Coll. Antropol. **47** (2023) 1: 55–59
Original scientific paper
doi:10.5671/ca.47.1.7

How Does Status of Longitudinal Arch of Feet Affect Sports Performances in Basketball Players in Iceland?

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ABSTRACT

Basketball is a highly anaerobic game, that consists of high-intensity efforts, such as jumping, landing, change of direction and sprinting, followed by lower-intensity efforts. Postural deformities can be a limiting factor in achieving maximal performances in basketball. Flat feet are one of the most common postural deformities and they can lead to poorer performances, discomfort, and pain. In this research we investigated the differences in certain sports performances among Icelandic basketball players in relation to the status of longitudinal arch of the feet. A sample of 143 basketball players (23 girls, age 12.7±1.4 and 97 boys, age 12.9±1.4 – development group; 14 women playing in the first Icelandic division, age 21±6.6 and 9 men, age 22.2±3.7 playing in the first Icelandic division) were tested on a podoscope to establish the degree of feet flatness and all participants performed countermovement jump, drop jump, 20m sprint and T-test for agility. To assign players in group with or without flat feet, Clark's angle has been used. Except in 20m sprint test, no differences were found between the groups with and without flat feet, which indicates that feet flatness was not a limiting factor in jumping and change of direction tasks but was in sprinting. We state that only strong and healthy feet might lead to excellent performance.

Key words: *flat feet, basketball, jumping, sprinting, agility, differences, Iceland.*

Introduction

Foot, with its 26 bones, 10 major extrinsic tendons and their muscles, numerous intrinsic musculotendinous units, and more than 30 joints represents a very complex structure and plays the most important role in human locomotion. Activities such as walking, running, jumping, landing, change of direction, directly depend on the ability of foot to act like a spring-like mechanism. Foot is flexible to act like a shock absorber[1], but at the same time is stiff to allow more rapid force production during push-off[2].

Foot consists of three arches, two longitudinal (medial and lateral) arches and one anterior transverse arch. The foot arches are fundamental for the dynamic function of the foot itself and during locomotion[1]. Stiff or inflexible medial longitudinal arch (MLA) is necessary for normal forward propulsion to occur[3]. Fundamental work of Ker and colleagues[4], identified the longitudinal arch of the foot as an elastic storage-return mechanism where 17% of the mechanical work of running could be stored and returned by the foot's arch as it undergoes compression and recoil over the stance phase.

Flat feet, also known as pes planus, are commonly described as any abnormality that causes MLA arch to collapse. The plantar surface of the foot of new-born children appears flat as a result of a thick fat pad that may persist for several years after birth[5] and which disappears around age of five. The longitudinal arch usually increases spontaneously during the first decade of life in almost all children[6]. Flat feet can be classified as flexible or structural. Flexible flat feet include more than 90% of all flat feet cases and it is caused by weak muscles that are supporting MLA, while structural flat feet disorder is characterized by changes in bones morphology.

Numerous different assessments are used to diagnose flatfoot based on MLA height, such as clinical assessment tools Foot Posture Index (FPI-6), measurement of navicular height, anthropometric measurements, visual observation, ultrasonography, photographic techniques, and

Received for publication February 22, 2023

footprint analysis[7], that during the last decade became incredibly popular due to their non-invasive nature and simple and reliable methodology.

Flat feet cause a lot of controversy, in terms of injury risk, but also performance wise. Queen et al.[8] investigated a difference during four sport-specific tasks (crosscut, side-cut, shuttle run, and landing from a jump) between flat and normal feet among healthy adult males. Individuals with normal foot were at a lower risk for medial and lateral midfoot injuries such as metatarsal stress fractures, indicating that foot type should be assessed when determining an individual's risk for metatarsal stress fractures. On the other hand, in work of Michelson et al.[9], it is stated that athletic population representative of collegiate athletics, the existence of flat feet does not predispose to subsequent lower extremity injury. Chuckpaiwong et al.[10] have concluded that participants with flat feet could be at a lower risk for injury (lateral column metatarsal stress fractures).

