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3D MODELLING OF PROPHYLACTIC FOOTWEAR FOR A HIGH ARCHED FOOT

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Abstract: *This article approaches the methodology of designing customized footwear for high arched foot. The authors propose to reconsider the classical structure of footwear bottom components for people with high arched foot and recommend incorporating custom components, with the role of compensation or adjustment. This study continues the authors' research, starting from a foot's 3D shape obtained by 3D scanning, the anthropometrical and biomechanical parameters, shoe lasts' 3D modelling and continuing with 3D footwear design. Including customized orthosis can help to stop the evolution of abnormalities, diminishes sensations of pain during walking and improves performance in various physical activities carried out during the day, walking, running, and standing. The prophylactic footwear has to meet four main requirements: to protect the foot and ankle during walking and static; to ensure the normal resistance systems (bones), muscle and joint of the foot; to prevent the installation of irreversible structural changes by reducing stress on the foot; to contribute to increased performance in conducting regular physical activity. It is presented the steps of modelling an orthosis, a virtual simulation of its cutting process, followed by the integration and development of the insole, filling and sole for a customized shoe. Delcam Crispin CAD system and its applications for orthopaedics are used to design the bottom components of prophylactic footwear for a high arched foot.*

Key words: *Prophylactic footwear, 3D CAD, virtual prototype, orthosis, footwear bottom components*

1. INTRODUCTION

It is widely accepted the hypothesis that foot comfort, while wearing a footwear product, is directly influenced by the shape and interior dimensions of the shoe, the materials' properties, the manufacturing technology. From this point of view, prophylactic footwear is defined as one that provides the greatest comfort of the foot. If the footwear doesn't maintain the anatomical structure and normal physiology of the foot, in time, it can be a contributing factor to the appearance and development of foot abnormalities. A series of criteria, deriving from the functions that it must satisfy: esthetical, functional, economical and technological, have to be respected during modelling and design stages [1].

The fundaments of 3D modelling of prophylactic footwear are consisted in a series of conclusions from the reported findings in studies and research carried out nationally or internationally [2, 3], such as:

- Elements like toe shape, sole shape and thickness in the arch area, heel height and shape have to be considered to solve foot pathology during orthostatic position or gait;

- The sole configuration in the arch area has an important role in foot biomechanics.

2. METHOD

This paper continues the authors' research, using the foot's 3D shape obtained by 3D scanning, the anthropometrical and biomechanical parameters, shoe lasts' 3D modelling [4, 5, 6]. With a 3D shoe last for a high arched representative foot and Delcam Crispin Shoemaker software, a women footwear product was proposed (figure 1).

Fig.1: *3D design of a women prophylactic shoe*

3. RESULTS AND DISCUSSIONS

3.1. 3D modelling of a foot orthosis

Foot orthosis is a medical device that can be introduced inside the shoe and designed so that it can modify the value and evolution of the reaction forces acting on the foot. Using the previous scanned foot [4], biomechanical parameters [7] and Delcam Crispin OrthoModel software, a foot orthosis for a high arched foot is designed [8, 9], the main stages being presented below, figure 2÷3.

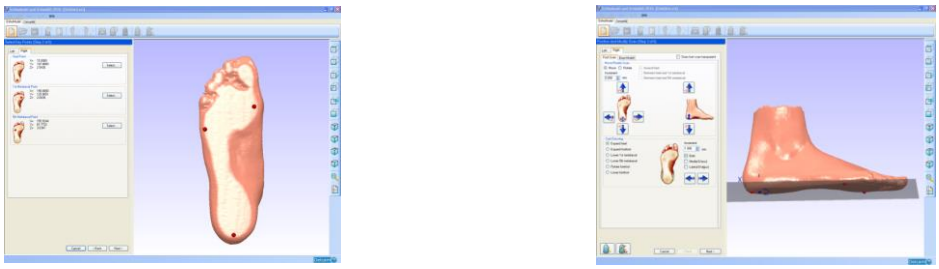

Fig. 2: *Establishing orthosis main points*

Fig. 3: *Virtual model of foot orthosis adapted to a high arched foot*

After the orthosis is designed it can be sent to a CNC machine in order to be produced, figures 4÷6. Delcam OrthoMill module allows simulating the cutting process. The advantages of using this system: reduced number of wastes; special devices for soft materials, like EVA; reduced working time.

