Ankle injuries in basketball: injury rate and risk factors

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Abstract

***Objectives*—To determine the rate of ankle injury and examine risk factors of ankle injuries in mainly recreational basketball players.**

***Methods*—Injury observers sat courtside to determine the occurrence of ankle injuries in basketball. Ankle injured players and a group of non-injured basketball players completed a questionnaire.**

***Results*—A total of 10 393 basketball participations were observed and 40 ankle injuries documented. A group of non-injured players formed the control group (n = 360). The rate of ankle injury was 3.85 per 1000 participations, with almost half (45.9%) missing one week or more of competition and the most common mechanism being landing (45%). Over half (56.8%) of the ankle injured basketball players did not seek professional treatment. Three risk factors for ankle injury were identified: (1) players with a history of ankle injury were almost five times more likely to sustain an ankle injury (odds ratio (OR) 4.94, 95% confidence interval (CI) 1.95 to 12.48); (2) players wearing shoes with air cells in the heel were 4.3 times more likely to injure an ankle than those wearing shoes without air cells (OR 4.34, 95% CI 1.51 to 12.40); (3) players who did not stretch before the game were 2.6 times more likely to injure an ankle than players who did (OR 2.62, 95% CI 1.01 to 6.34). There was also a trend toward ankle tape decreasing the risk of ankle injury in players with a history of ankle injury (p = 0.06).**

***Conclusions*—Ankle injuries occurred at a rate of 3.85 per 1000 participations. The three identified risk factors, and landing, should all be considered when preventive strategies for ankle injuries in basketball are being formulated.**

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Keywords: basketball; ankle; injury; risk; prevention

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In basketball, ankle injuries are among the most common injuries sustained and they are also amongst the most severe.[1–3] An Australian basketball study[2] determined that over half (53.7%) of the total time missed because of an injury in basketball was through an ankle injury. Ankle injuries may result in the player experiencing disability and residual symptoms,[4–6] the most common being pain, sense of instability, crepitus, and weakness.[5] However, arthroscopic surgery of 31 ankles[6] found that chondral lesions were evident in 95% of chronic ankle injuries and 89% of recently injured ankles. As ankle injury is a common occurrence, often with residual symptoms affecting performance and chondral lesions, preventive strategies need to be developed, but risk factors associated with ankle injuries must first be identified and understood.

Previous studies of risk factors for ankle injury have been carried out in either the laboratory, with emphasis on biomechanical assessment, or the sporting environment as a field/clinical study. Laboratory based studies examine the effectiveness of a specific variable such as ankle tape or brace or cut of shoe on aspects of performance such as restriction of postural sway,[7] wobble board performance,[8] sporting activities such as jumping and running,[9–11] or aspects of body function such as amount of joint restriction provided,[12–15] peroneal muscle activity,[16] and peroneal reaction time.[17 18] All of these authors have inferred how these factors may affect the incidence of ankle injuries, without assessing the actual occurrence of ankle injuries.

On the other hand, field studies usually assess risk factors for ankle injury with respect to the actual incidence of ankle injuries. These field based studies may question the validity of the biomechanical studies in making inferences about the risk of ankle injury on the sports field. Therefore the aim of this study was to examine risk factors of ankle injuries, such as history of ankle injury[4 19 20], ankle tape[15 16] and braces[12 13], playing shoes[21], warm up,[22] and position played[23 24] on the court, in the naturalistic environment of the basketball court.

Subjects and method

In Melbourne, Australia, an elite basketball competition and three recreational basketball competitions were observed to identify injuries prospectively. Injury observers were instructed to view games and note the occurrence of injuries during the game. At the end of a game, all players were asked about their injury status, and injured players completed a questionnaire. A control group was obtained by administering a questionnaire to entire teams of players who were not injured on a particular day but were from the same competition as the injured players. All games observed were played indoors on wooden floors.

