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Ankle sprain and podoscopic footprint pattern in female volleyball players

G. MONTELEONE[1,2], A. TRAMONTANA[3], R. SORGE[4], A. TILOCA[2,5], M. ROSELLI[6]

[1]Department of Biomedicine and Preventative Medicine, Faculty of Medicine and Surgery, University of Rome "Tor Vergata", Rome, Italy; [2]School of Sport and Exercise Sciences, University of Rome "Tor Vergata", Rome, Italy; [3]Department of Physical Medicine and Rehabilitation, University Rey Juan Carlos, Madrid, Spain; [4]Department of Systems Medicine Faculty of Medicine and Surgery, University of Rome "Tor Vergata", Rome, Italy; [5]Phd tissue engineering and remodeling biotechnologies for body functions, University of Rome "Tor Vergata", Rome, Italy; [6]Orthopedics and Traumatology Service, Martini Hospital, ASL City of Turin, Turin, Italy.

Correspondence at: Giovanni Monteleone, Via Montpellier 1 - 00133 Rome, Italy. E-mail: giovanni.monteleone@uniroma2.it

Ankle sprain (AS) is the most common sports injury that can be complicated by chronic joint instability. The aim of this study was to examine the relationship between foot types and the ankle sprain events suffered during the sport career in female volleyball players. In this retrospective study, we randomly selected 98 female volleyball players competing in several divisions. Data were obtained from self-administered questionnaires in which the athlete noted data about volleyball practice, whether they had had ankle sprains and the number of these events. Plantar footprint was photographed by a plantoscope classifying each foot as normal, flat or cavus (196 feet). Of the 196 feet, 145 (74.0%) were normal, 8 (4.1%) were flat 43 and (21.9%) were cavus. Thirthy-five athletes reported at least one AS during volleyball practice. In total 65 sprain injuries were reported (35 to the right side and 30 to the left side). In 22 ankles (14 right, 8 left) sprain reinjure (AS >1) have been reported. A higher AS reinjury rate is correlated to the cavus footprint pattern (p = 0,005). Cavus foot associates to a higher risk of reinjury for ankle sprains in female volleyball players. Knowing the athletes which are more likely to sustain a reinjure may be helpful for the orthopedic surgeon to plan preventive strategies.

Keywords : Ankle sprain, female volleyball player, podoscopic footprint, reinjure.

INTRODUCTION

AS is a frequent injury that can complicate with joint instability, recurrences, post-traumatic osteoarthritis of the ankle joint, and sometime need surgery[1-4].

Sports practice increases the risk of AS[5]: in the USA about 50% of all AS treated in emergency departments occurred during sports practice[6]. AS account for nearly 10% to 30% of all sports injuries[7].

In volleyball, a non-contact sport, AS is the most common injury, accounting for 41% of all volleyball related injuries[8]. Its incidence is approximately 0.9 injuries/1,000 player hours[9]. Volleyball, with soccer and basketball are the most represented sports in scientific literature about recurrent ankle injury and sprain and chronic ankle instability[10].

The risk factors for ankle injury in the athlete can be extrinsic (i.e., level of competition or playing surface) or intrinsic, lay in single variables (ei. Sex, Body Mass Index (BMI), and anatomical characteristics)[11,12].

Literature is ambiguous about the relationship between the risk of AS in sport and the anatomical features of the foot.

In a group of female infantry recruits, Mei-Dan et al[13]. saw an increase in the incidence of AS in subjects with a low longitudinal arch of the foot. In adolescent athletes with a history of AS, Saki et al.[14] found that navicular drop may have a greater risk of lateral AS.

Murphy et al.[11] noted a conflict and a lack of consistency between the results of studies that examined the association between foot morphology and lower limb injuries. In a literature review about inversion ankle injury in general population, Morrison et al.[15] report an increased risk of ankle sprain in subjects with cavovarus deformity. In a prospective study on female collegiate athletes, Beynnon et al.[16] believe the alignment of the hindfoot in combination with the lower extremity an important anatomical feature when evaluating the risk of ankle trauma.

Other Authors[17,18] found no correlation between sport ankle sprains, pronation, supination, or normal position of the foot, foot type.

Podoscopic assessment of the foot print pattern is a quick and low cost method to discern among normal, flat and cavus foot: no studies about female volleyball players' history of ankle sprain and foot type are reported in literature.