Prevalence of flat feet has shown the pattern to decrease with age. Pfeiffer et al.[11] studied 948 children (468 girls and 480 boys) between the age of 3 and 6 years from 14 kindergartens in Austria were studied and found the prevalence of flat foot decreases significantly with age: in the group of 3-year-old children 54% showed a flat foot, whereas in the group of 6-year-old children only 24% had a flat foot. Mihajlović et al.[12] concluded that on a sample of preschool girls' prevalence of flat feet is dramatically high (over 90%) and that the development of foot arches probably does not end at the age of 3–4 years but lasts until school age. Prevalence of flat feet was reported as 34.9% among Iranian school age girls[13], where the decreases in prevalence of flatfoot were proportional to the increase in age; flatfoot prevalence decreased from 48.1% in the six-year-old group to 15.6% in the 11-year-old group. Petrović et al.[14] reported that among 10-years old athletes flat feet deformity was present in 28% of a total sample, 25% of flat feet deformities were discovered among 15-years old group of football, basketball players and athletes and 26% of university students of sports and physical education had been diagnosed with flat feet, respectively.

Causation between feet flatness in basketball players and performances did not attract bigger attention of researchers, with only a few of them making an attempt to analyse their frequency and relationship with success in jumping abilities. Puzović et al.[15] have shown that the prevalence of flat feet deformity among 64 subjects (age 10-12 years) was 64.06% and they have observed a statistically significant difference between genders, and among children of different age. A limitation of this study was that the feet status was determined only visually, so these findings should be considered carefully. Ho et al.[16] have shown no differences in vertical and horizontal jump performances between flat-footed and normal arched. Their sample consisted of twenty-six male basketball players which were recruited from the teams in three local universities in Beijing, China. Meanwhile, Petrović et al.[14] suggest that flat feet are not a disadvantage in performing sport activities but can certainly cause other postural deformities, discomfort, and pain.

The aim of the paper was to show the differences in certain sports performances between the groups with and without flat feet, among Icelandic basketball players.

Materials and Methods

Study design and data collection

Conceptually, this is a cross-sectional, descriptive, and quantitative study. All participants performed the flat feet diagnostics and sports specific performances tasks.

Procedures

All procedures in this study complied with the Declaration of Helsinki. Inclusion criteria for this study consisted of participants consent form, that had signed informed consent from parents/guardians, attended regular basketball training practices (minimum 4 times a week) and did not have any type of cognitive or physical limitations. Participants were informed that their participation was voluntary and that they could withdraw from the study at any time.

Anthropometrical status

Body weight and body height were measured individually in a closed room in the sports hall, as well as the feet status. All measurements were conducted following the International Biological Program – IBP guideline[17]. A podoscope MultiReha®, manufactured by the company KOORDYNACJA, was used to evaluate feet status. After stepping barefooted on a platform of the podoscope, a snapshot was taken and used later for the analysis with the embedded software. This software automatically calculated the Clark angle. Clark angle is reliable and valid measurement[18] that in the last decade became very popular to use due to its simplicity and computerized methodology that does not require any specific education. As illustrated in Figure 1, the Clark angle consists of plotting a straight tangent to the inside of the foot and a straight tangent to the curvature of the arch. Any value below 42° is considered as flat feet, while values above 42° are classified as normal feet[7].

Sport performance measurements

Data collection was conducted in a basketball hall, after all participants completed an extensive warmup that consisted of 10 minutes jogging followed by dynamic stretching. All participants performed the tests 3 times, and the best result was taken into further analysis. Selection of tests was based on the regular pre-season, in-season and off-season screening procedures that are established in Icelandic basketball federation.

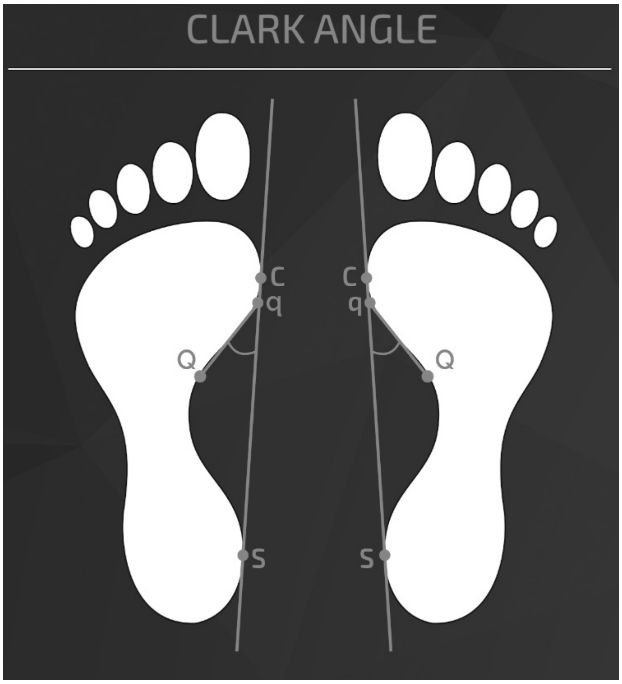

Fig. 1. Clark angle.

