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Project: SHOE FUTURE

HANDBOOK FOR EDUCATION MODUL:

Characteristics of the Human Foot

Prepared by:	CTCP	Date: 1. 11. 2011

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Introduction

The human lower limbs are particularly encumbered. In relation to inappropriate footwear, this may entail very likely complications for individuals in the future. Currently, when the selection on the footwear market is relatively extensive, there is a need to know how to appropriately select the correct footwear in order to respect our needs and the proportions of the foot.

On the contrary, this often leads to severe disorders and complications of the lower limbs simply because preventative measures, primarily footwear quality, have been overlooked.

The most regularly stressed muscles of the human body

With the development of civilization, man began to wear shoes on a regular basis either for reasons of protection and/or as a means for expressing social status.

In the case of shoes, the impact of fashion has significantly manifested itself both in the shapes of shoes, the color, materials etc.

Another trend of the past has been to increase footwear production by large-scale producers capable of investing in form development.

Another significant factor is the globalization of footwear production, through which significant differences have been created in the price of labor between the Far East and the industrially advanced states.

Globalization has changed the original efforts of producers to respect individual foot shapes and currently, the predominant effort is to offer a single shape and type of shoe for the world's entire population.

These trends have generated a series of complications, from the level of a feeling of discomfort through severe foot deformities, which in combination with other disorders (e.g. diabetes) may lead to amputation.

1. ANATOMY AND PHYSIOLOGY OF THE LOWER LIMBS

Anatomy is the scientific field for studying the shape, internal body structure and the correlative position of an organism's parts. Physiology is the science of the living functions of organisms or parts thereof. These two fields mutually complement one another. The foot is anatomically defined distally (toward the center of the body) as part of the lower limbs from the astragalar joint. During contact with the floor, the foot bears the force of the body's weight and plays several significant roles. It cushions tread force, informs the central nervous system and maintains stability.

1.1 Uniqueness of the human foot

The lower limb is the organ for support and locomotion of an upright body on two limbs. This means that in comparison with the upper limbs, while the lower limbs have the same basic parts, they have a more robust skeleton, stronger muscle groups and limited mobility in individual joints, which provides greater stability for an upright body.

The oldest and developmentally continuous part of the human body is the foot. Unlike the braincase, the spine, and the upper limbs, the construction and function of the foot has not changed in the last 3 - 4 million years. But, it is necessary to add in this context that over the past one hundred years, there has been a marked change in the surface along which humans move. The surface is level and primarily hardened. Modern man of today walks predominantly along hard, non-deformable surfaces.

1.2 Foot functions

When comparing the function of the feet between man and primates, the most striking difference rests in the fact that in man, the ability to grip using the feet has disappeared. In some species of primates, however, this has continued to develop and is currently highly mobile and considerably more sensitive. This enables the primate excellent and diverse mobility, while for man, walking, short runs or jumps predominate. In man, walking flexibility is ensured by transverse and longitudinal foot arches.

1.2.1 Static and dynamic foot functions

The significance of static foot function rests in separating body load to the plantar surface of the foot, through which the body is in contact with the surface. This load is divided in such a way that the larger half falls on the lower part of the foot - the heel - and only the lesser half on the front part of the foot. It is also possible to state that the area of the toe joint (big toe) is considerably more loaded than the other four toes of the foot.

In the 1950s and 1960s, a series of models was created that envision the foot as complicated and dynamically complex and distinguish its parts variously according to functionality. The dynamic

function of the foot rests in enabling movement and in maintaining stability during movement. Even though human walking (running or other sports movements) shoes are highly diverse, modern research methods studying the laws of human movement have facilitated their categorization for modeling and possible impact. The basis differences in walking are generally divided into two phases: the support and swinging phases.

The support phase begins with the contact of the heel with the surface and a gradual load, reducing the angle by which the sole of the foot grips the surface, up to the moment of contact of the foot's entire surface with the surface. The subsequent phase of central support ends with the lifting of the heel from the surface. For forward movement, the most important phase is the active push off of the foot from the surface. This phase concludes with the passive disconnection of the foot from the surface, usually in the area of the foot's toes.

