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INFLUENCE OF FOOTBALL TRAINING ON ALIGNMENT OF THE LOWER LIMBS AND SHAPING OF THE FEET

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ABSTRACT
Purpose. One of the aims of football training is to enhance the musculo-ligamentous apparatus and increase mobility of the lower limbs' joints. Proper football footwear is compulsory as games are being played on different surfaces. This has direct impact on the placement of one's feet and distribution of forces within feet arcs. The purpose of this study was to compare the placement of feet and toes of boys training football with their peers who did not practise football. **Basic procedures.** This study was carried out on 72 junior football players, aged 10–14 years, who were divided into 4 groups according to age and training level. The control group included 80 boys of similar age. The examination was performed using Moiré technique. Alignment of the knees was assessed visually. Computer analysis of the results covered the following parameters: Clarke's angle, α, β and γ angles, length-to-width index and KY index. **Main findings.** Feet anomalies were more frequent in footballers. In the older players these were mainly varus knees (around 40%), while the younger one's had valgus knees more often than the non-players. Hallux valgus (over 20%), especially of the left foot, and varus toes (over 90%) were also more frequent in the non-training boys. Besides there was a decrease of curvature of the longitudinal and transverse feet arcs that was more frequent in the right feet. However, longitudinal and transverse characteristics of the left feet arcs did not differ between the exercising and non-exercising groups. **Conclusions.** The examination of the feet confirmed the impact of football training on the placement of feet and toes and curvature of the feet arcs.

Key words: football training, alignment of the lower limbs, shaping of the feet, Moiré technique

Introduction

Sport training is a long-term, dynamic and comprehensive pedagogic process and players as a part of it learn, acquire and systematically master the techniques and tactics of a given sports discipline, develop their physical fitness as well as volitional and personal traits. The impact on physical constitution and harmonious development of players is aimed at increasing their physical ability, which divides into general, directed and special. High dynamic force of the lower limbs muscles, i.e. high efficiency of the musculo-ligamentous apparatus is an absolute priority in football training. It has been confirmed that an average footballer runs a distance of over 10 km during a single game [1, 2]. The multi-stage preparation scheme for footballers lists enhancement of the musculo-ligamentous apparatus and increasing the mobility of the lower limbs' joints as the fundamental part of football training. Proper football footwear is compulsory and the games are played on various types of surface, which has impact on the placement of the lower limbs and the curvature of the feet arcs in football players.

The aim of this study was to assess the placement of the lower limbs and toes and shaping of the feet of boys training football against their non-training peers.

Material and methods

The study covered 72 boys training football aged 10–14 years. They were divided into four groups, depending on age and training experience: Group 1 included 10 and 11 year-olds with training experience less than two years; Group 2 included 11 and 12 year-olds with training experience between two and five years; Group 3 included 13 year-olds with training experience between three and four years; Group 4 included 14 year-olds with training experience between three and seven years. The control group consisted of 80 non-training boys, who were divided into analogous age groups, so that the mean age of the subjects from both groups was nearly identical.

A questionnaire concerning the training experience, training frequency, documented postural faults and dominant side of the body was distributed among parents and, in the case of players, among coaching staff.

Placement of the lower limbs was assessed individually, in habitual position and looking from the front with knees and/or ankles adhering or with knees and medial ankles astray (cm). The following placement types were distinguished: valgus limbs, when the distance between the ankles was 5 cm or more with knees adhering; normal and varus, when the distance between the knees was 5 cm or more with ankles adhering [3].

The evaluation of feet arcs curvature was performed by means of a special photogrammetric kit produced by CQ Elektronik from Wrocław, Poland. The kit consisted of glass panel with a CCD camera fixed underneath it. The subjects had to stand on the panel in order for the camera to register the image of their feet, which were illuminated with rasterized light [3]. The images from the camera were subjected to computer analysis, which provided the following parameters: Clarke's angle (Cl), alpha (α), beta (β) and gamma (γ) angles, length-to-width index (LWI) and KY index.

