

## Erroneous theory of the transverse arch of the foot and its negative consequences

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### Abstract

Based on our own research and the literature overview we verified the concept of the transverse arch of the foot and the use of this concept in the aetiology of acquired female foot changes. The results of podological studies carried out for many years in the Orthopaedic Department in Lublin have not demonstrated the existence of a transversal arch, and thus questioned its impact on the formation of forefoot changes in women. In order to obtain a fully objective assessment of the issue, a study was carried out at the Vincent Pol University in Lublin in 2013, including, among others, a dynamic podographic evaluation of 25 women aged from 17 to 26 years. The analysis of the results obtained undermined the historical view of the existence of the transversal arch of the foot and its role in the formation of acquired pathological changes of the forefoot.

**Aim:** In view of the notion of the transversal arch of the foot that can still be found in a number of publications attributing to it a significant function in the formation of forefoot overload in women, the aim of the present study was to explain the above issue explicitly.

**Key words:** foot, dynamic podobarography, transversal arch, longitudinal arch, adults

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### Introduction

The concept of a transverse arch of the foot was introduced simultaneously with the concept of a longitudinal foot arch. The construction of the longitudinal arch is determined by the foot architecture; it is clearly visible both in the unloaded foot and loaded foot. The longitudinal arch is formed by the calcaneus, talus, navicular, cuneiform bones and the first metatarsal. It acts as a shock absorber during walking, running and jumping. The size of the longitudinal arch has been evaluated for a number of years using plantocontourograms.

Irrespective of the longitudinal arch of the foot, in normal anatomy, the transverse arch of the foot, formed by the tarsal bones- the cuneiforms and cuboid bone, is isolated. However, the existence of the transverse arch of the foot at the level of metatarsal heads has been a controversial issue

for years [11, 12, 18]. Accepting its existence made it possible to explain the occurrence of painful places under the heads of the second and third metatarsals in many older people, especially women. According to the assumption adopted, the cause of these problems is flattening of the arch at the level of metatarsal heads.

However, the fact that the transverse arch of the foot was not marked on plantocontourograms was explained by its flattening and widening during foot load. Another argument for the existence of the transverse arch of the foot was the assumption that the foot placed on the ground is supported by three places [2,8]. "The back support of the foot is the calcaneal tuberosities; only the heads of the I and V metatarsals are considered to be the first arch support points" [2].

Moreover, once this hypothesis has been adopted, the height of the transverse arch has to be

determined. The determinations were indirect. It was assumed that the ratio of the foot width to the horizontal metatarsal heads to its length might be related to the height of the transverse arch of the foot. Such a way for indirect identification of the transverse arch of the foot and its measurements was suggested by Wejsflog [19]. He adopted the length-width ratio as the basis for determining the size of the transverse arch - later called the Wejsflog index [19].

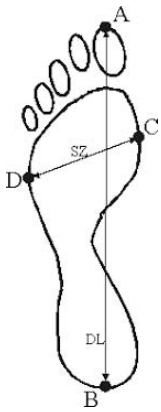


Fig. 1. Measurements to determine the Wejsflog index

The index of 2.55-3.00 denotes correct transverse arching and that of 2.00-2.50 - the transverse flatfoot.

Despite negative results of studies, the above view has been repeated in many textbooks, popular publications and even in some scientific publications.

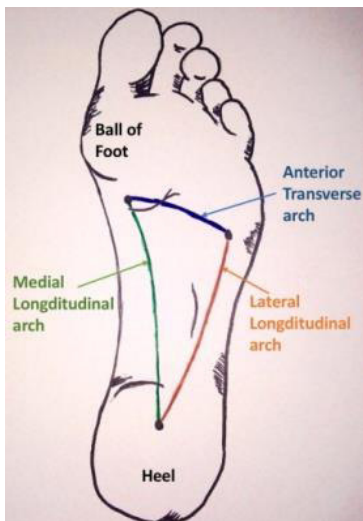


Fig.2. Foot longitudinal and transverse arches  
<http://teachmeanatomy.info/lower-limb/misc/foot-arches/>

The acceptance of the transverse arch of the foot at the level of the metatarsal bone and its reduction as a paradigm, without its thorough checking, facilitated the explanation of the causes of pain and callus formation, particularly under the heads of the second and third metatarsals.

This view was maintained despite prevailing findings questioning its existence, e.g.: no transverse arch on plantocontourograms performed normally in a standing position, in contrast to the well-visible medial longitudinal arch.