We hypothesize that different foot types associate to different risk of AS.

The aim of this study is to evaluate the risk of AS in female volleyball athletes with respect to the type of foot.

MATERIALS AND METHODS

Subjects

In this retrospective study, from a 224 volleyball player database of the Department of Biomedicine and Preventative Medicine, collected from February 2018 to December 2019, we randomly selected a sample of 98 female athletes applying the following inclusion criteria:

- subjects aged between 18 and 30 years;
- more than 5 years of competitive activity;

The exclusion criteria were:

- history of inferior limbs fracture or having had surgery to inferior limbs;
- subjects reported ankle traumas outside volleyball practice;

All the subjects were registered with Italian Volleyball Federation (FIPAV) and were playing in Italian teams into several divisions' championship.

Each subject compiled a self-administered questionnaire to obtain demographic information and data about volleyball practice, weekly training time, history of AS, training and competition.

The study was approved by the Institutional Review Board of the University of Rome Tor Vergata and was conducted in conformity with the ethical and humane principles of research.

Using a polarized light plantoscope, a podoscopic exam was performed by an orthopedic surgeon (GM) and a physiatrist (AT) to all players and the foot type were discerned. Foot was normal when the area between the front and rear supports (isthmus) was between a third and half of the metatarsal support, flat when the isthmus was greater than half of the metatarsal support, and cavus if the isthmus was less than a third of the metatarsal support[19-21] (Fig. 1).

All data were initially entered into an Excel database (Microsoft, Redmond, Washington – United States) and the analysis was performed using the Statistical Package for the Social Sciences Windows, version 15.0 (SPSS, Chicago, Illinois, USA). Descriptive statistics consisted of the mean ± standard deviation (SD) for parameters with gaussian distributions (after confirmation with histograms and the Kolgomorov-Smirnov test), was performed with the ANOVA one-way for parametric variables while the Chi-square test or Fisher's exact test (if cells<5) for frequencies variables. A p value of <0.05 was considered statistically significant. Taking into account the probability of a different foot type between the right and left legs, the association with the AS events were estimated for each foot.

RESULTS

Athletes' characteristics are displayed in Table I. No statistically significant difference was found between subjects with (n = 35) and without (n = 63) history of AS for age, weight, height, body mass index(BMI), years of volleyball practice. Furthermore, for the anagraphic and anthropometric characteristics and years of volleyball practice no statistically significant difference was found between subjects with history of only one AS and those with reinjure (AS>1) (Tables II,III).

A total of 196 podoscopic tests were perfomed:145 (74.0%) show normal feet, 43 (21.9%) cavus feet, 8 (4.1%) flat feet. Seven subjects have different foot types. Thirty-five athletes have reported a history of

Fig. 1 — Podoscopic exams showing normal (A), flat (B) and cavus foot (C).

one AS event during volleyball practice. In total, 65 ankle sprains injuries have been reported (35 right side, 30 left side). Fourteen athletes reported multiple sprain injuries to one or both ankles (AS >1); 22 ankles have been reinjured (14 right side, 8 left side). A higher prevalence of AS reinjure correlate to a cavus footprint pattern (p = 0,005) (Table IV).

DISCUSSION

The aim of this study was to correlate the history of AS injuries with the athletes' foot type in female volleyball players. In the group of volleyball players studied, we saw 74% of normal feet, 4.1% flat feet and 21.9% cavus feet. Our study showed no statistically significant difference between players who had one or more ankle sprains, and those who never had AS compared to the type of foot. The results showed greater prevalence of AS reinjure in the cavus foot group than in the other groups (p = 0.005).

The cavus foot is a group of foot types characterized by the accentuation of the plantar vault, corresponding to the increase in height of the longitudinal arches of the foot[20,22]. The prevalence of cavus foot in adults varies depending on the population examined and the diagnosis method. Studies have reported a prevalence of cavus foot in adults of between 10 and 52%[23-25]; other authors believe that the true incidence of cavus foot is unknown in the general population[26]. A slight increase in the cavus feet fraction in this cohort is conceivable since, as hypothesized by Verni et al.[27], the cavus foot stiffness supports the jumping athlete.

