Risk Factors for Noncontact Ankle Sprains in High School Athletes

The Role of Hip Strength and Balance Ability

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Background: Ankle sprains are among the most common sports injuries.

Hypothesis: Poor balance as measured on a balance board and weakness in hip abduction strength are associated with an increased risk of noncontact ankle sprains in high school athletes.

Study Design: Cohort study; Level of evidence, 2.

Methods: One hundred sixty-nine high school athletes (101 male athletes, 68 female athletes) from football, men's basketball, men's soccer, women's gymnastics, women's basketball, and women's soccer were observed for 2 years. Balance in single-limb stance on an instrumented tilt board and hip flexion, abduction, and adduction strength (handheld dynamometer) were assessed in the preseason. Body mass, height, generalized ligamentous laxity, previous ankle sprains, and ankle tape or brace use were also documented.

Results: There were 20 noncontact inversion ankle sprains. Balance ability ($P = .72$), hip abduction strength ($P = .66$), hip adduction strength ($P = .41$), and hip flexion strength ($P = .87$) were not significant risk factors for ankle sprains. The incidence of grade II and grade III sprains was higher in athletes with a history of a previous ankle sprain (1.12 vs 0.26 per 1000 exposures, $P < .05$). A higher body mass index in male athletes was associated with increased risk ($P < .05$). The combination of a previous injury and being overweight further increased risk ($P < .01$).

Conclusion: Balance as measured on a balance board and hip strength were not significant indicators for noncontact ankle sprains. The apparent high injury risk associated with the combination of a history of a previous ankle sprain and being overweight in male athletes warrants further examination.

Keywords: balance; hip strength; injury incidence; inversion injury

Ankle injuries account for approximately 10% to 28% of all athletic injuries.[2] Numerous studies have examined extrinsic and intrinsic risk factors for ankle sprain (for review, see articles by Barker et al[2] and Beynnon et al[5]). However, it is apparent that there is little consensus in the literature with regard to risk factors for ankle sprains.

Nicholas et al[14] observed that patients with ankle injuries had concomitant weakness in hip abduction and adduction. Although it was not apparent whether this weakness was a cause or a consequence of the injury, the findings highlighted the important relationship between the proximal stabilizing musculature and distal injury. More recently, Beckman and Buchanan[4] demonstrated that patients with a history of a previous ankle sprain had a delayed activation of the gluteus medius in response to an ankle inversion perturbation, whereas peroneal activation was not delayed. Decreased ankle eversion strength has been shown not to be a risk factor for lateral ankle sprain.[3] However, to our knowledge, the role of hip abduction strength in the risk of noncontact lateral ankle sprains has not been examined.

Balance training in a single-limb stance on an ankle disk has been shown to decrease the incidence of ankle sprains in athletes with a history of previous ankle sprain.[1,15] It was hypothesized that balance training improved proprioception, thereby imparting protection from injury. It is worth noting that in neither study were baseline balance

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No potential conflict of interest declared.

The American Journal of Sports Medicine, Vol. 34, No. 3
DOI: 10.1177/0363546505280427

impairments examined, nor were improvements in balance performance with training documented. Impaired balance has been shown to be a risk factor for ankle sprains in basketball[8] and soccer.[16] In these studies, balance was assessed according to indices of postural sway calculated from force plate measurements. Although balance was clearly identified as a risk factor for ankle sprains, this measurement technique does not lend itself to widespread use for identifying athletes at risk for sustaining an ankle sprain. By contrast, balance boards that are used routinely in rehabilitation can be instrumented to provide objective assessments of balance.[10,11] For instance, balance ability has been measured on an instrumented tilt board to show aging effects in athletes[11] and nonathletes.[10]

Therefore, the primary purpose of this study was to examine whether balance and hip abduction strength were risk factors for sustaining a noncontact lateral ankle sprain in high school athletes. Additional risk factors that were examined included hip flexion and hip adduction strength, gender, a history of previous ankle sprain, brace use, height, weight, body mass index (BMI), and generalized ligamentous laxity. It was hypothesized that preseason time out of balance would be higher and hip abduction strength would be lower in subsequently injured athletes compared with noninjured athletes.

