The sole arch indices of adolescent basketball players

Sedat T. Aydog, *MD, PhD,* ***Haydar A. Demirel,*** *MD, PhD,* ***Onur Tetik,*** *MD,*
Ece Aydog, *MD,* ***Zafer Hascelik,*** *MD,* ***Mahmut N. Doral,*** *MD,*

ABSTRACT

Objective: The aim of this study was to find out the difference between sole arch indices of adolescent basketball players and an age matched non-athletic group.

Methods: This study was carried out in the Sports Education, Health and Research Center, Ankara, Turkey, between November 1998 and December 1998. In junior (16-18 years) categories 48 male basketball players and 45 age matched controls were included in the study. Body mass index and podoscopic sole images of subjects were recorded, and the arch index was calculated for each group.

Results: The sole arch index has no difference between basketball players and controls. The right foot arch index of the control group was 59.62 ± 23.26 and 56.74 ± 17.21 in players (p=0.497). The left foot arch index was 54.54 ± 23.72 in control groups and 55.13 ± 17.33 in players (p=0.890). There was a significant negative correlation between sole arch index and training age in basketball players (r=-0.3312 for right sole arch index, p<0.05; r=-0.3056 for left sole arch index, p<0.05).

Conclusion: These results have shown that basketball might result in specific adaptation on sole arches of adolescent players.

Saudi Med J 2004; Vol. 25 (8): 1100-1102

Pes planus (PP) and pes cavus (PC) are frequent disorders of the foot. It is known that standing still for a long time, bony and neurological problems such as congenital tarsal coalition and cerebral palsy, trauma, inappropriate shoes, generalized ligamentous laxity, sole disorders in relatives and muscle imbalance all aggravate sole problems.[1-3] Since foot is the contact point during weight bearing and ambulation, the mechanical characteristics of the foot determine the energy transfer into the lower extremity, and therefore it helps to define the pattern of weight bearing and the potential for injury to the lower extremities. The presence of sole problems is the important intrinsic factor in overuse injuries.[4-8] However, numerous studies have indicated that there are neutral or even beneficial effects associated with PP.[1,9] Finally, effects of foot types on injuries are controversial, but the detection and correction of these problems may reduce these injuries. Staheli et al[9] found that the medial longitudinal arch has an undulating pattern according to age and arch indices (AI). The AI is approximately one (range: 0.7 -1.35) at first year of age, reducing to a minimum of 0.6 (range: 0.3-0.9) at 12-14 years of age, before increasing to 0.8 (range: 0.3-1.1) at older ages.[9,10] The medial longitudinal arch starts at the weight-bearing surface of the calcaneus and ends at the metatarsal heads. It is supported by passive (bone and ligaments) and active structures (muscles). In a standing position, few intrinsic or extrinsic muscles activity occur, and the arch is maintained primarily by passive

From the Department of Sports Medicine (Aydog S, Demirel, Tetik), Department of Physical Medicine and Rehabilitation (Hascelik), Department of Sports Medicine and Orthopedics and Traumatology (Doral), Faculty of Medicine, Hacettepe University, and the Department of Physical Medicine and Rehabilitation (Aydog E), SSK Ankara Education Hospital, Ankara, *Turkey*.

Received 29th December 2003. Accepted for publication in final form 10th March 2004.

Address correspondence and reprint request to: Dr. Sedat T. Aydog, Department of Sports Medicine, Hacettepe University, D Kati 06100 Sihhiye, Ankara, *Turkey*. Tel. +90 (312) 3051347. Fax. +90 (312) 3051347. E-mail: taydog@hacettepe.edu.tr

supporting elements. However, during walking and running the primary supporting elements become muscles. Depending on their insertions, muscles that inserted into the concavity of the medial longitudinal arch, such as posterior tibial, peroneus brevis and longus, flexor hallucis longus, flexor digitorum longus and abductor hallucis support the formation of the medial longitudinal arch. On the other hand, some other muscles, which inserted into the convexity of the medial longitudinal arch such as extensor hallucis longus and tibialis anterior muscles have depressing effect on this arch.[11,12] Depending on the type of sports, inappropriate development of these muscles may result in some changes of the arch.[13,14] Basketball involves a high level of jumping activities. In addition, during the basketball game foot muscles are under a heavy load. Therefore, this study is especially age of 12-14 at which sole AI changes dramatically; basketball training may result in some effects on soles. To the best of our knowledge, no study has been carried out regarding the effects of basketball on the sole arch. Therefore, this study was designed to find out the difference between the sole arch indices of adolescent basketball players and age matched non-athletic group.

