

Risk Factors for Noncontact Ankle Sprains in High School Football Players

The Role of Previous Ankle Sprains and Body Mass Index

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Background: In a previous study, we noted a possible connection between an athlete's weight and risk of ankle sprain.

Hypothesis: A high body mass index and a history of a previous ankle sprain increase the risk of a subsequent noncontact sprain.

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

Methods: One hundred fifty-two athletes from 4 football teams were observed (2 varsity and 2 junior varsity). Two teams were observed for 3 seasons, and 2 teams were observed for 1 season. Before each season, body mass, height, history of previous ankle sprains, and ankle tape or brace use were recorded.

Results: There were 24 ankle sprains, of which 15 were noncontact inversion sprains (11 grade I, 3 grade II, 1 grade III; incidence, 1.08 per 1000 athlete-exposures). Injury incidence was higher in athletes with previous ankle injuries (2.60 vs 0.39; $P < .001$). Body mass index was also a risk factor ($P < .05$): injury incidence was 0.52 for players with a normal body mass index, 1.05 for players at risk of overweight, and 2.03 for overweight players. Injury incidence was 0.22 for normal-weight players with no previous ankle sprain compared with 4.27 for overweight players who had a previous sprain.

Conclusion: An overweight player who had a previous ankle sprain was 19 times more likely to sustain a noncontact ankle sprain than was a normal-weight player with no previous ankle sprain.

Clinical Relevance: Ankle sprain prevention strategies should be targeted at football players with a high body mass index and a history of previous ankle sprains.

Keywords: noncontact lateral ankle sprain; football; adolescence; overweight

In a previous study,¹¹ an increased incidence of noncontact ankle sprains was noted in overweight male high school athletes with a history of a previous ankle sprain. The study sample included male and female athletes from 6 different sports teams. However, all the overweight athletes were on the football team. Given the limited number of football players in that study ($n = 53$), it was necessary to specifically look at the effects of a high body mass index (BMI) and previous ankle sprains in an expanded sample of high school football players. It was also unclear from the previous study whether the increased risk associated with a high BMI was caused by an increased incidence in noncontact sprains in

linemen compared with other positions because most of the overweight players were linemen. Gomez et al⁵ previously reported that a high BMI was associated with increased risk of injury (any type) in high school football linemen. It is worth noting that ankle sprains and medial collateral ligament sprains of the knee were the most common injuries. The injury incidence was not compared with players at other positions.

Considering that (1) childhood and adolescent obesity is a growing problem in the United States,⁸ (2) there are estimated to be 1.5 million athletes participating in high school football annually,¹² and (3) ankle sprains are among the most common injuries in high school sports,^{5,13} it is important from a public health perspective to clarify a possible link between a high BMI and ankle sprains in high school football players. Therefore, the purpose of this study was to expand the study sample from previous observations¹¹ and examine the association between BMI, a history of a previous ankle sprain, and risk of sustaining noncontact ankle sprains. Based on the preliminary findings¹¹ and the

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findings of Gomez et al,⁵ it was hypothesized that both a high BMI and a history of a previous injury would be significant risk factors and that there would be a compounding effect on risk independent of player position.

MATERIALS AND METHODS

The varsity and junior varsity football teams from 2 high schools were studied. The teams from 1 school were observed for 3 seasons (the first 2 seasons were reported in a previous article¹¹), and the teams from the other school were observed for 1 season. A total of 152 players were observed; 25 players were observed for 2 seasons, and 10 players were observed for 3 seasons.

Before each season, body mass, height, history of previous ankle sprains, and ankle tape or brace use were recorded. Body mass index was calculated as body mass (kg)/height² (m). Players 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 overweight (BMI for age, 85th percentile to less than 95th percentile), or overweight (BMI for age, greater than or equal to 95th percentile).

