact injuries in their reporting.[7,9] Researchers that do distinguish between contact and noncontact injuries tend to focus their investigation on either overuse injuries such as medial tibial stress syndrome or Achilles tendinopathy in running athletes or noncontact anterior cruciate ligament (ACL) injury exclusively.[10–12] However, it is important to distinguish between contact and noncontact injuries in investigations of risk factors across all sports, as injuries involving athlete-to-athlete contact involve circumstantial, extrinsic factors that are not readily mitigated through primary prevention. Conversely, noncontact and overuse injuries may be directly related to intrinsic factors of the individual athlete and thus represent a more viable interventional target for primary prevention efforts.[12–14] Thus, it is important for researchers investigating clinical assessment as a means of primary prevention to evaluate noncontact injuries separately, as the inclusion of both contact and noncontact injuries has the potential to confound study results.

In the present study, we seek to add to the understanding of potential risk factors associated with the first occurrence of a noncontact LE injury across multiple sports. By recording preseason athlete survey responses and clinical measurements, we sought to assess the relationship between athlete injury history, clinical measurements, and the likelihood of future LE injury. In doing so, we hope to determine candidate risk factors that, with further investigation, could be classified as risk factors that can be readily screened for and addressed as means of primary prevention of athletic injury. Based on the established evidence, we hypothesized that a history of previous low back, hip, or knee injury or pain, the presence of DKV during a single leg squat assessment, and decreased hip internal rotation (IR) and external rotation (ER) ROMs would be associated with an increased occurrence of future noncontact LE injuries, while hip provocative tests would not.[2,6,14]

METHODS

During the 2008–2012 seasons, we invited Division III varsity athletes from a single university to participate in a hip-specific screening examination. The screening examination was performed concurrently with their preseason medical screenings. Athletes were required by Washington University to participate in their preseason medical screenings before participating in any aspect of competition including practices; however, participation in the study was voluntary. This study was approved by the Washington University's Human Research Protection Office. To participate in the screening, athletes who were at least 18 years of age signed a statement of informed consent, and those younger than 18 years of age required parental consent and athlete assent. We have reported baseline data on these athletes in our previously published paper reporting the sex-related differences in hip ROM and provocative testing.[15]

Examiner Training

Due to the high volume of athletes during the screenings, we recruited and trained 35 examiners to complete testing procedures over the 5 years of data collection. Twelve examiners were orthopaedic physical therapists, 8 were physiatrists with specific expertise in nonoperative management of musculoskeletal conditions, and 15 were student physical therapists. All participating students completed their didactic training in clinical examination performance. Training for all examiners included review of the procedure manual and participation in 1 training session led by the principal investigator (M.H.H.), a physical therapist with greater than 10 years of clinical and teaching experience. Before data collection, all examiners were required to demonstrate proper testing procedures to measure hip ROM and perform provocative tests. If an examiner failed to demonstrate proper procedures, further training and assessment were provided. The testing was completed over a 5-year period; therefore, training sessions and performance checks were performed annually. Our research team has reported good reliability with these hip ROM measurements (intraclass correlation coefficients > 0.86) and 96% agreement for provocative tests.[16]

Athlete Testing

After enrollment into the study, athletes completed self-report questionnaires for demographic information and musculoskeletal pain history. For musculoskeletal pain history, athletes were asked, "Have you ever had pain or an injury to your low back?" Similar questions were asked for each hip and knee. We then asked athletes to complete test items at 2 different stations: 1 for hip ROM and provocative tests and 1 for the movement assessment. We used multiple stations with an examiner for the tests for hip ROM and provocative tests. One station with 1 examiner (M.H.H.) was available for the movement assessment.

Hip ROM and Provocative Testing

Two examiners completed testing at each station. The primary examiner performed the hip ROM and provocative tests. The secondary examiner assisted by holding the final limb position as the primary examiner completed the ROM measurement and recording the test values. We used a standard 12.5-inch goniometer to assess ROM. To minimize athlete burden and disruption of their medical screenings, we completed all test items once per athlete.

Hip ROM. All hip ROM testing was performed with the athlete in supine or prone position, with his or her contralateral limb extended and supported by the testing surface. Before performing each ROM measure, the examiner demonstrated the motion to the athlete by passively moving his or her limb through its full motion. During performance of the hip ROM items, the examiner used stabilization and monitoring to prevent compensatory motion at adjacent joints while determining the end of joint motion. Once the final position was determined, the secondary examiner held the limb in position, and the primary examiner completed the measurement.

