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Clinical Research

The Impact of Knee Surface Alignment on Ankle Sprain Occurrence

Elias Armenis, Nikolaos Pefanis, Georgios Tsiganos, Panagiotis Diamantis Karagounis, Christin Tokatlidouand, and Panagiotis Baltopoulos [AQ: 1] [AQ: 2]

Abstract: Background. *Knee position provides useful information for the anatomical alignment (AA) of the lower extremity. Analyzing the geometric components of this alignment should yield useful information about how these factors affect the occurrence of an ankle sprain. The aim of this study is to investigate the correlation among these anthropometric characteristics and the possible future occurrence of ankle sprain injuries.* Material and methods. *A total of 60 elite athletes (25.2 ± 3.2 years) participated in the current study. The data used for measuring knee surface alignment were the following: AA, condylar hip angle (CH), tibial plateau angle (PA), and joint surface (condylar plateau) angle (CP). Standardized radiography was used in all measurements. All knee alignment measurements were made on digital radiographs. The study lasted for 18 months. A logistic regression (probit) was used for the statistical analysis of the outcomes. A significance level of $P = .05$ was considered.* Results. *The knee angle factors (AA, CH, PA, and CP) proved to be statistically nonsignificant ($P > .05$).* Conclusions. *The geometric knee surface alignment factors do not seem to be a decisive factor that would increase the probability of spraining an ankle.*

Levels of Evidence: *Prognostic Level IV; Case Series*

Keywords: structural knee measures; knee joint orientation; knee alignment; injury risk factors; ankle sprain

Introduction

The horizontal orientation of the joint lines at the hip, knee, and ankle is an essential anatomical decisive factor for all weight-bearing functions. The normal relationship of the joints of the lower extremity has been the focus of several recent studies.[1,2] Abnormal joint orientation leads to forces[3] that can put an unusually high pressure on the surrounding tissues. Recently, the intraarticular alignment of the femoral condyles and the tibial plateau has been proposed as an indicator of how contact forces are distributed across the joint surfaces of the knee during weight-bearing activities.[4,5] Major changes in the alignment of the femur or tibia may affect the load distribution in the knee joint and influence soft-tissue loading at the hip and ankle joints as well.[2]

> "Major changes in the alignment of the femur or tibia may affect the load distribution in the knee joint and influence soft-tissue loading at the hip and ankle joints as well."

So as to follow a standard approach to the measurement and reporting of alignment data, all measurements in the present study were based on geometric analysis of the femur, tibia, and knee joint surfaces. From the anatomical and functional perspectives, the orientation of the femur and tibia at the knee are best described in terms of the axes of the bones (anatomical). The orientation of these axes reflects alignment in stance, which may be neutral, varus, or valgus.

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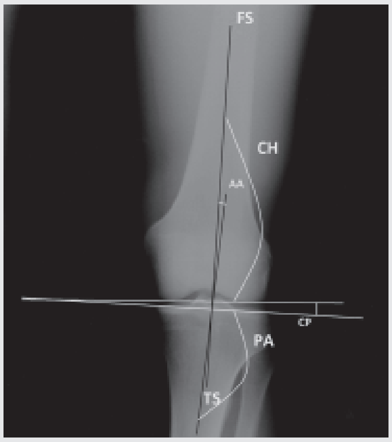
Figure 1.

Knee alignment angles



Abbreviations: CH, condylar hip angle; PA, tibial plateau angle; CP, condylar plateau angle; AA, anatomical alignment angle; FS, femur shaft; TS, tibia shaft.

On the basis of simple geometric analysis, the following elements define the geometry of the tibial and femoral surfaces and the angle between them when loaded stationary[6,7] (Figure 1): anatomical alignment (AA), the angle formed by the lines drawn along the femur and tibia shafts (FS and TS); condylar hip angle (CH), the angle of the femoral condylar tangent with respect to the FS axis; plateau angle (PA), the angle between the tibial margin tangent and the TS axis; condylar plateau angle (CP), the angle between the femoral and tibial joint surface tangents. A joint space angle (CP) that narrows medially is designated as varus (–) and laterally as valgus (+).

Garrick[8] first identified the lateral ligaments of the ankle as the most commonly injured structures in athletes, and subsequent reports support this finding. Fong et al[9] reported that the ankle joint was found to be the second most commonly injured area of the body, whereas ankle sprain was recorded as the most common type of injury (76.7%).

