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The Role of Shoe Design in Ankle Sprain Rates Among Collegiate Basketball Players

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Context: Much of the recent focus in shoe design and engineering has been on improving athletic performance. Currently, this improvement has been in the form of "cushioned column systems," which are spring-like in design and located under the heel of the shoe in place of a conventional heel counter. Concerns have been raised about whether this design alteration has increased the incidence of ankle sprains.

Objective: To examine the incidence of lateral ankle sprains in collegiate basketball players with regard to shoe design.

Design: Prospective cohort study.

Setting: Certified athletic trainers at 1014 National Collegiate Athletic Association (NCAA)-affiliated schools sponsoring basketball during the 2005–2006 regular season were notified of an online questionnaire. Athletic trainers at 22 of the 1014 schools participated.

Patients or Other Participants: A total of 230 basketball players (141 males, 89 females; age = 20.2 ± 1.5 years) from NCAA Division I–III basketball programs sustained lateral ankle sprains.

Main Outcome Measure(s): Ankle sprain information and type of shoe worn (cushioned column or noncushioned column) were collected via online survey. The incidence of lateral ankle sprains and type of shoes worn were compared using a chi-square analysis.

Results: No difference was noted in ankle sprain incidence between groups ($\chi^2 = 2.44$, $P = .20$, relative risk = 1.47, 95% confidence interval [CI] = 0.32, 6.86). The incidence of ankle sprains was 1.33 per 1000 exposures in the cushioned column group (95% CI = 0.62, 3.51) and 1.96 per 1000 exposures in the noncushioned column group (95% CI = 0.51, 4.22).

Conclusions: No increased incidence of ankle sprains was associated with shoe design.

Key Words: cushioned column shoe system, athletic injuries, lower extremity injuries

Key Points

- Shoe design did not play a major role in ankle sprain incidence among collegiate basketball players.
- Cushioned column shoes did not increase the risk of injury in collegiate basketball players.
- A significant percentage of collegiate basketball players wore prophylactic ankle supports while participating, leading to a decrease in ankle injuries.

Ankle sprains are one of the most common injuries in the United States, accounting for as many as 23 000 injuries per day.[1] Authors[2] of a study in 1983 reported that the United States spent approximately $2 billion that year on moderate and severe ankle sprains; the 2008 estimate is $4.22 billion with inflation.[3] Thus, although ankle sprains are often seen as commonplace, the economic ramifications are significant. Studies[4–10] of athletes have shown that these statistics carry over to the sports world, particularly basketball. Basketball players frequently land on another competitor's foot, causing an awkward, plantar-flexed inversion moment and stretching the lateral ankle ligaments beyond their capacity, resulting in an ankle sprain.[4,9,11–15] These ankle sprains leave the competitor with initial pain and swelling[6,7] but can also lead to long-term problems, such as costly medical bills, subsequent sprains,[16,17] decreased strength,[6,16] instability,[6,16] delayed muscle reaction time,[16,18] and disability.[16,18] Preventing ankle sprains becomes critically important to basketball players, coaches, strength and conditioning experts, team physicians, and certified athletic trainers (ATs) in order to minimize time and money lost and maximize their success.[7,9,14–17]

The mission statements of many athletic footwear manufacturers focus on creating innovative designs using technology to improve comfort and athletic performance.[19–21] Some shoes are marketed to absorb energy during impact and release it during liftoff, aiming to increase force output. According to the Web site,[21] Nike shoes are reported to increase vertical jump height and improve propulsion ability, resulting in faster sprint times. Currently, this concept has been delivered in the form of spring-like columns ("cushioned column systems") under the heel of the shoe in place of conventional heel counters.[22] The effect of this design on ankle sprain risk has not been reported. Therefore, the purpose of our study was to determine the effect of shoes with cushioned column systems under the heel on the frequency of lateral ankle sprains. We hypothesized that collegiate basketball players wearing the cushioned column shoe design would have a higher incidence of lateral ankle sprains than those not wearing this shoe type.

METHODS

Participants

Twenty-two collegiate ATs from National Collegiate Athletic Association (NCAA) Divisions I, II, and III

institutions participated in this study. The ATs recorded the type of shoe, practice and game exposures, and lateral ankle injuries for 141 male and 89 female collegiate basketball players between the ages of 18 years and 24 years (age = 20.2 ± 1.5 years).

Athletes with a history of a lower extremity injury within the past 3 months or any neurologic condition were excluded from this study. Consent to participate in this study was obtained by each team's AT, and the study was approved by the Illinois State University Institutional Review Board.

