

# Is sport practice a factor affecting plantar arch development during school age? A preliminary study

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## Abstract

**Objectives.** The sport of school age can play an important role in the proper development of the arch. The purpose of this investigation is to correlate the evolution of the shape of the plantar vault of the foot with the practice of different sports during the school age.

**Method.** 461 subjects aged between 6 and 15 years were examined by plantoscope examination and the footprint was classified according to Dennis<sup>1</sup> each subject answered two times a questionnaire on sport practice. The statistical analysis for assessment the differences between groups was performed with ANOVA for continuous parametric variables, Kruskal-Wallis (groups > 2) or Mann-Whitney (groups = 2) for nonparametric variables and the chi-square test or Fisher's exact test (if the cells <5) for categorical variables.

**Results.** The average age of the subjects was  $11 \pm 2.2$  years Analyzed, the average height was  $145 \pm 14.7$  cm and body weight of  $43.2 \pm 14.6$  kg; the mean Body Mass Index (BMI) was  $19.9 \pm 4.2$ . Among the 461 subjects evaluated, 75% of them showed normal feet, 17% pes cavus, and 8% pes planus.

In swimming, the most popular sport, 15% of subjects had pes cavus, 8% pes planus. Volleyball player had high percentage of cavus foot (29%) and no flatfoot. Among children who practice sport there was a sports related, significant disproportion between the rates of plantar vault morphologies ( $p < 0.005$ ). Pes planus percentage rise as the BMI increased.

**Conclusions.** Among those who practice different sports, already at school-age, there is a statistically significant difference in the percentage of plantar vault morphologies.

A further prospective study may explain the reason that fix this different distribution of plantar vault morphotypes in sports.

**Keywords:** cavus foot, flatfoot, plantar arch: vault, plantar vault development, sport, scholar age.

## Introduction

Although the plantar vault can change throughout all the life, it reaches a stable shape within the first 10-12 years of life.<sup>2,3</sup> The flat foot is typical in children who start walking and its prevalence decreases while the cavus foot frequency grows with increasing age because of the evolving foot<sup>4</sup>.

## Riassunto

**Obiettivi.** La pratica sportiva in età scolare può svolgere un ruolo importante per il corretto sviluppo della volta plantare. Lo scopo di questa indagine è quello di correlare l'evoluzione della morfologia della volta plantare con la pratica sportiva durante l'età scolare.

**Metodo.** 461 soggetti di età compresa tra i 6 e i 15 anni sono stati sottoposti ad esame podoscopico e l'impronta è stata classificata secondo i criteri di Denis.<sup>1</sup> Un questionario sull'attività motoria praticata è stato sottoposto a ciascun soggetto per due volte. L'analisi statistica per la stima delle differenze tra i gruppi è stata effettuata con il test di ANOVA per le variabili parametriche continue, Kruskal-Wallis (gruppi > 2) o di Mann-Whitney (gruppi = 2) per le variabili non parametriche e il test chi-quadrato o test esatto di Fisher (se le cellule <5) per le variabili categoriali.

**Risultati.** The average age of the subjects analyzed was  $11 \pm 2.2$  years, the average height was  $145 \pm 14.7$  cm and body weight of  $43.2 \pm 14.6$  kg; the mean BMI was  $19.9 \pm 4.2$ . Among the 461 subjects evaluated, 75% of them showed normal feet, 17% pes cavus, and 8% pes planus.

Nel nuoto, lo sport più praticato, il 15% dei soggetti presenta il piede cavo e 8% il piede piatto. Nella pallavolo si è osservato un'alta percentuale di piede cavo e nessun piede piatto. Tra i soggetti che praticano sport differenti esiste una disproportion tra le percentuali delle differenti morfologie di volta plantare statisticamente significativa ( $p < 0.05$ ). Una tendenza all'incremento della percentuale di piede piatto si osserva all'aumentare dell'indici di massa corporea.

**Conclusioni.** Tra soggetti che praticano differenti sport, già in età scolare, esiste una differenza statisticamente significativa nella percentuale delle morfologie di volta plantare.

Ulteriori studi possono fornire maggiori informazioni per spiegare la ragione che determina questa differente distribuzione delle morfologie delle volte plantari nei diversi sport.

**Parole chiave:** piede cavo, piede piatto, volta plantare, sviluppo della volta plantare, sport, età scolare.

The greater or lesser elasticity of the plantar vault can help or hinder in dissipating forces vertical to the ground<sup>5</sup>. Plantar vault with a flat medial arch or with a medial arch too high may contribute to some pathological conditions such as knee osteoarthritis<sup>6</sup>.