Table 1 outlines the areas of questioning. The ankle injured players were telephoned to monitor the progress of their injury, to obtain information about time missed, treatment sought, and changes in shoes, protective equipment, and warm up on returning to play.

Table 1 Items contained in questionnaire completed by all subjects and specific questions for players with ankle injuries

Questionnaire for all subjects
Personal characteristics: for example, age, sex, weight, height
Standard of competition played: elite, recreational
Position on court: guard, forward, centre
Protective gear worn: for example, ankle or knee tape/brace, mouthguard
Shoe type: (a) Cut: low, mid, high cut (b) Condition: good, fair, poor
(c) Cost: approximation in Australian dollars (d) Brand and style
Age of shoes: months
Warm up undertaken: including amount (time) and type (stretch, run, ball skills)
History of ankle or knee injury

Additional questions for players with ankle injuries
Side of injury: left, right
Mechanism of injury
Type of injury
When injury occurred: 1st, 2nd, 3rd or 4th quarter

Table 2 Characteristics of ankle injured and control basketball players

	Ankle injured			*Control group*		
	Mean	*SD*	*95% CI*	*Mean*	*SD*	*95% CI*
Age	25.2*	6.6	12.1 to 38.1	28.0	7.7	12.9 to 43.1
Games played a week	1.9	1.0	−0.6 to 3.9	1.9	0.9	0.1 to 3.7
Training sessions a week	1.0	1.4	−1.7 to 3.7	1.2	1.5	−1.7 to 4.1
Weight (kg)	70.5	14.4	42.3 to 98.7	71.0	13.1	45.3 to 96.7
Height (cm)	174.6	12.4	150.3 to 198.9	175.0	11.0	153.4 to 196.6

*Significant difference from control at p<0.05.

Before data collection was begun, the questionnaires were piloted and adjusted as appropriate.

Each injury observer viewed the recreational basketball competition on a weekly basis, viewing two courts at any time. For elite basketball, one court was viewed at any given time as these games were at single court venues. The injury observers documented the number of players participating in any game observed, thereby allowing injury rates to be calculated. Whenever possible, the injury observers administered the questionnaire in an interview format. They prompted the injured players to report the type of injury sustained at the time it occurred. This method has been shown to be reliable and valid.[2]

For the purpose of this study the following definitions were used:
Injury: an action in which the player perceives that bodily harm has been sustained necessitating stoppage of play, substitution, or a display of obvious disability. All players were questioned after the game to confirm the presence of observed or non-observed injuries. This definition is a modified version of that used for an earlier study investigating basketball injuries.[19]
Participation: a game in which a player participated in part or all of the game observed.

The method of data collection was approved by Monash University's committee on ethics in research on humans. Each injured player gave informed consent to participate in the study. The study also had the approval of the Victorian Basketball Association.

STATISTICAL ANALYSIS

Injury rates were expressed as injuries per 1000 participations. The *t* test was used to compare the characteristics of the ankle injured and control groups. From the *t* tests, the age of the basketball players was determined to be a potentially confounding variable. Therefore age was entered into a multivariate logistic regression equation with the other variables (risk factors) to determine the effect of age on the other variables as predictors of ankle injuries.

As many variables (risk factors) were assessed by this study, the variables that were entered into the multivariate logistic regression equation were selected by initially conducting a series of univariate logistic regression analyses. The univariate logistic regression assessed the relation of the outcome (ankle injury or no injury) to each of the independent variables separately. Some variables (age, height, weight, training sessions and games played a week, and cost and age of shoes) were categorised (with three levels) from a continuous scale (see table 3). About one third of the subjects were in each of the category levels of these variables. Warm up time consisted of six categorical levels and, for statistical analysis, was collapsed to three levels.

The most significant independent variables identified in the univariate stage of analysis were then entered into a multivariate logistic regression equation with the variable of age. Odds ratios with 95% confidence intervals (CI) were reported for the multivariate analysis. Values are expressed as mean (SD). A critical probability level of 0.05 was used throughout. The SPSS statistical package was used for data analysis.

