Mechanisms of Basketball Injuries Reported to the HQ Air Force Safety Center

A 10-Year Descriptive Study, 1993–2002

Bruce R. Burnham, DVM, MPH, G. Bruce Copley, PhD, MPH, Matthew J. Shim, PhD, MPH, Philip A. Kemp, MS

Background: Basketball is the most popular sport among the U.S. Air Force (USAF) active duty population and causes a large number of lost-workday injuries. The purpose of this study is to describe how basketball injuries occur to allow development of effective countermeasures.

Methods: This study used data derived from safety reports obtained from the USAF Ground Safety Automated System. Basketball injuries for the years 1993–2002 that resulted in at least one lost workday were included in the study conducted in 2003. Narrative data from 32,818 safety reports were systematically reviewed and coded in order to categorize and summarize mechanisms associated with these injuries.

Results: A total of 2204 mishap reports involving active duty USAF members playing basketball were documented by the study. This study identified seven mechanisms causing basketball injury. Two similar causes involving jumping (landing awkwardly and landing on someone's foot) accounted for 43% of basketball injuries followed by collisions with other players (10%).

Conclusions: This study shows that mechanisms of basketball-related injury can be identified using the detailed information found in USAF safety reports. Knowledge of leading hazards or mechanisms for basketball injuries can be used to prioritize and develop prevention strategies.
(Am J Prev Med 2010;38(1S):S134–S140) Published by Elsevier Inc. on behalf of American Journal of Preventive Medicine

Introduction

Historically the focus of military safety activities has been directed toward preventing fatalities. However, the U.S. Air Force (USAF) has recently taken a more active interest in reducing lost-workday injuries. In an effort to better understand the nature of lost-workday injuries, an in-depth descriptive epidemiologic study was conducted at the HQ Air Force Safety Center (AFSC) using data from the USAF's ground mishap reporting system, the Ground Safety Automated System (GSAS).

It is well established that sports and athletics are a major cause of serious, nonfatal injuries for the military.[1,2] Both civilian and military studies have shown basketball to be a leading cause of sports and recreation injuries.[3–8] While strains and sprains of the lower extremities are found to be the most common injuries, a wide range of injury types and body parts have been documented.[9–14] Studies that attempt to address the cause of basketball injuries through identifying risk factors or mechanisms are scarce.

While the studies reported in the sports medicine literature are a good start, they usually lack descriptions of the detailed events which cause basketball injuries. The present study attempts to use GSAS, a large, detailed mishap reporting (safety) database to fill the gap present in the literature regarding the different mechanisms of injury in adult recreational basketball. The generic external cause codes (ICD-10) employed by medical databases are not detailed enough for developing interventions for specific sports. This deficiency is in great part due to the

From the Headquarters, AFSC (Burnham, Kemp), Analysis and Integration Division, Kirtland AFB, New Mexico; ExxonMobil Biomedical Sciences, Inc. (Copley), Annandale, New Jersey; Air Force Institute for Operational Health (Shim), San Antonio, Texas

G. Bruce Copley was an employee of HQ Air Force Safety Center when this research was completed.

Address correspondence and reprint requests to: Bruce R. Burnham, DVM, MPH, HQ AFSC/SEAR, 9700 G Avenue SE, Kirtland AFB NM 87117-5670. E-mail: bruce.burnham@kirtland.af.mil.

0749-3797/00/$17.00
doi: 10.1016/j.amepre.2009.10.009

lack of detailed documentation of sports and recreation injuries in medical records. Most medical sources of data do not provide either an adequate number of injury reports to allow aggregation into mechanisms, or sufficient detail for meaningful action. The safety data in this report should provide a good start toward supplying details of how basketball injuries occur.

This study answered a request for information from a Department of Defense (DoD) organization, the Defense Safety Oversight Council's Military Training Task Force. The council and task force wanted to know if safety data could be used for injury prevention purposes. While safety data have historically been used to define priorities based on fatalities, the purpose of this study was to determine the potential capabilities of using safety data for the prevention of nonfatal injuries, in this instance, sports injuries. As an example of this capability, this report focuses on injuries arising from participation in organized basketball that were serious enough to cause 1 or more days of lost work or duty.

Methods

This paper describes a retrospective descriptive analysis of basketball injuries occurring among active duty USAF personnel over a 10-year period from 1993 to 2002. During that period of time the USAF population declined from 439,902 in 1993 to 363,787 in 2002 (Table 1). In 2002 the USAF population was 80.4% men and 19.6% women. The outcome of interest for this study was basketball injuries serious enough to cause 1 or more days of lost duty and requiring an accident report to the AFSC. In order to identify basketball injuries meeting that definition, 32,812 accident/mishap reports had to be reviewed and categorized.