Many different factors have been investigated in the search for predictors of sports injury. Studies relating structure or biomechanics to injury have been more successful than those focusing on strength, flexibility, training, and so on.[10] The intrinsic risk factors for sprains of the lateral ankle ligaments include the following: previous sprain; sex; height and weight; limb dominance; anatomical foot type and foot size; generalized joint laxity; AA, ankle-joint laxity, and range of motion of the ankle-foot complex; muscle strength; muscle reaction time; and postural sway.[11]

In sports and particularly in activities involving actions like running and jumping (soccer, basketball, volleyball, and so on.), the forces exerted on the foot and ankle are maximized.[12] Contact sports conceal the greatest risk for ankle sprains, with soccer being at the top for ankle sprain injuries followed by basketball, volleyball, and other team sports.[13,14]

Using data obtained from 60 participants and a logistic regression, this study aims to establish a link between geometric components of knee alignment and lateral ankle sprain occurrence. We expect to find a significant relation, sufficient enough to predict and prevent such injuries.

Materials and Methods

The study sample consisted of 60 male athletes taking part in different sports (basketball, soccer, and volleyball), whose ages ranged from 19 to 32 years (mean, 25.2 ± 3.2 years) Participants were excluded if they had a history of a surgical procedure involving the lower extremity. The athletes included in the sample were monitored for a period of 18 months. The study began 12 months before the radiological examination and concluded 6 months later. They also signed a consent form, which was approved by the university.

The lower extremity (femorotibial) alignment is commonly assessed from short views of the knee from which the anatomic (shaft) axes of the femur (FS) and tibia (TS) may be located. The femoral mechanical axis is not available from these views but may be approximated because the FS and femoral mechanical axis have a conservative angular offset from each other (about 4°-5°, with low variance).[15-20] Correlations (r) between the femorotibial angle obtained from knee radiographs and the mechanical axis angle obtained from full-limb radiographs are reported to range from 0.65 to 0.88.[17,18,21]

Radiographic film is being rapidly replaced by digital images. Software programs have been developed to aid the measurements of alignment from digital radiographs.[22-28] In this study, knee angle measurements were made on 35.6 × 43.2 cm^2 films with individuals standing in a weight-bearing position.[29] The radiographs were digitized, so that imaging software (AutoCAD 2011) could be used to compose reference lines and calculate the following angular measures[30]:

1. AA: the angle between lines drawn from the visual center of the femur and tibia at a point 10 cm from the joint line (when included in the field of view on the radiograph; otherwise, the furthest distance from the knee joint surfaces up to 10 cm was used)[18] through the visual midpoint of the tibial spines. This angle was measured laterally. If the AA is 180°, the mechanical axis of the lower extremity passes through the center of the knee. If the AA is less than 180°, the lower extremity is in relative valgus alignment, and if the angle is more than 180°, the lower extremity is in relative varus alignment.
2. CH: the angle between (measured laterally) a line tangent to the distal end of the femur (condylar line) and the line through the visual center of the femur. If the CH angle is more than 90°, then the FS is in relative valgus alignment, and if the angle is less than 90°, the FS is in relative varus alignment.
3. Tibial PA: the angle between a line tangent to the lateral aspect of the tibial plateau (tibial plateau line) and the line through the visual center of the tibia. This angle was measured laterally. If the PA angle is more than 90°, then the TS is in relative varus inclination, and the surface of the knee joint is higher laterally than medially with respect to the

Table 1.

Descriptive Statistics of Initial Measurements

Angle	N	Mean (degrees)		Standard Deviation (degrees)		Range (degrees)	
		Right Leg	Left Leg	Right Leg	Left Leg	Right Leg	Left Leg
AA	60	180.96	180.47	4.04	3.42	166-190	168-191
CH	60	91.36	91.16	2.65	2.56	85-97	85-97
PA	60	87.62	87.18	3.2	2.43	80-98	81-95
CP	60	1.98	2.13	0.98	1.05	0-5	0-4

Abbreviations: AA, anatomical alignment angle; CH, condylar hip angle; PA, tibial plateau angle; CP, condylar plateau angle.

mechanical axis of the tibia. If the angle is less than 90° the TS is in valgus inclination, and the surface of the knee joint is higher medially with respect to the TS.

4. CP: This is the angle formed by the condylar line and the tibial plateau line and represents the joint's orientation. If the knee joint is higher laterally, then the lower extremity is in varus alignment, and if the knee joint is higher medially, the lower extremity is in valgus alignment.