Methods. Junior level basketball players (16-18 age, n=48) along with non-player controls (n=45) were included in the study. This study was carried out in the Sports Education, Health and Research Center, Ankara, Turkey, between November 1998 and December 1998. To understand the effects of basketball on sole arch index, we compared the sole AI of junior players with their control. We also tried to find out the correlation between sole AI and training age. The training age of subjects was different (between 1-7 years) and all subjects had a training of 8 hours per week since the beginning of the basketball. Compromised body weight and height are measured before breakfast. Subjects were asked to stand still on the podoscope. Both sole images in the podoscope were transferred to computer by using video camera. On the stored images, AI was calculated by the division of the narrowest part of the sole to the widest part of the heel, then multiply the ratio by 100 (**Figure1).**[9] In our preliminary experiment by using same method on 30 foot arch indices, intra-class correlation coefficient of the sole AI was found as 0. 982.

The significance of the differences between the 2 mean tests was calculated and the Pearson correlation test was used. Significance level was accepted as $p<0.05$.

Results. The height, weight, age, body mass index (BMI) and arch indexes of both feet of the players and non-player controls are shown on **Table 1**. The height and weight in players were significantly higher than that of the controls. Body mass index of both study and control groups were less than 25 and neither foot sole AI nor BMI were different between players and control groups ($p>0.05$).

There was a significant negative correlation between sole AI and training age in players (right sole AI r=-0.3312, $p<0.01$; left sole AI r=-0.3056, $p<0.01$). On the other hand, we could not find any significant relation between sole AI and height, weight and BMI ($p>0.05$).

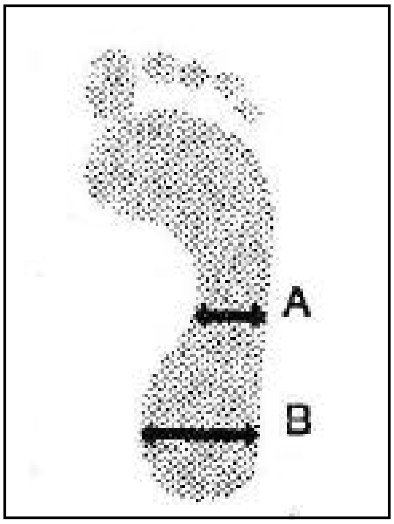

Figure 1 - Calculation of sole arch index (AI) by using the formula: AI = A/B x 100. A - minimum width on mid-foot arch, B - maximum width on heel arch.

Table 1 - Comparison of anthropological features and arch indices (AI) between players and the control group.

Characteristics	Players (N=48)	Control groups (N=45)	*p* value
Age	17.34 ± 0.63	17.18 ± 0.68	0.257
Height	184.55 ± 7.38	169.34 ±15.12	0.000
Weight	74.68 ± 10.34	67.10 ± 12.88	0.000
Body mass index	21.87 ± 2.31	22.66 ± 3.29	0.181
Right foot AI	56.74 ± 17.21	59.62 ± 23.26	0.497
Left foot AI	55.13 ± 17.33	54.54 ± 23.72	0.890

Discussion.

This study was designed to find out the difference between the sole arch indices of adolescent basketball players and age matched non-athletic controls. In this study, we used footprint analysis, which has been found high intra-rater reliability. Footprint analysis is a simple, readily available, low-cost, reliable and non-invasive technique. Therefore, it can be used for screening of the foot problems.[9,12,15-17] It is well known that there is a unilateral overhead athlete who may demonstrate an obvious discrepancy with increased external rotation and decreased internal rotation compared with the opposite site.[18] These changes were an important indicator of sport specific adaptation in musculo-skeletal system. Indeed, in longitudinal study, Volkov[19] has demonstrated that intense regular training (18-30 hour per week) results in flat foot for 10-11 years old children. Klingele[20] showed that endurance running and alpine skiing have an increased risk of longitudinal foot arch insufficiency. In our study, although there was no difference in sole arch indices of adolescent male basketball players compared with non-athletic controls, we have found a significant negative relationship between sole AI and training age (right sole AI r=-0.3312, $p<0.01$; left sole AI r=-0.3056, $p<0.01$). The reason for the discrepancy between our finding and Volkov's study[19] might be the differences of training hours per week for basketball players in studies.

