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## THE COMBINED FOOT PATHOLOGY CAUSED BY A COMMON ETIOLOGY OF FLAT AND DIABETIC FEET

**Abstract:** The paper analyzes the importance of means for preventing the combined foot pathology caused by a common etiology of flat and diabetic foot in order to maintain the health of a person suffering from diabetes. To that end, the necessary features of dia-shoes and a set of requirements are discussed, without which it is impossible for the shoe to ensure the protection of foot from the progression of pathologies during diabetic foot infections.

**Key words:** diabetes mellitus, diabetic foot infections, orthopedic footwear.

**Language:** English

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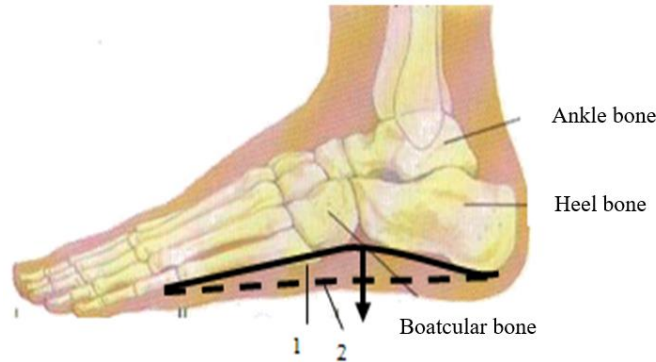
### Introduction

When walking, the feet of a person take on pressure and impulses from the support that are caused by the weight of the body, ensuring smoother moving, which in turn requires the feet to combine strength and elasticity. The foot bones are connected to each other by means of numerous joints, articulations, and muscles that form the shape of the arch. There are five longitudinal arches (according to the front foot bones) and one transverse arch of the foot. The heel bone and the front heads of the foot bones are considered to be the support points of longitudinal arches. These arches contribute to the cushioning capacity of the feet. A healthy, resilient "cushion" can neutralize more than 80% of impulses from the support and protect from impulse-induced loads the upper body, including backbone, which is especially important for people with diabetic foot infections to prevent severe concurrent processes.

In the process of movement and in the case of strain exerted on the foot, the foot articulations stretch and their arches are flattened (Fig. 1). At this time, a person gets a sense of fatigue and often pains in the feet, foot-shin articulations and shin muscles. This is due to the fact that the arch cannot completely suppress the impulses transmitted from the support to the feet, the impulse-like wave is instantly transmitted from the leg to the knee, hip joint and then to the entire backbone. During prolonged walking on a flat foot, these thousands of minor impacts trigger trauma in the entire musculoskeletal system, causing pain in the joints, back, neck and head, which, without timely prevention or therapy, leads to irreversible pathology of the musculoskeletal system. This is especially true during diabetes (fig. 2.), especially for people with diabetic foot infections [1, 2].

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**Figure 1. A change in the condition of the ankle arch (1. Normal arch; 2. A flattened arch).**



**Figure 2. Diabetic foot.**

Often, patients with diabetes do not pay attention to the skin roughness on the plantar side of the foot, and sometimes - the painful calluses. They do not even know that they are caused by the flatfoot, which is the result of the fact that pressure on the foot is not being evenly distributed but concentrated on the so-called "pillows", in the heel, or under the heads of the front foot bones.

The first symptoms during the flatfoot are as follows:

- The inside of the shoe starts to wear intensively (fig. 3);
- We get tired soon while walking;
- We begin to feel pain and heaviness in the lower extremities, which is transmitted to the spine;
- It is difficult for women to wear high heels.



**Figure 3. Shoe heel wear pattern caused by pathological ankle.**

Without timely prevention, the pain gradually progresses and other more serious, concomitant diseases begin to develop, both in terms of

musculoskeletal and internal medicine diseases. [1, 2, 3, 4].

Patients suffering from diabetes should know that the most important thing is to choose the right

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diabetic shoes (Dia-shoes) suitable for their feet. Indeed, rough shoes that do not take account for the specifics of the disease, especially in cases of reduced foot sensitivity - are the direct path to the acquisition of ulcerative defects of the foot, gangrene and even amputation of foot (fig. 2), while the properly chosen dia-shoes, manufactured according to world standards, will protect the foot completely from this problem. Therefore, the properly made shoes for patients suffering from diabetes are crucial - they are a real way to prevent complications, existing pathologies and minimize the risk factors for disability.