The swinging phase is defined by the time segment when the foot shifts to the front, then it is no longer in contact with the surface.

1.2.2 Impact cushioning

During each step in the treading phase of walking, impact forces are established, which are borne and add load to the spine, bones and joints of the lower limbs. The softness and flexibility of the surface have a great impact on the cushioning of impacts. Recently, when it is already possible to measure the course of pressures between the foot and shoe, it has been confirmed that when walking along hard surfaces (concrete, tiles, asphalt), essentially higher impact forces occur than when walking along flexible and soft surfaces (grass, sand) or along artificial surfaces used



particularly during sports.

Fig1. Shock waves when walking

The natural cushioning of impact force occurring when walking can be divided into three different levels. Cushioning of lower values of impact force is ensured by the pillows of fat beneath the heel

bone. This part of the foot is critically important for the movement of man; without it, man would not be able to move.

Medium impact forces are cushioned by the foot arches, both transverse as well as longitudinal. Inappropriately selected shoes may significantly decrease the cushioning function of the foot arches. On the other hand, well selected shoe sizes and appropriate sole structure and material could significantly reduce impact forces.

Significant cushioning capabilities, particularly for high value impact forces, which are typical for jumping and impacts, etc., provide a physiologically flexible effect on the lower limbs originating from the skeleton, muscles, tendons and joints. The cushioning mechanism is, in essence, the gradual rotation of segments in the joints, which are blocked by tendons - ligaments and muscles.

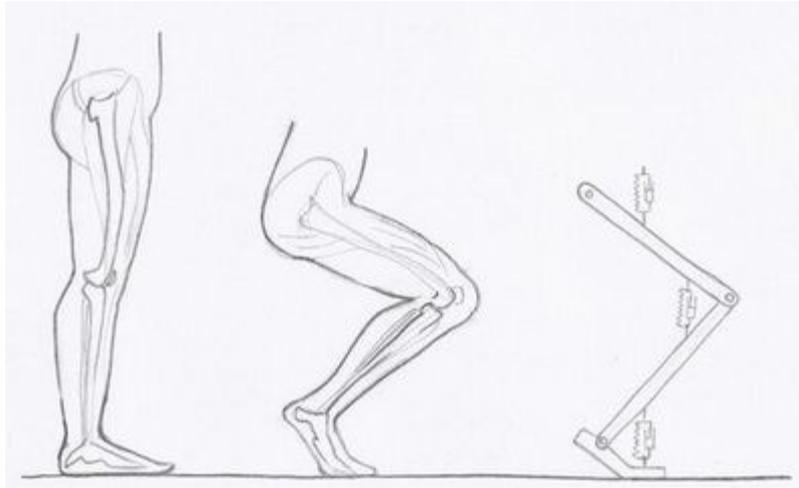


Fig. 2. Binding effect of joints of the lower limbs

2. BONES AND THEIR CLASSIFICATION

The skeleton is the supporting organ for the entire human body, composed of 233-235 bones of various shapes and sizes. Bones are connected by ligaments, muscles and tendons attached to the bones. Cartilage covers the contact surfaces of bones in joints,

connecting some bones and creating intervertebral lamellae.

In addition to a supporting role, human bones are important for other reasons. They play a role in protecting the organs critical for life; they are the reservoir for calcium in case of a threat to life and they provide blood generation.

Bones are classified according to the shape, structure, vascular supply, growth and biomechanical characteristics. We divide bones into four groups:

- tubular - long (femur, shoulder bone)
- short (phalanges)
- flat (skull, pelvis, shoulder blade)
- irregular bones (vertebrae, ankle and wrist bones)

2.3 Joints

Joints are divided into two groups. Simple joints connect just two bones and complex joints when they connect three or more bones. Cartilaginous disks (meniscii) are inserted between contiguous

surfaces, which balance out the unevenness of contiguous surfaces (e.g. knee joints). Important for the foot are the composite bones such as Chopart's joint, the behavior of which is explained as the mechanism for the occurrence of flat foot.