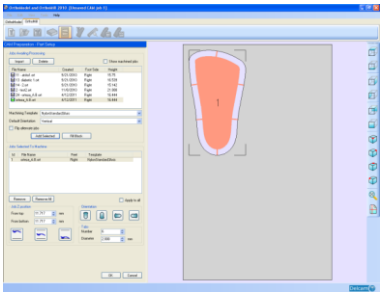

Fig. 4: *Positioning the orthosis on the cutting surface*

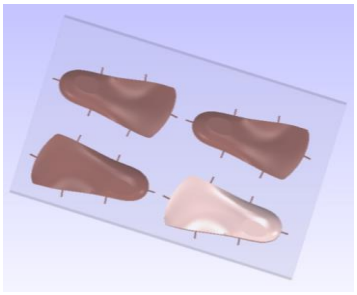

Fig. 5: *Multiplying the orthosis*

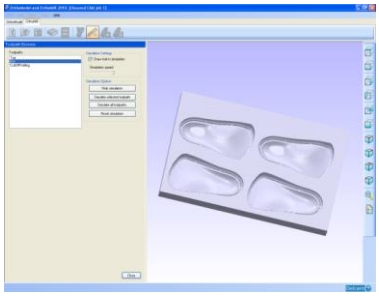

Fig. 6: *The cutting process*

3.2. 3D modelling of an insole, sole and filling by adapting to the orthosis

From a functional perspective, prophylactic footwear meets the four main requirements: protects the foot and ankle during walking and static; ensures the normal resistance systems (bones), muscle and joint of the foot; prevents the installation of irreversible structural changes by reducing stress on the foot; contributes to increased performance in conducting regular physical activity.

In order to obtain all footwear bottom components of for a high arched foot: sole, insole, filling, orthotics, Delcam PowerSHAPE software is used [10], figure 7÷10.

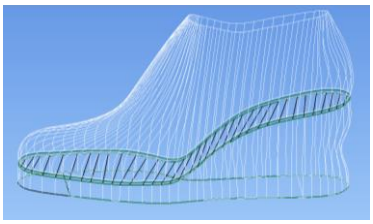

Fig. 7: *Insole lateral lines design*

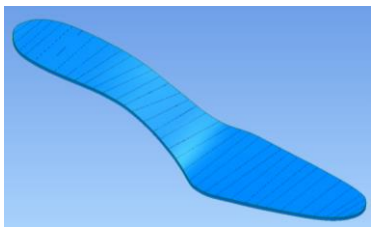

Fig. 8: *Insole surfaces design*

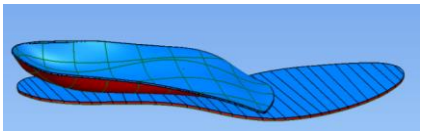

Fig. 9: *Positioning the orthosis on the insole*

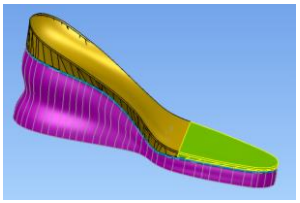

Fig. 10: *3D footwear bottom components: orthotics, filling, insole, sole*

4. CONCLUSIONS

Through this study, the authors propose to reconsider the classical structure of the footwear bottom components for people with high arched foot and recommends incorporating custom components, with the role of compensation or adjustment. Including customized orthosis can help to stop the evolution of anomalies, diminishes sensations of pain during walking and improves performance in various physical activities carried out during the day (eg. walking, running, standing

and so on). The research may continue in this direction, requiring to be extended to large selections of subjects, tested in practice by wearing samples and validated by technological transfer. The validation of these findings may change the classical structure of shoe's bottom components.

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