Table I. — Anagraphic and anthropometric characteristics of the volleyball players Ankle Sprain=0 vs Ankle Sprain>0.

	n° Players	Ankle	mean ± sd	Min ; Max	p
Age (years; mean ± ds)	63	Ankle Sprain=0	23,0 ± 3,8	18 ; 30	0,716 (*)
	35	Ankle Sprain>0	23,2 ± 3,1	18 ; 30	
Weight (cm; mean ± ds)	63	Ankle Sprain=0	65,4 ± 8,5	50,0 ; 86,0	0,368 (*)
	35	Ankle Sprain>0	67,0 ± 8.0	54,0 ; 81,0	
Height (kg; mean ± ds)	63	Ankle Sprain=0	175 ± 9,3	152 ; 196	0,871 (*)
	35	Ankle Sprain>0	175 ± 8,3	160 ; 192	
BMI (kg/m^2; mean ± ds)	63	Ankle Sprain=0	21,33 ±1,72	18,0 ; 26,8	0,232 (*)
	35	Ankle Sprain>0	21,83 ± 2,31	18,7 ; 30,5	
(*) Anova oneway					

Table II. — Years of Activity of the volleyball players Ankle Sprain=0 vs Ankle Sprain>0; Ankle Sprain=1 vs Ankle Sprain >1.

	Ankle	n° Ankle	mean ±sd	Min ; Max	p
Years of Activity all sample	Ankle Sprain =0	131	12,2 ± 4,7	5 ; 20	0,579 (*)
	Ankle Sprain >0	65	11,7 ± 3,6	6 ; 20	
Years of Activity Sample ankle Sprain>0	Ankle Sprain =1	43	11,8 ± 5,7	5 ; 20	0,409 (*)
	Ankle Sprain >1	22	12,9 ± 4,8	6 ; 20	
(*)Anova oneway					

Table III. — Anagraphic and anthropometric characteristics of the subgroup of the volleyball players Ankle Sprain<=1 vs Ankle Sprain>1 Reinjure.

Foot Type	Ankle Sprain<=1 (n°=174)	Ankle Sprain>1 (n°=22)	p
Age (years; mean ± ds)	22,8 ± 3,0	23,9 ± 3,2	0,336 (*)
Weight (kg; mean ± ds)	65,4 ± 8,3	69,4 ± 7,1	0,157 (*)
Height (cm; mean ± ds)	174,7 ± 8,6	176,1 ± 8,1	0,632 (*)
BMI (kg/m^2; mean ± ds)	21,41 ± 1,92	22,45 ± 2,75	0,198 (*)
(*) Anova oneway			

Table IV. — Foot Type of the volleyball players Ankle Sprain<=1 vs Ankle Sprain>1 Reinjure.

Foot Type	Ankle Sprain<=1	Ankle Sprain>1	Total
N° n° (%)	174 (100,0)	22 (100,0)	196 (100,0)
Normal n° (%)	135 (77,6)	10 (45,5)	145 (74,0)
Cavus n° (%)	33 (19,0)	10 (45,5) (*)	43 (21,9)
Flat n° (%)	6 (3,4)	2 (9,0) (^)	8 (4,1)
(*) chi square test; Normal vs Cavus; Ankle Sprain<=1 vs Ankle Sprain>1; p=0,005; (^) chi square test; Normal vs Flat; Ankle Sprain<=1 vs Ankle Sprain>1; p=0,064.			

The association between cavus foot and greater risk of AS is taken for granted when referring to the severe and disabling cases[20,28,29]. However, many adults may have a subtle cavus foot, a clinical condition with a varus hindfoot, and part of the heel pad visible from the front[0]. This condition leads to an underestimation of cavus foot diagnosis. According to Chilvers et al.[31], people with this foot type suffer from ankle sprains, stress fractures, peroneal tendinopathy, sesamoid injury, and less commonly with Achilles tendon disorders, plantar fasciitis, and ankle impingement.

Sports practice increases the risk of ankle sprain injury[5]; in volleyball the rapid movements and the closeness of teammates during the game increases the risk of AS[32]. Volleyball players' ankle is exposed to a greater risk of injury regardless foot type.

A prior AS is itself a predisposing reinjure cause, because of varying degrees of ligaments damage that always follows this injury; normal and flexible feet could better compensate for, thus limiting reinjures.

In a study conducted in 95 patients had surgery for chronic lateral ankle instability, Larsen et al.[33] found a higher prevalence of cavovarus deformity in the instability group.

According to Bosman et al.[34] isolated lateral ligament repair is less likely to be successful in the presence of uncorrected cavovarus.