Table 1. USAF population and frequencies and rates of lost workday basketball injuries reported to the AFSC from 1993 to 2002

Year	Population (*n*)	Frequency of lost workday basketball injury reports (*n*)	Rates of lost workday basketball injuries (per 10,000 population)
1993	439,902	387	8.8
1994	422,024	289	6.8
1995	396,102	244	6.2
1996	384,719	220	5.7
1997	373,082	200	5.4
1998	363,206	181	5.0
1999	356,214	174	4.9
2000	351,104	191	5.4
2001	347,782	161	4.6
2002	363,787	157	4.3

Detailed methods for identifying and developing hazard scenarios for activities and mechanisms of sports and other injuries are given in a separate paper in this supplement.[15] In 2003 GSAS data from Fiscal Years 1993 through 2002 were analyzed and grouped by activity (e.g., motor vehicles, falls, sports) as shown in Table 2. Within each injury activity, descriptive hazard scenarios were developed that could potentially inform prevention efforts. As a list of activities had not previously been developed from the GSAS, the list was formulated using a rigorous process of reading reports, categorizing similar mishaps, and continually refining the list to capture the greatest number of similar mishaps.[15] The final list of activities and mechanisms (Table 2) captured 86% of the mishaps that occurred during the study period.

This paper describes injuries from only basketball. GSAS does not contain reports on all injuries at the time of this study as reporting was required only on injuries resulting in at least one lost workday— hence the focus on lost-workday injuries. Although descriptive statistics (frequencies, distributions) were produced for a wide variety of factors such as fiscal year, age, major command, functional area, injury type, and activity, only overall activities/mechanisms and hazard frequencies are presented in this paper because of small numbers of women, and in age and race groups.

Results

Basketball was found to be the leading cause of injuries in the sports and recreation subcategory for the entire 10-year period, 1993 to 2002. With 2204 total lost-workday injuries reported, basketball ranks number four overall, with almost twice the number of injuries as softball, the second most frequent cause of sports and recreation injuries. For USAF active duty personnel during this time period, basketball ranked second overall in total injuries, and fourth in total lost workdays when only active duty military reports (no USAF civilian reports) were summarized (Table 2). The on-base percentage (%) column in Table 2 reflects the percentage of mishaps occurring on a military installation. For all three of the major sports (basketball, softball, and football) roughly three quarters of the injuries occur on-base—reflecting the high number of recreational facilities per capita on USAF installations.

Table 3 lists the top seven mechanisms of basketball injuries, and summarizes the findings for the 2204 basketball injuries reported. The top five such mechanisms or hazards could be summarized further as landing after jumping, player contact, and running/pivoting/cutting; these categories account for a majority of the injuries (71%) (Table 3). Overall the seven mechanisms listed accounted for 86% of all basketball inju-

Table 2. Top ten activities associated with lost workday injuries, reported to the AFSC, active duty USAF personnel, 1993–2002[a]

Rank	Activity	Total lost workdays	Total lost workday injuries (*n*)	Lost workdays per injury (M/median)	On-base %
1	Operating vehicles or equipment	46,818	4,390	10.7/3	13
2	Basketball	12,520	2,165	5.8/2	78
3	Slips/trips/falls[b]	14,554	2,032	7.2/3	61
4	Lifting/carrying (not slips, trips, or falls)	3,386	1,231	2.8/2	72
5	Softball	6,843	1,171	5.8/3	71
6	Riding in/on vehicles or equipment	13,023	1,147	11.4/4	16
7	Climb/descend stairs or ladder	6,902	965	7.2/3	59
8	Flag football	5,406	939	5.8/3	74
9	Struck/struck by object[c]	5,208	932	5.6/2	73
10	Trail riding—dirtbike/ATV/Quad	5,563	454	12.3/7	8

[a]Excludes categories such as "standing," which convey only incidental activities.
[b]Numerous activities were associated with this category, but specific well-defined activities (e.g., slip, trip, fall due to playing basketball or softball, or climbing a ladder or stairs) were included in those more-specific categories rather than being included under this general slip, trip, fall category. Activity breakdown: general walking (n=2363); stepping up or down from/to uneven surfaces such as curbs (n=380); entering/exiting buildings or vehicles (n=368); carrying items (n=254); handling or carrying items or equipment (n=155); running not associated with sports, jogging, or physical training (n=138); and dozens of other activities.
[c]Does not include people being struck by objects that they dropped; being struck by a dropped object is categorized here as lift/carry/handle; also does not include being hit by a motor vehicle (pedestrian injuries are included in lower-frequency categories not included in this table).