Results

DESCRIPTIVE VARIABLES

A total of 10 393 basketball participations were observed (3421 men (32.9%) and 6972 women (67.1%)). The sample was largely recreational (77.9%) rather than elite (22.1%). The follow up telephone interview was completed for 37 (92.5%) of the ankle injured players. Table 2 compares the player characteristics for the ankle injured (n = 40) and control (n = 360) basketball players. No significant differences were detected between the ankle injured group and the control group for height, weight, or the playing or training time a week. However, the ankle injured group was younger than the control group (p<0.05), therefore age was entered into a multivariate logistic regression equation with the other variables.

Rate and severity of ankle injury

The rate of ankle injury was 3.85 per 1000 participations. For the 37 ankle injured players telephoned, a total of 81.5 weeks of play were missed. Almost half (45.9%) of the ankle injuries prevented the player from returning to competition for one week or more.

Mechanism of ankle injury

Almost half (45.0%) of the ankle injuries were incurred during landing, with half of these injuries sustained by landing on another player's foot, and half were due to landing on the court surface. Other mechanisms of ankle injury were a sharp twist/turn (30.0%), collision (10%), fall (5.0%), other (5.0%), sudden stopping (2.5%), and tripping (2.5%).

Table 3 Univariate logistic regression: assessing the relation of the outcome (ankle injury or no injury) to independent variables separately

Variable	*Odds ratio*	*p Value*	*95% CI*
Age			
(1) <25 years and 25–34 years	0.78	0.48	0.37 to 1.65
(2) <25 years and 35+ years	**0.19**	**0.02**	**0.04 to 0.80**
Height			
(1) <169 cm and 170–180 cm	0.50	0.09	0.22 to 1.13
(2) <169 cm and 181+ cm	0.92	0.84	0.43 to 1.97
History of ankle injury			
No=0, Yes=1	**5.60**	**<0.001**	**2.61 to 11.94**
Cost of shoes			
(1) <$99 and $100–200	1.13	0.76	0.52 to 2.46
(2) <$99 and $201+	**4.89**	**0.003**	**1.70 to 14.15**
Warm up time			
(1) None and <10 min	0.58	0.16	0.27 to 1.23
(2) None and 10+ min	0.42	0.08	0.16 to 1.12
Stretching (warm up)			
(No=0, Yes=1)	**2.26**	**0.03**	**1.09 to 4.71**

The following variables were all not significant with $p>0.10$: weight, sex, standard of competition, number of training sessions a week, games played a week, ankle tape, ankle brace, cut of shoe, age of shoes, condition of shoes, running in warm up, ball skills in warm up, and position played. Bold type indicates significantly related to occurrence of ankle injuries.

Table 4 Multivariate logistic regression: assessing the relation of outcome (ankle injury or no ankle injury) to selected independent variables

Variable	*Odds ratio*	*p Value*	*95% CI*
History of ankle injury			
No=0, Yes=1	**4.94**	**<0.001**	**1.95 to 12.48**
Air cells in shoes			
No=0, Yes=1	**4.34**	**0.01**	**1.51 to 12.40**
Stretching (warm up)			
No=0, Yes=1	**2.62**	**0.03**	**1.01 to 6.34**
Age			
(1) <25 years and 25–34 years	0.62	0.30	0.25 to 1.53
(2) <25 years and 35+ years	0.17	0.10	0.02 to 1.37

Bold type indicates significantly related to occurrence of ankle injuries.

Treatment of ankle injuries

Many ankle injured basketball players used some form of self treatment, with 75.7% using ice, 54.1% applying compression, and 70.3% implementing elevation. No player used heat for immediate care. Over half (56.8%) of the ankle injured basketball players did not seek any professional treatment. Of those seeking treatment, 62.5% received medical attention, 56.3% received physiotherapy, and 0.07% (one) had surgery. It should be noted that some players may have sought more than one type of treatment.