MATERIALS AND METHODS

Athletes from 6 sports teams (football, men's soccer, women's soccer, men's basketball, women's basketball, and women's gymnastics) in one high school were studied during 2 consecutive years. Both varsity and junior varsity athletes were studied, providing a sample of 169 different athletes (101 male athletes, 68 female athletes) aged 16 ± 1 years (range, 14-18 years). Eighty-eight athletes participated in both years of the study, and 22 athletes participated in 2 sports (14 in the first year and 8 in the second year).

Baseline Measures

At the beginning of each season, all athletes completed preseason physical examinations that included measurement of height; weight; BMI; strength in hip flexion, abduction, and adduction; balance in single-limb stance; and generalized ligamentous laxity. Ankle injury history and limb dominance were also documented at this time. All athletes underwent testing before the season of their particular sport, regardless of whether they had been tested during the preseason for a different sport in that year or whether they had been tested for the same sport in the previous year.

Strength measures were made using a handheld dynamometer (Nicholas Manual Muscle Tester, Lafayette Instruments, Lafayette, Ind). Hip flexion strength was tested in the seated position with the dynamometer placed just proximal to the patella. The hip was flexed, with the knee flexed in a relaxed position. The examiner applied resistance against hip flexion until the subject's contraction was overcome (break test). Hip abduction strength was tested in side-lying with the dynamometer placed just proximal to the lateral maleolus. The hip was abducted approximately 30°, and a break test was applied. Hip adduction strength was tested in side-lying with the hip adducted approximately 15°. The dynamometer was placed just proximal to the medial malleolus, and the break test was applied. These tests have previously been used for strength assessments in professional athletes,[17] recreational athletes,[11] and anterior cruciate ligament–deficient patients.[12] Force values were converted to torque and expressed relative to body mass (N·m/kg). The lever arm for abduction and adduction was defined as the distance from the greater trochanter to the lateral maleolus. The lever arm for hip flexion was defined as the distance from the greater trochanter to the lateral femoral condyle.

A tilt board, similar to that used commonly in physical therapy, was used for testing balance. It consisted of a wooden block, 1.5 inches wide by 2 inches high, fixed centrally to a rectangular wooden board (17 inches × 15 inches). The block was slightly beveled at the edges to make it less stable. Each side of the board was instrumented with switches to detect ground contact (occurring with 10° of tilt). Subjects attempted to maintain balance while standing with 1 foot placed on the board (without shoes) for 1 minute with the arms folded across the chest (Figure 1). Subjects were positioned on the board so that board tilt occurred in the frontal plane. Previous research has shown that acute balance impairments after lateral ankle sprains are most apparent in the frontal plane.[8] A switch was placed on the contralateral foot to detect when that foot was used to correct balance (Figure 1). The time during which the switches were activated represented when subjects were out of balance. The dominant and nondominant limbs were tested, alternating the order between subjects. A test duration of 1 minute is in agreement with the 2 previous studies examining the role of balance in the risk for an ankle sprain. McGuine et al[9] used three 10-second trials with eyes open and 3 with eyes closed on each leg. Tropp et al[16] used one 60-second trial on each leg.

Generalized ligamentous laxity was assessed according to 5 tests[13]: (1) placement of the palms on the floor with the knees maintained in full extension; (2) hyperextension of the elbow with the wrist in supination and the shoulder flexed to 90°; (3) standing external rotation of the hips and knees such that the feet made an angle of 180° or greater with heels touching; (4) hyperextension of greater than 10° at the knee while standing; and (5) thumb abduction to the volar forearm with the wrist flexed. Athletes testing positive in 3 or more of these tests were categorized as having generalized ligamentous laxity.

An athlete-exposure was defined as a player's participation in a game or a practice. All missed games and practices were documented, as was ankle tape and brace use. A lateral ankle sprain was defined as an ankle injury with an inversion mechanism that required the player to miss at least 1 game or practice. Injuries were graded as I, II, or III using the same criteria as Baumhauer et al.[3] A contact injury was defined as an injury that occurred while the athlete was being tackled (ie, the external force causing

