Distribution of Foot Pressing Forces in a Standing Position of Children and Youth in the Light of Prevention and Correction

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A – Study Design
B – Data Collection
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D – Data Interpretation
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Key words: *foot abnormalities, platypodia, distribution of forces, corrective exercises, prevention.*

Abstract

Background: *The aim of this paper was to show abnormalities in distribution of foot pressing forces in standing position in children and youths, and also related consequences, in the light of preventive and corrective actions.*

Material/Methods: *The research was conducted in December 2009 at the Rehabilitation Centre in Malbork. It was part of a huge research project covering almost 2500 people. The control group comprised of 205 students in two age groups: 7–9 years old and 17–19 years old. The examined students attend two schools: No 3 Primary School in Pruszcz Gdański and No 2 Secondary Schools Group in Malbork. For analysis of the distribution of foot pressing forces Zebris FDM-S measuring plate aimed at a computer foot diagnosis was used.*

Results: *An analysis of the performed examinations shows that the highest values of pressuring forces among children and youth attending schools are at the calcanean tuber – 7.77 and 9.68 N/cm², accordingly. The average recorded value of the pressuring force at the calcanean tuber was more than twice bigger than the most loaded part of metatarsus among school children. A similar situation has been observed among the youths attending school.*

Conclusions: *Abnormalities in the value and distribution of foot pressing forces have been observed. Early-school children and secondary school youths tend to overload the calcanean tuber. An excessive load of the central part of metatarsus was observed as compared to its lateral and medial part in both the age groups.*

In the future those overloads can be a cause of pain ailments and lead to feet dysfunction and deformation such as transverse platypodia, hallux valgus, mallet toes, calcanean spur, callosities. Systematic check-ups and preventive actions can minimise posture distortions and prevent fixation of those changes.

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Introduction

Human feet, which in normal circumstances are the only supporting point for a human being, are constantly exposed to overload because of their location. But this lowest segment of our body, as every other part especially prone to injury or damage, has its own safety system [1,2]. Similarly to a car damper, the human foot has physiological fornices (Fig. 1), which under the influence of considerable load (during walking, running, jumping) get flattened, at the same time minimising the burden of the whole body which is cumulated on the feet [3,4,5,6].

In circumstances of relief, with efficient longitudinal and transverse plantar arches, a foot is supported in three points: heel, I and V heads of metatarsus bones (Fig. 2). A force pressing at those support points should be distributed evenly, both between the anterior and posterior, as well as between lateral and medial parts. Such a distribution of this force is a guarantee for relative safety of the directly burdened point and the whole foot, and also it conditions physiological location of the above body segments. Its distortion, on the other hand, can lead to anomalies localised within the area of the foot, and even the whole lower extremities.

The aim of this paper was to show abnormalities in distribution of foot pressing forces in a standing position in children and youths, and also related consequences, in the light of preventive and corrective actions.

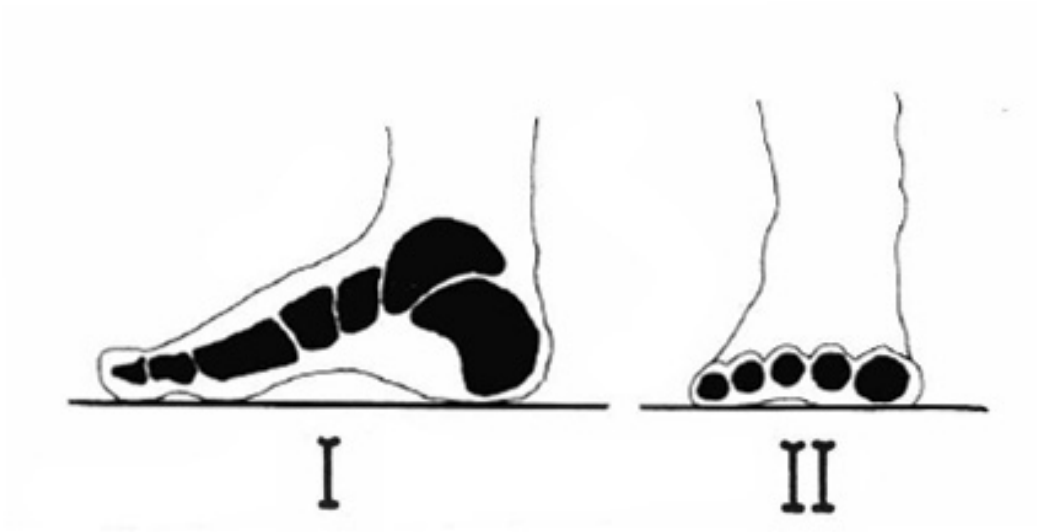

Fig. 1. Foot fornices: I - longitudinal, II - transverse [5, p. 8]