Drop jump (DJ) height was measured the same as CMJ, by using Optojump measurement system, and players were landing from the box 30cm high. They were instructed to perform, after landing, vertical take-off with maximum effort. Both jumps have shown excellent reliability and factorial validity [18]

Countermovement jumps (CMJ) were tested with an optical measurement system consisting of a transmitting and receiving bar (Optojump, Microgate, Bolzano, Italy). Players were given verbal encouragement during the test and maximum jump height was taken into consideration. Results of both CMJ and DJ tests are expressed in centimetres (cm).

Running and agility assessment

Photocell systems provide an accurate way to measure running speed[19]. Timing gate system Witty has been used to measure time. All players had three attempts to run 20-meter distance with 2 minutes break in between the trials.

The agility T-test was used to determine speed with directional changes such as forward sprinting, left and right shuffling, and backpedalling[20].

Results of running and agility assessments are expressed in seconds (sec).

Statistical analysis

All statistical analysis were performed in Jamovi program. Means and standard deviations (SD) were calculated for all variables. Statistically significant differences ($p<0.05$) between the groups with and without flat feet were tested with unequal variance independent t-test (Table 2).

Results

Data from 143 participants (23 girls, age 12.7±1.4 and 97 boys, age 12.9±1.4 – development group; 14 women playing in the first Icelandic division, age 21±6.6 and 9 men, age 22.2±3.7 playing the first Icelandic division) were used for the analysis (Table 1). In total, 27 players (19% of a total sample) were diagnosed with flat feet, 26 players in the development group (4 girls) and 1 player in women's first division.

No significant differences were obtained in CMJ, DJ and agility T-test between the groups with and without flat feet. The only significant difference was obtained in 20m sprinting (Table 2). However, group with normal feet status achieved slightly better results in all variables, despite not reaching significance. Normal feet group (N=116) consisted of 94 players in the development group, 13 players in the women first division and 9 players in men first division.

Discussion and Conclusion

The aim of the paper was to show the differences in certain sports performances between the groups with and without flat feet, among Icelandic basketball players. The main finding is that no differences were obtained between the groups with and without flat feet, except in one variable, 20m sprint. Analysis off frequencies of feet flatness revealed that 19% of the whole sample was diagnosed with flat feet. Physical activity plays an important role in correction and maintaining feet health and therefore the longitudinal medial arch of the foot in proper position. As indicated before[14] flat feet were not disadvantageous for jumping and agility performances, but certainly they can

TABLE 1

PARTICIPANTS CHARACTERISTICS

Group	Age (yr)	BW (kg)	BH (cm)	CMJ (cm)	DJ (cm)	20m sprint (sec)	Agility T-test (sec)
Development group	12.8 (1.3)	65.1 (4)	164.4 (2.4)	40.6 (9.5)	27.27 (4.0)	3.84 (0.4)	10.54 (0.5)
Women first division	21 (6.6)	66.9 (9)	174.1 (8)	37.6 (6.5)	37.51 (7.1)	3.31 (0.2)	10.43 (0.5)
Men first division	22.2 (3.7)	83.4 (8)	193.8 (7)	47.9 (7.4)	50.08 (7.9)	3.09 (0.1)	9.6 (0.4)

Results are means (SD). BW – body weight; BH – body height; CMJ – countermovement jump, DJ – drop jump.

TABLE 2
GROUP CHARACTERISTICS AND DIFFERENCES.

	Flat feet (N=116)	Normal feet (N=27)	t-test value	p
CMJ (cm)	39.4 (9.6)	41.4 (9.3)	–1.0	0.3
DJ (cm)	37.9 (10.4)	39.7 (11.5)	–0.2	0.9
20m sprint (sec)	3.9 (0.4)	3.7 (0.5)*	2.5	0.01
Agility T-test (sec)	10.2 (0.8)	10.2 (0.6)	–0.3	0.7

Results are means (SD). CMJ – countermovement jump; DJ – drop jump; * – statistically significant.