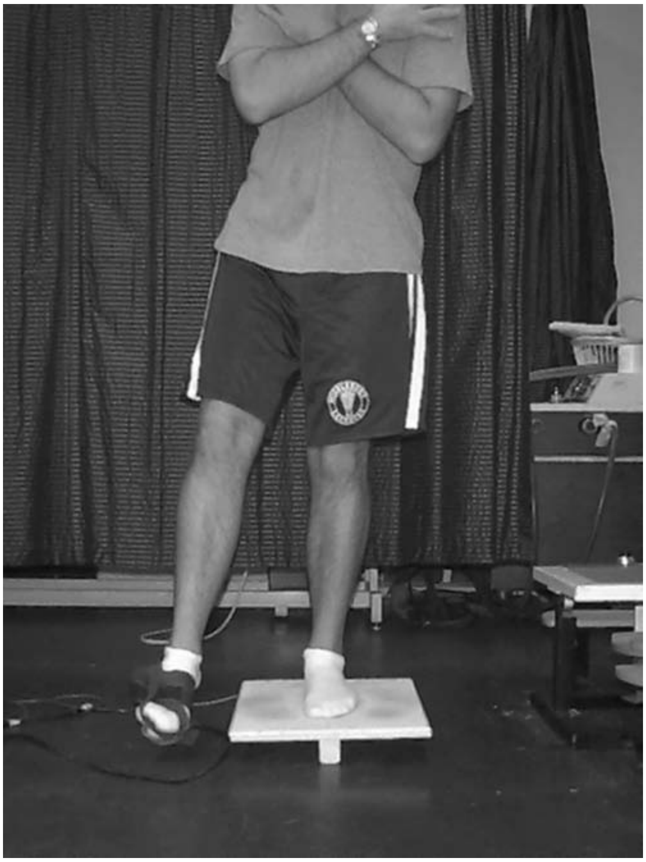

Figure 1. Single-limb balance test on an instrumented tilt board. Subjects attempted to maintain balance for 1 minute. Switches to detect ground contact were placed on both borders of the balance board and the nonbalancing foot. Time out of balance was defined as the total time that the switches were activated.

the inversion moment at the ankle was primarily caused by the force applied by another player). Only noncontact injuries were included for risk analysis. The same athletic trainer documented all injuries and recorded all relevant data. All games missed because of injury or other reason were recorded to provide an accurate measure of exposure for each athlete.

Sample Size and Statistical Power

In previous studies on high school basketball players[9] and college athletes from various sports,[3,6] at least 10% of athletes sustained lateral ankle sprains in a season. Therefore, based on the number of athletes per team, it was estimated that approximately 25 lateral ankle sprains would occur in the duration of this study (2 seasons). It was anticipated that most of these sprains would be noncontact injuries. Effect sizes for differences in balance and hip abduction strength between injured and noninjured athletes were estimated using intersubject variability in balance and hip abduction strength from 68 healthy subjects (39 women, 29 men, aged 29 ± 5 years) tested previously at this facility (unpublished data). Time out of balance was 9.2 ± 7.1 seconds, and hip abduction torque was 1.75 ± 0.54 N·m/kg in this control sample. Based on the intersubject variance in balance and strength in this sample of subjects, it was estimated that with a sample of 20 noncontact ankle sprains, a difference between injured and noninjured athletes of 4.3 seconds in balance and 0.33 N·m/kg in hip abduction torque could be detected as significant with an α level of .05 and a β level of .2 (80% power).

Statistics

Differences in strength and balance between teams were tested by 1-way analysis of variance with Tukey post hoc pairwise comparisons. Unpaired t tests were used to compare strength and balance results between injured and noninjured athletes. For these analyses, an injury was analyzed as occurring to an individual athlete rather than to a limb. Therefore, strength and balance measures were averaged across limbs to provide a mean value for each subject. In order to control for exposure, risk factors for injury were also tested by comparing injury incidences between selected groups. For these purposes, continuous variables were categorized into tertiles for comparison (eg, good balance, average balance, and poor balance; or strong, normal, weak). Injury incidences were calculated as injuries per 1000 athlete-exposures. Differences in the incidences between groups were tested by χ^2 or Fisher exact tests as appropriate. It was anticipated that strength and balance values would differ somewhat between teams, but the study was not powered to assess effects on injury incidence within a single sport. Therefore, the comparisons of injury incidence between strength or balance tertiles were repeated while controlling for team differences in strength and balance. This objective was achieved by categorizing athletes within each sport into tertiles (strong, normal, and weak; or good balance, average balance, and poor balance) for that particular sport. Then, the athletes in the same category for each sport were grouped together for analysis of injury incidence.

