Flat foot among Saudi Arabian army recruits: prevalence and risk factors

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القدم الرخَّاء بين المجندين في الجيش السعودي: الانتشار وعوامل الاختطار

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الخلاصة: استهدفت هذه الدراسة تقدير معدل انتشار القدم الرخَّاء وعوامل الاختطار المرتبطة بها لدى المجندين الذكور في الجيش السعودي في الفئة العمرية 18 — 21 عاماً. وقد بلغ معدل الانتشار 5٪ بين المجندين البالغ عددهم 2100 مجند. وقد بيَّن تحليل التحوُّف اللوجستي لعوامل الاختطار للحالات والشواهد (104 حالات، 412 شاهداً) أن التاريخ العائلي، وارتداء الأحذية في الطفولة، والبدانة، والإقامة في الحضر، كل هذه العوامل ترتبط ارتباطاً مهماً بالقدم الرخَّاء. ولم يتم الإبلاغ عن شكاوى مرتبطة بالحالات، ومن ثم فإن القدم الرخَّاء المرنة لا يبدو أنها تسبِّب أي إعاقة.

ABSTRACT This study determined the prevalence and risk factors for flat foot among 18–21-year-old male Saudi Arabian army recruits. Among 2100 military recruits, the prevalence of flat foot was 5.0%. A case–control logistic regression analysis of risk factors (104 cases and 412 controls) showed family history, wearing shoes during childhood, obesity and urban residence were significantly associated with flat foot. No associated complaints were reported among the cases and thus flexible flat foot does not seem to be a cause of any disability.

Le pied plat parmi les recrues militaires saoudiennes : prévalence et facteurs de risque

RÉSUMÉ Cette étude a déterminé la prévalence et les facteurs de risque pour le pied plat chez des recrues militaires saoudiennes âgées de 18 à 21 ans. La prévalence du pied plat s'élevait à 5,0 % parmi 2100 recrues militaires. Une analyse de régression logistique des facteurs de risque portant sur 104 cas et 412 témoins a montré que des antécédents familiaux, le port de chaussures durant la petite enfance, l'obésité et la résidence urbaine étaient significativement associés au pied plat. Aucune plainte associée n'a été signalée parmi les cas et le pied plat souple ne semble donc pas être une cause d'incapacité.

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Introduction

Flat foot is a condition in which the foot does not have a normal medial longitudinal arch when standing [*1*]. In the medical world, flat foot is associated with pronated foot. The term "pronated" describes the position of the foot when it is flexed upward (dorsiflexed), turned away from the body (abducted), and the heel is rolled outward (everted) at the same time [*2*]. Flat foot is usual in infants, common in children and uncommon in adults [*1*].

There are many different causes of flat foot, which can be separated into 2 main categories [*3*]. The first category, congenital flat foot, includes the completely asymptomatic, paediatric flexible flat foot, by far the most common form of congenital flat foot. Flexible means that an arch is present until weight is put on the foot, at which time the arch disappears. The second category, acquired flat foot, develops over time, rather than at birth, and many different factors contribute to its development. These include the type of shoes a child wears [*4–6*], rheumatic arthritis, compensation for other abnormalities further up the leg, or more severe factors such as rupture of the ligaments or tendons in the foot [*7*]. The most common acquired flat foot in adults is due to posterior tibial tendon dysfunction [*8*].

Flat foot can lead to many unpleasant problems including heel pain, bunions, hammertoes, shin splints and even knee, hip or back pain [*9*]. Most cases of flat foot are caused by loose joint connections. This develops with repetitive stress on the main supporting tendon of the arch over a long period of time [*3*]. It is believed that Asians (including Arabs) have less ligament laxity and accordingly lower prevalence of flat foot than Europeans and Americans [*10*].

Few subjects in orthopaedics have had such varied and diverse opinions expressed about every aspect of the condition, from etiology to treatment, as has flexible flat foot. This has resulted in part because there is no long-term study of the natural history of the untreated flexible flat foot [*3*]. Some people have no problems with flat foot. Others may experience foot pain, knee pain, shin splints and pain in the achilles tendon. Eventually, patients with adult acquired flat foot may develop severe arthritis in the foot and ankle [*11*].

The aim of this work was to determine the prevalence of flat foot among male Saudi Arabian army recruits and to identify the risk factors for flat foot in this group.

Methods

The study included all male army recruits attending the recruitment centre at Al-Hada Armed Forces Hospital, Taif, Saudi Arabia, during the period 1 January 2003 to 31 December 2003. Their ages ranged between 18–21 years.