ries as seen in Table 1. Two specific mechanisms from Table 3 for landing after jumping (landing awkwardly, and landing on someone else's foot) account for 43% of basketball injuries. Another key finding is that 21% of injuries (struck by another player and collisions) are caused by some form of contact with another player. Table 4 also gives specific examples of the injuries found in each hazard group. For example, the main type of injury associated with jumping and landing awkwardly or on another player's foot was sprains. Not unsurprisingly, sprains accounted for 58% of landing injuries.

Tables 2 and 3 also provide data regarding severity of injury, in terms of the average and median number of lost workdays per injury. Achilles tendon injuries caused the highest (12.5) average number of lost workdays. These data also indicate that jumping and landing on another player's foot caused less severe injuries than landing and rolling the ankle on the floor.

Summarizing across mechanisms in Table 4, sprains were the leading type of injury overall (38%), followed by fractures (24%), strains (15%), and ruptures (11%). These data indicate that GSAS reporting is weighted heavily toward more serious injuries. Table 4 provides data on which injury types are caused by different specific hazards/mechanisms.

Discussion

The greatest value of these data on basketball originates from the detail on causes and mechanisms, which is not available in most medical or sports databases. This study shows that safety report data can be coded and summarized in a way that could be useful for prioritization and prevention of time loss injuries. It identifies seven mechanisms of basketball injuries that can serve as a foundation for future prevention strategies.

Although the decreasing trend in frequency of basketball injuries during the 1990s is noteworthy, it should be interpreted with caution. Numbers of almost all of the injuries for other activities in the safety database have decreased in a similar manner during this 10-year period; the decrease was probably due to the drawdown in active duty members and changes in hospitalization practices (personnel communication) rather than from the implementation of any program or countermeasure (Table 1). Also, the unknown percentage of USAF personnel who play basketball, and likely changing recreational patterns, make it difficult to calculate rates. The detailed safety information on mechanisms of basketball and other injuries will be most useful for epidemiologic purposes if linked to more complete but less detailed medical data on injuries. Although such a linkage was beyond the capabil-

Table 3. Frequency of mechanisms and hazards producing basketball injuries, and potential prevention modalities, USAF personnel, 1993–2002 (2204 injuries)[a]

Mechanism/hazard	Example(s)	Injuries reported (% total)	Average number of lost workdays per injury	Possible prevention
Jumped, landed awkwardly	Jumped for rebound, rolled ankle	578 (26)	5.4	Implement training to improve balance[32]
	After lay up, landed on side of foot			Ankle braces[24]
Jumped, landed on player's foot	Jumped, landed on defender's foot	370 (17)	3.1	Implement training to improve balance
	Came down on foot when rebounding			Ankle braces
Collided	Collision with another player	221 (10)	6.5	Enforcement of rules
	Ran into from behind			
Achilles damage	Ruptured Achilles tendon	162 (7)	12.5	Conditioning, shift emphasis from stretching to warming up prior to play
	Tore Achilles tendon			
Ran, pivoted, cut	Pivoted quickly and injured foot	145 (7)	6.9	Shift emphasis from stretching to warming up prior to play
	Stopped quickly and strained knee			
Fell, unspecified	Slipped and fell	139 (6)	6.7	Implement training to improve balance; dry floors
	Fell and landed on wrist			
Struck by another player (push, kick)	Struck by player in eye	100 (4.5)	4.2	Eye guards, mouth guards
	Elbowed by player in nose			
Other		489 (22)	5.1	

[a]Total basketball-related lost workday injuries reported to the AFSC, 1993–2002=2204

ities of this safety data study, safety and medical data have been linked for priority setting purposes by the Defense Military Injury Priorities and Prevention Working Group.[16]