The effect of strength and balance deficits between limbs on injury risk was also assessed. Strength deficits were categorized as follows: no deficit = side-to-side difference less than 10%; equivocal deficit = side-to-side difference 10% to 20%; true deficit = side-to-side difference greater than 20%. The injury incidence between athletes classified as having no deficit, an equivocal deficit, and a true deficit were compared for all 3 strength measures. A balance deficit was defined as a side-to-side difference in time out of balance of greater than 5 seconds (based on control data). Injury incidence was compared between athletes with and without balance deficits.

Logistic regression was used to examine whether combinations of factors were predictive of injury. Using injured versus uninjured as the dependent variable, bivariate regressions were performed on the following factors: balance, strength, previous injury, number of exposures (games and practices), BMI, gender, and team. Factors that were significant at $P \leq .1$ were entered into a multivariate regression model.

TABLE 1
Preseason Strength and Balance Measures for Each Team (mean ± SD)

Sport	Time out of Balance, s	Hip Abduction Strength, N·m/kg	Hip Adduction Strength, N·m/kg	Hip Flexion Strength, N·m/kg	Total Exposures	Number of Ankle Sprains
Football (F), n = 48	12.7 ± 7.6	1.81 ± 0.38	1.46 ± 0.39	1.33 ± 0.35	5708	8
Men's soccer (MS), n = 33	12.5 ± 8.1	1.94 ± 0.43	1.58 ± 0.39	1.44 ± 0.42	4542	3
Women's soccer (WS), n = 27	5.7 ± 6.4	1.98 ± 0.44	1.54 ± 0.29	1.49 ± 0.34	2493	3
Men's basketball (MB), n = 20	9.6 ± 6.5	1.77 ± 0.23	1.44 ± 0.23	1.38 ± 0.32	2069	2
Women's basketball (WB), n = 14	7.6 ± 4.9	1.69 ± 0.41	1.22 ± 0.25	1.26 ± 0.37	1923	2
Women's gymnastics (WG), n = 27	6.0 ± 6.6	1.69 ± 0.30	1.30 ± 0.24	1.19 ± 0.30	1660	2
Analysis of variance	$P < .0001$	$P < .01$	$P < .0001$	$P < .01$		
Pairwise differences $P < .05$	F & MS > WS & WG; F > WB	WS > WB & WG	F, MS & WS > WB; MS & WS > WG	MS & WS > WG		

RESULTS

Baseline Measures

Time out of balance was significantly different between teams ($P < .001$) (Table 1), but this effect was primarily dictated by gender (gender effect, $P < .001$), with female subjects showing better balance. Strength differences were also apparent between teams, but gender effects (Table 1) did not cause these differences. Soccer players (both genders) displayed the highest mean strength values, whereas gymnasts and women's basketball players had the lowest strength values.

Ten male athletes (10%) and 29 female athletes (56%) had generalized ligamentous laxity. Seventy athletes (41%) had a history of a previous ankle sprain. Of these, 23 (33%) had recurrent sprains. A history of a previous ankle sprain was more prevalent in female athletes (51%) than in male athletes (35%, $P < .05$). Similarly, a history of previous recurrent sprains was more prevalent in female athletes (21%) than in male athletes (9%, $P < .05$). With respect to the individual teams, a history of a previous ankle sprain was found in 25% of football players, 39% of men's soccer players, 41% of women's soccer players, 50% of men's basketball players, 64% of women's basketball players, and 56% of gymnasts. The prevalence in football players was lower than in basketball players and gymnasts.

Time out of balance was not different between athletes with a history of a previous ankle sprain (9.9 ± 7.4 seconds) and the other athletes (8.5 ± 7.1 seconds, $P = .28$). Athletes who had recurrent sprains did not have poorer balance than the athletes who had no previous ankle sprains (9.9 ± 7.4 seconds vs 7.6 ± 7.6 seconds, $P = .18$). Similarly, hip abduction, adduction, and flexion strength was not different between athletes with a previous ankle sprain and the other athletes (hip flexion: 1.34 vs 1.33 N·m/kg, $P = .78$; hip abduction: 1.80 vs 1.82 N·m/kg, $P = .73$; hip adduction: 1.44 vs 1.42, $P = .73$).