All measurements were taken by a single reader who was blinded to the study question and the outcome status of the participant. The intrarater intraclass correlation coefficient (ICC) ranged from 0.96 to 0.98, and the interrater ICC ranged from 0.90 to 0.93 for the different angular measures. Anthropometric measurements and characteristics were also recorded (age, height, weight, and BMI).

Given the lack of significant differences between knee angle values on the 2 legs, the use of a knee angle as an independent variable was constructed as follows: the final value was the average of the angle of both legs for each participant who did not suffer an ankle sprain during the research period and the magnitude of the leg for each of those who did suffer an ankle sprain.

The current research recorded an ankle sprain as an injury of the ankle joint occurring during sports participation (training or game) that led to immediate cessation of sporting activity with at least 1 abstention from sports (game or training).[31] The occurrence of an ankle sprain was the dependent variable if it occurred during the research period (12 months preceding the radiograph and during the subsequent 6 months).

A logistic function (probit) was used to determine the importance of each factor for the probability of ankle sprain occurrence. The specificity of the dependent variable (appearance of ankle sprain), which is binary (qualitative), imposed the use of a logistic regression that estimates the probability by using a maximum likelihood method.[32,33] It should be noted here that when a probit regression is used, one should not interpret the b coefficient as the marginal effect of the independent variable on the underlying probability, which is given by the partial derivative with respect to that variable. The derivative is given by b[prob (Y = 1)][1 − prob (y = 1)]. In our case prob(Y = 1) = 0.6, whereas [1 − prob (Y = 1)] = 0.4.

Our dependent variable is constructed based on the fact that 36 lateral ankle sprains occurred during the sample period. The analysis was conducted using the statistic/econometric software Stata. A significance level of P = .05 was used.

Results

Measurements were obtained from 120 lower extremities (60 right and 60 left; Table 1). Mean values of the AA angle were 180.96° ± 4.04° (right) and 180.47° ± 3.42° (left). Thus, the overall axial alignment (180.76° ± 3.33°) of the lower extremities used in this model was slight relative varus angulation, with the anatomical axis of the lower extremity tending to pass slightly medial to the point that was chosen as the knee center. Using the paired t test, the AA angle, which averaged 180.96° on the right and 180.47° on the left lower extremity, was not significantly different from 180° (P > .05). The mean values of the CH angle were 91.36° ± 2.65° (right) and 91.16° ± 2.56° (left). Using the paired t test, the CH angle, in both the right and the left lower extremities, was significantly different from 90° (P < .05). Thus, the surface of the knee joint had a mean of 1.36° (right) and 1.16° (left) of valgus inclination with respect to the FS. The mean values of the PA angle were 87.62° ± 3.2° (right) and of 87.18° ± 2.43° (left). Using the paired t test, the PA angle, which averaged 87.62° on the right and 87.18° on the left lower extremity, was significantly different from 90° (P < .05). Thus, the surface of the knee joint had a mean of 2.38° (right) and 2.82° (left) of varus inclination with respect to the anatomical axis of the tibia. The mean values of the CP angle were 1.98° ± 0.98° (right, 31 lower extremities varus and 29 valgus inclinations) and 2.13° ± 1.05° (left, 40 lower extremities varus and 20 valgus inclinations).

Table 2 provides a summary of the descriptive characteristics of the independent variables (age, BMI, and knee surface angles) and the dependent variable

Table 2.

Descriptive Characteristics of Variables Used

	N	Mean	SD	Minimum	Maximum
Dependent variable (ankle sprain)	60	0.6	0.50	0.00	1.00
AA	60	180.7	3.33	168	189.5
CH		91.23	2.14	85	97
PA		87.5	2.78	81	98
CP		2.04	0.89	0	5
Age	60	25.2	3.2	18	30
BMI	60	24.49	2.05	21.07	31.02
Previous ankle sprain	60	0.60	0.94	0.00	4.00

Abbreviations: AA, anatomical alignment angle; CH, condylar hip angle; PA, tibial plateau angle; CP, condylar plateau angle.

Table 3.

Asymmetry of Knee Angles

Knee Angles	>For Left Leg	>For Right Leg	Equal for Both Legs	N
CH	19	28	13	60
PA	22	29	9	60
CP	20	9	31	60
AA	27	28	5	60

Abbreviations: CH, condylar hip angle; PA, tibial plateau angle; CP, condylar plateau angle; AA, anatomical alignment angle.