Fig. 3. Plantograms with various longitudinal arches (web page - flat feet). The transverse arch- invisible

Likewise, the transverse arch at the level of the metatarsal heads is not found during podoscopic examinations of feet [14].



Fig. 4. The transverse arch- invisible. A podoscopic image (photos taken by the authors)

The above studies have not fully and reliably disproved the existence of the transverse arch at the mid-foot level because they were carried out in a standing position, during which the transverse arch could flatten. However, the assessment of possible existence of the transverse arch of the foot during anatomical preparation has revealed the ease with which the dorsal bone IV and V can be moved, questioning the existence of the transverse arch of the foot.

Further progress in the views on the etiopathogenesis of forefoot distortion has been made with the introduction of a foot-and-beam platform for the assessment of foot loads, equipped with precise systems for recording and evaluating the degree of pressure on the plantar side of the foot under static and dynamic conditions. Thanks to such devices data regarding the degree of pressure and its distribution on the entire plantar side of the feet can be collected. Various genographic examinations carried out in different centres have demonstrated the existence of the greatest pressure on the substrate under the heads of the second and third metatarsals within the forefoot, both in static and dynamic assessment.

### Research problems

Is there the transverse arch of the foot at the level of the metatarsal heads?

Is it possible to explain the occurrence of painful overloads beneath the metatarsal heads by flattening of the unproven transverse arch?

Is it possible to objectively prove or otherwise the presence of the transverse arch?

The present study was focused on the above problems.

### Methods

In order to clarify the problems, in 2013 a comprehensive study was performed in 35 women aged 17 - 26 years. The measurements included

the range of dorsiflexion and plantarflexion of feet, the extent of active plantar flexion of toes in the metatarsophalangeal joints and determinations of the ability to actively spread the toes. Moreover, static and dynamic loading of feet while walking were podobarographically evaluated. Besides archiving measurements, photographic documentation of data was prepared. These results were used in a separate study.

In order to carry out the podobarographic foot evaluation, 25 women were randomly selected from the study population.

The following was performed:

1. Analysis of photographic images made at intervals of 17msek, separately for each foot, during 1 cycle of its loading while walking.
2. Colour gradation of foot load and determinations of the places of the highest load along with the line of the largest values of foot loading while walking.

With respect to the lateral arch of the foot, the podobarographic examinations of feet in a standing position did not demonstrate its existence. In contrast, in dynamic podobarography, totalled images of foot load indicated the forefoot as a place of significant loading. Furthermore, imaging in the sub-axes of dynamic movement of the centre of gravity from the heel (Initial Contact - Heel Strike) to the toe (Toe Off - Pre-Swing) indicated its movement over the heads of the second and third metatarsals.

The above results do not completely exclude the existence of the transverse arch of the foot, which could have flattened under pressure.

Therefore, in order to clarify the issue, analysis of foot loading during one phase of walking from heel contact with the ground until toe detachment from it was carried out. For this purpose, dynamic podobarography was performed at 17- msecond intervals for both feet showing the location of foot load during one gait phase. In the face of the