Injury Incidence and Risk Analyses

There were 27 lateral ankle sprains during the study (incidence, 1.47 per 1000 exposures). Of these, 20 were noncontact injuries (incidence, 1.13 per 1000 exposures). One athlete sustained a grade I injury in soccer and subsequently sustained a grade II injury to the contralateral side in basketball. No other athletes sustained more than 1 ankle sprain during the study. There were 10 grade I injuries, 6 grade II injuries, and 4 grade III injuries. Injury incidence per 1000 exposures was not significantly different between teams (football, 1.49; men's soccer, 0.71; women's soccer, 0.8; men's basketball, 0.97; women's basketball, 1.56; women's gymnastics, 1.2), but the study was not powered to detect differences in injury incidence between teams because of the limited number of injuries per team. Injury incidence was not different between genders (male athletes: 1.12 per 1000 exposures, 95% confidence interval [CI], 0.6-1.9; female athletes: 1.15 per 1000 exposures, 95% CI, 0.5-2.4; $P = .9$).

Time out of balance and hip strength were not different between the athletes who subsequently sustained ankle sprains and the noninjured athletes (Table 2). Injury incidence per 1000 exposures was not different between athletes classified as strong (2.19 ± 0.35 N·m/kg), normal (1.8 ± 0.22 N·m/kg), and weak (1.46 ± 0.19 N·m/kg) in hip abduction (Table 3). Similarly, no differences in injury incidence per 1000 exposures were seen between groups classified according to hip adduction and flexion strength (Table 3). Strength did not affect injury incidence, even when adjusted for differences in strength between teams (Table 3, adjusted incidence). Injury incidence per 1000 exposures was not different between athletes classified with good balance (time out of balance, 3.6 ± 2.3 seconds), average balance (8.6 ± 3.9 seconds), and poor balance (16.3 ± 7.9 seconds) (Table 4). Similarly, balance did not affect injury incidence, even when adjusted for differences in balance between teams (Table 4).

TABLE 2
Preseason Balance and Strength Measures in Athletes Who Subsequently Sustained Noncontact Lateral Ankle Sprains and Noninjured Athletes (mean ± SD)

	Time out of Balance, s	Hip Abduction Strength, N·m/kg	Hip Adduction Strength, N·m/kg	Hip Flexion Strength, N·m/kg
Noninjured	9.2 ± 7.3	1.82 ± 0.41	1.44 ± 0.35	1.35 ± 0.37
Injured	9.2 ± 7.1	1.74 ± 0.36	1.38 ± 0.34	1.26 ± 0.27
Significance	*P* = .99	*P* = .43	*P* = .47	*P* = .33

TABLE 3
Incidence of Noncontact Ankle Sprains in Athletes Classified as Strong, Normal, or Weak in Hip Abduction, Hip Adduction, and Hip Flexion[a]

	Strong	Normal	Weak	Significance
Hip abduction	0.82 (0.3-1.9)	1.55 (0.7-2.9)	1.08 (0.4-2.3)	*P* = .66
Adjusted incidence	1.21	0.92	1.28	*P* = .89
Hip adduction	0.67 (0.2-1.7)	1.63 (0.7-3.1)	1.18 (0.5-2.4)	*P* = .41
Adjusted incidence	1.03	1.09	1.3	*P* = .67
Hip flexion	1.13 (0.5-2.3)	1.06 (0.4-2.3)	1.24 (0.5-2.5)	*P* = .87
Adjusted incidence	0.97	0.77	1.63	*P* = .28

[a]Data are presented as injuries per 1000 athlete-exposures (95% confidence interval). The adjusted incidence is the injury incidence adjusted for differences in strength between teams.

TABLE 4
Incidence of Noncontact Ankle Sprains in Athletes Classified as Having Good Balance, Average Balance, or Poor Balance[a]

	Good Balance	Average Balance	Poor Balance	Significance
Incidence	1.12 (0.4-2.4)	1.37 (0.6-2.7)	0.92 (0.3-2.0)	*P* = .72
Adjusted incidence	1.52	0.74	1.1	*P* = .48

[a]Data are presented as injuries per 1000 athlete-exposures (95% confidence interval). The adjusted incidence is the injury incidence adjusted for differences in balance between teams.