(ankle sprain occurrence), which were used for the construction of the models of the sample. The average values of knee alignment measurements used in the model (the value for the corresponding leg for those who were injured and the mean value for both legs for those who did not suffer an ankle sprain) were as follows: 180.76° degrees for AA, 91.23° for CH, 87.5° for PA, and 2.04° for CP. On the other hand, the mean values of the sample of participants independently of whether they were injured or not were not significantly different ($P > .5$).

Although the knee angles of the left and right legs were seemingly asymmetric, the differences were not statistically significant ($P > .5$). In addition, the Pearson coefficient showed a positive correlation ($r = 0.79$; Table 3). Participants had higher values for AA, PA, and CH in the right leg than in the left except for the CP angle, whereas 51.6% showed equal values for both legs for the CP angle.

All variables are of the expected sign. Regarding the first model, the likelihood ratio test is 16.03, suggesting that the overall regression is significant (Table 4). The only variable that seems to significantly contribute to the probability of suffering an ankle sprain is the history of previous injuries. In particular, the presence of a sprained ankle increases the probability of suffering a new one by 27 percentage points. Our results show that the presence of a past sprain dominates the effect on the probability of being injured again. All other variables, including the knee angles, do not seem to significantly affect the likelihood of being injured. This is the case for both the age of the participant as well as his BMI. The result holds regardless of which model is used.

Discussion

Opinions in the literature differ regarding the influence of lower leg alignment on the probability of ankle sprain occurrence. Knee alignment angles are important indicators of lower leg alignment,[34] and values outside the normal range could be a potential risk factor for ankle sprain occurrence.[35] Until now, the impact of knee alignment on ankle sprain occurrence has not been studied systematically.[36] Therefore, we did not expect the factors that determine the AA of the knee to show high statistical significance. The expected impact of these factors on the dependent variable (ankle sprain occurrence) was positive.

Several researchers have reported that ankle sprain is the most frequent injury in team sports.[37-39] The results of this study are consistent with the findings of studies reporting the incidence of ankle sprains.

The existing literature is divided on the issue of whether a previous ankle sprain can predispose an athlete to future sprains.[40] Several studies in athletes who take part in team sports support the conclusion that a previous ankle sprain increases the possibility for athletes to be injured again,[31,41] whereas Barrett et al[42] reported no increased risk. In the current study, the results showed that a previous ankle sprain significantly increases the likelihood of injury and the variable "previous ankle sprain" was statistically significant and had a sizeable marginal effect. An additional ankle sprain increases the chances for injury by 27% to 28%. This appeared to be the strongest predictive factor in this study. The knee angles do not appear to affect the occurrence of such injuries. These results are consistent with previous studies by Pefanis et al,[43,44] where the effect of the Q angle

Table 4.

Results of Regressions in Total Sample (Dependent Variable: Ankle Sprain)[AQ: 3]

Variable	Model 1 (LR = 16.03)			Model 2 (LR = 15.91)			Model 3 (LR = 15.97)			Model 4 (LR = 16.02)		
	Coefficient	z Statistic	Marginal Effect	Coefficient	z Statistic	Marginal Effect	Coefficient	z Statistic	Marginal Effect	Coefficient	z Statistic	Marginal Effect
Age	0.04	0.63	0.01	0.03	0.56	0.01	0.04	0.67	0.01	0.04	0.62	0.01
Past sprain	1.14	3.13	0.27	1.16	3.22	0.28	1.18	3.17	0.28	1.16	3.23	0.28
BMI	0.13	1.23	0.03	0.14	1.26	0.03	0.13	1.25	0.03	0.13	1.26	0.03
Condylar hip angle	0.03	0.40	0.01									
Tibial plateau angle				–0.24	–0.9	–0.06						
Condylar plateau angle							–0.02	–0.33	0.00			
Anatomical alignment angle										–0.03	–0.39	–0.01
Constant	–7.09	–0.97	–1.70	–3.99	1.32	–0.96	–2.42	–0.35	–0.58	0.62	0.05	0.15

as well as that of the tibiofemoral angle on the probability of suffering a sprained ankle was not proved to be statistically significant.

Although it has been statistically proved that the CH and PA angles are not equal to 90°, which suggests a varus inclination of the lower extremity's AA, they do not seem to affect the probability of an ankle sprain occurrence. This is consistent with all prior research efforts, where a possible association between knee surface alignment and ankle sprain injuries could not be proved.

