

## Designing and fabricating a medical insole with universal fluid layer with auto customizability to reduce the effective pressure on the plantar region (suitable for diabetic patients)

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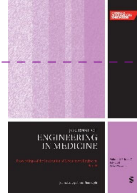
### Abstract:

Medical insoles play a significant role in pressure reduction and proper stress-strain distribution for the feet of diabetic patients. The aim of the present research is to design and fabricate a new medical insole consisting of medical insole with universal fluid layer. After determining the required mechanical properties as well as the pressures exerted to the feet in conditions with no insole application (using PEDAR system), finite element analysis was performed using ABAQUS software, whereby the flat insole and silica flat insole with universal fluid layer were fabricated. Eventually, PEDAR system was employed to compare the plantar pressure for three situations including without insole, with silicon flat insole, and with silicon insole equipped with universal fluid layer. The results of the finite element analysis showed that absorption of stress and development of strain in the static state by the silicon insole with universal fluid layer was 63 and 63%, and in the dynamic state 84 and 89% more than those obtained by the flat silicon insole, respectively. The experimental results of the PEDAR system also showed that in the standing state, the silicon insole with fluid layer and a flat silicon insole had 58 and 30% pressure reduction, respectively. Also, in the gait state, the silicon insole with fluid layer and the flat silicon insole showed 37 and 9% pressure reduction respectively. Eventually, it was found that the silicon insole with fluid layer reduces plantar pressure well in comparison to flat silicon insole, and is very suitable for diabetic patients.

**Keywords:** medical insole, silicon gel, finite element analysis, PEDAR test, pressure, stress and strain

### 1. Introduction

Activities such as walking, standing, and running alongside other daily activities can be done more suitably using proper shoes and insoles. Accordingly, it is predictable that today usage of medical insoles would enjoy a special status in human life [1]. When a person is standing, walking, or running, there is always an interaction between the plantar region and the ground level. During this interaction, the body weight force is transferred to the supporter surface through the feet, and in response, the ground reaction force is exerted to the feet. These forces are important since they are repetitive. The increase and frequency of impact forces and the loading rate in the primary phase of gait have some impact which damage the musculoskeletal system [2,3]. Most diseases associated with the feet, knees, and back are heavily dependent on the improper distribution of plantar pressure [4,5]. Every day, a normal person takes 7000 to 10000 steps on average without doing any special sport activity; this means 3 million steps per year. Notably, when taking every step, they exert twice or three times of their body weight on their feet [6-8]. Over time, this causes development of damages in the feet, which are mostly normal based on age. Furthermore, for example in sports



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