Hip Flexion (Supine). Final hip flexion ROM was identified as the point in which the hip could no longer be flexed without compensatory posterior pelvic tilt. The goniometer was aligned with 1 arm along the bisection of the pelvis and 1 arm along the bisection of the thigh to determine the hip flexion ROM angle.

Hip IR and ER With the Hip at 90° Flexion (Supine). The examiner flexed the hip to approximately 90°, then determined the final hip IR and hip ER ROMs. Final hip IR and ER ROMs were identified as the point in which the hip could no longer be rotated without compensatory pelvic tilt. The goniometer was aligned with 1 arm parallel to the trunk and 1 arm along the bisection of the lower leg to determine the hip IR and ER ROM angle.

Hip IR and ER With the Hip at 0° Flexion (Prone). The examiner flexed the knee to approximately 90°, then determined the final hip IR and hip ER ROMs. Final hip IR and ER ROMs were identified as the point in which the hip could no longer be rotated without compensatory pelvic rotation. Rotation at the knee joint was also monitored to prevent inflated hip rotation ROM values.[17] The goniometer was aligned with 1 arm perpendicular to the testing surface and 1 arm along the bisection of the lower leg to determine the hip IR and ER ROM angle.

Provocative Tests. We performed provocative tests with the athlete in supine position, with his or her contralateral limb extended and supported by the testing surface. Before performing each test, the examiner explained the test to the athlete and instructed him or her to report if he or she had any pain during the test. A *positive* test was defined as an onset of pain that was not associated with a stretching sensation or muscle soreness. If the test was positive, the examiner would ask for the location of pain. Location of pain was noted as groin (anteriorly along inguinal crease between pubis and anterior-superior iliac spine), lateral hip (between iliac crest and superior greater trochanter laterally), or buttock (posterior between gluteal fold and iliac crest).

Flexion-Adduction-IR Test. The flexion-adduction-IR (FADIR) test is a commonly used test in the assessment of hip pain in the young adults, and it has been shown to be a sensitive test but is not specific in detecting hip-related groin pain.[18] To perform the test, the examiner flexed the hip to approximately 90°, moved the hip joint into end of range IR and adduction, then applied overpressure. We have previously reported the prevalence of positive tests and location of pain during the FADIR testing in a parent study.[15]

Flexion-Abduction-ER Test. The flexion-abduction-ER (FABER) test is a provocative test commonly used in the assessment of hip, lumbar spine, or sacroiliac joint pathology. The examiner placed the ankle of the athlete's tested limb just above the opposite knee in a figure-4 position. Overpressure was applied to the knee of the tested limb, perpendicular to the table with stabilization force applied on the contralateral pelvis to avoid pelvic rotation.

Movement Assessment Using the Single-Leg Squat. One examiner (M.H.H.) performed all visual assessments of the single-leg squat and classified the movement as *DKV* or *no DKV*. The athlete was instructed to perform the single-leg squat with his or her arms crossed over his or her chest. To perform the squat, we asked the athlete to flex the knee opposite his or her tested (weightbearing) limb so that his or her foot was positioned posteriorly, then squat down as far as he or she could. If the athlete did not achieve a minimum of 60° knee flexion, determined visually by the examiner, or he or she lost his or her balance during the squat, we asked him or her to repeat the squat. The examiner classified knee valgus as *yes* or *no*. We have reported our methods to classify LE movement patterns previously.[19] Briefly, the examiner used the change in the frontal plane projection angle of the knee between the single-leg stance position and at the maximum depth of the squat movement. If the frontal plane projection angle changed more than 10° between the 2 positions, and the knee moved toward the midline of the body, then the movement was classified as dynamic valgus. Otherwise, the movement was classified as no dynamic valgus.

Injury

Injury surveillance was completed by the athletic training department at Washington University between the years 2008 and 2016 to capture all active years for each athlete. Injuries sustained during the athlete's collegiate career which resulted in time lost in sport were assessed and recorded by one of the certified athletic trainers. The athletic training team recorded information related to the injury classification, mechanism (contact or noncontact), and outcome, including days lost due to injury and if surgery was required.

Data Analysis

We screened a total of 488 athletes. For this analysis, we focused on injuries that occurred prospectively, after the screening; therefore, we excluded 58 and 30 athletes who reported current hip or knee pain, respectively. Because we focused on noncontact LE injuries, we also excluded 11 athletes who reported contact injuries and 3 athletes that reported a low back injury. Seventeen athletes were excluded because their mechanism of injury (contact or noncontact) was not recorded. The final dataset included data from 369 athletes. We conducted a univariate analysis to compare the characteristics of the included and excluded students. For continuous variables, we compared medians using Wilcoxon tests. Categorical variables are compared using χ^2 tests or Fisher exact tests.