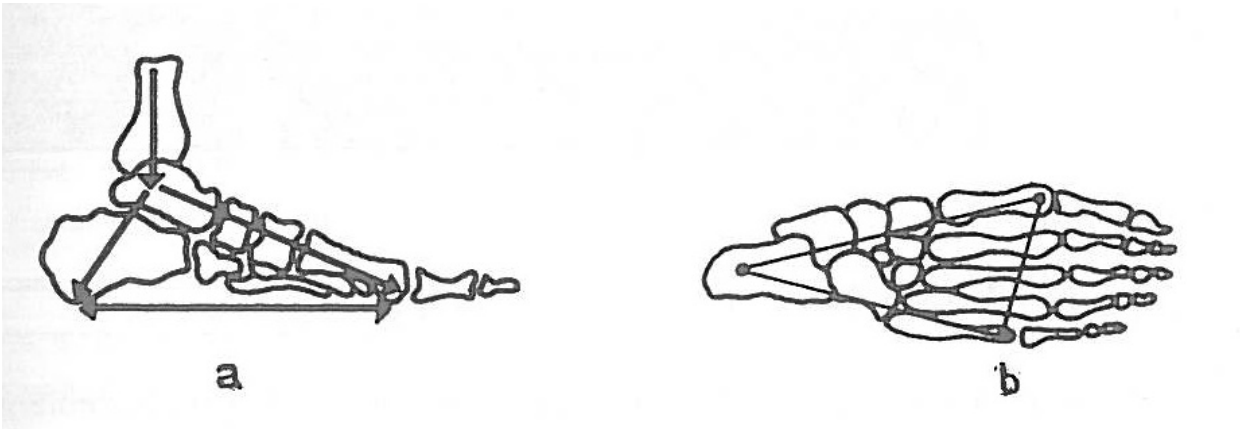

Fig. 2. Direction of pressing forces (a) and foot support points (b) [7, p. 67]

Material and method

The research was conducted in December 2009 at the Rehabilitation Centre in Malbork. It was part of a huge research project covering almost 2500 people. For the purpose of this paper a control group has been chosen (Table 1), which comprised 205 students in two age groups: 7–9 years old and 17–19 years old. The control group comes from the area of the Pomeranian Province. The examined students attend two schools: No 3 Primary School in Pruszcz Gdański and No 2 Secondary Schools Group in Malbork.

Tab. 1. Number of the examined group

AGE	BOYS	GIRLS	TOTAL
7–9	36	58	94
17–19	12	99	111
Total	48	157	205

For analysis of the distribution of foot pressing forces Zebris FDM-S measuring plate aimed at a computer foot diagnosis was used. This plate measures 34 x 54 cm, has 2560 active sensors guaranteeing its high sensitivity: 1 sensor/ cm². It records loads within 1–120 N/cm². The research was conducted in a habitual standing position, without shoes, looking straight ahead (Fig. 3).

Fig.3. Stance analysis examination on Zebris FDM-S plate (www.zebris.de)

During a 20-second analysis, this device records loads on individual plate points, resulting in a graphic representation of soles, with force distribution to individual parts (Fig. 4).