The results of the study showed that diabetic shoes should be characterized by five main features. These are:

- **The first** feature - the shoes should be made without a toe case. The toe case is intended for keeping the shape of the shoe toe. For diabetic patients, the solid toe case plays a major role in the acquisition of deformities of the toe bone part. Therefore, orthopedic shoes with a toe case are generally not considered to be a means of day-to-day use for patients suffering from diabetes;

- **The second** feature - a rigid sole, which should not be bent while walking. It is known that the sole in the shoes undergo many types of deformations and impacts from the foot, much of which is caused by the flexion of this sole. The main feature for the flexion of sole is its elasticity, which ensures the flexion of sole in the insole ball as a result of the ankle flexion while walking. For patients suffering from diabetes, the multiple ankle flexions, especially in angiopathic and arthropathic pathology, contribute to acute exacerbation and acceleration of the disease. While the elasticity of the foot conditions the amount of energy spent by the foot on the flexion of the shoe, the soles made of high-elastic materials does not protect the foot from the risks of injuries posed by movement. Moderate elasticity is therefore permissible for sole so that it can return the foot to an initial position in the event of an unstable walking surface, or an imbalance while walking. Moreover, when the foot has become desensitized, the person can not control the process of disturbing the balance of the foot, and sole can not prevent this process. The rigid sole counteracts the deformity of the front of the foot, while the step smoothness and meaningful walk is achieved by giving the toe part of the shoe the ability to roll, that is, by the oval shape of the toe part, which eliminates the need for the ankle flexion while walking and the foot remains in the correct position during the full step cycle. This excludes energy consumption by the foot and overloads on joints, muscles and blood vessels;

- **The third** feature - the seamless inner surface, that is, the lining is taking shape so that there are no stitches (and other irregularities) in the front

part of the shoe, in order to prevent rubbing and damage of the patient's foot;

- **The fourth** feature – the largest possible inner space, additional capacity for placing the orthopedic insole and enabling the foot to function freely. The orthopedic insole in must be individual, in which case its dimensions (especially thickness) must be calculated and provided in the volume of the diabetic shoe (in the height of individual anatomical sections). Otherwise, the reduction in the inner volume of the shoe caused by the thickness of the shoe makes the shoe narrow. There is a second way: it is possible to use an absolutely flat insole, which is made of a material that can easily fit on the foot, with a thickness of 8-10 mm. Such type of insole, soon, shortly after the start of functioning, takes on the shape of the plantar side of the foot, and the high-risk zones no longer arise for patients; if the patient has normal sensitivity, then it is better to use an individual insole (although it is quite expensive), moreover, such high technology is not yet sufficiently introduced in many countries, due to its expensiveness. If the patient leans into a lack of sensitivity, then it is better to use an insole with the ability to fit well on the foot. The use of the second option is safe and eliminates the risk of causing pathologies to the foot, or progression of the existing ones.

- **The fifth** feature - materials used in the diabetic shoes, such as: soft, natural surface and lining materials, treated in environmentally friendly conditions (using the high quality tannins, non-toxic dyes, etc.), which have high hygroscopic properties - good ability to absorb steam and perspiration released from the foot, so as not to accumulate excess moisture inside of the shoe.

Given the above listed features, diabetic shoes cannot be cheap, especially if they are made individually, which in turn requires a greater share of hand work. However, the shoes that have high performance characteristics are more durable than shoes that are made of uncomfortable and poor-quality materials. In addition, the risk factors for injuries in high-quality shoes are minimized, which is a key prerequisite for maintaining good health and reducing costs in this regard.

A prerequisite for the purchase of orthopedic shoes of mass-produced shoes must be a certificate that certifies high quality (safety) and consumer characteristics of the materials used for its manufacturing, which must describe the specific factors that are emphasized during the manufacture of shoes, because all specific pathologies require particular conformity of the consumer characteristics of shoes. Of course, that means a conscientious attitude of the businessman to work. When choosing the shoes, the consumer can more or less timely discover the mechanical characteristics, but it is impossible to identify the hygienic-toxicological characteristics without laboratory tests. Even its

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negative effects on the human body are very difficult to identify, as it has not been the case that the cause of any disease has been discussed in connection with the hygienic-toxicological characteristics of clothing and footwear. This is a mistake, because the clothes that a person wears all day and are in constant contact with his/her body can become a source of migration of numerous dangerous chemicals and toxic substances through the skin (because the skin is one of the main organs of metabolism). The risk and rate of infection during ulceration of the foot are much higher.

It is fashionable today to wear shoes without socks, on bare feet, which is unequivocally improper conduct on by footwear consumer. Shoe is a durable product and it is not easy to ensure its hygiene as it is not subject to direct washing (it is impossible to completely clean the shoes from bacteria by cleaning the outside or by periodically cleaning the inside). Wearing it on the bare foot causes its inner surface to become dirty and then constantly touching the foot with a dirty surface, easily transferring dirt and bacteria to the foot, as well as contributing to further multiplication of bacteria by steam and perspiration released from the foot. The use of socks and their frequent change help to maintain the hygiene of the inside of the shoe for a long time. In addition, the sock-less foot can be easily damaged mechanically by the impact on the inner surface of the shoe, resulting in constant friction between the foot and the shoe while walking.

To date, despite the scale of modern media, people's awareness of the consumer and hygienic characteristics of shoes, pathologies caused that they cause or progressing under their influence, as well as of the role of the foot in the state of health is very low. Some people completely ignore the role of shoes in terms of their impact on health and think that the injury caused by shoes is local and they have even no idea that the foot is a "mirror of health" because it is rich in neuro-receptor zones and points of almost all vital organs, and it plays an essential role in changing the state of an organism and maintaining health [5].