Despite possible shortcomings, the findings of this study are consistent with other studies regarding mechanisms of basketball injury.[16,17,18] One large observational study[17] documented 10,393 participations (a game in which a player participated in part or all of the game observed) and 40 injuries. That study identified eight mechanisms of basketball injuries: landing (45%, half on another person's foot and half on floor); sharp twist, cut, or turn (30%); collisions (10%); falls (5%); sudden stopping (2.5%); and tripping (2.5%).[17] Three risk factors for injury were identified by that study: a history of ankle injury, players wearing shoes with air insoles, and players who did not stretch before the game. Another study, which reported results of a large interview survey that used a classification scheme based on the International Classification of External Causes of Injury system, found that the most common mechanisms for all sports and recreation injuries were being struck by/against, falls, and overexertion.[18] A study that used video analysis of 39 anterior cruciate injuries of basketball players determined that female players landed with more knee and hip flexion and had a higher relative risk of sustaining a valgus collapse than male players.[19] Hootman's extensive review of 15 NCAA sports found that player contact was the most common mechanism for all sports, and produced the majority of injuries even in sports that limit or restrict player contact such as basketball.[20] The similarity of the seven leading injury mechanisms identified in this

Table 4. Frequency of injury type by mechanism

Mechanism	Injury type	Frequency
Achilles	Rupture (complete organ tears/achilles tendon)	144
	Sprain (tear of ligament/joint/cartilage/tendon)	10
	Strain (includes muscle injuries/whiplash/spasm)	8
Collision	Contusion	21
	Dislocation (separation/subluxation)	18
	Fracture (chipped bones/compression/compound)	77
	Sprain (tear of ligament/joint/cartilage/tendon)	48
	Strain (includes muscle injuries/whiplash/spasm)	30
	Other	27
Fell	Fracture (chipped bones/compression/compound)	65
	Sprain (tear of ligament/joint/cartilage/tendon)	27
	Strain (includes muscle injuries/whiplash/spasm)	22
	Other	19
Jumped	Dislocation (separation/subluxation)	18
	Fracture (chipped bones/compression/compound)	103
	Rupture (complete organ tearsachilles tendon)	33
	Sprain (tear of ligament/joint/cartilage/tendon)	308
	Strain (includes muscle injuries/whiplash/spasm)	106
	Other	10
Landed awkwardly	Contusion	4
	Dislocation (separation/subluxation)	10
	Fracture (chipped bones/compression/compound)	93
	Rupture (complete organ tears/achilles tendon)	6
	Sprain (tear of ligament/joint/cartilage/tendon)	241
	Strain (includes muscle injuries/whiplash/spasm)	16
Running, cutting	Fracture (chipped bones/compression/compound)	15
	Rupture (complete organ tears/achilles tendon)	15
	Sprain (tear of ligament/joint/cartilage/tendon)	60
	Strain (includes muscle injuries/whiplash/spasm)	46
	Other	9
Struck by player	Abrasion/scrape/scratch	24
	Concussion	12
	Contusion	36
	Fracture (chipped bones/compression/compound)	82
	Laceration (tears/cuts)	27
	Rupture (complete organ tears/achilles tendon)	24
	Sprain (tear of ligament/joint/cartilage/tendon)	37
	Strain (includes muscle injuries/whiplash/spasm)	27
	Other	20
Other	Sprain	29
	Strain (includes muscle injuries/whiplash/spasm)	57

paper to those identified by other investigations gives credence to safety data.[17,20]

The large percentage of injuries associated with jumping in this paper is also consistent with the current literature[21–24] and is particularly noteworthy, as they are largely injuries to the ankle, and point to the potential benefits of developing successful countermeasures targeted against preventing ankle sprains. These injuries also present a unique opportunity for prevention as a higher percentage (78%) occur on-base than any other sports and recreation activity. The USAF could well provide the evidence and impetus needed to fuel a much broader acceptance of successful ankle injury countermeasures.

A number of articles focus on preventing ankle injuries, the most common basketball injury.[25–34] These studies have examined ankle braces, ankle taping, and balance training. The most compelling of these is the systematic review by Thacker et al.,[31] which found semirigid ankle braces to be effective in preventing ankle sprain, and that braces do not adversely affect performance.

It was judged by the AFSC that some successful prevention strategies, such as ankle taping and balance training, would require a substantial amount of time and expertise that may not be practical. For this reason, the AFSC initiated a demonstration project in 2006 to evaluate the acceptability of mandating universal use of semirigid ankle braces at two USAF bases. Ankle braces were required for all intramural basketball games for one complete season. Ankle sprains were noticeably reduced during the demonstration; however, the numbers of players at the USAF bases were insufficient to prove the efficacy of ankle braces. The project did show that required use of braces on a community-wide scale was possible. Although the braces were supplied to the players by the AFSC, the project found that a greater selection of braces might increase acceptability (unpublished report). These findings were consistent with the results of a randomized trial of an ankle brace for intramural basketball at West Point Military Academy showing a 64% reduction in ankle injuries among brace-wearers.[34]

The list of potential countermeasures included in Table 3 is not limited to "proven" prevention countermeasures; rather, it is a brainstorming list of potential prevention strategies. It is included to illustrate that possibilities for prevention exist for each of the mechanisms identified. These would require evaluation prior to broad implementation.