Some studies have found a correlation between the

morphology of the foot arch, represented by the index value of the plantar arch, and the intensive competitive practice of some sports during growth<sup>7,8</sup>.

Sport practice during the school age may therefore play a role to develop the arch and cause or prevent abnormal plantar vault morphologies.

The goal of this research is to find out correlations between the prevalence of some morphotypes of plantar vault and sports practice in school-age people.

## Materials and Methods

### Study population

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

The study concerns 461 children (278 females and 183 males) aged from 6 to 15 years selected from a group of 689 children attending four schools in Rome (Italy).

Children not giving informed consent form signed by parents, those who have not completed the protocol and those who use orthotics or orthopedic shoes, those who have undergone surgery to the lower extremities did not enter the study.

Children were divided into two age groups; the first group was from 5 to 10 years (131 females and 39 males) and the second group was from 10 to 15 years (146 females and 145 males).

### Physical activity assessment

Each child filled out a physical activity assessment questionnaire twice within two week. The questionnaire fit to primary and middle schools to allow children of all ages a better understanding. The questionnaire recorded sports practiced in the past and in the last year, the number of training sessions by week and the duration (in hours) of each session. In addition, we have explored the habits of life of the subjects (such as hours of sleep, hours devoted to television and video games). Data were entered into a database Excel to perform statistical analysis. Each child had a code number to make nameless the questionnaire.

### Anthropometry

Body weight was measured to the nearest 0.1 kg on an electronic beam scale, without clothes and shoes. Height was measured to the nearest 0.5 cm with a stadiometer. Body mass index (BMI) was calculated as weight (kg)/height (m)<sup>2</sup>.

### Plantar vault exam

A polarized light plantoscope exam discerned the vault shapes according to Denis. 'Plantar vault was normal when the central zone (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. Images are taken of the hindfoot to discerned the valgus hindfoot from the varus hindfoot.

To identify flexible from rigid flatfoot, Jack's toe raising and Toe standing test<sup>2</sup> are performed (Fig.1).

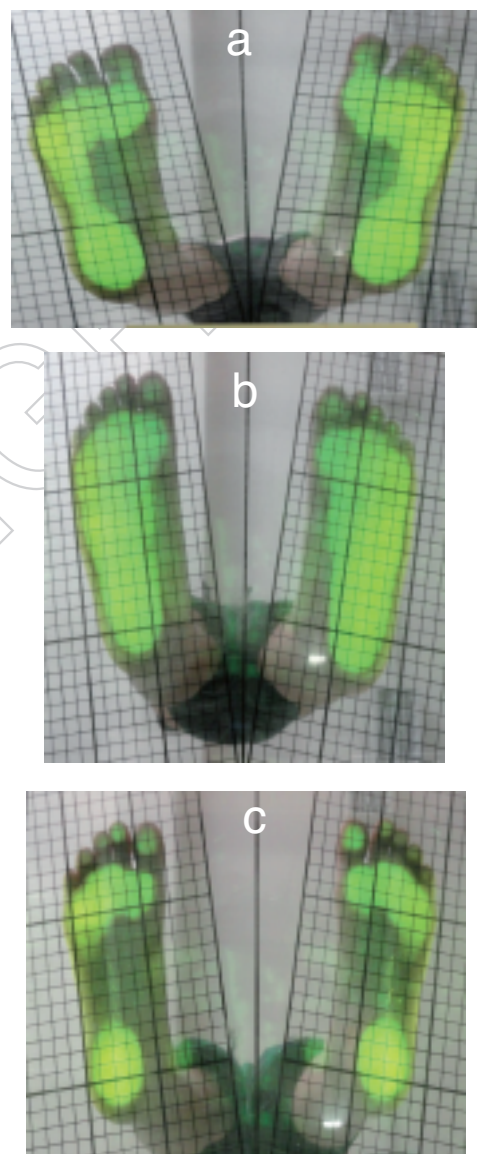


Figure 1. normal (A), flat(B) and cavus (C) feet.

