Article

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

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Abstract: Basketball is a highly anaerobic game, that consists of high-intensity efforts 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 deformities and they can lead to poorer performances, discomfort and pain. In this research we made an attempt to link the degree of feet flatness with sports performances among Icelandic adolescent basketball players. A sample of 100 basketball players was tested on a podoscope to establish the degree of feet flatness and all participants performed countermovement jump, 20m sprint and pushups in 30 seconds. No significant correlation was observed between feet status and sports performances. No differences were found between groups with and without flat feet, which indicates that feet flatness was not a limiting factor in achieving better results. However, we state that only strong and healthy feet might lead to excellent performance.

Keywords: flat feet, Clark angle, performances, basketball, trend, correlation.

1. 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 like 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 newborn 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 position.

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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, radiological assessment, ultrasonography, photographic techniques, and 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 (cross-cut, 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. Mihajlovic et al. [12] concluded that on a sample of preschool girls prevalence of flat feet is dramatically high (over 90%) and that probably he formation 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. Petrovic 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.

Connection 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. Puzovic et al. [15] have shown that the prevalence of flat feet deformity among 64 subjects (age 10-12 years) in their study was 64.06% and they have observed a statistically significant difference between the sexes, 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 trend, frequencies, sex and sport performance differences in relation to feet flatness among Icelandic adolescent basketball players.

2. Materials and Methods

2.1 Study design and data collection

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

2.1.1. Participants

After obtaining approval from parent of all players, all players attending BIBA basketball summer training camp (ages 10-16) in Reykjavik, Iceland were invited to participate in the study. Data from 100 participants in basketball camp (n=100 complete data) were used for analysis (23 girls and 77 boys). All procedures in this study complied with the Declaration of Helsinki. Inclusion criteria for this study consisted of participants, boys and girls aged 10-16, that had signed informed consent from parents/guardians, attended regular basketball training practices and did not have any type of cognitive or physical limitations. Written consent was given by the participants, and they were informed that their participation was voluntary and that they could withdraw from the study at any time.

2.1.2 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 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.

2.1.3 Sport performance measurements

Data collection was conducted in a basketball hall, after all participants completed a 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.

Jumping assessment

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.

Running and agility assessment

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 backpedaling [19].

Upper body strength

Upper body strength was assessed as the maximum number of pushups that can be performed within 30 seconds.

2.2 Statistical analysis

All statistical analysis were performed in Jamovi program and figures were made in Microsoft Excel. Mean and standard deviation were calculated for all variables (Table 1). The correlation between Clark angle and all other variables was examined with the Pearson correlation coefficient (where r = +/- 0.10 is a weak correlation, r = +/- 0.30 is a medium correlation and r = +/- 0.50 is a strong correlation) and presented in Table 1. An R-squared

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values were presented to measure how well a statistical model predicts an outcome. Differences between feet status and sexes were tested by using Independent t-test.

3. Results

In total, 26 players (26% of a total sample) were diagnosed with flat feet. No significant differences were obtained in body height (flat feet group 164.68±0.24, normal feet group 167.21±0.36, respectively) or body weight (flat feet group 62.89±13.15, normal feet group 65.13±14.64, respectively).

No significant differences were obtained in CMJ, 20 m sprint or upper body strength when groups were divided based on feet status (Figure 1). However, group with normal feet status achieved slightly better results in all variables.