The alpha and beta angles traced on the plantocontourograms show the placement of the hallux and the small toe. Correct angle of valgity of the hallux, according to Wejsflog, ranges between 0° and 9°. The calcaneal gamma angle is an angle between the tangents from the external and internal edge of a foot and in normal conditions it should range between 15° and 18°. This angle is the measure of transverse vaulting of a foot [4–7]. The length-to-width index (LWI) is a length to width ratio of a foot and also is an indicator of the transverse vaulting of a foot. In normal conditions it is close to a value of 3 and in the case of excessive flattening of the foot arcs it reaches the value of 2 and thus the following classification criteria have been determined: transverse platypodia – below 2.3, depressed vaulting – between 2.3 and 2.59, normal vaulting – 2.6 or higher [4]. KY index is a ratio of the shaded part of the plantocontourogram to its overall width and Clarke's angle (Cl) is the angle between a tangent from the medial edge of a foot and a tangent from the apex of the tarsus recess measured at the point where those tangents intersect with the frontal tarsus line. Both Clarke's angle and the KY index express the longitudinal vaulting of a foot. In the case of excessive vaulting (hollow foot) the KY index is lower, whereas in feet with lowered vaulting its values are higher than the recommended ones. On the other hand, lower values of Clarke's angle indicate the flattening of a foot and higher ones show that a foot is hollowed out. Evaluation by means of those parameters should take into account the age of the subjects (Tab. 1) [3–5].

Table 1. Assumed normal values for KY index and Clarke's angle (Cl) (based on Kasperczyk and Lizis standards)

Age	KY index				Clarke's angle (Cl)			
	Hollow foot	Normal foot	Flattened foot	Flat foot	Hollow foot	Normal foot	Flattened foot	Flat foot
10–11 years	under 0.4	0.4–0.54	0.54–0.75	over 0.75	over 45	31–45	20–30.9	under 20
11–12 years	under 0.3	0.3–0.45	0.45–0.75	over 0.75	over 47	32–47	20–31.9	under 20
13–14 years	under 0.3	0.3–0.45	0.45–0.75	over 0.75	over 50	42–50	30–41.9	under 30

Table 2. Arithmetic means ($\bar{x}$) of alpha, beta and gamma angles (α, β, γ), length-to-width index (LWI), KY index and Clarke's angle (Cl)

Age	Group	n	α ($\bar{x}$)		β ($\bar{x}$)		γ ($\bar{x}$)		LWI ($\bar{x}$)		KY ($\bar{x}$)		Cl ($\bar{x}$)	
			Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
10–11 years	FG	19	3.2	**6.6**	**19.9**	**17.9**	**20.3**	17.4	2.53	2.47	0.42	0.45	38.1	40.5
	CG	24	1.0	2.8	13.7	10.0	16.3	15.4	2.58	2.47	0.39	0.43	38.1	36.7
11–12 years	FG	24	**3.1***	4.6	**21.0**	**17.9**	**18.9**	17.0	2.60	2.50	0.40	0.46	38.9	40.4
	CG	21	–0.9	1.1	15.3	9.9	16.5	15.4	2.60	2.47	0.46	0.46	37.5	37.2
13 years	FG	16	2.5	**5.6**	17.3	15.5	19.0	15.7	2.54	2.45	0.42	0.47	39.6	41.5
	CG	18	–0.1	0.5	16.0	17.1	17.5	13.8	2.59	2.49	0.48	0.48	41.2	41.4
14 years	FG	13	2.2	5.1	**21.1**	**19.7**	**20.3**	**17.1**	2.48	2.39	0.46	0.49	**37.3**	36.9
	CG	17	–0.2	3.8	16.1	15.3	18.5	14.4	2.54	2.42	0.45	0.44	43.5	41.9

* statistically significant differences between the means of footballers (FG) and control group (CG) at $p = 0.05$, statistically significant differences of means of footballers (FG) in comparison to control group (CG) in bold

Results

The assessment of the lower limbs placement indicated a high percentage of feet anomalies, mainly in 13- and 14-year old players (Fig. 1). Varus knees were not observed in non-training boys, while the 14-year old players, who had the longest training experience, showed the highest prevalence of this anomaly (approx. 40%). Valgus knees were also more frequent in younger players than in non-training boys.