Almost three quarters (73.0%) of the ankle injured basketball players reported a previous ankle injury. About one quarter (25.9%) of these players had not sought professional treatment for their earlier ankle injuries. Of all the past ankle injuries reported, a doctor had been consulted in 51.9% of cases and a physiotherapist in 40.7% of cases.

Return to competition

On returning to play, 29.7% of the ankle injured players changed their warm up routine. All but one of these players included more stretching (for the ankle and calf regions) and only one player added extra running. External ankle support was used by two thirds (67.6%) of the ankle injured players returning to competition. Of the players using external support, 40% used ankle tape, 40% used a compression bandage/elastic support, and 20% used an ankle brace. Only 10.8% of the players changed their footwear on returning to play, with only one player changing to a high cut shoe.

RISK FACTORS OF ANKLE INJURY

Univariate analysis

Table 3 shows the relation of the outcome (ankle injury or no injury) to independent variables separately, using univariate logistic regression. At the univariate stage, four variables were found to be significantly related to the occurrence of ankle injuries (age, history of ankle injury, cost of shoes, and stretching during warm up).

Multivariate analysis

The four independent variables determined to be significant after the univariate analysis were then entered into a multivariate logistic regression equation to investigate how the combination of variables predicted ankle injury, and to adjust for the potentially confounding effect of age. Table 3 shows that the cost of shoes was significant when the cheapest shoes were compared with the most expensive. By reviewing the brand and style of shoes worn by the players, it was determined that all of the most expensive shoes had air cells in the heel and the cheaper shoes did not. Therefore the cost of shoes was reclassified for the multivariate analysis to compare shoes with and without air cells in the heel. Table 4 shows the results of the multivariate analysis. Three variables were determined to be predictors of ankle injury: history of ankle injury, presence of air cells in the heels of the shoes, and stretching during warm up.

History of ankle injuries

A history of ankle injuries was the strongest predictor for the occurrence of ankle injuries. Basketball players who had previously injured their ankle were almost five times more likely to injure an ankle than their previously uninjured counterparts (table 4). Almost three quarters (73.0%) of the ankle injured basketball players reported a previous ankle injury, with a mean of 3.46 (2.7) previous ankle injuries. Less than one third (32.5%) of the control group reported previous ankle injury, with a mean of 2.41 (4.1) ankle injuries.

Air cells in heels of shoes

The second strongest predictor of ankle injury was air cells in the heels of the shoes worn, with players wearing shoes with air cells being 4.3 times more likely to injure an ankle than those wearing shoes without air cells (table 4).

Stretching during warm up

The third strongest predictor of ankle injury was the use of stretching during warm up. Players who did not complete a general stretching programme as part of their warm up routine were 2.6 times more likely to injure an ankle than players who stretched. In the ankle injured group, about half (52.9%) of the players stretched, while in the control group almost three quarters (71.8%) stretched.

OTHER VARIABLES

Ankle tape and braces

This study found that the use of ankle tape and ankle braces was not significantly related to the

Table 5 Comparison of the use of non-stretch ankle tape and ankle brace between injured and control groups (as percentage of sample)

	Total sample		*History of ankle injury*	
Ankle support	*Ankle injured (n=40)*	*Control (n=360)*	*Ankle injured (n=27)*	*Control (n=106)*
Tape	7.5	9.7	11.1*	29.2*
Brace	12.5	8.9	18.5	17.0

*p=0.06.

occurrence of ankle injuries in basketball. However, it should be noted that this sample of mainly recreational players made little use of ankle tape or braces, and therefore only strong relations would be detected. Table 5 outlines the use of ankle tape or ankle braces by the basketball players.