We used generalized estimating equation (GEE) models to analyze the relationship between the clinical test measurements and the first occurrence of a noncontact LE injury. Noncontact LE injuries were coded as a binary variable. Each limb was included as a separate observation in the analysis, resulting in a total n of 738 limbs. Since our goal was to assess the association of potential risk factors with the first occurrence of a noncontact LE injury, once an injury occurred, the athlete no longer contributed data to the analysis. The GEE models employed an exchangeable correlation structure to account for repeated measurements for each limb from each athlete. Univariable odds ratios (ORs) and 95% confidence intervals are provided as 5-unit increases for the hip ROM variables and 1-unit increases for the other clinical tests. We conducted all statistical analyses using SAS 9.4, and a significance level of $\alpha = .05$ was considered statistically significant.

RESULTS

Demographics for the total sample, those removed, and the final sample are provided in Table 1. Most athletes who

Table 1. Descriptive Data

Variable	All Athletes, n = 488	Removed, n = 119	Remaining, n = 369	*P* Value
Sex, No. (%)				
Male	341 (69.88%)	89 (74.79%)	252 (68.29%)	.14[a]
Female	146 (29.92%)	29 (24.37%)	117 (31.71%)	
Missing	1 (0.2%)	1 (0.84%)	0	
Race, No. (%)				
Asian	23 (4.71%)	3 (2.52%)	20 (5.42%)	<.001[a]
Black or African American	19 (3.89%)	4 (3.36%)	15 (4.07%)	
White	376 (77.05%)	66 (55.46%)	310 (84.01%)	
Other	70 (14.34%)	46 (38.66%)	24 (6.50%)	
Ethnicity, No. (%)				
Hispanic	16 (3.28%)	4 (3.36%)	12 (3.25%)	<.001[b]
Not Hispanic	353 (72.34%)	54 (45.38%)	299 (81.03%)	
Unknown	119 (24.39%)	61 (51.26%)	58 (15.72%)	
Primary sport, No. (%)				
Baseball or softball	31 (6.35%)	6 (5.04%)	25 (6.78%)	Not calculable[c]
Basketball	57 (11.68%)	13 (10.92%)	44 (11.92%)	
Cross, run, or track	102 (20.9%)	21 (17.65%)	81 (21.95%)	
Football	150 (30.74%)	33 (27.73%)	117 (31.71%)	
Soccer	58 (11.89%)	18 (15.13%)	40 (10.84%)	
Swimming	31 (6.35%)	2 (1.68%)	29 (7.86%)	
Volleyball	10 (2.05%)	1 (0.84%)	9 (2.44%)	
Other	1 (0.84%)	2 (1.68%)	24 (6.5%)	
Missing	23 (4.71)	23 (19.33)	0	
Age, median (IQR)[d]	18 (18–19)	18 (18–19)	18 (18–19)	.08[e]
BMI (kg/m^2), median (IQR)[f]	23.1 (21.3–26.0)	21.1 (21.7–27.4)	23.0 (21.3–25.8)	.13[e]

Abbreviations: BMI, body mass index; IQR, interquartile range.
[a] *P* value from a χ^2 test.
[b] *P* value from a Fisher test.
[c] Not calculable due to small cell sizes.
[d] 49 athletes did not report age.
[e] *P* value from a Wilcoxon test.
[f] BMI was calculated using self-reported height and weight.

participated in our study were male (252/369, 68.29%) and White (310/369, 84.01%) with a median age of 18 (interquartile range [IQR], 18–19). The primary sport among athletes varied, with the largest groups being in football (117/369, 31.71%) and cross-country, running, and track (81/369, 21.95%).

We recorded 69 injuries. Table 2 presents the distribution and percentages of injury diagnoses, injury sport, injury types, and the effect of injuries on surgery and time lost due to injury. Most injuries were acute in nature (59/69, 85.51%), with the most prevalent injury diagnosis being thigh strain (16/68, 23.53%), followed by ankle sprain (15/68, 21.74%), knee sprain (7/68, 10.14%), and knee tear (6/68, 8.70%). Football had the highest occurrence of injuries among athletes, accounting for 28/68 (41.18%) of reported injuries. All injured athletes reported some amount of time lost due to injury, indicating that all injuries in the study had an effect on athletes' ability to participate.