All missed games and practices were documented, as were ankle tape and brace use. There was no specific policy with regard to tape or brace use on these teams. The decision to use either tape or braces was made by the player, with no input from the study investigators. A lateral ankle sprain was defined as an ankle injury with an inversion mechanism requiring 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.² A contact injury was defined as an injury that occurred while the athlete was being tackled (ie, the external force causing the inversion moment at the ankle was primarily caused by the force applied by another player). All other injuries were classified as noncontact. Two athletic trainers documented all injuries and recorded all relevant data. One trainer was responsible for each school. All games missed because of injury or other reason were recorded to provide an accurate measure of exposure for each athlete. Injury incidence was calculated as injuries per 1000 player exposures, with an exposure defined as a player's participation in a game or practice. Exposures for players who sustained contact ankle sprains were not included in analyses of risk factors for noncontact injuries, as these players could not be categorized as uninjured.

Based on the prevalence of noncontact ankle sprains in the varsity and junior varsity teams in the first 2 seasons (8 injuries in 2 teams observed in 2 seasons), it was estimated that there would be an additional 8 noncontact ankle sprains observed in 4 teams for 1 additional season (varsity and junior varsity teams from 2 schools). With this increase in sample size and assuming a similar distribution of noncontact sprains among players in each BMI group, it was estimated that a 5-fold difference in injury incidence between groups could be detected as significant ($P < .05$) with 80% power. The primary purpose of expanding the sample of football players was to ensure that the previous

TABLE 1
Effect of a Previous Ankle Sprain on Incidence
(Injuries per 1000 Exposures) of Noncontact
Ankle Sprains ($P < .001$)

Previous Injury	No	Yes
Subjects	102	50
Exposures	9793	4155
Sprains	4	11
Incidence	0.41	2.65
95% confidence interval	0.1-1.0	1.3-4.7

observations of increased incidence of noncontact ankle sprains in athletes with a history of a previous sprain and in overweight players were not type I errors. In addition, an increased sample size was necessary to examine whether the effect of a high BMI was a function of playing position rather than of BMI. Approximately two thirds of overweight players in the original sample were linemen, and one third of the linemen were overweight. It was estimated that the increase in sample size would double the number of noncontact ankle sprains and provide sufficient power to examine injury incidence between playing positions, in addition to the effects of a high BMI and previous injury.

Differences in the incidences between groups were tested by χ^2 or Fisher exact tests, as appropriate. Injury incidence is reported in the text and tables as injuries per 1000 exposures (including games and practices) with 95% confidence intervals (CIs). Differences in BMI between playing positions were tested using 1-way analysis of variance with Tukey post hoc pairwise comparisons. Mean \pm SD is reported.

RESULTS

There were 24 ankle sprains, of which 15 were noncontact inversion sprains (11 grade I, 3 grade II, 1 grade III) resulting in 17 missed games and 125 missed practices (incidence, 1.08 noncontact sprains per 1000 athlete-exposures). Eight of the noncontact injuries occurred in the original data set,¹¹ and 7 occurred to players in the extended sample. Injury incidence was significantly higher in athletes with previous ankle injuries (2.65 vs 0.41; $P < .001$) (Table 1). Of the 50 players who had a previous ankle sprain, 11 (22%) sustained a noncontact sprain and 2 sustained a contact sprain (4%) during the study. Of the 102 players without a previous ankle sprain, 4 sustained a noncontact sprain (4%) and 7 sustained a contact sprain (7%). Of the 11 players who had a previous ankle sprain and sustained a noncontact sprain in this study, 9 injured the same ankle (incidence, 2.1; 1 of these players had previously sprained both ankles) and 2 injured the opposite ankle (incidence, 0.47). No player who sustained an ankle sprain during this study had a recurrent injury to that ankle or an injury to the contralateral ankle during the study.