Further investigation (table 5) shows the use of ankle tape for the subgroup of players reporting previous ankle injury. In the control group, 29.2% of players with a history of ankle injury used ankle tape, while fewer (11.1%) in the ankle injured group with previous ankle injury used tape. Univariate logistical regression assessing the use of ankle tape in these two groups showed an association (odds ratio 3.3; 95% CI 0.9 to 11.9; p = 0.06), suggesting that ankle tape may decrease the risk of ankle injury in players with a history of ankle injury.

In this study, basketball players generally used external ankle support once they had sustained an ankle injury, and not for preventive purposes. If the control group is considered alone, ankle tape was more likely to be used by players with a history of ankle injuries (29.2%) than players reporting no previous ankle injury (1.8%) (odds ratio 3.4; 95% CI 2.7 to 4.3; p = <0.001). Similarly, players in the control group reporting a history of ankle injury were more likely to wear an ankle brace (17.0%) than players with no previous ankle injury (5.5%) (odds ratio 2.0; 95% CI 1.4 to 2.8; p = 0.001).

Non-significant variables

Many factors were not significantly related to the occurrence of ankle injury, including the player characteristics (sex, age, height, weight, games played a week, and amount of training a week), cut of shoe worn, position played on the court, or quarter of the game injured.

Discussion

This study prospectively observed 10 393 basketball participations, four times the number of courtside observations made by the Garrick and Requa basketball study over 25 years ago.[19] However, the rate of ankle injury observed in basketball players in our study was 5.7 times lower than in the previous study.[19] It could be speculated that the lower rate was due to factors such as training methods, quality of footwear, and ankle taping/bracing. Despite the decrease in incidence of ankle injuries, the rate and severity of injury documented here highlights the need to reduce the incidence further. A total of 81.5 weeks were missed by 37 players, with almost half (45.9%) missing one week or more of competition. Further preventive strategies therefore need to be developed to decrease the impact of cost of rehabilitation and time missed due to ankle injuries.

Jumping and landing are skills often performed by basketball players, and therefore it is not surprising to find that almost half (45%) of ankle injuries were sustained during landing. Almost another one third (30%) of ankle injuries occurred during a sharp twist or turn. The sharp twist or turn is a component of cutting and changing direction, again an integral part of basketball. As half of the landing injuries and all of the twisting/turning injuries were incurred during weight bearing on the court surface, more research needs to be directed towards identifying appropriate landing and body movement strategies and whether they can be taught and then become effective injury prevention strategies in basketball. A volleyball study[25] showed a twofold reduction in ankle injuries after correct landing techniques and body movement strategies had been taught, along with ankle disc training. A comparable study in basketball is warranted.

This study found that over half (56.8%) of ankle injured players did not seek professional treatment, although about three quarters (75.6%) administered some type of self treatment. Of the players reporting previous ankle injuries, 25.9% had not sought professional treatment for their earlier ankle injuries. Of these previously ankle injured players, only half (51.9%) consulted a doctor and fewer (40.7%) underwent a rehabilitation programme with a physiotherapist. This high rate of non-treatment is consistent with an American varsity study,[4] which reported that 55% of the male basketball players in their study did not seek medical attention for their ankle injuries. Does the failure of players to receive treatment for an ankle injury contribute to the high re-injury rate observed here? Studies that have shown a reduction in the rate of ankle injury after rehabilitation[25] and balance training[25,26] would suggest this to be the case. However, a further randomised controlled trial of ankle injured basketball players that controls for treatment would be valuable in answering such a question.

The strongest predictor of ankle injuries identified by this study is a history of ankle injury. Players with a history of ankle injury were almost five times more likely to sustain an ankle injury than previously non-injured players. Basketball players with a history of previous ankle injury accounted for 73% of the ankle injured group but only 32.5% of the control group. The finding that players with a history of ankle injury are prone to re-injure is supported by previous studies across various sporting arenas.[4,19,20,27,28] Clearly, ankle injuries are not just a simple sprain, but often incur a cycle of repeated injury. Ankle injured players and health professionals need to be made aware of the increased risk of injury after the initial injury. Education about the benefits of rehabilitation and other preventive measures needs to be provided to this largely recreational basketball group in which rehabilitative treatment was not commonly undertaken.