Table 3 provides descriptive data and ORs with 95% CIs for the univariable GEE models assessing association of clinical test measurements with the first occurrence of injury. Responding *yes* to, "Have you ever had pain or an injury to your low back?" was associated with an increased risk of noncontact LE injury during an athlete's collegiate career. No other measured variables were associated with an increased injury risk.

DISCUSSION

In this study, we investigated factors believed to be associated with noncontact LE injury risk among collegiate athletes. Of the variables tested, we found an athlete's self-report of previous back pain or injury was associated with an increased likelihood of future noncontact LE injury. Contrary to our hypothesis, DKV during a single-leg squat, ever having hip pain or knee pain, or hip ROM were not associated with increased risk. Additionally, provocative tests were not associated with increased risk. While our study was not designed to investigate potential causal relationships between any of the measured variables and injury outcomes, we speculate that previous low back pain or injury may serve as a prognostic indicator for latent low back, LE impairments, or both that predispose athletes to noncontact LE injuries. Given the close anatomical functional relationship between the low back and lower extremities, it is possible that impairments in either the low back or lower extremities may predispose the other to future injury.[20–22]

In our study, we found that an athlete's report of previous low back pain or injury may indicate the athlete will be at risk for a future LE injury. Our findings are consistent with those of Zazulak et al, who also found an association between low back pain history and future knee injury among athletes.[23] Knowledge of an athlete's history of

Table 2. Summary of Noncontact Injuries

Variable	No. (%)
Location, injury type	
Hip, strain	3/68 (2.0)
Thigh, strain	16/68 (23.5)
Thigh, tendinitis	2/68 (2.9)
Knee, dislocation	1/68 (1.5)
Knee, inflammation	1/68 (1.5)
Knee, sprain	13/68 (18.8)
Shank, fracture	3/68 (4.4)
Shank, rupture	1/68 (1.4)
Shank, strain	4/68 (5.8)
Ankle, bursitis	1/68 (1.5)
Ankle, sprain	15/68 (23.2)
Ankle, tendinitis	1/68 (1.5)
Foot, fracture	3/68 (4.4)
Foot, sprain	3/68 (4.4)
Foot, tendinitis	1/68 (1.5)
Injury sport	
Baseball or softball	2/68 (2.9)
Basketball	6/68 (8.8)
Cross, run, or track	19/68 (27.9)
Football	28/68 (41.2)
Soccer	6/68 (8.8)
Swimming	1/68 (1.5)
Tennis	1/68 (1.5)
Volleyball	5/68 (7.4)
Injury type	
Acute	59/69 (85.5)
Gradual onset	10/69 (14.5)
Injury resulted in surgery	
No	40/51 (78.4)
Yes	11/51 (21.6)

previous low back pain or injury may assist in personalizing training programs before starting his or her sport season. Although the report of previous low back pain itself is not a modifiable factor, it may suggest the need to screen for neuromuscular impairments of the trunk. Previous low back injury has been associated with persistent impairments in trunk muscle activation, even after symptoms have resolved and athletes have returned to their previous level of sporting function.[24,25] Further, these trunk impairments have been associated with future LE injury, which may explain why we found a relationship between self-report history of low back pain and future LE injury.[9,23,26] However, we can only speculate, given that we did not collect measures related to impairments of the trunk. If future investigators find that previous low back pain or injury is a risk factor for future LE injury, a simple questionnaire could be used to identify athletes who may benefit from a more thorough examination and treatment of impairments associated with low back pain or injury.

Although a history of low back pain was the only intrinsic factor found to be associated with future noncontact injury in our study, limitations in our methodology may have prevented identification of other associations as well. While we did not find an association between noncontact injury and DKV during a single-leg squat task, previous evidence has suggested that athletes demonstrating a greater amount of knee valgus during sport-specific movements had a higher risk of noncontact ACL injury than matched controls.[12] Screening tests assessing DKV have been used to identify ACL injury risk.[4,14] The screening tests used are often single- and double-leg landing tasks that involve greater amounts of joint excursion and an impact, which may mimic the mechanism of ACL injuries better than the single-leg squat. This difference in movement task and demand of neuromuscular control could explain why we were unable to find an association between DKV and future noncontact ACL injury using our methods. Finally, in our study, we were primarily concerned with general LE injury risk as opposed to solely ACL injuries, which also may have limited our ability to find more specific associations. Other limitations were mostly logistical in nature. For instance, we collected data during athletes' preseason physical screening sessions. Due to athletes' schedules, we were only able to collect data for the single-leg squat test from 75% of the athletes, which may have also influenced our findings.