The limitations of this investigation—namely, the lack of reliable methods for knee angle measurement with full descriptions and participants who represent the general population as well as the small number of participants—mean that the above results should be used with caution. An ideal research design would be a longitudinal prospective study where a group of healthy participants will be monitored for a period of time for the emergence of such injuries. This is probably the only way in which research could finally reveal whether knee alignment angles are the cause or the result.

Conclusion

Knee surface alignment and the magnitude of derived angles do not seem to be a decisive factor that could increase the probability of spraining an ankle. The most important factor that could affect the probability of sustaining a lateral ankle sprain is prior injuries. The results of this study indicate that the reasons why athletes are susceptible to this injury should be investigated further.

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References

1. Cooke TD, Harrison L, Khan B, Scudamore A, Chaudhary. Analysis of limb alignment in the pathogenesis of osteoarthritis: a comparison of Saudi Arabian and Canadian cases. *Rheumatol Int*. 2002;22:160-164.
2. Chao EY, Neluheni EV, Hsu RW, Paley D. Biomechanics of malalignment. *Orthop Clin North Am*. 1994;25:379-386.
3. Harding ML. A fresh appraisal of tibial osteotomy for osteoarthritis of the knee. *Clin Orthop Relat Res*. 1976;114:223-234.
4. Cooke TD, Harrison L, Khan B, Scudamore A, Chaudhary MA. Analysis of limb alignment in the pathogenesis of osteoarthritis: a comparison of Saudi Arabian and Canadian cases. *Rheumatol Int*. 2002;22:160-164.
5. Cooke TD. Definition of axial alignment of the lower extremity. *J Bone Joint Surg Am*. 2002;84-A:146-147.
6. Cooke TD, Li J, Scudamore RA. Radiographic assessment of bony contributions to knee deformity. *Orthop Clin North Am*. 1994;25:387-393.
7. Cooke TDV, Scudamore A. Healthy knee alignment and mechanics. In: Callaghan JJ, Rosenberg AG, Rubash HE, et al, eds. *The Adult Knee*. Philadelphia, PA: Lippincott Williams & Wilkins; 2003:175-186.
8. Garrick JG. The frequency of injury, mechanism of injury, and epidemiology of ankle sprains. *Am J Sports Med*. 1977;5:241-242.
9. Fong DT, Hong Y, Chan LK, Yung PS, Chan KM. A systematic review on ankle injury and ankle sprain in sports. *Sports Med*. 2007;37:73-94.
10. Shambaugh JP, Klein A, Herbert JH. Structural measures as predictors of injury basketball players. *Med Sci Sports Exerc*. 1991;23:522-527.
11. Bruce DB, Murphy DF, Alosa DM. Predictive factors for lateral ankle sprains: a literature review. *J Athl Train*. 2002;37:376-380.
12. Nagano A, Ishige Y, Fukashiro S. Comparison of new approaches to estimate mechanical output of individual joints in vertical jumps. *J Biomech*. 1998;31:951-955.
13. Bahr R, Holme I. Risk factors for sports injuries: a methodological approach. *Br J Sports Med*. 2003;37:384-392.
14. Sonne-Holm S, Sorensen CH. Risk factors with acute sports injuries. *Br J Sports Med*. 1980;14:22-24.
15. Sanfridsson J, Ryd L, Svahn G, Friden T, Jonsson K. Radiographic measurement of femorotibial rotation in weight-bearing: the influence of flexion and extension in the knee on the extensor mechanism and angles of the lower extremity in a healthy population. *Acta Radiol*. 2001;42:207-217.
16. Hsu RW, Himeno S, Coventry MB, Chao EY. Normal axial alignment of the lower extremity and load-bearing distribution at the knee. *Clin Orthop Relat Res*. 1990;255:215-227.
17. Issa SN, Dunlop D, Chang A, et al. Full-limb and knee radiography assessments of varus-valgus alignment and their relationship to osteoarthritis disease features by magnetic resonance imaging. *Arthritis Rheum*. 2007;57:398-406.
18. Kraus VB, Vail TP, Worrell T, McDaniel G. A comparative assessment of alignment angle of the knee by radiographic and physical examination methods. *Arthritis Rheum*. 2005;52:1730-1735.
19. Moreland JR, Bassett LW, Hanker GJ. Radiographic analysis of the axial alignment of the lower extremity. *J Bone Joint Surg Am*. 1987;69:745-749.
20. Yoshioka Y, Siu D, Cooke TD. The anatomy and functional axes of the femur. *J Bone Joint Surg Am*. 1987;69:873-880.
21. Hinman RS, May RL, Crossley KM. Is there an alternative to the full-leg radiograph for determining knee joint alignment in osteoarthritis? *Arthritis Rheum*. 2006;55:306-313.
22. Cooke TD, Scudamore RA, Bryant JT, Sorbie C, Siu D, Fisher B. A quantitative approach to radiography of the lower limb: principles and applications. *J Bone Joint Surg Br*. 1991;73:715-720.
23. Prakash U, Wigderowitz CA, McGurty DW, Rowley DI. Computerized measurement of tibiofemoral alignment. *J Bone Joint Surg Br*. 2001;83:819-824.
24. Sled E, Costigan P, Cooke TD, Sheehy L, Hundt H, Qiu M. Measuring malalignment in knee OA [abstract]. *Osteoarthritis Cartilage*. 2005;13:S120.
25. Rozzanigo U, Pizzoli A, Minari C, Caudana R. Alignment and articular orientation of lower limbs: manual vs computer aided measurements on digital radiograms. *Radiol Med*. 2005;109:234-238.
26. Hankemeier S, Gosling T, Richter M, Hufner T, Hochhausen C, Krettek C. Computer-assisted analysis of lower limb geometry: higher intraobserver reliability compared to conventional method. *Comput Aided Surg*. 2006;11:81-86.
27. Sitler MR, Ryan J, Wheeler B. 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;22:454-461.