Measurements of alpha angle showed that hallux valgus was more frequent in footballers (18% in the right foot, 32% in the left foot), while in the control group the hallux was in normal or varus position (Fig. 2, 3). Mean values of alpha angle were higher in footballers than in the control group and in several cases differences were statistically significant (Tab. 2). Beta angle measurements showed common occurrence of varus deformity of the small toes and it was more frequent in footballers (over 90%) than in the control group (80%). Mean values of beta angle were definitely higher in footballers, and apart from 13 year-olds, the differences were statistically significant (Tab. 2). Larger varus deformity was observed in the right feet, while valgity was more common in the left feet.

Gamma angle, which is a measure of transverse vaulting of feet, indicated a quite common depression of transverse foot vaulting (above 18). On average, 66% of footballers had depressed transverse vaulting of the right foot, 37% of the left foot, while in non-training boys those numbers were 36% and 10% respectively. Statistically significant differences were observed between the mean values, mainly in the right foot (Tab. 2). The length-to-width index (LWI) is also an indicator of the transverse vaulting condition. Readings of this parameter confirmed depression of the transverse vaulting of the feet. Depressed transverse vaulting of the right foot was more common in footballers, while in non-training boys it was equally common, but in the left foot (Fig. 4, 5; Tab. 2).

The KY index based evaluation of the longitudinal vaulting of foot showed its depression. Just as the transverse vaulting, it was more common in the footballers, but only in the right foot. In the youngest subjects, the depressed vaulting of feet was less frequent than in the

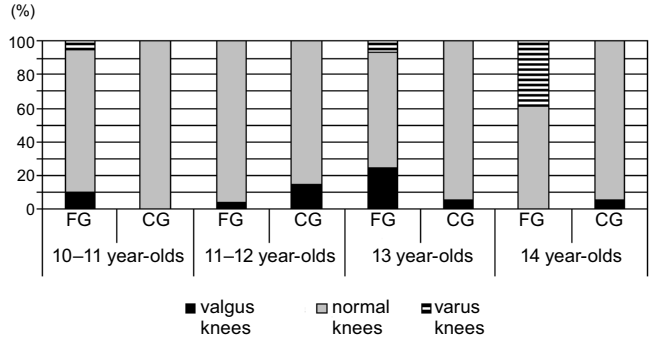

Figure 1. Placement of the lower limbs in football players (FP) and in non-training boys (CG)

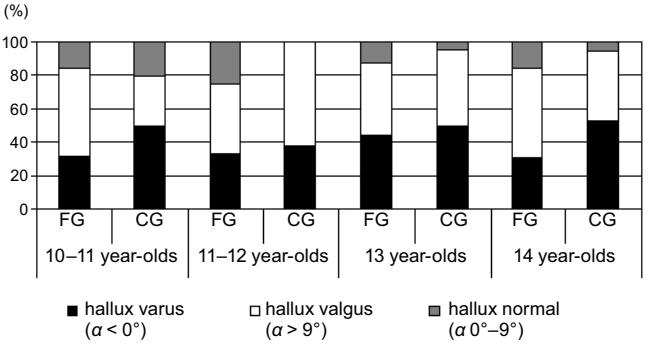

Figure 2. Placement of the right hallux in footballers (FG) and in non-training boys (CG)

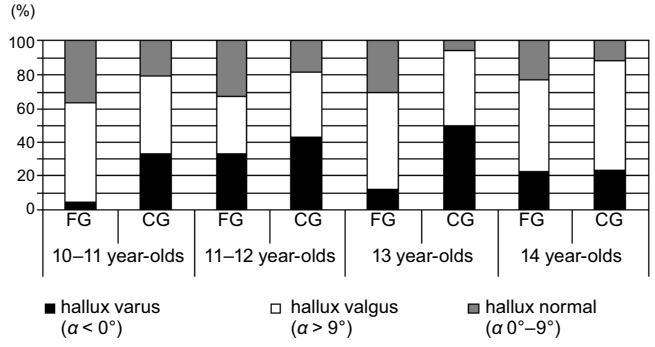

Figure 3. Placement of the left hallux in footballers (FG) and in non-training boys (CG)