Among the basic joints of the foot are:

Upper tarsal (astragalar) joint, art. talocruralis is composed of joints in which are joined both tarsal bones forming a socket for the joint with heads represented by the block of the astragalar bones.

Lower tarsal (astragalar) joint, art. subtalaris is a functional unit on the lower side of the astragalar bones and on the upper surface of the heel bones. The subtalaris joint has two segments: rear and front.

Chopart's joint, art. tarsi transversa is the clinical name for the connection of the astragalar bones with the navicular bones (art. talonavicularis), and the heel bones with the cuboid bones (art. calcaneocuboidea). The Latin name of the joint is taken from the transversal course of the joint interstices, which assumes the shape of a prone letter "S."

2.4 Foot bones

The bones of the foot consist of 26 bones (plus two sesamoid bones). Anatomically and also physiologically, we divide the foot into sections: the tarsus, the metatarsus and the phalanges.

The tarsus: this is formed by seven tarsal bones. It is the part of the foot that is not very mobile and is fixed, bearing the weight of the body. It consists of the following bones:

Heel **I.** and ankle bones **II.**, navicular bone **III.** , 3 cuneal bones **V.** and a calcaneus bone **IV.**

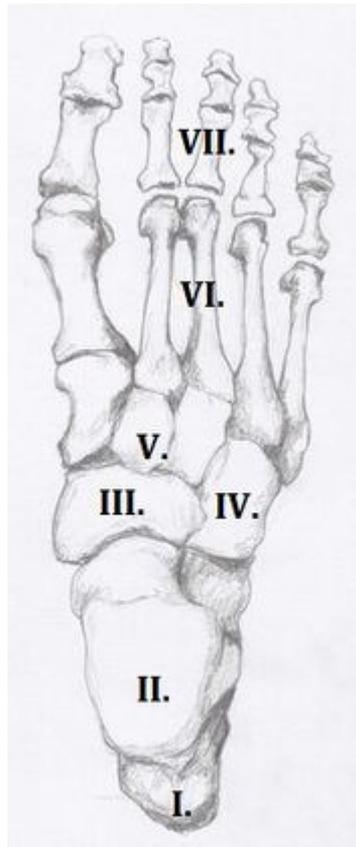


Fig. 3. Foot bones

The heel bone I. is the most robust of the tarsal bones. It projects to the rear in a powerful heel bulge, to which is attached the tendon for the three-headed muscle of the calf –the Achilles tendon. Located on the interior side is the so-called "astragal buttress bones," beneath which pass the long toe flexor, which significantly assists in the correct maintenance of the longitudinal foot arch. Distally (toward the toes), the heel bone is connected with the navicular bone surface with the calcaneus bone. Above it is the astragalus bone

The astragalus (ankle) bone II. is the second largest of the tarsal bones. We distinguish in it the proximally placed body and the distally placed head. Both of these parts are connected by a narrow neck. On the dorsal side is a contiguous surface – a block, which falls into the forks of the crural bones. The head of the astragalus bone ends in a rounded contiguous surface for the navicular bone.

The navicular bone III. has a proximally concave contiguous surface for the heads of the astragalus bones and distally convex joint surface for jointing with the cuneal bones.

Cuneal bones V. are of three types: They number from the toe side, or are marked also as internal, middle and external. At the internal, the sharp cuneal is directed into the ridge of the foot, at the middle and external to the sole. Distally, they have contiguous surfaces connecting with the insole bones, proximally with the navicular bones.

The calcaneus bone IV. has a proximally saddle-shaped joint surface for the heel bone and distally a contiguous surface for the IV and V instep bones. On the plantar side, there is a diagonal groove, into which rests the tendon of the long calf muscle.

Foot metatarsus VI. The metatarsus of the foot is the flexible part of the foot, which cushions impact forces when walking. The metatarsus consists of five metatarsal bones, parts of which are called the base, body and head.