In a retrospective study conducted on 1493 athletes in different sports treated for lateral AS, Verni et al.[27] noted a high correlation between anterior cavo-varus foot and the occurrence of ankle reinjure (66.3%). According to these authors, foot cavism causes an early first metatarsal head support on the ground, this forces the foot to rotate in inversion to achieve ground contact with the remaining forefoot and, therefore, the heel. The foot, already in a state of adaptation in inversion, is poorly prepared to tolerate a further fast inversion in case of a sudden stop or a direction change. Biomechanical characteristics of the cavus foot remain silent until the first AS. Late, they become active in causing reinjures. Moreover, cavism does not allow the foot to pronate adequately and leads to lessened subtalar eversion[35]. The longitudinal arch remains rigid instead of becoming flexible, and the tibia remains in some external rotation: the cavus foot cannot adapt to ground surfaces changes, leaving the ankle more vulnerable to sprain[36].

Anyway, some athletes with cavus feet report no AS: in our series 22,9% (30 feet) cavus feet are not associated with sprain events. Further studies are needed to deepen the causes of the least susceptibility of these athletes to the AS.

Other authors suggest that sprains may remain rare in the pes cavus as long as it maintain elasticity[27].
Our study has some limitations. In our sample, the effects due to the differences in training of athletes from different divisions were not evaluated. The plantoscope does not allow to evaluate the valgus of the heel as it would be possible with more technological tools[37]; besides, possible injuries of the lateral ligaments and syndestmosis were not assessed.

CONCLUSION

We found a greater prevalence of AS reinjures in the cavus foot group. Cavus foot may be a risk factor for ankle sprains reinjures in female volleyball players. Podoscopic footprint exam is a simple and inexpensive method, which can be used by both healthcare and technical staff. It can be helpful in early identifying the athlete at high risk of multiple ankle sprains, needing further individualized ankle injury prevention protocols.

Future studies may investigate the foot structure with 3D imaging tools[38] and find other causes of AS risk.

REFERENCES

1. Bestwick-Stevenson T, Wyatt LA, Palmer D, Ching A, Kerslake R, Coffey F, et al. Incidence and risk factors for poor ankle functional recovery, and the development and progression of posttraumatic ankle osteoarthritis after significant ankle ligament injury (SALI): the SALI cohort study protocol. BMC Musculoskelet Disord. 2021;22(1):362.