Instrumentation

A survey was constructed to address the specifics of each lateral ankle sprain encountered throughout the 2005–2006 basketball season. The survey was posted online at a Web page accessible to the ATs to record lateral ankle sprains and total exposures (practices and games) on a weekly basis. The AT was responsible for recording information about each sprain, including ankle sprain type and any prophylactic measures in place when injured. Other information recorded included sex, division of competition, and the setting in which the sprain occurred (practice or game). We specifically looked at the type of shoes worn when the lateral ankle sprain was sustained. The AT was required to document the number of total exposures as a weekly demographic measurement. An exposure was defined as 1 athlete's participation in 1 game or practice.[23]

Procedures

A list of all NCAA participating institutions was obtained using the 2005 NCAA directory.[24] A search of the institutions' Web sites was performed to obtain contact information for those ATs working with basketball players. All ATs were contacted via e-mail about participating in the study. The 22 ATs who consented were responsible for maintaining records on each ankle sprain they evaluated and treated during the 2005–2006 collegiate basketball regular season. An ankle sprain was defined as an injury to the ankle ligaments.[25] Only injuries to the ankle ligaments resulting in absence from at least 1 day of activity were recorded by ATs as ankle sprains.[26] Cushioned column shoes were defined by Aguinaldo and Mahar[22] as rearfoot cushioning systems made in the form of spring-like columns.

At the beginning of the season, the ATs at participating schools received a cover letter describing the purpose of our study along with a sample questionnaire. This form provided the AT with a guide to the information to be recorded during the season in an attempt to improve the return rate. All ATs were informed that a cushioned column shoe should be defined as one with a spring-like rearfoot cushioning system, column-like in design. Each AT filled out questionnaires on a weekly basis documenting the number and types of exposures encountered that week. In this information, the ATs were required to stratify their exposures based on prophylactic measures in place during the activity. Any ankle injuries encountered that week were reported at that time as well. Specifics about the ankle sprain were documented (Table 1). Participants with questions were directed to correspond with the authors via e-mail. We sent monthly e-mails reminding the ATs to continue to submit their data.

Table 1. Survey Instrument

1. Injured Athlete:
   - Male
   - Female
2. Level:
   - Division I
   - Division II
   - Division III
3. Affected Limb:
   - Dominant
   - Nondominant
4. Injury Occurrence:
   - Game
   - Practice
5. Prophylactic Measures Used:
   - Tape
   - Brace
   - Both
   - Neither
6. Sprain Type:
   - Acute
   - Recurrent
   - If recurrent, date of last episode
7. Type of Injury:
   - Inversion sprain
   - Eversion sprain
   - Syndesmosis sprain
   - Fracture
   - Other
8. Degree of Sprain:
   - I
   - II
   - III
   - N/A
9. Mechanism:
   - Uneven surface
   - Force
   - Contact
   - Other
   - Uneven surface: landing on another player's foot
   - Force: cutting, planting and pivoting
   - Contact: collision with another player
10. Shoes Worn During Injury:
    - Men's
    - Women's
11. Shoe Type When Injured:
    - Nike Shox
    - Nike Zoom
    - Adidas a3
    - Adidas Gameday
    - Adidas Superstar
    - Adidas Response
    - Adidas Blindside
    - Adidas Team MAC
    - Adidas D-Cool
    - Reebok ATR
    - Reebok Boulevard
    - Reebok Settlement
    - Other

Data Analysis

Once submitted to the Web site, data were converted into a spreadsheet file (version Excel XP; Microsoft Corp, Redmond, WA). These data were then exported into the SPSS software package (version 11.5; SPSS Inc, Chicago, IL). Chi-square analysis was used to examine the significance of any differences between those athletes wearing

Table 2. Results of Survey on Ankle Sprain Incidence

Shoe Type	Ankle Sprains	Exposures[a]				
		Without Sprains	Braced	Taped	Both	Neither
Cushioned column	41	30 724	13 309	7601	1465	8390
Noncushioned column	27	13 767	5250	3619	409	4516

[a] Exposure indicates 1 athlete's participation in 1 game or practice.

cushioned column shoes and those not wearing these shoes. Chi-square analysis was used to examine the effect of prophylactic measures, adjusting for athlete-exposures. Relative risk was then calculated to compare the incidence of injury between groups. Level of significance was set a priori at $P < .05$.

RESULTS

No difference was noted in the incidence of lateral ankle sprains between collegiate basketball players wearing cushion columned and those wearing noncushioned column shoes (Tables 2 and 3). Athletes wearing cushioned column shoes sustained 41 ankle sprains; those wearing noncushioned column shoes, 27. The incidence of ankle sprains with cushioned column shoes was 1.33 ankle sprains per 1000 exposures (95% confidence interval [CI] = 0.62, 3.51). In athletes wearing noncushioned column shoes, the incidence was 1.96 ankle sprains per 1000 exposures (95% CI = 0.51, 4.22). No difference was observed in lateral ankle sprains between the control and experimental groups ($\chi^2 = 2.44$, $P = .2$, relative risk = 1.47, 95% CI = 0.32, 6.86).