Phalanges VII. these help in maintaining the stability of the foot, the hallux or big toe (I phalange) is important when unwinding the foot from the surface.

The phalangeal section of the foot consists of fourteen phalangeal bones - the big toe has two parts,

the other phalanges are three-part.

2. 5 Longitudinal and transversal arches

Of crucial significance for the correct function of the foot are the formed foot arches, which are comprised of a utility grouping of the tarsal and metatarsal bones. We then distinguish between the longitudinal and transversal foot arches.

The longitudinal arch of the foot is higher on the internal side and lower on the external side. The interior arc is formed by the tarsal and navicular bones, three cuneal bones, the first through the third metatarsal bones and the articles of the first and third phalange. The exterior arc is formed by the heel and calcaneus bones, the fourth and fifth metatarsal bones and the articles of the fourth and fifth phalange.

The transversal arch of the foot is oriented approximately vertical in the direction of the longitudinal arch. The metatarsal bones arch into the ridge of the foot.

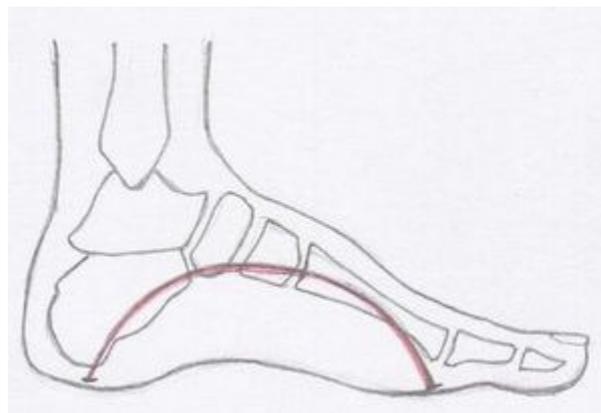


Fig. 4. Longitudinal foot vault.

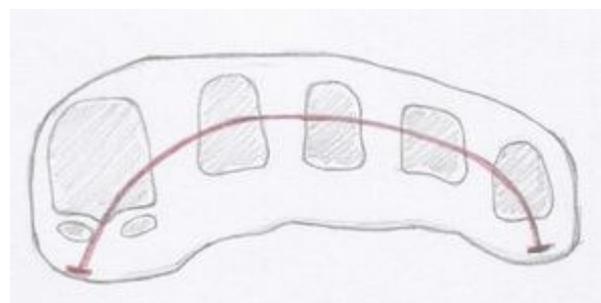


Fig. 5. Transverse arch foot.

3. MUSCLES OF THE FOOT

The basic physiological characteristic of the muscles is the ability to contract, caused by muscle

cells reacting to a stimulus. The movement of the entire body, or locomotion, is facilitated by means of skeletal (transversally striated) musculature. Movement activity related to the actions of internal organs is provided by smooth musculature. The movement of blood in the vascular system is mediated by the activity of the cardiac muscle (heart muscle), which has some characteristics of a skeletal muscle (transversal striation) and some characteristics of a smooth muscle.

Muscles are divided according to shape into long, short and flat muscles. Short muscles are typical for the foot and hands.

4. SKIN

The skin is the largest organ of the human body, both in weight as well as area. The main function of the skin is protective, preventing the loss of fluids, preventing the incursion of harmful microorganisms and impurities into the organism. It is also a sensory organ, which informs the central nervous system about the temperature, unevenness of the terrain, humidity, possibly also about injury. It shares significantly in the thermal regulation of the body. By evaporating sweat, it consumes evaporative heat, by which the organisms cools itself. Indispensable is the role of secretion; sweat glands secrete water and salts. The sebaceous glands secrete fats.

Two basic types of skin can be distinguished. Characteristic for the first type is the occurrence of fuzz and hair; this occurs on the majority of the body and contains both sweat as well as fat glands. The second type of skin occurs on the surfaces of the foot and on the palms of the hand. This type of skin does not have fat glands; the occurrence of sweat glands is significantly higher; it has the ability for greater swelling and for preserving softness or elasticity; it needs a larger occurrence of water. In case of a reduction in the volume of water, this leads to the cracking of the skin, which is painful and heals poorly. For both types of skin, the number of sweat glands declines with age.