Body mass index was also a significant risk factor ($P = .04$): injury incidence was 0.52 for players with a normal BMI, 1.05 for players at risk of overweight, and 2.03 for overweight players (Table 2). Of 38 overweight players, 7 (18%) sustained noncontact sprains and 3 sustained contact sprains (8%). Of 50 players at risk of overweight, 5 (10%) sustained

TABLE 2
Effect of Body Mass Index (BMI) on Incidence
(Injuries per 1000 Exposures) of Noncontact
Ankle Sprains (Linear Effect of BMI, $P = .04$)

	Normal	At Risk of Overweight	Overweight
Subjects	64	50	38
Exposures	5751	4742	3455
Sprains	3	5	7
Incidence	0.52	1.05	2.03
95% confidence interval	0.1-1.6	0.3-2.5	0.8-4.2

noncontact sprains and 5 sustained contact sprains (10%). Of 64 normal-weight players, 3 (5%) sustained noncontact sprains and 1 sustained a contact sprain (2%).

The combination of having a previous ankle sprain and being overweight (based on BMI) dramatically increased the risk of sustaining a noncontact ankle sprain (Figure 1). The incidence of injury was 0.22 (95% CI, 0.01-1.2) in normal-weight players with no previous ankle sprain compared with 4.27 (95% CI, 1.6-9.3) for overweight players with a previous sprain ($P < .001$). Furthermore, 42% of players who were overweight or at risk of overweight reported having had a previous sprain compared with 22% of normal-weight players ($P < .05$).

An increased incidence of injury was seen in those using ankle tape or braces. The incidence of noncontact ankle sprains was 0.5 (95% CI, 0.2-1.1) for players who did not use a brace or tape compared with 3.9 (95% CI, 1.8-7.4) for the players using tape, a brace, or a combination of both ($P < .001$). Of interest was the use of braces or tape in players with a previous ankle sprain. Players with a previous ankle sprain who did not use tape or a brace had an injury incidence of 1.13 (95% CI, 0.2-3.3; 3 injuries) compared with 4.9 (95% CI, 2.1-9.6; 8 injuries) for players with a previous injury who were using tape, a brace, or a combination of both ($P = .04$). Four of these players wore a brace, 3 had their ankles taped, and 1 had both.

The total number of players grouped by position was 187, as players participating in more than 1 season were counted for each season because several players changed positions between seasons. Players were grouped by playing position as follows: receivers/defensive backs ($n = 37$), quarterbacks/running backs/linebackers ($n = 47$), linemen/tight ends ($n = 84$), multiposition players ($n = 17$). Two exclusively special teams players (kickers who did not play another position) were not included in position analyses. None of the receivers/defensive backs sustained noncontact ankle sprains. Four of the quarterbacks/running backs/linebackers sustained a noncontact sprain (incidence, 1.1; 95% CI, 0.3-2.8). Nine of the linemen/tight ends sustained a noncontact sprain (incidence, 1.38; 95% CI, 0.6-2.6). Two of the multiposition players sustained a noncontact sprain (incidence, 1.5; 95% CI, 0.2-5.4). Injury incidence was not different between quarterbacks/running backs/linebackers, linemen/tight ends, and multiposition players ($P = .9$).

Body mass index was significantly higher ($P < .01$) in linemen/tight ends (28.2 ± 4.7) compared with receivers/

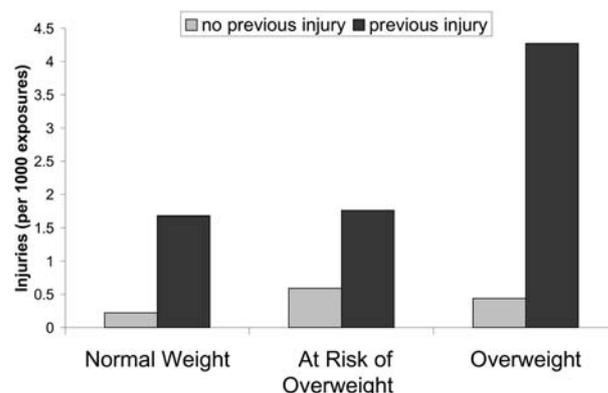


Figure 1. Effect of body mass index (BMI) and previous ankle sprains on the incidence of noncontact ankle sprains. Incidence of injury for overweight players with a previous injury was 19 times higher than the incidence for normal-weight players with no previous injury ($P < .001$).

defensive backs (22.8 ± 3.8) and quarterbacks/running backs/linebackers (24.4 ± 3.4). Nineteen percent of the receivers/defensive backs were at risk of overweight, and 5% were overweight. Forty-seven percent of the quarterbacks/running backs/linebackers were at risk of overweight, and 11% were overweight. Thirty-six percent of the linemen/tight ends were at risk of overweight, and 44% were overweight. Twenty-nine percent of the multiposition players were at risk of overweight, and 12% were overweight.