Since our study had a cross-sectional design, we have not strictly established our findings as results of sport specific adaptation. Longitudinal studies started in childhood could better demonstrate the effects of different sports on sole AI. Nevertheless, this study has shown that sport specific adaptations in musculo-skeletal system might include changes in sole AI.

References

1. Michelson JD, Durant DM, McFarland E. The injury risk associated with pes planus in athletes. ***Foot Ankle Int*** 2002; 23: 629-633.
2. Rao UB, Joseph B. The influences of footwear on the prevalence of flat foot. A survey of 2300 children. ***J Bone Joint Surg (Br)*** 1992; 74: 525-527.
3. Sachithanandam V, Joseph B. The influences of footwear on the prevalence of flat foot. A survey of 1846 skeletally mature persons. ***J Bone Joint Surg (Br)*** 1995; 77: 254-257.
4. American Academy of Orthopaedic Surgeons. Athletic training and sports medicine. In: The knee. 2nd ed. United States of America: American Academy of Orthopaedic Surgeons; 1991. p. 353-357.
5. Jenner JR, Emerson MS. Sports Injuries. In: Maddison PJ, Isenberg DA, Woo P, Glass DN, editors. Oxford Textbook of Rheumatology. 2nd ed. Oxford (UK): Oxford University Press; 1998. p. 1784-1785.
6. Solomon L, Warwick D, Nayagam S. Apley's System of Orthopaedics and Fractures. In: The knee. 8th ed. London (UK): Arnold Publishers; 2001. p. 465-467.
7. International Olympic Committee. Injuries to the Musculoskeletal System. In: IOC Medical Commission. Alberta (Canada): Hurford Enterprises Ltd; 1990. p. 281-362.
8. Kaufman KR, Brodine SK, Shaffer RA, Johnson CW, Cullison TR. The effect of foot structure and range of motion on musculoskeletal overuse injuries. ***Am J Sports Med*** 1999; 27: 585-593.
9. Staheli LT, Chew DE, Corbett M. The longitudinal arch. A survey of eight hundred and eighty-two feet in normal children and adults. ***J Bone Joint Surg*** 1987; 69A: 426-428.
10. American Academy of Orthopaedic Surgeons. Athletic training and sports medicine. In: The foot. 2nd ed. United State of America: American Academy of Orthopaedic Surgeons; 1991. p. 425-432.
11. Kapandji IA. The physiology of the joints. In: Lower limb. Vol. 2. Edinburgh (UK): Churchill Livingstone; 1976.
12. Forriol F, Pascual J. Footprint analysis between three and seventeen years of age. ***Foot Ankle*** 1990; 11: 101-104.
13. Kayano J. Dynamic function of medial foot arch. ***J Nippon Seikeigeka Gakkai Zasshi*** 1986; 60: 1147-1156.
14. Giladi M, Milgrom C, Stein M, Simkin A, Kashtan H. The low arch, a protective factor in stress fractures. A prospective study of 295 military recruits. ***Orthop Rev*** 1985; 14: 709-712
15. Kanatli U, Yetkin H, Cila E. Footprint and radiographic analysis of the feet. ***J Pediatr Orthop*** 2001; 21: 225-228.
16. Cavanagh PR, Rodgers MM. The arch index: a useful measure from footprints. ***J Biomech*** 1987; 20: 547-551.
17. Volpon JB. Footprint analysis during the growth period. ***J Pediatr Orthop*** 1994; 14: 83-85.
18. Hawkins RJ, Mohtadi N. Rotator cuff problems in athletes. In: DeLee JC, Drez D, editors. Orthopaedic Sports Medicine. Philadelphia (PA): WB Saunders Company; 1994. p. 631-632.
19. Volkov BM. Influence of considerable athletic training on the foot condition of young athletes at a boarding school with a cross-section of sports. ***Arkh Anat Gistol Embriol*** 1977; 72: 32-34.
20. Klingele J, Hoppeler H, Biedert R. Statistical deviations in high-performance athletes. ***Schweiz Z Sportmed*** 1993; 41: 55-62.