5. FOOT DEFORMITIES

Foot deformities may be congenital or acquired. The classification of the types of foot deformities is divided according to the parts in which they occur. From this standpoint, we may speak of deformities of the toes, deformities of the foot arches, possibly heel deformities.

5.1 Static toe deformities

Among the most frequently acquired deformities are the so-called static deformities, among which belong hammer toe and claw toe, suffered by the third phalange. This type of deformity is caused by wearing small shoes, or wearing shoes with a non-physiological tip shape.

5.1.1 Hammer toes

Hammer toes are in essence permanently crooked, when the base joints decline and this gradually leads to the curvature of the afflicted toes. Over time, the toes harden into the incorrect position. Shoes press on the protruding joints, and endangered toes form bunions in a final attempt to protect sensitive bones against pressure overload. These aforementioned types of toe deformities increase

with age.

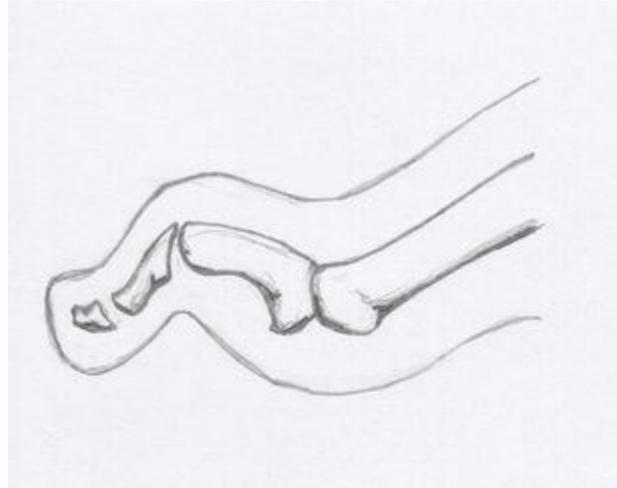


Fig. 6. Hammertoe

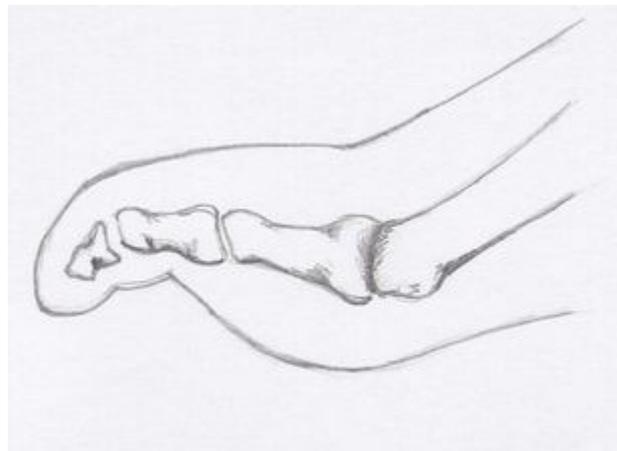


Fig. 7. claw toe



Fig. 8. mallet toe

5.1.2. Hallux valgus

The second most frequent type of foot deformity is bunions (Hallus Valgus) and the big toe turned inward (Hallus Varus). There is no unified opinion as to the causes of these defects.

According to medical studies, Hallux Valgus is included by congenital disposition and occurs mainly in relation to concurrent external causes, particularly by wearing spatially inappropriate shoes (too pointed and with high heels). Therefore, Hallux Valgus most frequently occurs in women than in men. In small children, this may occur by wearing tights and socks that are too tight.