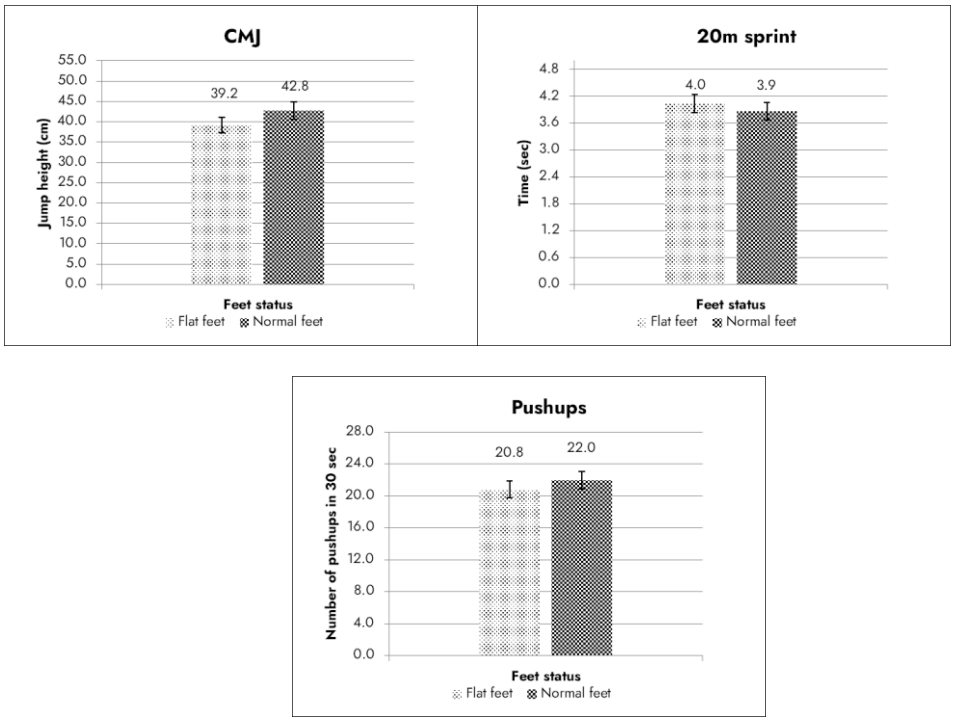
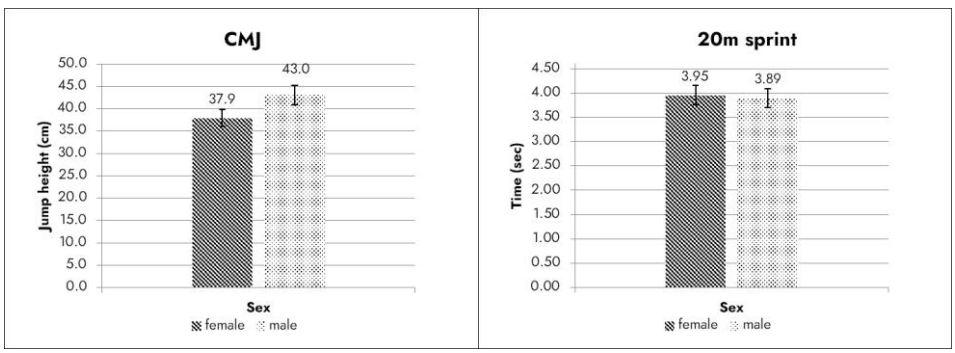


Figure 1. Sport performances in relation to feet status.

Despite boys performed better at CMJ, 20 m sprint and upper body strength (Figure 2), independent t-tests did not reveal any significant difference between the sexes.



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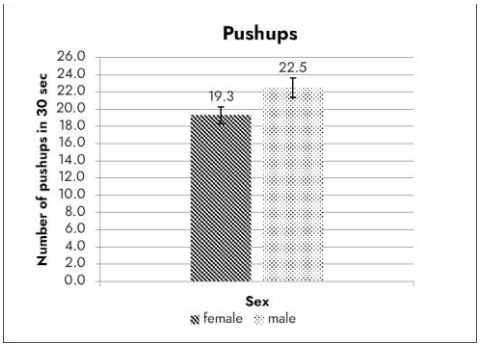

Figure 2. Sport performances in relation to sex.

There was no statistically significant correlation observed among sport performances and Clark angle, as R^2 indicate low values in Figure 3.