### Statistical analysis

All data were initially entered into an ACCESS database (Microsoft, Redmond, Washington – United States) and the



analysis was performed using the Statistical Package for the Social Sciences Windows, version 13.0 (SPSS, Chicago, Illinois, USA). Descriptive statistics consisted of the mean  $\pm$  standard deviation for parameter with gaussian distributions (after confirmation with histograms and the Kolgomorov-Smirnov test), median and range (min.; Max.) for frequencies and variables categorial with non-gaussian distributions. Comparison among groups A vs. B vs. C was performed with the one-way ANOVA for continuous parametric variables, Kruskal-Wallis (groups>2) or Mann-Whitney (groups=2) for non-parametric variables and the Chi-Square test or Fisher's exact test (if cells<5) for categorical variables. Time-to-event analysis was performed using Cox regression for censored data and to assess the weight of variables covariates. *p* value of < 0.05 was considered statistically significant.

## Results

The average age of the subjects analyzed was  $11 \pm 2.2$  years, the average height was  $145 \pm 14.7$  cm and body weight of  $43.2 \pm 14.6$  kg; the mean BMI was  $19.9 \pm 4.2$ . BMI fixed according to Cole index for Italian growing tables, 90.7% of subjects had normal weight (Table 1).

Sports practice spread among 71% of the male students and 66% of the females; the sedentary individuals, who do not practice any sport, were 32% of the sample (147 subjects). The most popular sport among males chil-

dren was football (34%) followed by swimming (31%) and basketball (15%). Females more often practiced swimming (45%), artistic and rhythmic gymnastics (26%) and dance (10%).

Among the 461 subjects evaluated, 75% of them showed normal feet, 17% pes cavus, and 8% pes planus (table 1), the latter was rigid in 50% of cases. 75 subjects (16%) had dissimilar plantar vault between the right foot and left foot.

In swimming (122 subjects), 15% had pes cavus, 8% pes planus. In dance (48 subjects) 25% had pes cavus and 4% flatfoot. Soccer (45 subjects) 4% pes cavus and 9% pes planus. In basketball (26 subjects), 35% had a pes cavus and 4% flat. In artistic and rhythmic gymnastics (20 subjects) 35% had pes cavus and 10% pes planus. In volleyball (14 subjects), 29% had pes cavus while nobody had pes planus. The inactive subjects had a pes cavus in 16% of cases and a pes planus in 9%. Among children who practice sport there was a sports related, significant disproportion between the rates of plantar vault morphologies ( $p < 0.005$ ).

Children belonging to the first age group (170 subjects) were 77% females and 23% males. In the second age group (288 subjects) 51% where female and 49% male. In the first age group females who practiced sports were 53%, while 78% in the second. In the first age group males who practiced sports were 54%, in the second 77% (Fig. 2).