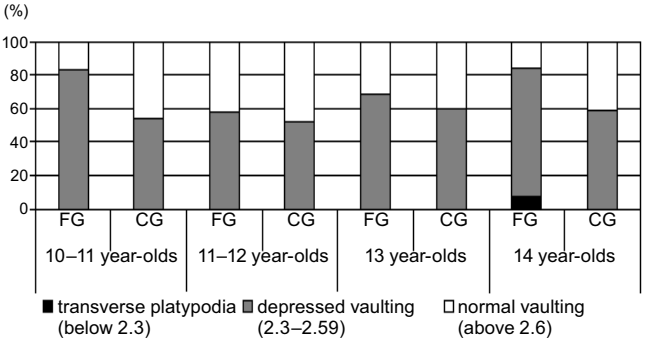

Figure 4. Transverse vaulting of the right foot in footballers (FG) and in control group (CG)

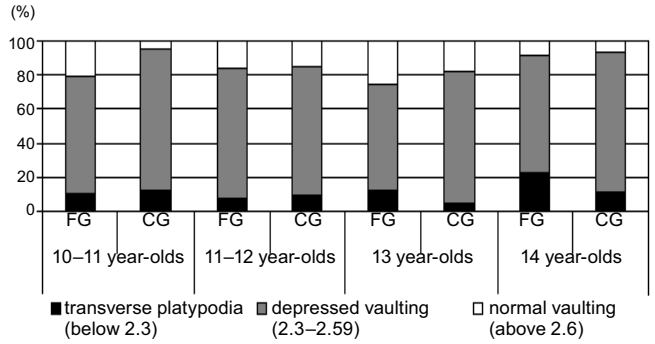

Figure 5. Transverse vaulting of the left foot in footballers (FG) and in control group (CG)

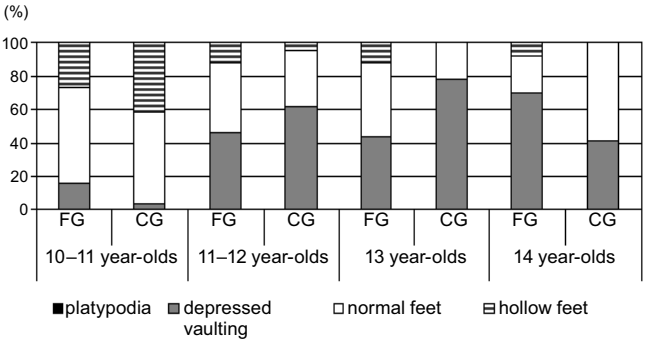

Figure 6. Longitudinal vaulting of the right foot according to KY index in footballers (FG) and control group (CG)

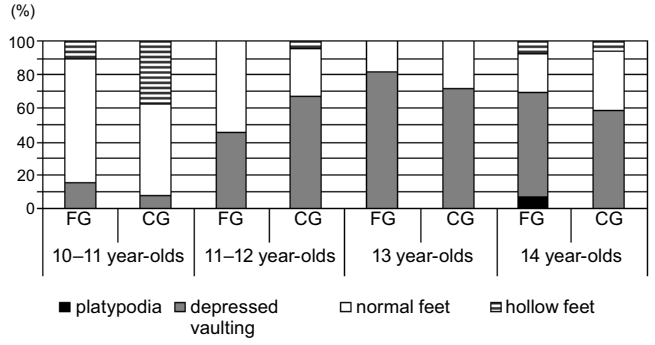

Figure 7. Longitudinal vaulting of the left foot according to KY index in footballers (FG) and control group (CG)

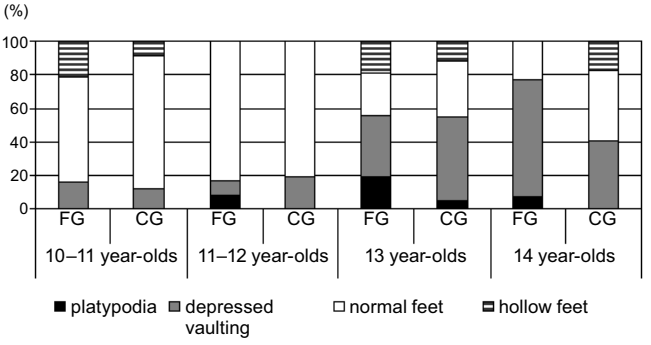

Figure 8. Longitudinal vaulting of the left foot according to Clarke's angle in footballers (FG) and control group (CG)