DISCUSSION

The results of this study show that a previous ankle sprain and a high BMI are independent risk factors for sustaining a noncontact ankle sprain in high school football. Furthermore, the combination of these risk factors had a cumulative effect on risk. Injury incidence was 19 times higher in players who had a previous ankle sprain and were overweight compared with players with no previous ankle sprain and who were of normal weight. It is worth noting that a previous ankle sprain was a stronger independent risk factor than a high BMI. Injury incidence was 6.6 times higher in players with a previous sprain and 3.9 times higher in overweight players. Given the limited number of noncontact ankle sprains ($n = 15$), it is possible that the independent effect of BMI was subject to a type I error. However, 3 factors support this possibility as a real effect. First, the prevalence of previous ankle sprains was higher in overweight players and players at risk of overweight (42%) compared with normal-weight players (22%). Second, the combined effect of previous injury and BMI on risk of subsequent injury was marked (Figure 1). Third, the effect of BMI on injury incidence was progressive (0.52 in normal-weight players, 1.05 in players at risk of overweight, and 2.03 in overweight players).

An additional concern with respect to a possible type I error is one of sampling bias because some of the data in this study are from the previous study.¹¹ When looking

at the data separately for the initial sample and the additional sample, it is clear that the effects of a previous sprain and a high BMI are in the same direction. With respect to the effect of a previous ankle sprain on injury incidence, in the initial sample, injury incidence was 3.8 per 1000 exposures for players with a previous sprain and 0.87 per 1000 exposures for players with no previous sprain ($P = .09$). In the additional sample, injury incidence was 2.26 per 1000 exposures for players with a previous sprain and 0 for players with no previous sprain ($P = .002$). With respect to the effect of BMI on injury incidence, in the initial sample, incidences were 0.58, 1.03, and 2.97 per 1000 exposures for normal-weight, at-risk-of-overweight, and overweight players, respectively ($P = .07$). In the additional sample, injury incidences were 0.50, 1.07, and 1.13 per 1000 exposures for normal-weight, at-risk-of-overweight, and overweight players, respectively ($P = .37$). When looking at the combined effects of a previous ankle sprain and being overweight, the initial sample and additional sample showed similar effects. In the initial sample, injury incidence was 5.58 per 1000 exposures for overweight players with a previous ankle sprain compared with 0.67 per 1000 exposures for normal-weight players with no previous ankle sprain ($P = .07$). In the additional sample, injury incidence was 2.91 per 1000 exposures for overweight players with a previous ankle sprain compared with 0 for normal-weight players with no previous ankle sprain ($P = .04$).

The effect of BMI on injury incidence was not a function of playing position. Although 79% of the overweight players were linemen, linemen did not have an increased incidence of injury compared with other positions. This finding may be explained by the fact that 56% of linemen were not overweight. These findings with respect to BMI and injury risk are in agreement with the previously observed increased injury incidence (all injuries) in high school football linemen with a high BMI compared with linemen with a low BMI.⁵ The present data indicate that the effect of a high BMI on risk of a noncontact ankle sprain is not limited to linemen. Although a previous ankle sprain and a high BMI are associated with the occurrence of noncontact ankle sprains, this association does not necessarily imply causation. For example, a high BMI may reflect relative inactivity, and it may be the lack of regular weightbearing activity that causes the increased risk. Furthermore, a high BMI does not necessarily imply increased fatness. Population-based BMI categories may not be valid for athletic populations in which increased mass may be caused by increased muscle mass. However, it is important to note that both a high BMI and high body fat have been associated with increased risk of lower extremity injuries in linemen.⁵