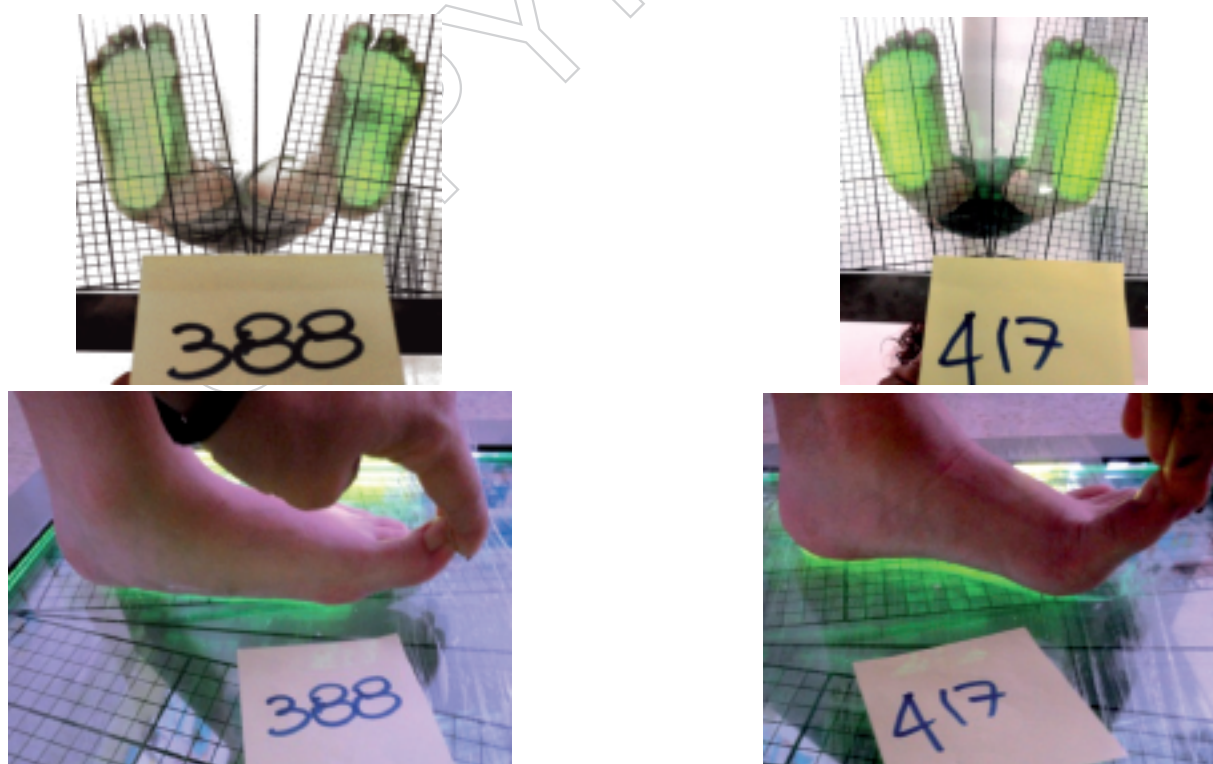


Figure 2. Jack's toe raising and Toe standing test for rigid flatfoot: left positive, right negative.

In the first age group 68% of the plantar vault were normal, 18% were pes cavus and the 14% pes planus. In the second age group we saw 79% of normal feet, 16% of pes cavus and 5% of pes planus. In 19% of females and 14% of the males the feet were cavus in 7% of females and 10% males the feet were flat (Table 1).

## Discussion

The study showed a statistically significant disproportion by gender (females > males). This were not relevant for the study which depended by prevalence.

The most popular sport among the study group was swimming while among males was soccer; Females more often practiced swimming.

The rates of normal (75%), cavus (17%) and planus feet (8%), were similar to those of Promenzio et al.<sup>4</sup> Monteleone M. et al.<sup>9</sup> and Vergara et al.<sup>10</sup> Comparing our study with the many epidemiological studies<sup>11,12,13</sup> reported in literature is difficult, because of the different method and sample characteristics. Our sample showed an increase in the percentage of the normal feet and a significant decrease of the flatfeet proportionately with increasing age. In both sexes, 16% of subjects showed a different morphology between left and right foot.

There were no statistically significant correlations between anthropometric measurements and the different foot morphotypes, although there was a trend in increasing the rate of pes planus as the BMI increase. This is evident even if the children have a BMI in the physiological growth curves for subjects of the same age and nationality according to limits set with the index of Cole applied to the last cross-sectional growth charts for height, weight and BMI<sup>14,15</sup>.

The goal of the survey was to examine potential associations between the rates of certain morphotypes of plan-

tar vault and sports in a group of school-age subjects.

Among children who practice sport there was a sports related, significant disproportion between the rates of plantar vault morphologies. This is evident in volleyball (29% of the cavus feet and no flat feet). Previously, we observed<sup>16</sup> the absence of flat feet and a high percentage of cavus foot (35%) in a group of adolescent and adult volleyball players of several playing levels.

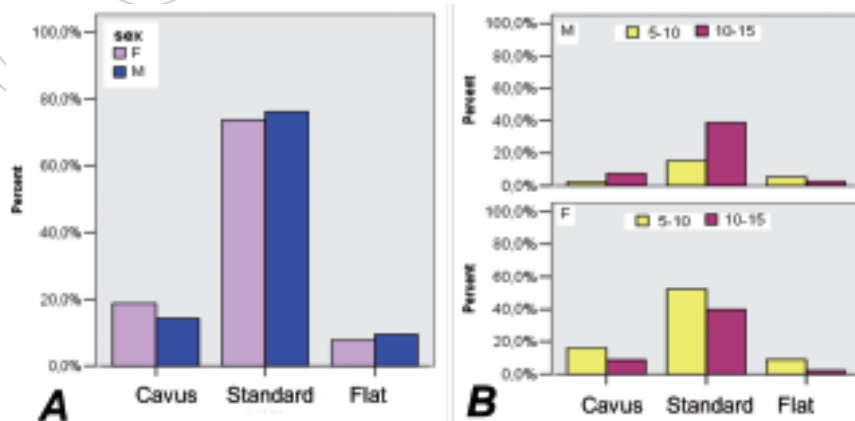
Further studies could explain the high percentage of cavus vaults in volleyball. This phenomenon could be due to the more frequent volleyball practice by people with vaults that are stiffer (cavus vaults) and more biomechanically suited to the movements needed in volleyball (such as jump, short shots).

