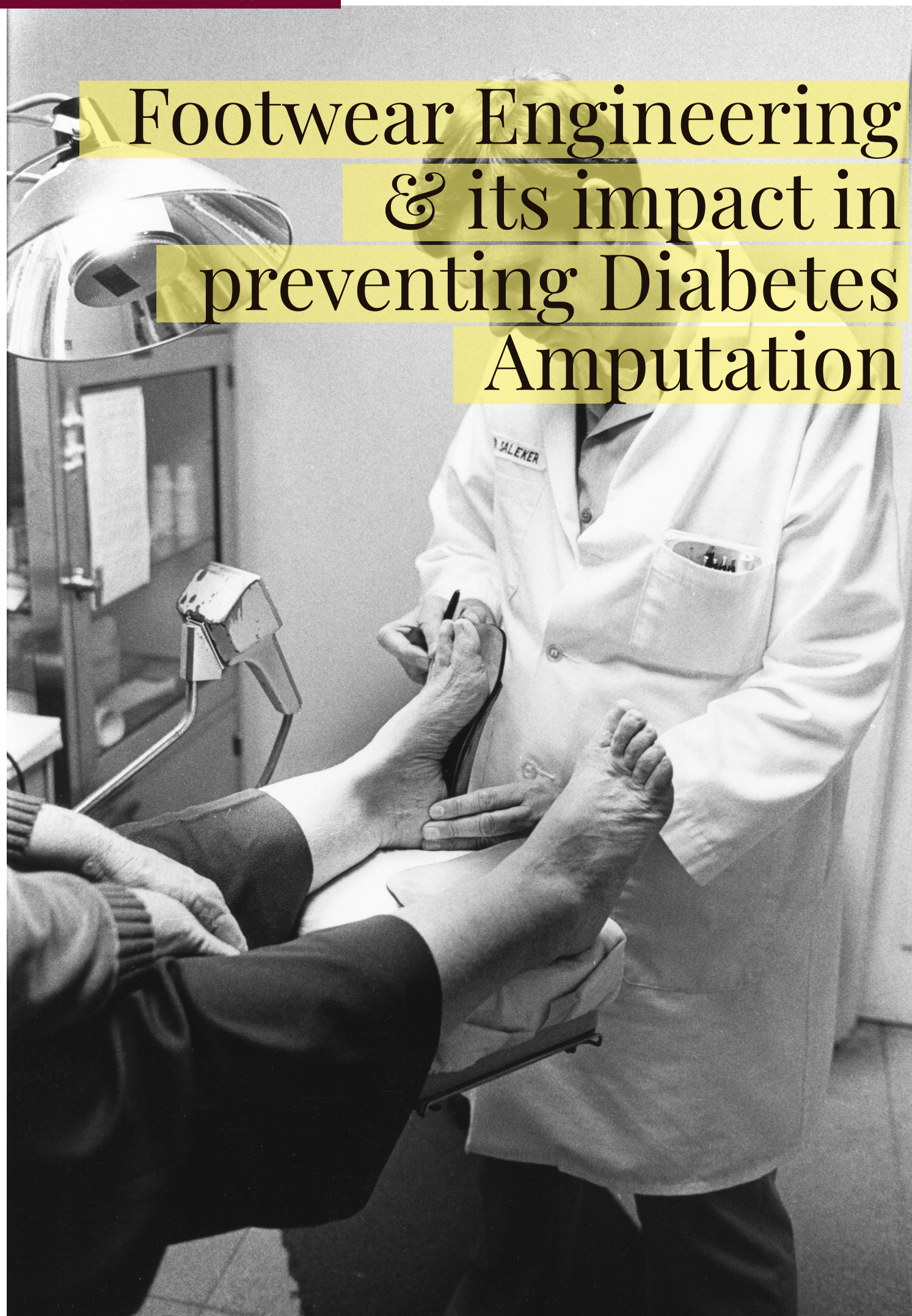


Footwear Engineering & its impact in preventing Diabetes Amputation



When we think of cutting edge technology our minds usually think of latest smartphones, artificial intelligence based chatbots, machine learning, data science, AR/VR and what not. But what if the most life changing technology that we are discussing does not lie in our hand but something that we put our feet into everyday? What if the future of life-saving medical device is waiting right under your feet? Yes, we are talking about footwear.