The high rate of recurrence of noncontact ankle sprains has been attributed to factors such as joint position sense deficits, delayed peroneal reaction time, strength deficits, decreased dorsiflexion motion, ligament insufficiency, and inadequate rehabilitation.^{4,6,7,9,10} Although the cause of recurrence may be multifactorial, it has been shown in a randomized study that supervised physical therapy with an emphasis on proprioception exercise reduces the incidence of recurrent sprains.⁷ In the current study, the incidence of

noncontact ankle sprains was 6.5 times higher for players who reported having a previous sprain. This increased incidence associated with a previous injury was similar in the normal-weight players (7 times higher incidence) and overweight players (7.7 times higher incidence). It is worth noting that 9 of the 11 players who had a previous ankle sprain and sustained a noncontact sprain during this study injured the same ankle. The incidence of injury to the same side was 2.1 per 1000 exposures compared with 0.47 for injury to the contralateral side and 0.39 for the players who had no previous ankle sprain. Therefore, the increased risk associated with a previous ankle sprain seems to be limited to the injured ankle. However, the number of injuries was insufficient to make a conclusive statement in this regard.

Previous research has indicated that the use of ankle braces can reduce the incidence of recurrent injuries.^{14,15,16} In this study, a decreased incidence of noncontact ankle sprains was not seen in previously injured players using tape or braces. Overall, there was an increased incidence of noncontact ankle sprains in players who reported using tape and braces. These conflicting findings may be because of factors such as the following: (1) the sports involved (basketball¹⁴ and soccer^{15,16} vs football); (2) brace and tape uses were not checked for every game and practice in this study; (3) the decision to use tape or braces was made by the player and was not based on specific criteria or injury history; (4) the players who used a brace and/or tape may represent a sample whose previous injury was more severe than the other previously injured players; (5) brace use was arbitrary, and the study was not designed to test the efficacy of brace use; and (6) tape and brace use tended to be higher ($P = .1$) in players who were overweight (23%) and at risk of overweight (21%) compared with normal-weight players (11%).

Body mass index is intended to provide an indication of how fat a person is by adjusting body mass for height. The impact of a high BMI on the incidence of noncontact ankle sprains may be related to the person's inability to effectively and rapidly change momentum. The equation $F = ma$ (Force = mass \times acceleration) states, "The rate of change of momentum of a body is proportional to the applied force and takes place in the direction in which the force acts."³ Because momentum equals mass times velocity, at any given movement velocity, a greater force is required to change the momentum of a heavier person. For the person with a high BMI, body fat is presumed to contribute significantly to the increased body mass. Noncontact ankle sprains may occur when a player attempts to decelerate or change direction; that is, change momentum. Because the pivot on which the body changes momentum is the foot, the ankle joint must be sufficiently stable to transfer the ground reaction forces for an effective change in momentum. Ankle sprains can occur when the forces required for the change in momentum exceed the dynamic stability of the ankle joint. Players with a higher BMI will have to generate greater forces to change momentum at a given movement velocity. If these forces generate an inversion moment at the ankle, dynamic stability may be insufficient to stabilize the joint. In this manner, the combination of a high BMI and a previous ankle sprain (which likely

decreases ankle stability) can have a compounding effect on risk of injury.

Although ankle sprains are relatively minor injuries in terms of games and practices missed (slightly more than 1 game and 8 practices missed per injury in this study), the high prevalence of this injury has a public health impact, considering that an estimated 1.5 million high school athletes participate in football annually.¹² The high prevalence of ankle sprains emphasizes the importance of identifying specific risk factors and developing interventions to lower injury incidence. Future studies should target interventions at players who have a high BMI and have had a previous ankle sprain. Adding dynamic single-limb stance stability training to the normal practice session has been shown to reduce the occurrence of ankle sprains in volleyball players and ankle injuries in European team handball players.^{1,17} A similar program for at-risk high school football players may also be effective at reducing the incidence of ankle sprains.

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