In elite adult athletes, Aydog et al.<sup>17</sup> saw a higher arch index (AI) (lower plantar vault) in wrestling than that in gymnastic and nonathletic control. The AI in gymnastic was lowered (higher plantar vaults) than that of nonathletic controls and wrestlers. Aydog et al.<sup>18</sup> noted a negative correlation between sole AI and training age in Junior level basketball players (16-18 age). This would indicate an hollow effect of basketball practice.

During a twelve months study, in a group of 10-11 years old children practicing competitive sport and subjected to systematic purposive training, Volkov<sup>7</sup> noted a flattening of the plantar vault in skaters and gymnasts compared with swimmers.

Our study showed that, in both sexes, as age increased children who practice sports increased as well, while inactive children decreased.

A further prospective study may provide more informations about the plantar vault development, especially to discover the reason that decides the different distribution of the different morphotypes of the plantar vault in different sports.



Tab. 1 Prevalence of vault shape in all the examined subjects (divided by sex - A and by age - B)

## References

1. Denis A. Pied plat valgus statique. In: Encyclopedie medico-chirurgicale appareil locomoteur. Paris, France, Editions Techniques, 1974.
2. Mosca VS. Flexible flatfoot in children and adolescents. *J Child Orthop.* 2010; 4(2):107-21.
3. Cappello T, Song KM. Determining treatment of flatfeet in children. *Curr Opin Pediatr.* 1998; 10(1):77-81.
4. Promenzio L, Gabrielli A, Monteleone M. Fisiopatologia del piede in età scolare. *Riv Patol Appar Locomot.* 2004; 3:11-17
5. Franco AH. Phys Ther. Pes cavus and pes planus. Analyses and 1. treatment. 1987;67(5):688-94.
6. Bresnahan P. Flatfoot deformity pathogenesis. A trilogy. *Clin Podiatr Med Surg.* 2000; 17(3):505-12.
7. 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(6):32-4.
8. Aydog ST, Tetik O, Demirel HA, Doral MN. Differences in sole arch indices in various sports. *Br J Sports Med.* 2005; 39(2):e5.
9. Monteleone M., Promenzio L. Valutazione podoscopica dell'appoggio plantare nella popolazione scolastica della provincia di Crotone” 2006 17-19 - Ed. Amministrazione Provinciale di Crotone, Università di Roma “Tor Vergata”.
10. Vergara-Amador E, Serrano RF, Correa JR, Molano AC, Guevara OA. Prevalence of flatfoot in school between 3 and 10 years. Study of two different populations geographically and socially. *Colombia Med.* 2012; 43(2): 141-6
11. Garcia-Rodriguez A, Martin-Jimenez F. Flexible Flat Feet in Children: A Real Problem? *Pediatrics.* 1999; 103 (6): 1-3.
12. Forriol F, Pascual J. Footprint analysis between three and seven-teen years of age. *Foot Ankle.* 1990;11(2):101-4.
13. Echarri JJ, Forriol F. The development in footprint morphology in 1851 in Congolese children from urban and rural areas, and the relationship between this and wearing shoes, *J Pediatr Orthop B*”. 2003; 12: 141-6.
14. Bordin D, De Giorgi G, Mazzocco G, Rigon F. Flat and cavus foot, indexes of obesity and overweight in a population of primary-school children. *Minerva Pediatr.* 2001 Feb; 53(1):7-13.
15. Cacciari E, Milani S, Balsamo A, Dammacco F, De Luca F, Chiarelli F, Pasquino AM, Tonini G, Vanelli. Italian cross-sectional growth charts for height, weight and BMI (6-20 y). *M. Eur J Clin Nutr.* 2002 Feb; 56(2):171-80.
16. Monteleone G, Pistillo P, Sorge R, Simio P, Tiloca A, Padua E. Distorsione di collo piede e volta plantare nel pallavolista: indagine epidemiologica in una città del sud d'Italia. *Rivista di Patologia dell'Apparato Locomotore (nuova serie).* 2010; 9(1): 73-79.
17. Aydog ST, Ozçakar L, Tetik O, Demirel HA, Hasçelik Z, Doral MN. Relation between foot arch index and ankle strength in elite gymnasts: a preliminary study. *Br J Sports Med.* 2005; 39(3):e13.
18. Aydog ST, Demirel HA, Tetik O, Aydog E, Hasçelik Z, Doral MN. The sole arch indices of adolescent basketball players. *Saudi Med J.* 2004 Aug; 25(8):1100-2.  
Presented at the XXXII World Congress of Sports Medicine – Rome, Italy 27-30 September 2012.