2. Halabchi F, Hassabi M. Acute ankle sprain in athletes: Clinical aspects and algorithmic approach. World J Orthop. 2020;11(12):534-558.
3. Song K, Wikstrom EA, Tennant JN, Guskiewicz KM, Marshall SW, Kerr ZY. Osteoarthritis prevalence in retired national football league players with a history of ankle injuries and surgery. J Athl Train. 2019;54(11):1165-1170.
4. Herzog MM, Kerr ZY, Marshall SW, Wikstrom EA. Epidemiology of ankle sprains and chronic ankle instability. J Athl Train. 2019;54(6):603-610.
5. 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.
6. Waterman BR, Owens BD, Davey S, Zacchilli MA, Belmont PJ Jr. The epidemiology of ankle sprains in the United States. J Bone Joint Surg Am. 2010;92(13):2279-84.
7. 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(1):73-94.
8. Verhagen EA, Van der Beek AJ, Bouter LM, Bahr RM, Van Mechelen W. A one season prospective cohort study of volleyball injuries. Br J Sports Med. 2004;38(4):477-81.
9. Cassell E. Spiking injuries out of volleyball: A review of injury countermeasures. Victoria (AU): Monash University, Accident Research Centre; 2001. 24 p. Report No.: 181.
10. Attenborough AS, Hiller CE, Smith RM, Stuelcken M, Greene A, Sinclair PJ. Chronic ankle instability in sporting populations. Sports Med. 2014;44(11):1545-56.
11. Murphy DF, Connolly DA, Beynnon BD. Risk factors for lower extremity injury: a review of the literature. Br J Sports Med. 2003;37(1):13-29.
12. Kobayashi T, Tanaka M, Shida M. Intrinsic Risk Factors of Lateral Ankle Sprain: A Systematic Review and Meta-analysis. Sports Health. 2016;8(2):190-3.
13. Mei-Dan O, Kahn G, Zeev A, Rubin A, Constantini N, Even A, Nyska M, Mann G. The medial longitudinal arch as a possible risk factor for ankle sprains: a prospective study in 83 female infantry recruits. Foot Ankle Int. 2005;26(2):180-3.
14. Saki F, Yalfani A, Fousekis K, Sodejani SH, Ramezani F. Anatomical risk factors of lateral ankle sprain in adolescent athletes: A prospective cohort study. Phys Ther Sport. 2021; 48:26-34.
15. Morrison KE, Kaminski TW. Foot characteristics in association with inversion ankle injury. J Athl Train. 2007;42(1):135-42.
16. Beynnon BD, Renström PA, Alosa DM, Baumhauer JF, Vacek PM. Ankle ligament injury risk factors: a prospective study of college athletes. J Orthop Res. 2001;19(2):213-20.
17. Baumhauer JF, Alosa DM, Renström AF, Trevino S, Beynnon B. A prospective study of ankle injury risk factors. Am J Sports Med. 1995;23(5):564-70.
18. Beynnon BD, Murphy DF, Alosa DM. Predictive Factors for Lateral Ankle Sprains: A Literature Review. J Athl Train. 2002;37(4):376-380.
19. Belabbassi H, Haddouche A, Ouadah A Kaced H. Pes Cavus and Idiopathic Scoliosis from School Screening. J Spine. 2014; 3(1): 152.
20. Curvale G, Rochwerger A. Pieds creux. Encycl Méd Chir, Appareil locomoteur, Elsevier, Paris, 2002; 14-112-A-10, 1-13.
21. Zing E, Goldcher A. Clinical examination of the foot and ankle in adults. Rev. du Rhum. Monogr 2014; 81: 71–75.
22. Aminian A, Sangeorzan BJ. The anatomy of cavus foot deformity. Foot Ankle Clin. 2008;13(2):191-8.
23. Sachithanandam V, Joseph B. The influence of footwear on the prevalence of flat foot. A survey of 1846 skeletally mature persons. J Bone Joint Surg Br. 1995;77(2):254.
24. Braun S. Formes cliniques du pied creux antérieur. In: Claustre J, Simon L éd. Troubles congénitaux et statiques du pied: orthèses plantaires. Paris: Masson;1982: p.70-83.
25. Ledoux WR, Shofer JB, Ahroni JH, Smith DG, Sangeorzan BJ, Boyko EJ. Biomechanical differences among pes cavus, neutrally aligned, and pes planus feet in subjects with diabetes. Foot Ankle Int. 2003;24(11):845-50.
26. Seaman TJ, Ball TA. Pes Cavus. In: Stat Pearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022
27. Verni E, Cucca G, Ensini A, Blasi A, Romagnoli M, Giannini S: I traumi di inversione della tibio/tarsica nello sportivo - Incidenza del morfotipo sulle recidive. Med Sport 2002; 55:29-37.
28. Pitzen P, Rössler H. Ortopedia. Napoli: Ed. Idelson; 1987 p. 379.
29. Rosenbaum AJ, Lisella J, Patel N, Phillips N. The cavus foot. Med Clin North Am. 2014;98(2):301-12.
30. Manoli A 2nd, Graham B. The subtle cavus foot, "the underpronator". Foot Ankle Int. 2005;26(3):256-63.
31. Chilvers M, Manoli A 2nd. The subtle cavus foot and association with ankle instability and lateral foot overload. Foot Ankle Clin. 2008;13(2):315-24.
32. 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(3):166-71.
33. Larsen E, Angermann P. Association of ankle instability and foot deformity. Acta Orthop Scand. 1990;61(2):136-9.
34. Bosman HA, Robinson AH. Treatment of ankle instability with an associated cavus deformity. Foot Ankle Clin. 2013;18(4):643-57.
35. Donatelli RA. Abnormal biomechanics of the foot and ankle. J Orthop Sports Phys Ther. 1987;9(1):11-6.
36. Lutter LD. Cavus foot in runners. Foot Ankle. 1981;1(4):225-8.
37. Burssens A, Peeters J, Buedts K, Victor J, Vandeputte G. Measuring hindfoot alignment in weight bearing CT: A novel clinical relevant measurement method. Foot Ank Surg. 2016; 22(4):233-238.
38. Lintz F, de Cesar Netto C, Barg A, Burssens A, Richter M; Weight Bearing CT International Study Group. Weight-bearing cone beam CT scans in the foot and ankle. EFORT Open Rev. 2018;3(5):278-286.