lead to a number of different postural deformities, where increased foot pronation, if the muscle structures are not strong enough, might lead to increased knee valgus and consequently to spine deformation, pain and therefore poorer performances. Despite previous findings[14,16,21] that flat feet were not disadvantageous for jumping and sprinting in various populations, this research has shown for the first time that sprinting abilities are affected by feet flatness. From biomechanical point of view, it is very likely that participants with flat feet developed certain strategy of recruiting and activating plantar flexor muscles and feet pronators in a way that compensates weakness of medial longitudinal arch, where during push-off phase in jumping this muscle group corrects valgus position of knee and pronation of feet, together with hip abductors and knee flexors, so the joints were aligned before the take-off. Slow-motion analysis and electromyography could be of great use and the next studies should focus on investigating deeper this phenomenon. Another possible explanation is that making ground contact with flat foot in sprinting will result in a contact with the whole surface of foot and that will causes longer contact time and slower running. When performing sprinting it is always advantageous to grab and push the ground only with metatarsal bones, so the contact is short, force production is great and that allows body to move fast forward[22].

Despite this kind of work being novelty in Icelandic sports society, we would like to acknowledge some limitations. The study was conducted on a quite unique and small sample that consisted of 143 basketball players from Iceland, with small percentage of adult players, so the further studies should include larger samples of older players, more sports performance tests and different sports. However, these results and its findings can help strength & conditioning coaches to think how individual sessions should be planned and that the emphasis on a proper feet function must be taken into consideration every day and that it may differently affect various motor tasks. Regular, persistent, and everyday work on injury prevention should include exercises for feet[23,24], since the whole body is supported by them, and the quality of game relies on good posture[25].

Further studies should consider simultaneous slow-motion analysis and electromyography analysis of plantar flexors, hip abductors and knee extensors, where the muscle triggering pattern would provide more information about the muscle recruitment and how the movement is performed in athletes with flat feet. The role of fatigue remains unclear, and we believe that further studies will provide better understanding and the performances might be affected by the fatigue of plantar flexors, knee extensors and hip abductors.

The degree of feet flatness has not been completely linked to success in sports performances in basketball, but attention should be paid to strengthening all parts of the body, particularly feet, a unique structure that holds the whole body and helps it to move in various directions and ways.

Despite general beliefs that flat feet are limiting factor in jumping and sprinting abilities, we have shown in our paper that both groups, with and without flat feet achieved very similar results, with only sprinting being affected by feet flatness. Although flat feet were not limiting factor in jumping and agility, but yes in sprinting, group with normal feet has shown better athleticism, achieving slightly better results in jumping, both, countermovement jumps and drop jumps, sprinting and agility. The role of the feet remains to be extremely important in all sports and for maintaining postural control, therefore emphasis on strong and healthy feet should be an ultimate aim in everyday training regime.

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KAKO STATUS UZDUŽNOG SVODA STOPALA UTJEČE NA SPORTSKE REZULTATE KOŠARKAŠA NA ISLANDU?

S A Ž E T A K

Košarka je iznimno anaerobna igra koja se sastoji od napora visokog intenziteta, kao što su skokovi, doskoci, promjene smjera kretanja i sprintovi, nakon kojih slijede napori niskog intenziteta. Posturalne deformacije mogu predstavljati ograničavajući čimbenik u postizanju maksimalnih rezultata u košarci. Ravna stopala spadaju među jedne od najčešćih posturalnih deformacija, te mogu dovesti do slabijih rezultata, nelagode i boli. U ovom istraživanju ispitivali smo razlike u pojedinim sportskim rezultatima kod islandskih košarkaša u odnosu na status uzdužnog svoda stopala. Uzorak ispitanika sastojao se od ukupno 143 košarkaša i košrakašica (23 djevojčice, dob 12,7±1,4 i 97 dječaka, dob 12,9±1,4 - razvojna skupina; 14 košarkašica koje igraju u prvoj islandskoj ligi, dob 21±6,6 i 9 košarkaša, dob 22,2±3,7 koji igraju u prvoj islandskoj ligi) koji su testirani na podoskopu s ciljem utvrđivanja stupnja spuštenosti stopala, te su svi ispitanici izvodili skok u vis iz mjesta (countermovement jump), dubinski skok (drop jump), sprint 20 metara (20m sprint) i T-test za procjenu agilnosti. Za svrstavanje igrača u jednu od dvije skupine, sa ili bez ravnih stopala, korištene su vrijednosti prema Clarkovoj metodi. Osim kod testa sprinta na 20 metara, nisu utvrđene razlike između grupa sa i bez ravnih stopala, što ukazuje da spuštenost stopala nije ograničavajući čimbenik u zadacima skakanja i promjene smjera kretanja, međutim je u sprintu. Smatramo da isključivo snažna i zdrava stopala mogu dovesti do izvrsnih rezultata.