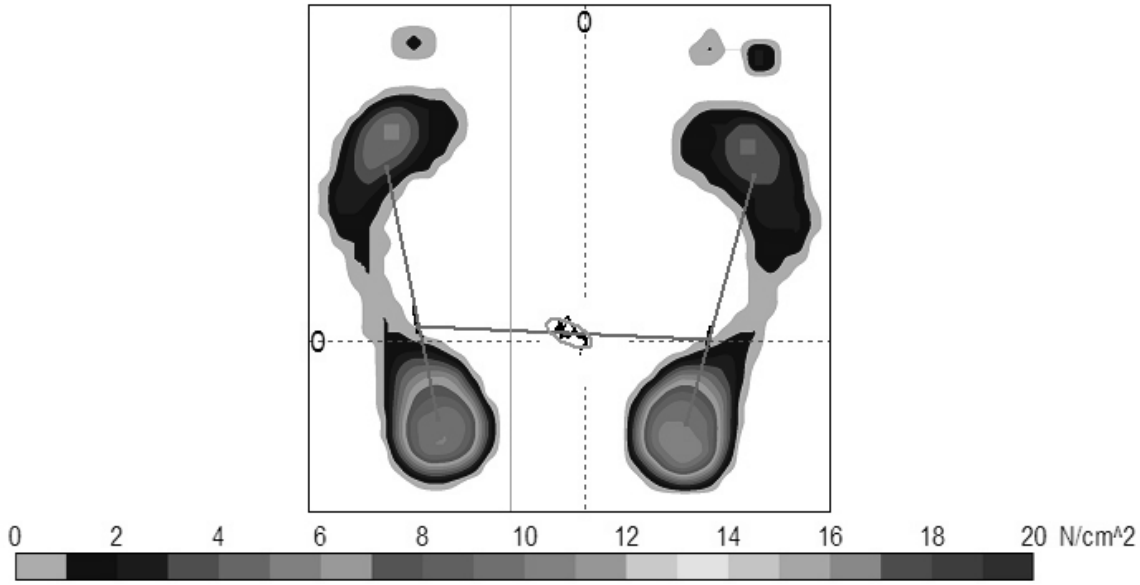

Fig. 4. Distribution of foot pressing forces in the standing position (www.zebris.de)

Based on the examination the highest values of pressing forces have been determined [N/cm²] on calcanean tuber and metatarsus (I–V heads of metatarsus bones, Fig. 5).

Fig. 5. Analysed bone points (www.zebris.de)

Each of the participants has been familiarised with the examination procedure and advised on behaviour during the analysis of foot pressuring forces. The recorded material has been processed, and the results interpreted.

Results

An analysis of the performed examinations shows that the highest values of pressuring forces among children and youth attending schools are at the calcanean tuber – 7.77 and 9.68 N/cm², accordingly. The average recorded value of the pressuring force at the calcanean tuber was more than twice bigger than the most loaded part of metatarsus among school children (Fig. 6).

A similar situation has been observed among the youths attending school: almost a double load on the calcanean tuber as compared to metatarsus (Fig. 3). Loads on individual parts of metatarsus were different among those two age groups. In children it was accordingly: II (2.71 N/cm²), III (2.62 N/cm²), I (2.61 N/cm²), IV (2.23 N/cm²) and V (1.67 N/cm²) head of metatarsus bones, but with the youth it was as follows: III (5.01 N/cm²), IV (4.34 N/cm²), II (4.12 N/cm²), V (3.8 N/cm²) and I (3.01 N/cm²) head of metatarsus bones.

