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An Integrated Model for Computer Assisted Diagnosis, Treatment and Design of Insoles for Diabetic Foot

The incidence of diabetes has increased significantly in recent decades. In Germany, there is an estimate of three million diabetics and this number is growing at a rate of about 2 percent per year. In the U.S.A., the American Diabetes Association estimates that thirteen million people suffer from this condition, representing 5.2 percent of the entire population and every year, some 35 thousand patients have a lower limb amputated. In Latin America, it has been reported that the prevalence of diabetes is of the order of 14 to 20 percent, according to a research conducted by the WHO's Ad Hoc Diabetes Reporting Group. In Colombia, a study by Ashner et al concludes that the prevalence is 7 percent in both sexes.

Ulcers may appear on the feet of the diabetic due to neurovascular conditions that lead to loose sensitivity. This lack of sensitivity impedes the patient to detect biomechanical alterations in the transmission of load through the sole, which produce zones of pressure overload on the plantar feet surface. Measures have to be taken in order to prevent the appearance of ulcers, which may finally lead to amputation.

As part of the diagnosis and treatment of this condition, it is therefore important to discover and quantify the distribution of static and dynamic pressure points on the sole, i.e. when standing still and walking. While in developed countries gait analysis is commonplace, in Colombia there was no reliable equipment to measure pressure points on the soles of diabetic patients. The patients are evaluated empirically and the prescription of inner soles and shoes "as a preventive treatment" is carried out on a "made-to-measure" basis, using rather crude and unreliable methods. In some cases, inner soles, standardized for other populations, such as the USA and Europe, are imported but are not reliably tested to conform to the anthropometric characteristics of the colombian population and thus, its application may not be effective.

Description of the System

A research group from the Pontificia Universidad Javeriana from Colombia in colaboration with Bioengineering Unit of Strathclyde University from the United Kingdom and COLCIENCIAS have developed an improved and articulated model for the diagnosis and treatment of the diabetic foot, and design of inner soles, all assisted by computer. A knowledge-based system has been developed whose inputs consisted of clinical, biomechanics, anthropometric, plantar pressure, and the criteria for design process information. This information combines both qualitative and quantitative data, which together with a case database will be used to produce a diagnosis and prescription of the type of insole for the specific patient. The diagnosis and prescription system will combine case-based reasoning, objects and production rules for knowledge processing and numeric computation. The prescription produced by the system constitutes an initial specification of the insole, which will be interactively refined by the insole designer utilizing finite element models of the foot and insoles. Prototype insoles will be implemented and tested with the patients and both, the information from the finite element models and patient measurements and clinical observations will be fed to the case database of the system thus producing a close-loop system. With this interactive approach it is expected that the insole design is optimized and that the system knowledge base evolves over time thus leading to a continuous insole design improvement.

Methodological Aspects of the Project

An epidemiological study had been developed to determine the characteristics of the normal and the diabetic populations in Santafé de Bogotá - Colombia. Within the diabetic population and using the pressure measurements from the PAROTEC system, groups of foot pathologies has been analyzed using data analysis techniques.

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