The principal limitation of this study is the unknown degree of under-reporting of injuries by safety officials. The reporting process relies on a chain of events with a number of weak links: the injured player notifying the supervisor, the supervisor notifying safety, and the safety office investigating the mishap and finally reporting to the AFSC. Internal and external estimates of under-reporting have varied from 50% to 90% under-reporting (unpublished data). In 2003, a DoD working group found that only 4% of USAF outpatient visits were reported to safety (unpublished data). This problem of probable under-reporting is most likely due to many factors, but the issue of possible under-reporting may not be as serious as first appears when it is considered that the system captures only acute traumatic injuries that are immediately reported and that result in 1 or more days of lost duty. Another limitation is the lack of accurate denominator or exposure data. Exposure data on the number of USAF personnel who play basketball and other sports are needed. Nevertheless, because there will be no data on the underlying mechanisms of basketball and other sports or occupational injuries if safety data are not utilized, the USAF and other Services should proceed to code and use mishap reports to help prevent nonfatal injuries. At the same time, ways to improve the data should be pursued.

Conclusion and Recommendations

The results of this study allowed the development of a useful list of codable hazards for basketball injuries reported to the Air Force Safety Automated System. This list and other similar ones should allow the USAF's mishap reporting system to incorporate more detailed hazard codes in the future. The USAF safety data are sufficient to help identify priorities and to begin development of interventions to prevent basketball and other injuries.

Safety data provide details of the mechanisms and hazards of basketball and other injuries that are absent in the current medical surveillance systems, which use less precise medical coding systems. Safety data such as those presented here would be most valuable for public health and epidemiologic purposes if linked to medical surveillance data, such as was done by Ruscio et al.[16] Even without such linkages to medical data, safety data such as those on basketball presented in this paper are of substantial value. Without data such as these, all that would be known is that basketball causes injuries, without further insight into the fact that hazards such as landing on another player's foot or collisions with other players are important, direct, proximate causes of injury. It is recommended that safety data be used to routinely subcategorize injury causes by underlying mechanism and hazards of injury. Furthermore, it is recommended that epidemiologic studies using medical data on basketball and other injuries be supplemented with safety data to acquire more adequate detail for injury prevention purposes.

We gratefully acknowledge all the members of the Research and Epidemiology Branch who participated in this project. DJ Atkins, Tom Schultz, and Donna Roper all provided invaluable support in data abstraction and guidance in this project. The work was entirely funded by the AFSC.

The views expressed in this academic research paper are those of the author and do not reflect the official policy or position of the U.S. Government or the DoD.

No financial disclosures were reported by the authors of this paper.

