Plantar pressure distribution and foot geometry of Dutch and Malawian adults

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The foot is one of the most complex parts of the human body. It consists of 26 bones, 33 joints, and over 100 ligaments, tendons and muscles. In humans, the feet are the only part of the body that contacts the ground during gait and standing. As such, the feet are key players in the deceleration during landing, in weight bearing, maintaining balance and providing propulsion during locomotion. The plantar aponeurosis plays a key role in the function of the foot while weight bearing. Hicks (1954) was the first to describe the role of the plantar aponeurosis as a windlass mechanism explaining the relation between passive extension of the toes on the one hand and the rise of the medial arch, supination of the rearfoot and external rotation of the leg on the other hand [1]. During gait, the windlass mechanism acts in two ways; 1) it helps to maintain the shape of the Medial Longitudinal Arch (MLA) when the foot has to manage downward forces at stance (reversed windlass mechanism) and 2) it causes a rise of the MLA and shortening of the foot at late stance, as the plantar fascia tightens at toe off due to dorsiflexion of the MTP joints [2].

In many western countries, many people suffer from foot complaints [2,3]. Approximately 10% of the Dutch population suffers from foot complaints, increasing up to 24% in the population of above 65 years [3]. In contrast to western countries, foot complaints are rare in Africa [4,5]. This is remarkable, as many African adults walk many hours each day, often barefoot or with worn-out shoes. The reason why Africans can withstand such loading without developing foot complaints might be related to the way the foot is loaded and function. As the loading of the foot is highest during locomotion and the shape of the foot and biomechanical behavior of the foot differs between the phases of the walking cycle, it seems important to investigate the foot in a dynamic situation. Therefore, the aim of this study was to compare the static foot geometry, dynamic plantar pressure pattern and roll off of the foot between Malawian and Dutch shod adults.

Static foot geometry and dynamic plantar pressure distribution of 77 adults from Malawi were compared to 77 adults from the Netherlands. None of the subjects had a history of foot complaints. The plantar pressure pattern as well as the Arch Index (AI) and the trajectory of the center of pressure during the stance phase were calculated and compared between both groups. Plantar pressure data were normalized for foot size, width and foot progression angle [5]. Standardized pictures were taken from the feet to assess the height of the MLA. In principle, differences in plantar pressure between the Malawian and Dutch group could be the result of covariates such as body weight and walking velocity. Therefore, a stepwise multiple regression analysis with forward selection was performed to find the set of predictors/variables that were most effective in predicting the plantar pressure pattern.

We found that Malawian adults: 1) loaded the midfoot for a longer and the forefoot for a shorter period during roll off, 2) had significantly lower plantar pressures under the heel and a part of the forefoot and 3) had a larger AI and a lower MLA compared to the Dutch.
These findings demonstrate that differences in static foot geometry, foot loading and roll off technique exist between both groups. The advantage of the foot loading pattern as shown by the Malawian group is that the plantar pressure is distributed more equally over the foot. It is striking that these characteristics fit quite nicely with some of the main current goals of the treatment of foot problems in the west, namely to pursuit an equal distribution of pressure by insoles.

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