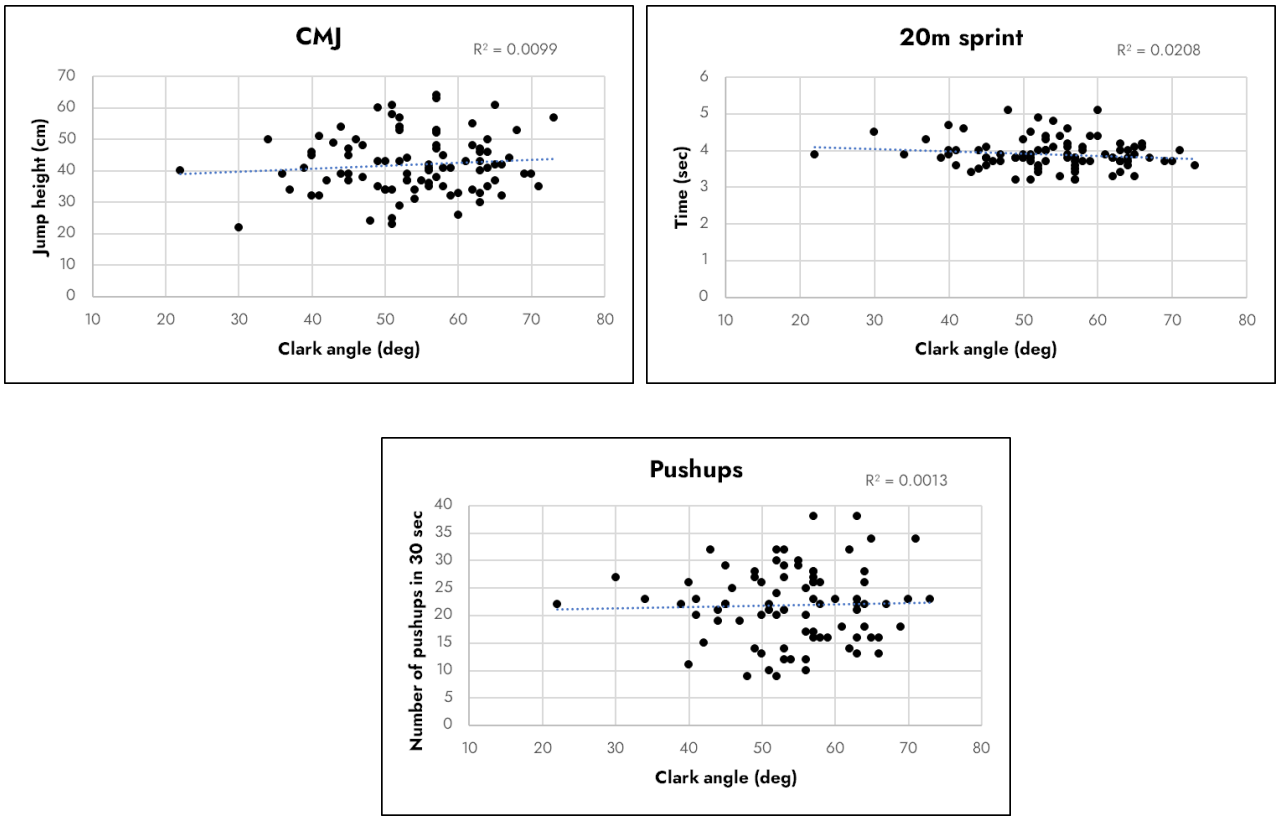

Figure 3. Distribution of sport performances in relation to Clark angle.

A clear pattern has been observed across ages for all analyzed variables, with R^2 values of 0.94 for CMJ; 0.88 for 20 m sprint and 0.40 for upper body strength, respectively.

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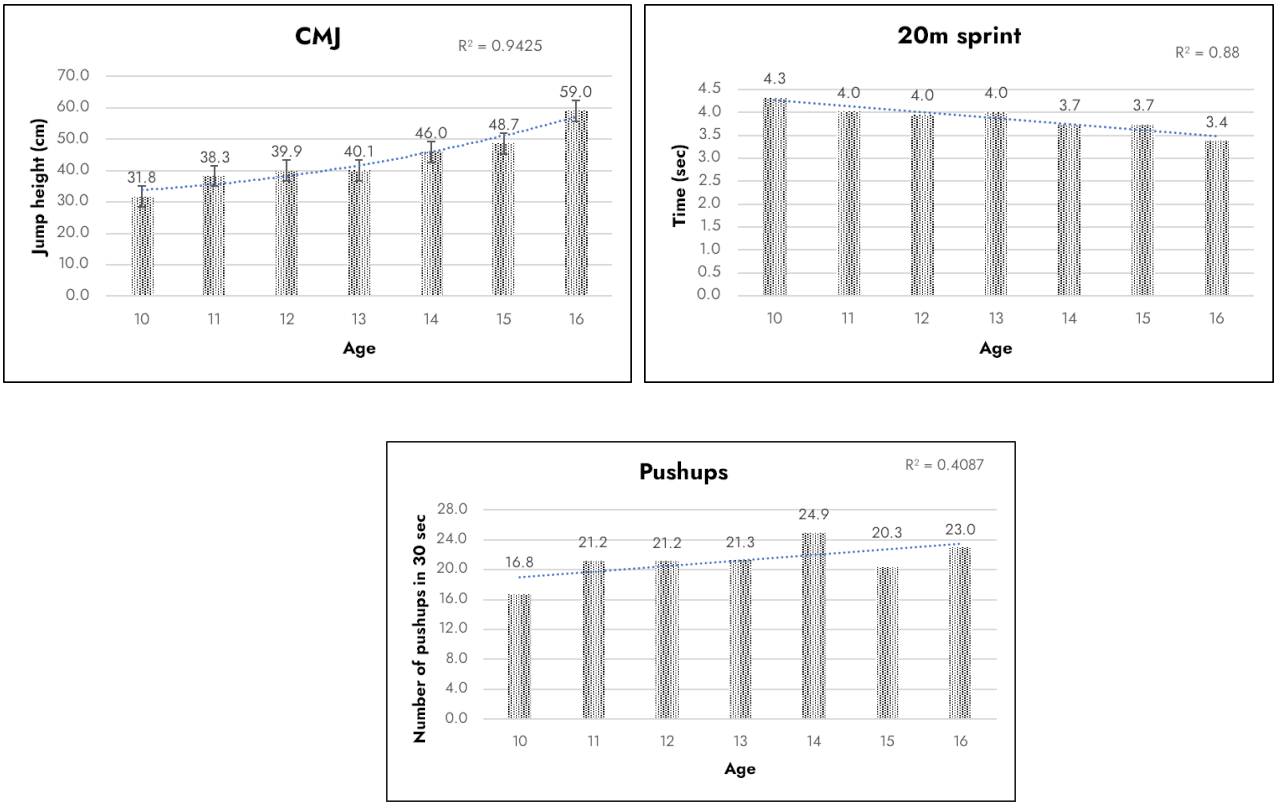