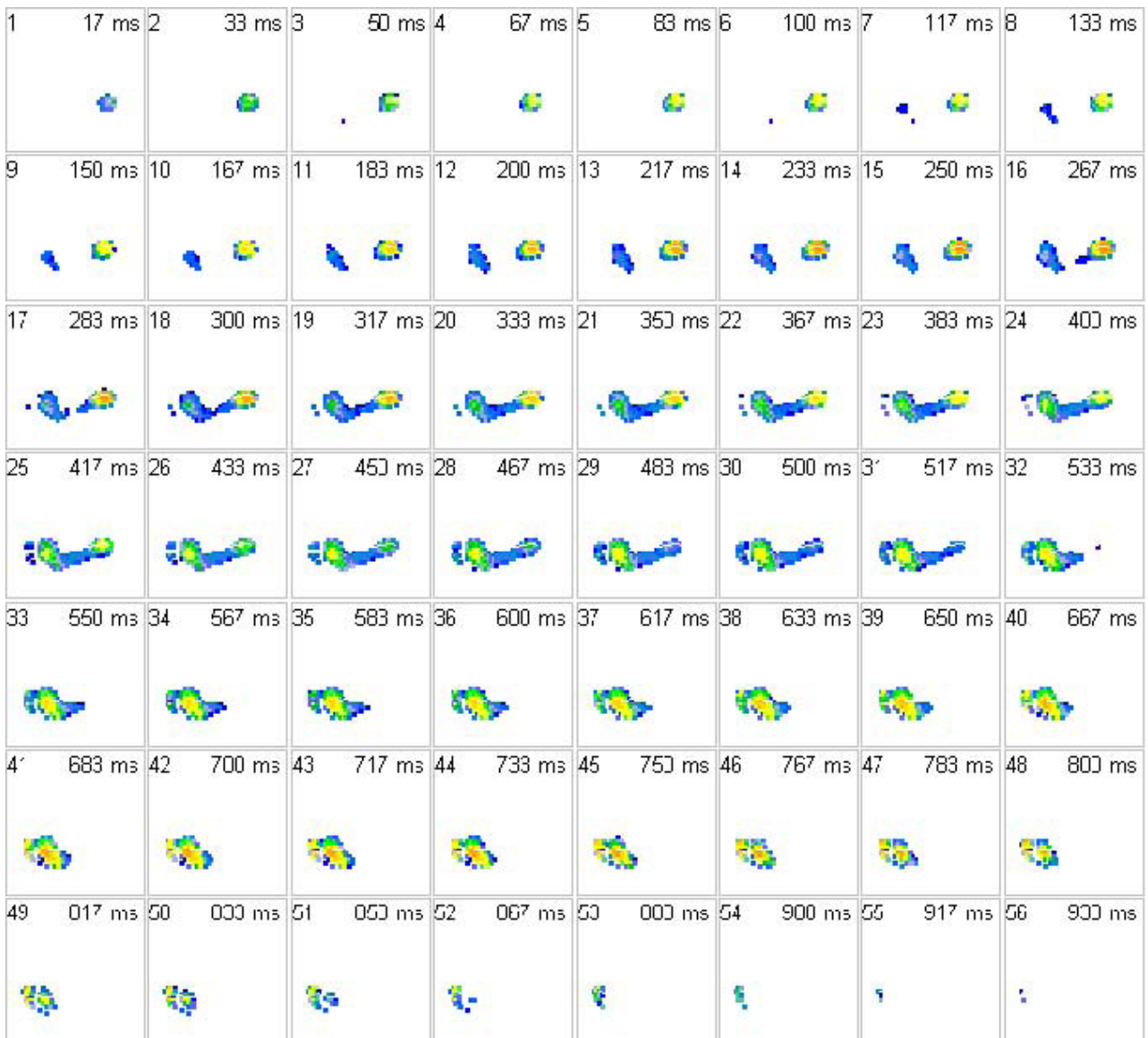


Fig. 5. A series of podobarographic images of the same size in one of the subjects at intervals of 17msek for the left foot during 1 cycle, from Initial Contact - Heel Strike to Toe Off - Pre-Swing (photos taken at the IRM Lublin)

same foot images with respect to the transverse arch, their analysis was presented on the example of one randomly selected study. The collected data, unrelated to the transversal arch issue, will be used in other studies.

The particular images included in figure 5 did not demonstrate an arch within the forefoot on contact with the ground (photos 6 to 19). The results of this study negate the existence of the transverse arch of the foot. Another argument is that the transverse arch of the foot did not appear during the gradual loss of contact of the forefoot

with the ground (photos 46 to 56); and with every msecond the forefoot load decreases and we should observe the transverse arch.

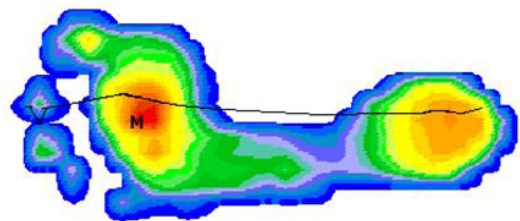


Fig. 6. Dynamic podobarography: M - the place of the highest load. The line of the highest load (Study and photo performed at the IRM\_in Lublin)



Therefore, the tests carried out excluded the existence of the transverse foot arch at the level of metatarsal heads.

### Conclusions

1. The authors of a series of works [4, 5, 10, 13, 16] have denied the existence of the transverse foot arch based on measuring the pressure of feet on the sensory platform. Researchers without this device [1,3,6,7,9,14,15,17] have negated its existence based on a thorough biomechanical analysis of the foot.
2. The dynamic podographic scans taken at 17-msecond intervals while walking clearly negate the existence of the transverse arch of the foot, even at low forefoot pressure on the ground. This finding is of great practical significance.
3. In the light of our study findings demonstrating that the transverse foot arch does not exist, the controversial view that its lowering causes pain under the metatarsal heads is unfounded.

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