28. Specogna AV, Birmingham TB, DaSilva JJ, et al. Reliability of lower limb frontal plane alignment measurements using plain radiographs and digitized images. *J Knee Surg*. 2004;17:203-210.

29. Takahashi T, Yamanaka N, Komatsu M, Ogawa Y, Yoshida S, Yamamoto H. A new computer-assisted method for measuring the tibio-femoral angle in patients with osteoarthritis of the knee. *Osteoarthritis Cartilage*. 2004;12:256-259.

30. Nelson EA, Braga L, Braga-Baiak A, et al. Static knee alignment measurements among Caucasians and African-Americans: the Johnston County Osteoarthritis Project. *J Rheumatol*. 2009;36:1987-1990.

31. McKay GD, Goldie PA, Payne WR, et al. Ankle injuries in basketball: injury rate and risk factors. *Br J Sports Med*. 2001;35:103-108.

32. Gujarati D. *Basic Econometrics*. 4th ed. New York, NY: McGraw-Hill; 2003.

33. Kennedy P. *A Guide to Econometrics*. 3rd ed. Cambridge, MA: MIT Press: 1992.

34. Charrette M. Abnormal Q angle and orthotic support. *Dynamic Chiropractic*. 2003;21.

35. Gross MT. Lower quarter screening for skeletal malalignment: suggestions for orthotics and shoe wear. *J Orthop Sports Phys Ther*. 1995;21:389-405.

36. Cowan DN, Jone B, Frykman PN, et al. Lower limb morphology and risk of overuse injury among male infantry trainees. *Med Sci Sports Exerc*. 1996;28:945-952.

37. Giza E, Fuller C, Junge A, et al. Mechanisms of foot and ankle injuries in soccer. *Am J Sports Med*. 2003;31:550-554.

38. Stevenson MR, Hamer P, Finch F, et al. Sport, age, and sex specific incidence of sports injuries in Western Australia. *Br J Sports Med*. 2000;34:188-194.

39. Zelisko JA, Noble HB, Porter M. A comparison of men's and women's professional basketball injuries. *Am J Sports Med*. 1982;10:297-299.

40. Beynnon BD, Murphy DF, Alosa DM. Predictive factors for lateral ankle sprains: a literature review. *J Athl Train*. 2002;37:376-380.

41. Verhagen EA, Van der Beek, Bouter LM, et al. A one season prospective cohort study of volleyball injuries. *Br J Sports Med*. 2004;38:477-481.

42. Barrett JR, Tanji JL, Drake C, et al. High versus low-top shoes for the prevention of ankle sprains in basketball players: a prospective randomized study. *Am J Sports Med*. 1993;21:582-585.

43. Pefanis N, Papaharalampous X, Tsiganos G, Papadakou E, Baltopoulos P. The effect of Q angle on ankle sprain occurrence. *Foot Ankle Spec*. 2009;2:22-26.

44. Pefanis N, Karagounis P, Tsiganos G, Armenis E, Baltopoulos P. Tibiofemoral angle and its relation to ankle sprain occurrence. *Foot Ankle Spec*. 2009;2:271-276.