All subjects were referred to the orthopaedic clinic at the same hospital. They were given a brief general medical examination and a short questionnaire to collect data about age, residence, past history of accidents (with ruptured ligaments and/or tendons in the feet) and usual footwear during childhood. Weight and height were measured to calculate body mass index (BMI). A detailed medical examination was made of the lower limbs by trained orthopaedic surgeons to record whether the participant had flat foot or not, and whether the flat foot was unilateral or bilateral and mobile or fixed (does not disappear when the feet are raised). For those with flat foot, the orthopaedic surgeon noted the follow-

ing: whether flat foot was accompanied by symptoms or not, what was its condition (neutral, varus or valgum) and was it associated with other deformities (none, genu varum or genu valgum).

Planter footprints were done and classified according to Denis [*12*] into 3 grades: grade 1 in which the support of the lateral edge of the foot is half that of the metatarsal support; grade 2 in which the support of the central zone and forefoot are equal; and grade 3 in which the support in the central zone of the foot is greater than the width of the metatarsal support. Normal BMI was defined as < 25 kg/m^2, overweight was 25–30 kg/m^2 and obese was > 30 kg/m^2.

All recruits with any degree of flat foot were considered cases. For each case, 3 age-matched controls were randomly enrolled from among the whole group of army recruits using *SPSS* software.

Sample size estimation

Since there is no previous study determining the prevalence of flat foot in this country, the rate was estimated from a pilot sample (n = 570) to be 4.7%. The number of subjects required for this study was estimated to be 1722 individuals to give the true population proportion of flat foot with 95% confidence intervals (CI) and 2% margin of error. It was estimated that recruiting all the men in a 1-year period was sufficient to recruit more than the required sample size.

Statistical analysis

Analysis was initially carried out based on a series of univariate comparisons. In order to control simultaneously for the possible confounding effect of the variables, a multiple logistic regression analysis with stepwise variable selection was utilized for the final analysis [*13*]. Thus, in both univariate and multivariate analyses, the association between exposures and outcomes was expressed as odds ratio (OR) with 95% CI. When the 95% CI include the null value of 1, no statistically significant difference (at the 5% level) is present. In the final analysis, odds ratios were controlled for all the variables retained in the model.

Results

This study included 2100 military recruits, with a mean age 19.3 years (standard deviation 0.8 years). Among them, flat foot was diagnosed in 104 recruits (5.0%).

A total of 104 military recruits with flat foot and 412 without flat foot were included in the case–control study of risk factors (Table 1). Most of them were from rural regions of Saudi Arabia (75% and 85% of cases and controls respectively). Obesity was reported among 5.8% of cases compared with only 2.2% among controls.

The clinical characteristics of flat foot cases are shown in Table 2. Flat foot was bilateral in 75.0% of cases, mobile and with neutral heel in nearly all cases (99.0%)

Table 1 **Baseline characteristics of participants in the case–control study of flat foot among Saudi Arabian army recruits**

Characteristic	Cases (n = 104)		Controls (n = 412)	
	Mean	**(SD)**	**Mean**	**(SD)**
Age (years)	19.13	(0.43)	19.33	(0.91)
Residence	**No.**	**%**	**No.**	**%**
Urban	26	25.0	62	15.0
Rural	78	75.0	350	85.0
Body mass index				
Normal (< 25 kg/m^2)	85	81.7	372	90.3
Overweight (25–30 kg/m^2)	13	12.5	31	7.5
Obese (> 30 kg/m^2)	6	5.8	9	2.2

SD = standard deviation.

Table 2 **Clinical characteristics of Saudi Arabian army recruits with flat foot**

Characteristic	Cases (n = 104)	
	No.	%
Site		
Unilateral	26	25.0
Bilateral	78	75.0
Mobility		
Mobile	103	99.0
Fixed	1	1.0
Grade[a]		
Grade 1	18	17.3
Grade 2	39	37.5
Grade 3	47	45.2
Accompanying symptoms[b]		
No	0	0.0
Yes	104	100.0
Heel condition		
Neutral	103	99.0
Varus	1	1.0
Valgum	0	0.0
Associated deformities in knee		
No	83	79.8
Genu varum	18	17.3
Genu valgum	3	2.9
Other congenital defects		
No	102	98.1
Yes	2	1.9

[a]*Classified according to Denis [11].*
[b]*Metatarsalalgia and disfigurement.*

and moderate or severe degree in the great majority of cases (37.5% and 45.2% respectively). Flat foot was asymptomatic in all studied cases and no accompanying symptoms, such as metatarsalalgia or disfigurement, were reported. It was associated with deformities in the knee joint in nearly one-fifth of cases (20.2%) and congenital defects in only 2 cases (1.9%). No history of congenital deformities of lower limbs was recorded in any case or control men.