According to the International Diabetes Federation, more than half a billion people worldwide are diagnosed with diabetes mellitus. The complications of diabetes mellitus in a person suffering from diabetes not only lead to mortality and a deterioration in the quality of life, but also place a heavy burden on the health system and lead to irreversible economic consequences [6, 7].

Studies conducted by endocrinologists have shown that the development of 80-90% of the foot ulcers was accelerated by external injuries (usually due to poorly fitted shoes) [7]. Therefore, the properly chosen shoes are crucial in creating normal living conditions and life extension for people suffering from diabetes.

The studies provide little information on the percentage distribution of flat foot among diabetic

foot combined diseases. Flatfoot can be both congenital and acquired. Acquired flatfoot in turn can be traumatic and age-related. Among the age-related pathologies of the foot, flatfoot is one of the most common deformities, which causes many complications both in the spine and internal organs, because without preventive measures it becomes a progressive pathology, and this disease is not something that just goes away.

In combination with diabetic foot infections, the treatment of flatfoot or amelioration of signs, especially during the ulcerative disease of the foot, when the contact area with the plantar side of the foot reaches a maximum, is possible only using the orthopedic means. These can be orthopedic shoes made individually, as well as comfortable household shoes with orthopedic elements (insole, sole in the arch region or otherwise). However, if we also take into account that the shoemaker should not be a random person, and he/she should realize what a product he/she made is, and what impact it can have on a person's health. The quality of the product he/she made very much depends on his/her knowledge and good faith. The quality of shoes is determined by a number of factors. Just as the safety of food and other products is brought under the control of the State, important items of personal use that can adversely affect human health, especially the orthopedic devices, must also be brought under the same control.

In connection with the above, in case of combined pathology of the foot caused by a common etiology of flat and diabetic foot, the shoes must meet the following requirements: [8–18]:

- The shoe must be accompanied by a GMP certificate from the manufacturer to confirm compliance of the materials used in its manufacture with the hygienic-toxicological characteristics, as well as the firm must be authorized (with appropriate qualifications, staffed with certified specialists) to manufacture the orthopedic shoes and components;
- The appearance of the shoes must be appropriate to the season and geographical location of person in a particular situation and climatic conditions. It is unacceptable to walk barefoot, especially on the rough ground and similar-type walking surface;
  - It is unacceptable to wear shoes (especially with closed design) without socks, barefoot;
  - Shoes should fit well and comfortably to the foot not only when trying it on, but also after walking for a few minutes, and it should not fit tightly the foot, or be oversized. Frictional forces during walking in the oversized shoes (consequently the risk of mechanical damage to the skin of the foot) are greater than when using the tightly fit shoes, so it is a mistake to believe that the oversized shoes cause less problems on the foot;

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- Shoes should be made with laces or cosmic zipper to easily change their volume during the day according to changes in the size of the foot;
- The shoe upper should be made of natural, soft materials, without internal seams; the workpiece parts should not be connected to each other in the toe and ball region, and the edges of the surface should be treated by pleating, and in order to connect the surface with lining, it is necessary to use the reverse stitch, with an insert of a soft intermediate part along the edge;
- A toe case cannot be used in the forepart region of the workpiece toe; the heel thickness should be gradually reduced above the stretching edge until the most bulging point of the heel, and it must be minimal in the area of direct contact with the heel part of the foot, while the length of its wings depends on the workpiece design, and it is taken in accordance with the norms allowed by the standard (the heel wings must pass in front of the front part of the heel and be no more than  $0.3 \div 0.35$  of the foot length);
- The sole must be rigid, characterized by good rolling and gripping ability on the walking surface;
- Shoes should be made with the medium or low heels. It is unacceptable to use the high-heeled and heelless shoes;
- The relief insole should allow for optimal load distribution on the walking side of the foot, and should be made with an individual or optimally computed construction, and made of soft, natural, or

other hygienic materials, as well as be appropriate to the natural plantar side of the foot and must have a quick molding ability.

Considering that a person who leads an active life, makes an average of 6000 steps per day. Performing a complete step cycle normally, without excessive loads, or without factors impeding the walking smoothness, the day will pass without excessive fatigue, while under the influence of such factors, on the contrary, the energy spent while walking is added to the excessive energy consumption caused by external factors, and at the end of the day, the situation is tough. The multitime repeat negative factors lead to the intensification of the existing pathologies, or provocation of new deformities. The progression of the pathologies on the foot is due to the fact that the foot is the most physically loaded organ compared to all other organs. Added to this is the age-related excess weight, which is why the load on the foot is much higher during the day.

Each specific case requires an individual plan of conservative treatment and, above all, an adequate management-compensation of diabetes. However, when patient has already developed "diabetic foot infections", in most cases the structural abnormalities are irreversible. In such a situation, the issue is in the foreground to minimize the mechanical impact on the foot, which provides injury prevention. Shoes should be made for this purpose, in strict compliance with all the above characteristics.

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