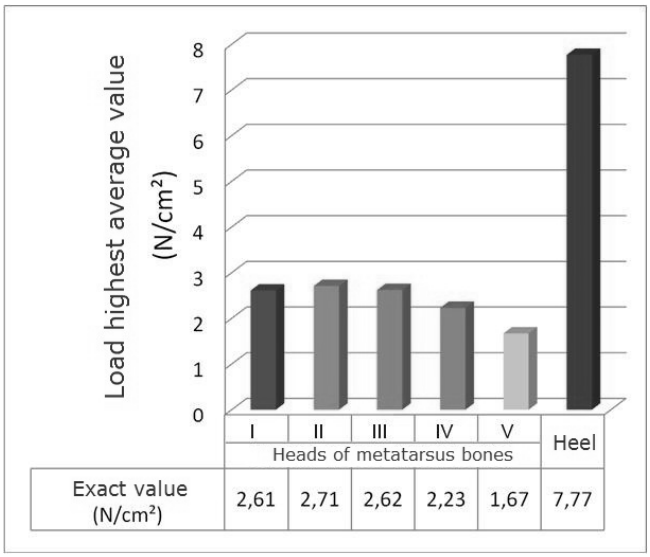

Fig. 6. Pressing force with analysed bone points among children aged 7–9

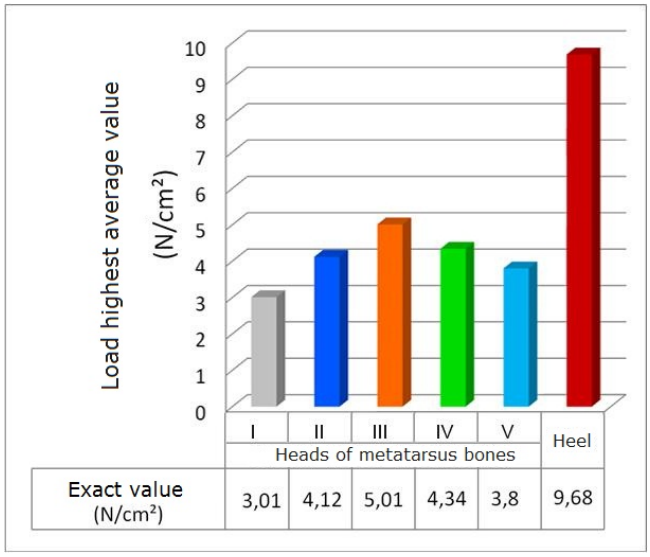

Fig. 7. Pressing force with analysed bone points among the youth aged 17–19

Discussion

The examinations show abnormalities in the distribution of foot pressing forces in the standing position in children and youth. The recorded abnormalities in values and distributions of forces can cause functional and structural changes within feet. Both the above types of abnormalities are closely related to each other. Functional changes, being the insufficiency of structures conditioning the presence of physiological arches of the foot, with time lead to fixed structural changes. Calcanean tuber overload observed during the examinations, at a later age, can lead to the emergence of exostosis like calcanean spur, which, in turn, will lead to considerable pain ailments and impairment of human motor abilities.

The recorded inefficiency of the transverse anterior foot arch can transform into a transversely flat foot. It is connected to considerable impairment of the foot function and makes the emergence of other structural changes easier, such as an intoe or hammer toes, which cause even more impairment of the foot efficiency. The most important issue conditioning long-lasting and efficient foot functioning seems to be systematic control check-ups among children even younger than preschool-aged and, based on that, individually adjusted prevention or corrective measures.

The aim of corrective exercise is to correct and adjust the foot part which has been more or less distorted or damaged (therapeutic character). This means an application of exercises which stretch, shorten and strengthen muscles in relief or under load. Shaping of the bone-ligament-

muscular system takes place. Another dimension of correction is the normal body posture as a sign of physical and mental health. In such a type of exercises regularity is the key. A teacher or coach, who should apply among others 15 minutes of corrective exercises during each set of motor exercises, plays an important role.

Among school-aged children, a negative implication and excessive load may be caused by limitation of free and spontaneous motor activity by means of introduction of a sitting schooling system, and because of that the posture of a child or a student is subjected to a considerable load. A regular, well thought corrective training session prevents those spinal deformations [8]. In such a way lower extremities are not burdened and abnormalities localised in the spine are not reflected in lower body segments. When it is impossible to cure a given abnormality, one should take action to limit its worsening.

It is widely known that sport is a measure of health and affects the body posture and appearance. That is why physical activity, let it be doing some sports, like swimming, ballet dances, gymnastics, dancing and walking or running bare-feet on different surfaces (beach, clearing), has a positive influence on limitation of defect development [9,10]. Also whirlpool baths or regular baths in warm water with addition of salt are advised. What is more, sport is a preventive action reducing body mass, because in the case of overweight, the risk of emergence of abnormalities both within longitudinal and transverse fornices is greater.

Another method of curing changes which are not fixed yet are orthopaedic inserts. Usually they are of a standard size but they should be made to measure. Most often inserts maintaining physiological foot arches are used (transverse or longitudinal platypodia). There are also inserts correcting valgus toe or an abnormal position of the heel bone which are often used [11].

In the case of changes which have not fixed yet kinesytherapy is often applied, usually as corrective exercises. Those exercises are conducted both in state and private institutions by duly educated PE teachers or physiotherapists. Actions should be taken through appropriate exercises to shape passive structures with correction of the abnormality. In the case of foot defects, there are exercises for adduction of the frontal part of the foot, supination, plantar flexion and any other movement within toes excluding prehensile exercises. Walk on toes, lifting medial end without lifting toes as well as exercises for normal foot propulsion and balance exercises are also indicated. Walking on medial ends of aspaced feet, and on heels and prolonged standing in a straddle position (deterioration of feet valgity) should be avoided. Exercises can be done in relief: while sitting, in a lying position, or in water, which is the most advised in the case of advanced defects, either in relief in a standing position or while walking [12,13].