Injury incidence was 1.33 per 1000 exposures (0.3-3.9) in athletes with strength deficits (greater than 20%) in hip abduction, and this result was not different (*P* = .97) from injury incidence in athletes with normal strength (1.2 per 1000 exposures; 95% CI, 0.6-2.2) or equivocal deficits (0.99 per 1000 exposures; 95% CI, 0.4-2.1). Injury incidence was also unaffected by deficits in hip adduction strength (*P* = .98) or hip flexion strength (*P* = .18). Injury incidence tended (*P* = .07) to be higher in athletes classified with balance deficits (1.74 per 1000 exposures; 95% CI, 0.9-3.0) compared with the remaining athletes (0.68 per 1000 exposures; 95% CI, 0.3-1.4). It is worth noting that in the group with balance deficits only 7 of 13 injuries occurred on the side with the poorer balance.

Three ankle sprains occurred in athletes with generalized ligamentous laxity (incidence, 0.9 per 1000 exposures; 95% CI, 0.2-2.7) compared with 17 in the other athletes (1.18 per 1000 exposures; 95% CI, 0.7-1.9; *P* = .9). Athletes with a history of previous ankle injury tended to have a higher incidence of injury (1.76 per 1000 exposures; 95% CI, 0.9-3.1 vs 0.78 per 1000 exposures; 95% CI, 0.4-1.5; *P* = .1). The incidence of grade II or III injuries was higher (*P* < .05) in athletes with a history of a previous sprain (1.12 per 1000 exposures; 95% CI, 0.5-2.3 vs 0.26 per 1000 exposures; 95% CI, 0.1-0.8). The use of ankle tape or an ankle brace was examined with respect to history of previous injury. Injury incidence was 2.01 per 1000 exposures in athletes with a positive history who did not use a brace or tape compared with 1.45 per 1000 exposures in athletes with a positive history who did use a brace or tape, 1.79 per 1000 exposures in athletes with no previous injury who used a brace or tape, and 0.73 per 1000 exposures in athletes with no previous injury who did not use a brace or tape. None of these incidences differed significantly.

No factors were significantly related to the occurrence of a noncontact ankle sprain with logistic regression. Previous ankle sprain (*P* = .07) and BMI (*P* = .08) were entered into a multivariate model, but the combination did not result in a significant association with injury occurrence. Other factors were not entered into the regression, as the significance of the bivariate regressions was greater than 0.1 (gender, P = .6; team, P = .6; exposure, P = .5; balance, P = .9; hip flexion strength, P = .6; hip abduction strength, P = .9; hip abduction strength, P = .6; height, P = .3; BMI, P = .13). The association between BMI and injury occurrence was significant for male athletes ($P < .05$) but not for female athletes (P = .15). Similarly, the association between previous injury and injury occurrence was significant for male athletes ($P < .05$) but not for female athletes (P = .6). For male athletes, the combination of previous injury and BMI improved the Nagelkerke R^2 from 0.073 for bivariate analysis to 0.13 ($P < .05$). Athletes were categorized using age-specific and gender-specific BMI normative data provided by the Centers for Disease Control and Prevention: underweight (BMI for age, ≤ fifth percentile), normal weight (BMI for age, greater than fifth percentile to less than 85th percentile), at risk of being overweight (BMI for age, 85th percentile to less than ≥95th percentile), or overweight (BMI for age, 95th percentile). There were 18 overweight and 19 at-risk-of-overweight male athletes compared with 1 overweight and 6 at-risk-of-overweight female athletes. Injury incidence was 3.0 per 1000 exposures (95% CI, 1.0-6.9) for overweight male athletes compared with 0.8 per 1000 exposures (95% CI, 0.03-1.6) for the rest of the male athletes ($P < .05$). In male athletes, the combination of being overweight and having a history of a previous ankle sprain resulted in an injury incidence of 5.58 per 1000 exposures (1.5-14.2), which was 9.6 times higher than the incidence for normal-weight athletes with no previous ankle sprain (0.58 per 1000 exposures; 95% CI, 0.1-1.7; $P < .01$). It is worth noting that all of the overweight athletes were on the football team. Further analysis of the role of BMI in risk of ankle sprain limited to just football players was not performed because of the small sample size.