Hallux Varus manifests itself by an inclination toward the other toes and may in rare cases move underneath or above another toe. This may be accompanied by a decline and expansion of the front transversal foot arch. The foot spreads out transversally and in the location of the heads of the metatarsal bones, pressure from the vamp of shoes may create bone growth. Among growth and skin this occurs as a protection against the pressure of sacs that not uncommonly aggravated painfully, creating corns or bunions. The basic toe joints gradually harden and restrict the correct unrolling of the toes when walking. As a result, the entire foot begins to become incorrectly strained. Used as support is a "toe corrector" but often this effectively helps until the performance of an operation of which there are several variations today.

Removing Hallux Varus deformations are painful, requiring a relatively longer period of convalescence and the high probability of a return in the deformity.

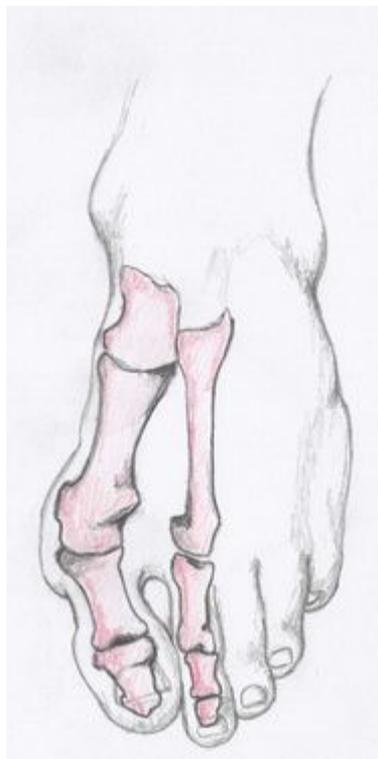


Fig. 9. Hallux Valgus

Hallus Valgus is a mirror image of Hallux Varus and is a relatively less frequent phenomenon; however, it has a smaller impact on the biomechanics of the lower limbs. Hallux Valgus deviates toward the other toes; during greater deviation this may lead to a shifting across the fourth toe. Used as a corrector is a shaped part, which is commonly available for sale in pharmacies.

5.1.3. Hallux Varus

This static foot deformity is less frequent; its occurrence is commonly higher in populations without shoes. On the basis of this circumstance, some authors believe that our foot originally assumed a rather buckled position for big toe.

5.2 Issue of flat foot

Principally, we distinguish three types of flat foot. Transversal flat foot, longitudinal flat foot and high foot (rigid).

5.2.1 Transversal flat foot

Opinions as to the cause of flat foot, whereas the predominant opinion attributes it to the occurrence of overloading the front transversal arch, e.g. long-term wearing of shoes with high heels or long-term wearing of shoes that are too narrow. The consequences of this foot deformity could be pain in the forefoot, in the calf muscle, and a stiff gait, which lead to pain in the hips and back. Footwear with a fixed sole, heel and low heels is recommended. Used for correction of problems are parts called "little hearts", which support the heads of receding metatarsal bones pressing on the soft tissue of the surface of the soles. Support (a metatarsal little heart) may not be placed directly beneath the heads of the metatarsal bones, but must be placed in front of the heads of the metatarsal bones in such a way that this results in raising them up. Thus the transversal arch will be regenerated and the heads of the metatarsal bones then are functionally relieved and high local pressure is not invoked.

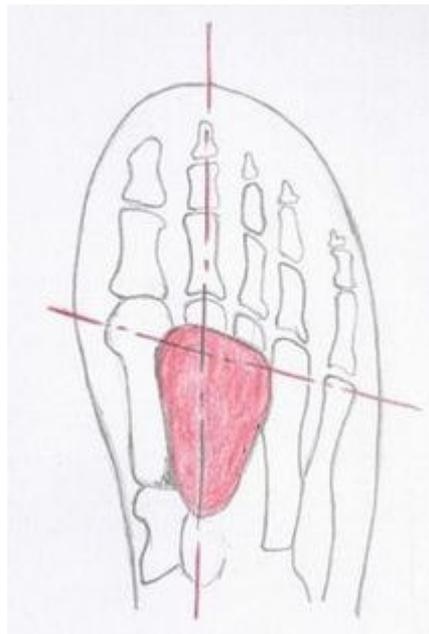


Fig. 10. Proper placement of the transverse arch support.