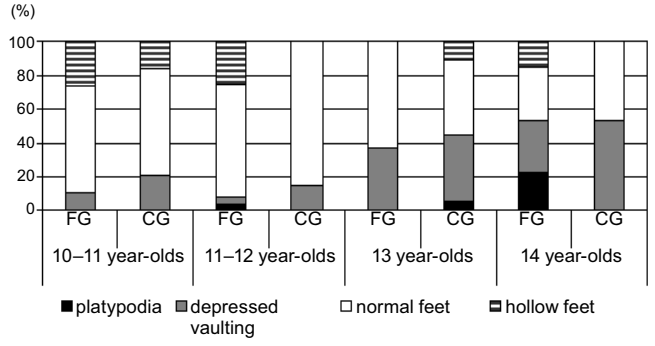

Figure 9. Longitudinal vaulting of the left foot according to Clarke's angle in footballers (FG) and control group (CG)

older ones, yet there were many cases of hollow feet (Fig. 6, 7; Tab. 2). Clarke's angle measurements showed fewer feet with depressed vaulting and fewer hollow feet. The difference between vaulting of the right and left feet was apparent, but not so much pronounced (Fig. 8, 9; Tab. 2).

Discussion

The results show that football training has impact on the placement of the lower limbs, which is confirmed by high percentage of varus knees in boys with longest training experience. Training also affects the placement of toes and vaulting of feet. Hallux valgus, varus deformity of the small toe and depressed longitudinal and transverse vaulting of feet were more common in footballers, especially those with the longest training experience, than in non-training boys.

Those observations found confirmation in results of examinations of 17–18-year old footballers done by Klata [8]. Klata observed depression of the longitudinal vaulting of mainly right feet based on KY index (20% of subjects) and transverse depression, and an increase of gamma angle (25% of subjects) [8]. Klata [8] discovered larger depression of the right foot in players of the 1st, 2nd and 5th junior league. Klata found out, based on answers to the questionnaire, that majority of the footballers examined were right-handed (92%) and right-legged (85%), therefore, one may assume that the right leg is dominant and thus much more burdened during training and games.

Plantographic examinations of 8–15-year old girls and boys indicate higher variability of vaulting of the

left feet and more regular improvement of vaulting of the right feet. Clarke's angle of the majority of feet ranged between 32° and 47°. Moreover Lizis, the author of that study indicated asymmetric distribution of Clarke's angle [5, 9]. Our own studies confirm those observations, yet only in the case of non-training boys.

Photogrammetric assessment of feet of non-training boys aged 8–13 years showed that depressed transverse vaulting of the right feet was present in 50% of boys and of the left feet in over 80% of boys. There were no visible differences in longitudinal vaulting of both feet [3].

The present examination indicates the existence of changes under influence of regular football training. Overburdening of the lower limbs during training and games is certainly one of the causes of those changes. A footballer most often marches, trots, jogs, but also runs with moderate speed or sprints, and moves backwards. The examinations revealed that an average football player runs over 10 km distance during one game [10]. Football training emphasizes enhancement of the musculo-ligamentous apparatus and increasing mobility of the lower limbs. Games are played on various types of surface. Special football footwear, characteristic movements of the front part of feet, shift weight to one of the limbs, unnatural movements of shanks affect the development of the lower limbs and feet. Shaping of feet in a child can become disturbed by intense training that mostly involves the lower limbs, resulting in characteristic placement of the limbs and vaulting of the feet of football players.

Conclusions

The examination showed correlation between football training and placement of the lower limbs, toes and vaulting of feet. The footballers examined, especially those with the longest training experience, had varus knees, hallux valgus, and varus deformity of the small toes and depressed transverse and longitudinal vaulting of the feet more often than the non-training boys. Most probably it is a result of overburdening of the lower limbs, especially of the dominant right leg, wearing special football footwear and movements of shanks characteristic of football playing.

Introduction of corrective exercises for knees and feet to the football training routine should be strongly considered. It would be advisable to order players to perform those exercises at home. It is important that those exercises involve muscles that support the longitudinal and transverse vaulting of the feet and toes.

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