DISCUSSION

Ankle sprain incidence values in our study were similar to those previously reported. McKay et al[6] found an incidence of 3.85 ankle sprains per 1000 exposures in recreational and elite basketball players. These ankle sprain rates were also consistent with those seen by Dick et al[27] and Agel et al[28] in NCAA athletes.

Our results showed no evidence that the presence of cushioned column systems contributed to an increased incidence of lateral ankle sprains among collegiate basketball players. Our findings did not support the hypothesis based on growing anecdotal evidence and speculation within the athletic training community over the past few years.

Many authors[22,29–31] have assessed the effect of shoe construction on various kinematic and kinetic factors. Hansen and Childress[29] and Kersting et al[30] looked at shoe-surface interaction of nonathletic shoes based on heel height and degree of plantar flexion. Kersting et al[30] examined the effect of midsole stiffness, cushioning, and heel height in lower extremity loading among food caterers. Shoe heel height influenced how the body interacted with the ground, leading to changes in muscular and mechanical loading conditions. These shoes also had the least amount of deformation on contact, prohibiting ankle pronation. Hansen and Childress[29] investigated the effect of heel height during walking. Shoes of mid and high heel height were used, with the overall difference between the rearfoot and forefoot sole thickness quantified. Rollover shape was then examined during walking. People in higher heels adapted to the change in heel height by allowing their ankle joints to rest in a more plantar-flexed position, leading to a more supinated rollover shape with walking.

Table 3. Number of Ankle Sprains by Shoewear and Prophylactic Measures

External Support	Cushioned Column Shoes	Noncushioned Column Shoes
Braced	12	6
Taped	6	8
Braced and taped	2	2
Neither braced nor taped	21	11
Totals	41	27

Specific nuances of shoe design may play a role in lower extremity kinematics in both everyday and sport-specific activities.[22,29–31] Some of these factors, such as increased heel height, may place the lower extremity in a compromised position that may make the person vulnerable to ankle sprains. Basketball shoes with an increased heel height may also prevent normal pronation motion, increasing the risk of lateral ankle sprains.

Shoes must also be designed to limit inversion stress on the ankle, which is greatest in supination, a combination of inversion and plantar flexion.[12,15] The major concern about cushioned column shoe design that had not been addressed previously[22] involved the capacity to minimize lateral ankle motion due to the perceived increase in plantar flexion at rest. Lateral stability is a major concern for the ankle, and increasing the plantar-flexion angle of the ankle joint causes the body to rely more on ligamentous support as the source of ankle stabilization.[15] By placing the ankle in a state of initial plantar flexion, it could be hypothesized that less movement and external force were required to cause a lateral ankle sprain. The findings of Wright et al[15] were somewhat inconclusive with regard to quantifying a specific angle of plantar flexion that led to ankle sprains, but the threshold for ankle sprain occurrence was considered to be 32° of supination. Although other angles produced similar results, questions arose as to whether or not supination at touchdown would occur in the same manner in a situation outside the laboratory.

Possible limitations of our study include the inability to regulate the use of other external support measures. Of the 30 765 exposures in the cushioned column shoe group, external support was used during 22 375 exposures (72.7%). In the noncushioned column group, external support was used during 9278 of the 13 794 (67.3%). These rates were assumed to be random across the shoe conditions, based on the data collected. Another limitation was the reliance on external data collectors for research in our study. Survey research relies heavily on other people to collect data. This leads to the assumption that all of the ATs in this study adhered to the guidelines in terms of inclusion and exclusion criteria. The volunteer pool in our study was

small given the overall population invited to participate. Significant results might have been obtained with a greater response rate. Lastly, the cushioned column shoes are available in 2 designs. One involves the columns just under the heel, whereas the other has columns spanning the entire length of the shoe sole. The shoe design was recorded for those athletes suffering sprains; however, the designs were not monitored in overall exposures.

Future researchers should quantify the actual plantar flexion angle required to increase the risk of lateral ankle sprains. Investigators should also address the likelihood of ankle sprains among athletes wearing different styles of cushioned column shoes, as well as the relationships between previous ankle injury and type of prophylactic device(s) worn in determining the incidence of ankle injuries. Repeating this study using a much larger sample size may also yield beneficial results.

CONCLUSIONS

We found no difference in the lateral ankle sprain rates of collegiate basketball athletes wearing cushioned column shoes and those wearing noncushioned column shoes. Our hypothesis that cushioned column system shoes reduce the amount of lateral stability in the ankle joint as a result of a perceived increase in ankle plantar flexion was not supported. Therefore, these results do not indicate that wearing cushioned column system shoes places the athlete at greater risk for sustaining a lateral ankle sprain.

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