Diabetes mellitus which is one of the most prominent disease quietly escalated as global health crisis which is affecting almost more than 300 million individuals across every continent. This is a type of epidemic which is quietly spreading in a way that it is estimated that it will get doubled among people by 2030. While most of the public manages diabetes mellitus (grade 1 and grade 2) both with strict diet control, blood glucose monitoring, oral medicine/ insulin intake; they are extremely unaware about a completely different background associated with human lower limb deformity.

As per data reported in literature it has been found that almost 15 to 25% of people suffering from diabetes mellitus will develop a foot ulcer commonly known as DFU in medical terminology at some point of time after being diagnosed.

The root cause of this life threatening disease lies in chronic hyperglycemia (persistent elevated blood glucose level usually over an extended period of month/weeks as diagnosed in HbA1c test taking three month of blood glucose average, average blood sugar ~ 154 mg/dL or above), which causes damage to both vascular and nervous system both.



The damage caused to nervous system otherwise known as diabetic peripheral neuropathy (DPN) slowly numbs the lower end extremities resulting in development of diabetic foot ulcers which gets unnoticed for a long period of time. Due to this numbness, patient usually notice no change in their walking pattern losing their protective sensation developing initial blisters that too without pain or discomfort. An addition to this deformity is also development of peripheral arterial disease (PAD) resulting in plaque formation and restricting the vital blood flow to the lower limbs. When these tissues are deprived of essential oxygen and nutrient due to both DPN as well as PAD, consequently their healing mechanism stalls entirely resulting into diabetic foot ulcer (DFU).

Today, diabetes related foot infections are the primary causes of hospitalization and subsequently leading to foot amputation which at the other end is the extreme consequence of the same. Thanks to the intersectional alliance of footwear engineers, designers and medicals podiatrists that we are turning the waves by providing solution to these critical problems & by translating a basic everyday shoe into a protective armor against these catastrophic injuries before they even start.

The process of shoe development in a way preventing this diabetic foot ulceration lies in the core of "plantar pressure offloading" process. In a normal healthy person not affected with diabetes mellitus, high impact stress naturally occurs under the heel and ball of the foot.

However, in a diabetic patient when their gait pattern is closely analyzed it is observed that these patterns gets altered due to neuropathy and various structural deformity like hammertoe get developed due to which these high impact stress get concentrated and dangerous. The medical community focuses on redistribution of these concentrated stresses evenly across the foot entire biological surface. This reduces entire foot stress thus ensuring that foot deformity gets avoided. This successful offloading of pressure lies in utilizing the different types of material including multi density material arranged in a strategic layout pattern. The footwear often developed for solving this issue is therapeutic footwear. The choice of material for this therapeutic footwear varies according to the part of footwear being developed. For shoe uppers and linings, stretchable materials like fabrics, elastane bends, soft stretchable mesh can be used for treating bunions, hammertoe deformity and swelling without causing friction. High quality breathable leather can also be used which conforms to foot's shape while allowing for air circulation.

For Insole and footbed, EVA, Polyurethane, microcellular rubber (MCR), multi density layered material are also some of the options for developing the insole. However, for outsole and modifications, stiffed curved outsole from durable polyurethane along with slip resistant rubber material are mostly used.

Apart from material selection, it has also been found that walking speed also significantly affects the changing underfoot pressure. *Walking speed of 4 km/h is suggestive of dropping tissue strain to its lowest possible values.*

Also tools of Industry 4.0 like integrating smart technologies, automated manufacturing and digital design are used to creative an adaptive type of footwear which could be used on a day to day basis.