The second ranked predictor of ankle injury was air cells in the heels of the shoes worn. Basketball players wearing shoes with air cells in the heels were 4.3 times more likely to injure an ankle than those wearing shoes without air cells (table 4). It may be hypothesised that air cells located in the heels of basketball shoes decrease rear foot stability, which may in turn increase the risk of ankle injury. Further research is required to explore this hypothesis.

The third ranked predictor of ankle injury was the use of general stretching during the warm up period. Basketball players who did not stretch were 2.7 times more likely to injure an ankle than players who did stretch. A relation has been shown between tightness of the calf muscles and ankle injuries,[29] suggesting that tightness of the calf muscles may be responsible for ground contact of the feet in the supinated position, with a high risk of an ankle sprain.[29] Further, traditionally stretching has been used as part of the warm up before sporting contests because of the suggested decreased risk of injury.[30 31] It has been hypothesised that stretching decreases the risk of injury by decreasing the stiffness of the connective tissue and increasing the range of motion of a joint.[22] However, the benefits of stretching have recently been challenged by a randomised clinical trial involving 1317 male Australian army recruits.[32] This study reported that stretching as part of the warm up before physical activity did not significantly decrease the risk of lower limb injury (bone or soft tissue) during a 12 week training programme. The study documented 276 injuries, with a small portion (14%) involving ankle sprains. Of the ankle sprain group, there was a trend towards more ankle sprains occurring in the non-stretching group (59%) than the stretching group (41%). As our study suggests injury prevention benefits of stretching, it seems warranted to conduct a randomised controlled study to evaluate the role of stretching specifically for ankle injuries.

Ankle injuries were not found to be associated with the use of ankle tape or braces in this study. However, in this largely recreational sample there was little use of ankle tape and braces (table 5), and given this low level of use only strong relations to the incidence of ankle injuries would have been found. The finding of no association between ankle tape and braces and ankle injuries contrasts with the results of other field/clinical studies,[33–35] which have shown the efficacy of ankle braces in the reduction of ankle injuries.

Interestingly, our study found that, in the subset of players who had experienced previous ankle injuries, there was a trend toward ankle tape decreasing the risk of ankle injury in players with a history of ankle injury ($p = 0.06$). This finding would tend to support the results for the ankle brace.[33–35] Further, it has been determined that ankle tape provided the most effective restriction of ankle motion in people with chronic instability of the ankle.[36]

It seems that players from this largely recreational sample would only use ankle tape or braces after an ankle injury, and not for preventive measures (table 5). Further, for players with a history of ankle injury, there were fewer players in the ankle injured group wearing tape than in the control group. The apparent failure of previously ankle injured players to wear ankle tape may call into question the long term compliance of wearing ankle tape. Use of ankle braces by players with a history of ankle injury was similar for the injured and control groups, and may be evidence of long term compliance for those using ankle braces.

Interestingly, the risk of ankle injury was not related to factors that players could not change, such as sex, age, and height. Some more changeable factors such as the player's weight, the amount of training undertaken, the number of games played a week, the cut of shoe worn, the position played on the court, and the quarter of the game played were also not significantly related to the occurrence of ankle injuries in this study.

This study observed a large number of players in their natural environment using a prospective observer based cross sectional method of injury surveillance. However, a relatively small number of ankle injuries was documented. This study focused on acute ankle injuries during games and did not document injuries incurred at training sessions nor the more insidious gradual onset injuries. The findings would be generalisable to similar players and playing conditions, but further studies would be required to examine different age groups—for example, adolescents—standards of play, and playing conditions—for example, outdoors, other court surfaces.