Advanced foot abnormalities with fixed bone changes are qualified for operative treatment. They are complicated procedures, which do not always give demanded results; they also cause pain and long rehabilitation. On the other hand, research in effects of surgical procedures like osteotomy, which is e.g. operative treatment of toe valgity, show positive results. 93% of operated feet were assessed as good or very good results after performing such operations. The majority of patients stated that pain before operation has been a few times bigger that after it [14]. Even better results were seen during similar research with people older than 60. They reported additional considerable reduction of front-foot pain and efficiency improvement [15]. Other research suggests that operative treatment of an intoe in moderate or serious cases brings effects [16].

All efforts should be taken in order not to let any changes fix. A priceless role in such a process should be played by school health care represented by nurses and preschool PE teachers. The topic of foot abnormalities and prevention should be discussed during meetings with parents at school. Systematic, periodic preventive check-ups conducted by the above will enable a swift reaction with corrective actions at the same time preventing abnormalities against fixing.

Conclusions

1. Abnormalities in value and distribution of foot pressing forces have been observed.
2. Early-school children and secondary school youths tend to overload the calcanean tuber.
3. An excessive load of the central part of metatarsus was observed as compared to its lateral and medial part in both the age groups.
4. In the future those overloads can be a cause of pain ailments and lead to feet dysfunction and deformation such as transverse platypodia (Fig. 8), hallux valgus (Fig. 9), mallet toes (Fig. 10), calcanean spur (Fig. 11), callosities (Fig. 12).
5. Systematic check-ups and preventive actions can minimise posture distortions and prevent fixation of those changes.

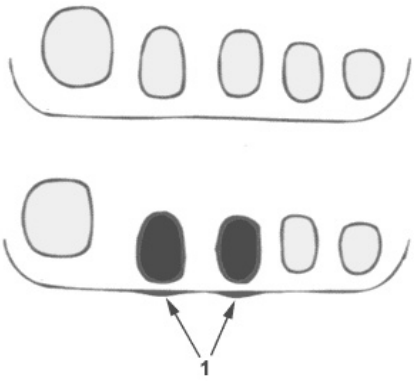

Fig. 8. Transverse platypodia

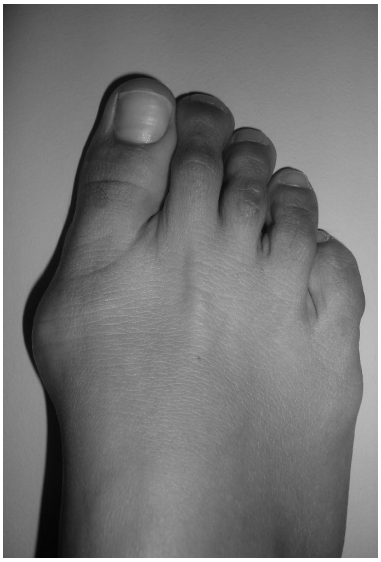

Fig. 9. Hallux valgus

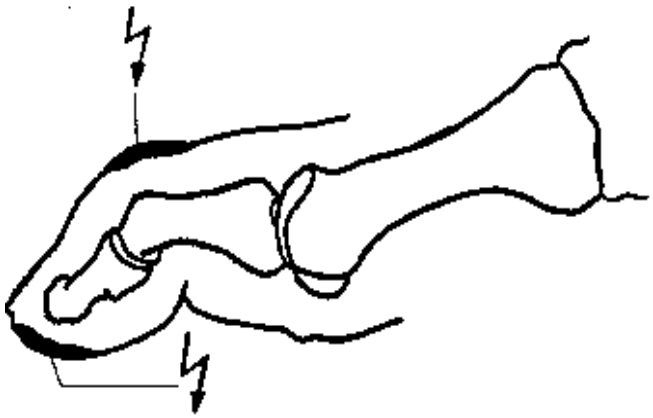

Fig. 10. Mallet toe (source: www.clp.com.pl)

Fig. 11. Calcanean spur

Fig. 12. Callosities

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