References

1. Jones BH, Perrotta DM, Canham-Chervak ML, Nee MA, Brundage JF. Injuries in the military: a review and commentary focused on prevention. Am J Prev Med 2000;18(3S): S71–84.
2. Smith GS, Dannenberg AL, Amoroso PJ. Hospitalizations due to injuries in the military: evaluation of current data and recommendations on their use for injury prevention. Am J Prev Med 2000;18(3S):S41–53.
3. Centers for Disease Control and Prevention (CDC). Nonfatal sports- and recreational-related injuries treated in emergency departments—U.S, July 2001–June 2000. MMWR 2002;51: 736–40.
4. CDC. Sports-related injuries among high school athletes—U.S. 2005–06. MMWR 2002;55(38):1037–40.
5. Lauder TD, Baker SP, Smith GS, Lincoln AE. Sports and physical training injuries in the Army. Am J Prev Med 2000; 18(3S):S118–28.
6. Finch C, Cassel E. The public health impact of injury during sport and active recreation. J Sci Med Sport 2006;9(6):490–7.
7. Krentz J, LI G, Baker SP. At work and play in a hazardous environment: injuries aboard a deployed U.S. Navy aircraft carrier. Aviat Space Environ Med 1997;68(1):51–5.
8. Harmer PA. Basketball injuries. Med Sport Sci 2005;49:31–61.
9. Lien WC, Wang HP, Liu KL, Wu VC. Duodenal stump perforation after an elbow strike in a basketball player. Am J Emerg Med 2006;24(3):372–4.
10. Hsieh CH, Lin GT. Thumb amputation resulting from an attempted basketball slam-dunk. Clin J Sports Med 2006; 16(3):274–5.
11. Starkey C. Injuries and illnesses in the National Basketball Association: a 10-year perspective. Journal of Athletic Training 2000;35(2):161–7.
12. Prebble TB, Chyou PH, Wittman L. Basketball injuries in a rural setting. WMJ 1999;98(7):22–4.
13. Messina DF, Farney WC, DeLee JC. The incidence of injury in Texas high school basketball: a prospective study among male and female athletes. Am J Sports Med 1999;27(3):294–9.
14. Dick R, Hertel J, Agel J. Descriptive epidemiology of collegiate men's basketball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988–1989 through 2003–2004. J Athl Train 2007;42(2):194–201.
15. Copley GB, Burnham BR, Shim MJ, Kemp PA. Using safety data to describe common injury-producing events: examples from the U.S. Air Force. Am J Prev Med 2010;38(1S):S117–S125.
16. Ruscio B, Smith J, Amoroso P, et al. DoD Military Injury Prevention Priorities Working Group: leading injuries, causes, and mitigation recommendations. Washington: Office of the Assistant Secretary of Defense for Health Affairs, 2006. www.stormingmedia.us/75/7528/A752854.html.
17. McKay GD, Goldie PA, Payne WR, Oakes BW. Ankle injuries in basketball: injury rate and risk factors. Br J Sports Med 2001;35(2):103–8.
18. Conn JM, Annest JL, Gilchrist J. Sports- and recreation-related injury episodes in the U.S. population, 1997–99. Injury Prevention 2003;9:117–23.
19. Krosshaug T, Nakamae A, Boden BP, Engebretsen L. Mechanisms of anterior cruciate ligament injury in basketball; video analysis of 39 cases. Am J Sports Med 2007;35(3):359–67.
20. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. J Athl Train 2007;42(2):311–9.
21. Pfeifer JP, Gast W, Pforringer W. Traumatology and athletic injuries in basketball. Sportverletz Sportschaden 1992;6(3): 91–100.
22. Leanderson J, Nemth G, Eriksson E. Ankle injuries in basketball players. Knee Surg Sports Traumatol Arthrosc 1993; 1(3–4):200–2.
23. Isabel de Camargo Neves Sacco, Takahashi HY, Suda EY, Battistella LR. Ground reaction forces in basketball cutting maneuvers with and without ankle bracing and taping. Sao Paulo Med J 2006;124(5):245–52.
24. McGuine TA, Keene JS. The effect of a balance training program on the risk of ankle sprains in high school athletes. Am J Sports Med 2006;34(7):1103–11.
25. Gross MT, Liu HY. The role of ankle bracing for prevention of ankle sprain injuries. J Orthop Sports Phys Ther 2003;33(10): 572–7.
26. Stasinopoulus D. Comparison of three preventive methods in order to reduce the incidence of ankle inversion sprains among female volleyball players. BR J Sports Med 2004;38(2):182–5.
27. Olmstead LC, Vela LI, Denegar CR, Hertel J. Prophylactic ankle taping and bracing: a numbers-needed-to-treat and cost–benefit analysis. J Athl Train 2004;39(1):95–100.
28. Verhagen EA, van Mechelen W, de Vente W. The effect of preventive measures on the incidence of ankle sprains. Clin J. Sport Med 2000;10(4):291–6.
29. Parkkari J, Kujala UM, Kannus P. Is it possible to prevent sports injuries? Review of controlled clinical trials and recommendations for future work. Sports Med 2001;31(14):985–95.
30. Moiler K, Hall T, Robinson K. The role of fibular tape in the prevention of ankle injury in basketball: a pilot study. J Orthop Sports Phys Ther 2006;36(9):661–8.
31. Thacker SB, Stroup DF, Branche CM, Gilchrist J, Goodman RA, Weitman EA. The prevention of ankle sprains in sports. A systematic review of the literature. Am J Sports Med 1999;27 6):753–60.
32. Jenkins WL, Raedeke SG. Lower-extremity overuse injury and use of foot orthotic devices in women's basketball. J Am Podiatr Med Assoc 2006;96(5):408–12.
33. Trojian TH, McKeag DB. Single leg balance test to identify risk of ankle sprains. Br J Sports Med 2006;40(7):610–3.
34. Sitler M, Ryan J, Wheeler B, et al. The efficacy of a semirigid ankle stabilizer to reduce acute ankle injuries in basketball: a randomized clinical study at West Point. Am J Sports Med 1994;22(4):454–61.