In conclusion, three risk factors of ankle injury were identified for this largely recreational basketball sample.

(1) Players with a history of ankle injury were 4.9 times more likely to sustain an ankle injury. Ankle injured players need to be made aware of the increased risk of injury after the initial injury and pursue preventive strategies.

(2) Players wearing shoes with air cells in the heels were 4.3 times more likely to injure an ankle than those wearing shoes without air cells. Further research is necessary to explore the hypothesis that air cells decrease rear foot stability and consequently increase the risk of ankle injury.

(3) Basketball players who did not stretch were 2.7 times more likely to injure an ankle than players who did stretch. Hence appropriate stretching programmes need to be taught to basketball players, particularly those with a history of ankle injuries.

Noteworthy was the trend toward ankle tape decreasing the risk of ankle injury in players with a history of ankle injury. Finally, the most common mechanism of ankle injuries was landing. As jumping and landing are integral components of a basketball game, more research is needed into whether appropriate landing and body movement strategies can be taught to basketball players to effectively prevent injury, as shown in volleyball.[25]

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1 Colliander E, Eriksson E, Herkel M, *et al*. Injuries in the Swedish elite basketball. *Orthopaedics* 1986;**9**:225–7.
2 McKay GD, Payne WR, Goldie PA, *et al*. A comparison of the injuries sustained by female basketball and netball players. *Aust J Sci Med Sport* 1996;**28**:12–17.
3 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**: 294–29.
4 Smith RW, Reischl SF. Treatment of ankle sprains in young athletes. *Am J Sports Med* 1984;**14**:465–71.
5 Yeung MS, Chan KM, So CH, *et al*. An epidemiological survey on ankle sprain. *Br J Sports Med* 1994;**28**:112–16.
6 Taga I, Shino K, Inoue M, *et al*. Articular cartilage lesions in ankles with lateral ligament injury: an arthroscopic study. *Am J Sports Med* 1993;**21**:120–7.
7 Bennell KL, Goldie PA. The differential effects of external ankle support on postural control. *J Orthop Sports Phys Ther* 1994;**20**:287–95.
8 Hamer PW, Munt M, Harris CD, *et al*. The influence of ankle strapping on wobbleboard performance before and after exercise. *Aust J Physiother* 1992;**38**:85–92.
9 MacKean LC, Bell G, Burnham RS. Prophylactic ankle bracing versus taping: effects on functional performance in female basketball players. *J Orthop Sports Phys Ther* 1995;**22**:77–81.
10 Macpherson K, Sitler M, Kimura I, *et al*. Effects of a semirigid and softshell prophylactic ankle stabilizer on selected performance tests among high school football players. *J Orthop Sports Phys Ther* 1995;**21**:147–52.
11 Gross MT, Everts JR, Roberson SE, *et al*. Effect of DonJoy ankle ligament protector and Aircast sport-stirrup orthoses on functional performance. *J Orthop Sports Phys Ther* 1994;**19**:150–6.
12 Anderson DL, Sanderson DJ, Hennig. The role of external non-rigid ankle bracing in limiting ankle inversion. *Clin J Sports Med* 1995;**5**:18–24.
13 Alves JW, Alday RV, Ketcham DL, *et al*. A comparison of the passive support provided by various ankle braces. *J Orthop Sports Phys Ther* 1992;**15**:10–18.
14 Green TA, Wight CR. A comparative support evaluation of three ankle orthoses before, during and after exercise. *J Orthop Sports Phys Ther* 1990;**11**:453–66.
15 Shapiro MS, Kabo JM, Mithcell PW, *et al*. Ankle sprain prophylaxis: an analysis of the stabilizing effects of braces and tape. *Am J Sports Med* 1994;**1**:78–82.