5.2.2 Longitudinal flat foot

This manifests itself in the foot primarily through the decline in the internal longitudinal arch with accompanying rise in the valgus position of the heel. The most frequently used method for categorization of longitudinal flat foot is the method "Shipaux-Šmirák," which evaluates the share at the narrowest and widest points of the foot outline. According to the degree of mildly flat, flat...verify

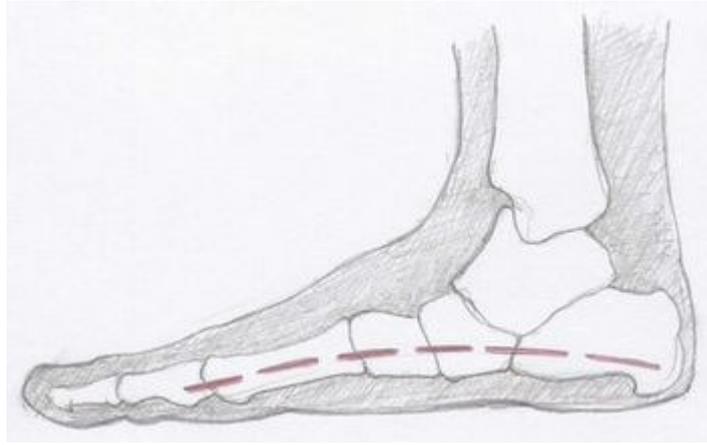


Fig. 11. Longitudinally flat foot.

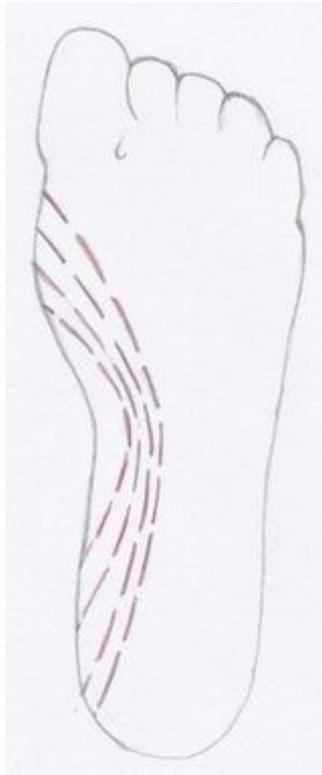


Fig. 12. Example of longitudinal arch support.

A particular case of foot deformation is the so-called high arch (cavus). In comparison with the occurrence of the longitudinal decline in the foot arch, its occurrence is less frequent. This deformation is not often related to wearing inappropriate shoes and opinions differ as to its treatment. Sometimes, it is called rigid foot, because the foot's flexibility and cushioning characteristics are reduced. According to Šťasný, high arch is more frequent in girls, to a degree up to 16%. It manifests itself in extremely raised longitudinal arches, whereas the front transversal arch is usually reduced. High instep of I phalange is known in the population as a defect and often complicates the purchase of common shoes. The Achilles tendon is usually shortened; the foot is not very flexible and sometimes painful. The cause of the deformity is a muscle imbalance occurring in relation to a defective spinal cord, muscular disorders, in polio, or through the continued wearing of short footwear. It is recommended to wear laced shoes with sufficient vamp space.