The results of the univariate and logistic regression analyses are reported in Table 3. Residence in urban areas was significantly associated with double the risk of flat foot (adjusted OR: 2.04; 95% CI: 1.11–3.48). As compared with normal subjects, overweight or obese subjects were at significant higher risk for flat foot (adjusted OR: 2.22; 95% CI: 1.23–4.06). A family history of flat foot was strongly and positively related to flat foot (adjusted OR: 8.06; 95% CI: 4.55–15.25). The type of usual footwear during childhood was a significant predictor for the development of flat foot. Considering cases who went bare-footed during childhood as the reference category, those who wore shoes during their early childhood were at double the risk of having flat foot (adjusted OR: 2.18; 95% CI: 1.01–5.73).

No association emerged with a history of accidents with ruptured ligaments and/or tendons in the feet or with a history of rheumatic arthritis.

Discussion

Our study of the literature revealed that there is a great variation in the prevalence of flat foot reported by different authors [*10,14–16*]. These differences could be explained by the fact that the authors used different age groups or only made their diagnosis at the end of the usual evolutionary period when additional evolution toward healthy feet was improbable. Rose states that the critical age for development of the plantar arch is 6 years, and consequently, if the prevalence of flat foot is evaluated before this age, the finding will overestimate the problem [*14*]. Our figure (5.0%) was much lower than that reported by Staheli (20%) who studied subjects ranging in age from 1 to 80 years [*1*]. This figure also confirms previous reports that Asians (inclu-

Table 3 **Univariate and multivariate analyses of risk factors for flat foot (104 cases and 412 controls) among Saudi Arabian army recruits**

Risk factors	Crude OR	(95% CI)	Adjusted OR	(95% CI)
Residence				
Rural[a]	1.0		1.0	
Urban	1.88	(1.08–3.26)*	2.04	(1.11–3.48)*
Body mass index				
Normal[a]	1.0		1.0	
Overweight	1.84	(0.87–3.83)	1.75	(0.91–4.02)
Obese	2.92	(0.89–9.26)	2.69	(0.91–10.02)
Overweight or obese	2.08	(1.10–3.91)*	2.22	(1.23–4.06)*[c]
History of accidents[b]				
No[a]	1.0			
Yes	0.79	(invalid CI)	Removed	
Family history				
No[a]	1.0		1.0	
Yes	10.10	(5.71–17.91)*	8.06	(4.55–15.25)*
History of rheumatoid arthritis				
No[a]	1.0			
Yes	1.72	(0.35–7.53)	Removed	
Usual footwear during childhood				
Bare feet[a]	1.0		1.0	
Sandals	0.82	(0.49–1.37)	0.91	(0.44–1.45)
Shoes	2.06	(0.71–5.88)	2.18	(1.01–5.73)*

[a] *Reference category.*
[b] *With ruptured ligaments and/or tendons in the feet.*
[c] *Separate logistic regression model.*
**P < 0.05; OR = odds ratio; CI = confidence interval.*

ding Arabs) have a lower prevalence of flat foot than Americans and Europeans [*10*].

In agreement with Riddiford-Harland et al. [*17*], there was a significant tendency in our study towards flat foot in obese subjects compared with normal subjects.

Children with the healthiest and most supple feet are those who habitually go barefoot, according to Staheli [*18*] and a growing number of other paediatric orthopaedists [*4,6,10,19*]. His studies in developing countries show that non-shoe-wearers have better flexibility and mobility, stronger feet, fewer deformities and fewer complaints than those who wear shoes regularly. Our findings agree with his finding and that of others. Echarri et al. [*20*] stated that footwear during childhood has very little influence on the morphology of the foot; however, in agreement with our study, he found that the greater proportion of those with flat foot came from an urban environment.

A strong familial tendency for flexible flat foot has been observed in our study. The same has been reported by others [*3,19*].

In adults, the flexible flat foot may be regarded as the normal contour of a strong and stable foot, rather than the result of weakness in foot structure or weakness of the muscles in the foot. No associated complaints were reported among our studied cases. This finding supports the hypothesis that a flexible flat foot is of little consequence as a cause of disability in adults [*2,21*].

In conclusion, the present study showed that the prevalence of flat foot among Saudi military recruits is 5.0%. All the cases were asymptomatic. Family history, type of shoe wearing during childhood, obesity and urban residence were significant risk factors for flat foot.

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Correction

Food fortification: good to have or need to have? A. Verster. *Eastern Mediterranean Health Journal*, 2004, Vol. 10, No. 6, pages 771–777.

In Figure 4, for the chart on Costa Rica, the y axis title should read: NTD per 10 000 live births.