16 Loos T, Boelens P. The effect of ankle tape on lower limb muscle activity. *Int J Sports Med* 1984;**5**:S45–6.
17 Karlsson J, Andreasson GO. The effect of external support in chronic lateral ankle joint instability: an electromyographic study. *Am J Sports Med* 1992;**20**:257–61.
18 Konradsen L, Ravn JB. Prolonged peroneal reaction time in ankle instability. *Int J Sports Med* 1991;**12**:290–2.
19 Garrick JG, Requa RK. Role of external support in the prevention of ankle sprains. *Med Sci in Sports* 1973;**5**:200–3.
20 Bahr R, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. *Scand J Med Sci Sports* 1997;**7**:166–71.
21 Barrett JR, Tanji JL, Drake C, *et al*. High- versus low-top shoes for the prevention of ankle sprains in basketball players. A prospective randomised study. *Am J Sports Med* 1993;**21**:582–5.
22 Brukner P, Khan K. Principles of injury prevention. In: *Clinical sports medicine*. Sydney: McGraw-Hill Book Company, 1993:30–4.
23 Henry JH, Lareau B, Neigut D. The injury rate in professional basketball. *Am J Sports Med* 1982;**10**:16–18.
24 Apple DF, O'Toole J, Annis C. Professional basketball injuries. *Physician and Sportsmedicine* 1982;**10**:81–6.
25 Bahr R, Lian O, Bahr IA. A twofold reduction in the incidence of acute ankle sprains in volleyball after the introduction of an injury prevention program: a prospective cohort study. *Scand J Med Sci Sports* 1997;**7**:172–7.
26 Wester JU, Jespersen SM, Nielsen KD, *et al*. Wobble board training after partial sprains of the lateral ligaments of the ankle: a prospective randomised study. *J Orthop Sports Phys Ther* 1996;**23**:332–6.
27 Ekstrand J, Tropp H. The incidence of ankle sprains in soccer. *Foot Ankle* 1990;**11**:41–4.
28 Milgrom C, Shlamkovitch N, Finestone A, *et al*. Risk factors for lateral ankle sprain: a prospective study among military recruits *Foot Ankle* 1991;**12**:26–30.
29 Lysens RJ, Lefevre J, Ostyn MS, *et al*. Study of the evaluation of joint flexibility as a risk factor in sports injury. *The CIBA-GEIGY award of the Belgian Society of Sports Medicine and Sports Science*. Leuven: University Press, 1984.
30 Shellock FG. Physiological benefits of warm-up. *Physician and Sportsmedicine* 1983;**11**:134–9.
31 Leard JS, Guilfoyle JE. Physiological basis of warm-up and cool-down. *Clinics in physical therapy*. New York: Churchill Livingstone, 1986;**10**:81–8.
32 Pope RP, Herbert RD, Kirwan JD, *et al*. A randomised trial of preexercise stretching for prevention of lower limb injury. *Med Sci Sports Exerc* 2000;**32**:271–7.
33 Sitler M, Ryan J, Wheeler B, *et al*. The efficacy of a semirigid ankle stabilizer to reduce acute ankle injuries in basketball. *Am J Sports Med* 1994;**22**:454–61.
34 Surve I, Schwellnus MP, Noakes T *et al*. A fivefold reduction in the incidence of recurrent ankle sprains in soccer players using the sport-stirrup orthosis. *Am J Sports Med* 1994;**22**: 601–6.
35 Rovere GD, Clarke TJ, Yates CS, *et al*. Retrospective comparison of taping and ankle stabilizers in preventing ankle injuries. *Am J Sports Med* 1988;**16**:228–33.
36 Larson E. Taping the ankle for chronic instability. *Acta Orthop Scand* 1984;**55**:551–3.

Take home message

Future programmes for preventing ankle injuries in basketball players should examine the identified risk factors of history of ankle injury, the presence of air cells in the heels of the shoes, and the use of stretching. Other preventive strategies such as teaching correct landing strategies and the use of external support (tape or braces) may also be relevant and require further research.