We did not find a relationship between LE injury and hip ROM or provocative tests. Authors of previous studies have suggested that limited hip rotation ROM may be associated with ACL injury.[5,28,29] These studies had relatively small samples, and 2 were retrospective, in which authors assessed hip ROM after the ACL injury had occurred.[28,29] Our findings specific to provocative tests were consistent with the study by Cheng et al,[8] who also reported no association between hip provocative tests and future LE injury. Given the limited number of studies in which authors have assessed the relationship between LE noncontact injury and hip ROM or provocative tests, we are hesitant to make any definitive conclusions. More research is needed.

Additional limitations to our study existed. We could not account for every factor that may be associated with noncontact injury including sex and ethnic diversity, both of which have been shown to influence injury rates among athletes.[26,30] Due to the limited number of athletes in some of the sporting teams, we did not assess the relationship between future injury and sport or player position. As mentioned above, our results indicate that history of low back pain is an associated risk that does not appear to be context dependent; however, other associations may have been determined by data analysis that accounts for athlete sport as a confounding variable. Our surveillance program relied on athletes reporting an injury to the athletic training department if the injury was not viewed by the athletic training team, so it is possible that some injuries were left unreported. Finally, the athletes in our study do not represent all college athletes. Most included athletes were White males participating in either football or cross-country running. Our results are specific to the Division III athletic population from a single institution. This has implications both for the results of our study as well as for future research in so far as these athletes may be exposed to potential risk factors that athletes from other divisions or institutions are not. Additionally, the availability and access to resources to mitigate these risk factors are likely to differ both across and within National Collegiate Athletic Association divisions.

Ultimately, with this study, we add to and support the well-established body of research indicating that index injuries increase the risk of subsequent injuries to adjacent body regions in the LE.[2,3] Specifically, in our study, we offer new evidence that a history of low back pain is associated with an increased risk of noncontact LE athletes

Table 3. Descriptive Data and Odds Ratios (ORs; (95% CIs) for Univariate GEE Models. In This Analysis, Each Athlete Has 2 Observations, 1 for Right Limb and 1 for Left Limb (369* × 2 = 738 Limbs)

Variable	Overall, No./Total Limbs[a] (%)	Noncontact Injury, No./Total Limbs[b] (%)	No Injury, No./Total Limbs[c] (%)	OR	Lower 95% CI	Upper 95% CI	*P* Value From Wald Test
Ever low back pain	324/730 (44.4)	76/136 (55.9)	248/594 (41.8)	1.59	1.03	2.45	.04
Ever hip pain	119/729 (16.3)	20/138 (14.5)	99/591 (16.8)	1.00	1.00	1.00	.40
Ever knee pain	229/733 (31.2)	48/138 (34.8)	181/595 (30.4)	1.00	1.00	1.00	.43
Positive FADIR	98/737 (13.3)	17/138 (12.3)	81/599 (13.5)	1.00	1.00	1.00	.96
Positive FABER	83/738 (11.3)	14/138 (10.1)	69/600 (11.5)	1.00	1.00	1.00	.64
Dynamic knee valgus	303/552 (54.9)	48/91 (52.8)	255/461 (55.3)	1.00	0.99	1.01	.92
		Mean ± SD					
ER 90°	47 ± 11	46 ± 11	47 ± 11	1.00	1.00	1.00	.37
IR 90°	29 ± 11	28 ± 10	30 ± 11	1.00	1.00	1.00	.17
ER 0° (n = 636)[e]	39 ± 11	39 ± 10	40 ± 11	1.00	1.00	1.00	.57
IR 0° (n = 636)[ed]	32 ± 11	32 ± 12	32 ± 11	1.00	1.00	1.00	0.81
Flexion	118 ± 12	117 ± 12	118 ± 11	1.00	1.00	1.00	0.44

Abbreviations: CI, confidence interval; ER, external rotation; FABER, flexion-abduction-ER; FADIR, flexion-adduction-IR; GEE, generalized estimating equations; IR, internal rotation; OR, odds ratio.

[a] The number of limbs rated as *yes* for the variable/total limbs with available data.

[b] The number of limbs rated as *yes* for the variable/total limbs in athletes with noncontact injury.

[c] The number of limbs rated as *yes* for the variable/total limbs in athletes with noncontact injury.

[d] ER 0° and IR 0° were not collected in the first year of screening.

regardless of the sport. Further research is necessary to determine whether a history of low back pain is only an associative factor or a true risk factor for noncontact injury. Nevertheless, based on our results, sports medicine providers may consider screening for a history of low back pain to identify athletes that may require follow-up assessment of their low back pain, function, or both, as these are known to influence future LE injury rates.[23–25]

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