DISCUSSION

The main findings in this study were that hip abduction strength and balance in single-limb stance were not significant risk factors for sustaining a noncontact ankle sprain in high school athletes.

Although the results were negative with respect to the effect of balance and strength on injury risk, it is important to ensure that these results were not subject to a type II error. The estimated effect sizes based on this sample allowed for differences of 4.3 seconds in balance and 0.33 N·m/kg in hip abduction strength between injured and noninjured athletes. Given a mean time out of balance of 9.2 seconds and a mean abduction strength of 1.82 N·m/kg for the study sample, these effect sizes were 47% and 18% of the group means. Therefore, there was greater power to detect a difference in strength between injured and uninjured athletes than there was for balance. However, it was the comparison of injury incidence between the upper and lower tertiles in balance and strength that were the most important results. There was minimal difference (P = .88) in injury incidence between the athletes classified as strong (0.82 injuries per 1000 exposures) versus those classified as weak (1.08 injuries per 1000 exposures), despite that the strength difference was 0.73 N·m/kg (40% of the group mean). For balance, injury incidence was not different (P = .96) between athletes classified as good (1.12 injuries per 1000 exposures) versus those classified as poor (0.92 injuries per 1000 exposures), whereas time out of balance was 3.6 seconds compared with 16.3 seconds, respectively. Therefore, it is unlikely that the results were subject to a type II error. Given the total number of exposures and the occurrence of 20 noncontact sprains, it was estimated that in this study, a relative risk of approximately 0.33 would have been significant ($P < .05$); that is, an injury incidence in the at-risk group would have had to have been 3 times the injury risk in the control group to have been deemed statistically significant.

It was hypothesized that both weakness in hip abduction and poor balance would increase risk. With respect to hip abduction strength, this hypothesis was based on the previous observations of abnormal hip abductor function in patients with ankle injuries.[4,14] With respect to balance, the hypothesis was based on (1) previous work indicating that risk in basketball[9] and soccer players[16] was related to poor balance and (2) intervention studies that demonstrated injury reduction with balance training[1,14] in subjects with a history of previous ankle sprains. The sample sizes for men's basketball and men's soccer were insufficient to corroborate the findings of McGuine et al[9] and Tropp et al[16] that demonstrated poor balance was a significant risk factor. This study was designed to assess whether balance and strength were risk factors for noncontact ankle sprains in high school athletes of all sports. However, it is possible that intrinsic risk factors for ankle sprains may be sports specific. It is important to note that the previous studies showing poor balance to be a risk factor for ankle sprains[9,16] used sophisticated instrumentation for balance assessment (force plate). Although indices of postural sway calculated from force plate data are likely more sensitive measurements of balance than the approach taken here, it is not feasible to use such an approach for balance screening of large samples of athletes. Therefore, in the present study, an attempt was made to use a balance measurement that was conducive to screening a large number of athletes during a short period. However, this approach was not effective at identifying athletes at risk for noncontact ankle sprains. The results indicate that the tilt board assessment of balance used in this study was not effective at identifying athletes at risk for noncontact ankle sprains.

The goal of this study was to identify risk factors so that at-risk athletes could be identified for potential interventions aimed at reducing the incidence of injury. The only risk factors that were identified were a history of a previous ankle sprain and a high BMI in male athletes. Because all the overweight athletes were on the football team, further study on a larger sample of high school football players is warranted to corroborate this finding. In support of the current findings, Gomez et al[7] found that in high school football, a high BMI in linemen was associated with an increased risk of lower extremity injuries.

In conclusion, balance and hip strength were not significant risk factors for noncontact ankle sprains in high school athletes. A force plate test of balance may be required for assessment of balance as a risk factor for ankle sprains. Unfortunately, such an approach would not be conducive to screening large numbers of athletes. The previously observed hip weakness in patients with an ankle injury[14] is likely a consequence of the injury and not a causative factor. The apparent high injury risk associated with the combination of a high BMI and a history of a previous ankle sprain in male athletes warrants further examination.

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