Figure 4. Trend of sports performances across different age groups.

4. Discussion

The aim of the paper was to investigate the trend, frequencies, sex and sport performance differences in relation to feet flatness among Icelandic adolescent basketball players. No differences were obtained between the groups with and without flat feet and no differences were observed between the sex, despite boys achieving better results. Statistical analysis revealed that the degree of feet flatness does not play an important role in sports performances, despite popular believe. As indicated before [14] flat feet were not disadvantageous for sports performances, but certainly they can 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], [20] that flat feet were not disadvantageous for jumping and sprinting in various populations, this research has shown a detailed analysis and importance of measuring feet status in a particular way, rather than just using conventional models which categorizes participants into groups with and without flat feet deformity. Lower values of the Clark angle indicate a higher degree of feet flatness, and this is, in our knowledge, the first time that this kind of investigation was conducted. From biomechanical point of view, it is very likely that participants with flat feet developed certain strategy of recruiting and activating muscles in a way that compensates weakness of MLA, where during push-off phase in running and jumping this group corrected valgus position of knee and pronation of feet so the joints were aligned before take-off. Slow motion analysis could be of great use and the next studies should focus on investigating deeper this phenomenon. Another important finding was that there were no significant difference between sexes, where boys performed jumps, sprints and pushups just slightly better than girls. This finding helps to coaches to organize, plan and conduct strength and conditioning sessions so the training

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load can be equally distributed over both sexes. More sex difference among basketball players starts to appear in late adolescence period.

As expected, there was a clear trend where with increase of age all motor skills, i.e. jumps, sprinting and upper body strength, have shown very linear growth. This finding shows that age differences must be acknowledged in order to avoid any overuse injuries and overtraining.

When sport performance data were plotted against the Clark angle there was no significant correlation, with very low values of R^2. This finding supports previous findings that there were no differences between the groups with and without flat feet in manifestation of sport performances.

Despite the novelty of the analysis made in this work, we would like to acknowledge one limitation. The study was conducted on a quite unique and small sample that consisted of 100 basketball players from Iceland, so further studies should include larger samples and more sports performance tests. 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. Regular, persistent, and everyday work on injury prevention should include exercises for feet, since the whole body is supported by them, and the game quality relies on good posture.

The novelty of this work is that for the first time flat feet analysis went a step further and moved from conventional grades to the examination of Clark's angle of individuals and how it is correlated with performances in basketball.

In conclusion, the degree of feet flatness has not been 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.

Further studies on a larger sample size should provide better explanation whether there is a trend in decreasing of flat feet among older athletes, that we would expect to see.

This study used a classification system that attempted to include all foot types. This grading system could be considered an expansion of Clark's classification.

5. Conclusions

Despite popular believes 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. No sex differences were present between groups, probably due to the nature of basketball games and trainings, where all players are treated in a same way and very often training together. A clear pattern has been observed showing that this cohort is developing sports performances in a proper way. Although flat feet were not limiting factor in jumping and sprinting, group with normal feet has shown better athleticism, achieving slightly better results in jumping, sprinting and upper body strength. Role of the feet in extremely important in all sports and postural control, therefore emphasis on strong and healthy feet should be an ultimate aim in everyday training regime.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all subjects and their parents/guardians of those involved in the study.

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