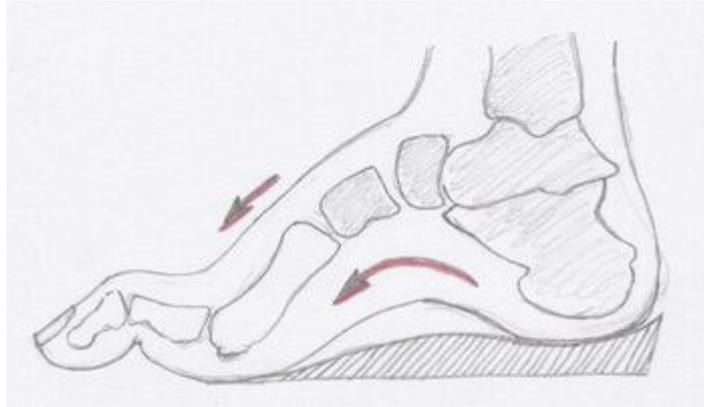
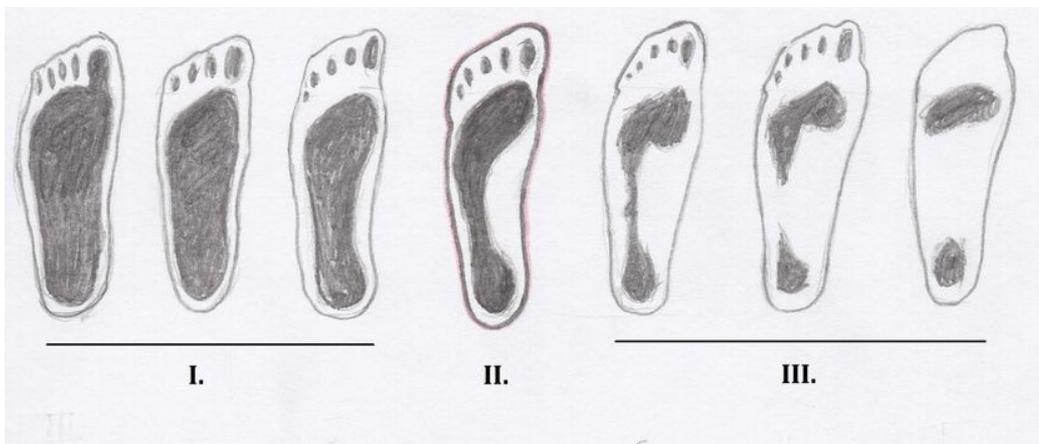


Fig. 13. High leg.



I. Flat foot

II. Normal foot

III. High foot

Fig. 14. Degrees of foot deformities.

5.3 Deformities of the heel part of the foot

The most frequent deformity of the heel part of the foot is related to the incorrect position of the heel bone. This involves:

- a) The valgus (inturned) position into the shape of the letter X (valgus in -X).
- b) The varus (turned outward) position into the shape of the letter O. see fig. 9.

For customers with markedly deviated positions of the heel bone either already valgus or varus, shoes with higher cuts are recommended, with sufficiently rigid heels. In sports shoes, soles with different degrees of deformation in the heel section on the external and interior sides occur.



Fig. 15. The position of the heel bone.

5.3.1. Heel spurs

Heel spur, or lower bulges of the heel bone, (fig. 11), may occur in longitudinal flat foot and is occasionally accompanied by sacs, which may be very painful when walking and therefore are relieved by a heel piece (fig. 12), which a recess for the spur.

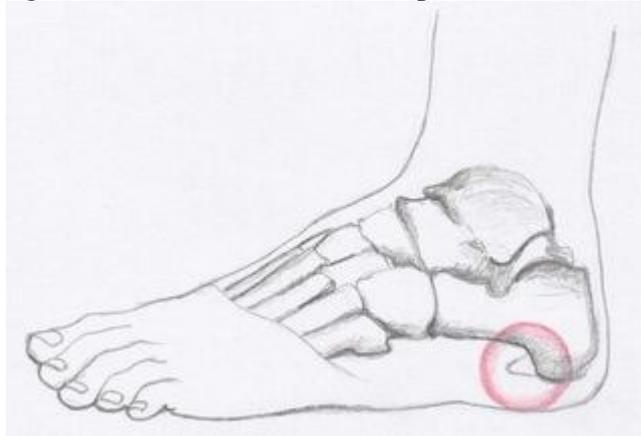


Fig. 16. The leg with the heel spur.

In maturing girls, during frequent use of loose types of shoes (moccasins or pumps), the so-called double heel or "Haglund exostosis" may occur.