Numerical study on monitored foot temperature

A. H. Encinas[†], J. Martín-Vaquero[†], A. Queiruga-Dios[†], J. Bullón Pérez[†], Jose Torreblanca González[†], Alfonso Martínez Navas [*]

University of Salamanca. Salamanca. E37008 Spain[†]

University of Extremadura, Spain [*]

1 Introduction

Diabetic disease is one of the most important health problems. Because of its extraordinary frequency and also because of its enormous socio-economic repercussions. Most people with diabetes are prone to suffering some kind of nerve damage or injury throughout their lives, especially as they get older and have diabetes for a long period of time.

One of the possible lesions of nerves that can be caused by diabetes is the so-called peripheral neuropathy. Peripheral neuropathy causes pain or loss of sensation in the toes, legs, hands, and arms. In general, the feet and legs are affected before the arms and hands.

Its symptoms vary depending on the affected nerves. Some patients have no signs or evidence. But these symptoms and problems get worse over time and may include: numbness; tingling; loss of sensation or pain in the limbs; loss of muscle in the feet or hands; and changes in heart rate.

One of the most feared problems, as it affects the quality of life of diabetic patients, is the appearance of ulcers in their feet. They are a sequel to two of the most common chronic complications of this disease: peripheral neuropathy and vascular insufficiency. The combination of these factors, neuropathy and angiopathy, together with the high risk of infection and the intrinsic and extrinsic pressures due to bone malformations in the feet, are the final triggers of the diabetic foot.

The prevalence of ulcers varies according to sex, age and population from 2.4% to 5.6%. It has been estimated that at least 15% of diabetics will suffer from foot ulcerations during their lifetime. It is also estimated that about 85% of diabetics suffering from amputations have previously had an ulcer [2].

Additionally, World Health Organization estimates that the prevalence of Diabetes Mellitus (DM) at the start of the twenty-first century was 2.1% of the world's population. That is, about 125 million people.

This motivates the use and emergence of wearable physiological monitoring systems. As a consequence, our research group is trying to develop a system that measures temperature in diabetic feet and sends the information to an

[*]e-mail: {ascen, jesmarva, queirugadios, perbu, torre}@usal.es, podoalf@unex.es

electronic device that collects it for research purposes. In the meanwhile, we are analyzing some numerical results obtained from a survey conducted amongst a control group. This survey and its statistical results will be detailed in the next sections.

2 Collection of numerical data taken from a survey

The main goal of this work is analyzing the main factors of the increase or decrease of the feet temperature in several points. But also, we want to know how these and other data (external temperature, practice of sport activity, intensity of this practice, blood pressure, body mass index, etc.) may affect to the comfort in the feet.

Thus, we have developed a survey to collect several data from diabetic and non-diabetic patients. Some aspects included in this survey are the following:

1. General personal information as: name, surnames, gender, age, weight, height, body mass index, step size. We also inquire if they are wearing hills (we suspect that this fact has influence in the feet temperature near the fingers), type of foot (pronation, supination, etc), core body temperature or if they have diabetes and which kind of diabetes they have.

2. Different habits: feeding, healthy, drinks or medication.

3. Date of the survey, and weather data.

4. Temperature and humidity data in the room, and the temperature data from other several different points in the feet. In fact, we will start with the measure of the temperature in 17 point per foot, 9 in the sole and 8 in the dorsal side.

   In a previous work [1], some previous statistical analysis (dendograms and correlations) suggested that it might not be necessary to obtain the temperature in so many points in the control group. Now, we are also adding data with diabetes patients.

5. Comfort data: this part of the survey includes questions about the activity done in the last half an hour, intensity of this activity (we would like to obtain temperature data of the same people before and after sport activity), comfort of the footwear, if they have any ulcers or pain in the feet and where.

We show some screenshots on the survey in Fig. 1. They display different types of questions in the survey. Data are taken with a thermal FLIR E60bx camera that take images with the following characteristics: Resolution: 320×240 pixels; Total Pixels: 76,800; Thermal Sensitivity: $< 0.045^oC$; Accuracy: $\pm 2\%$ or $\pm 2^oC$ of reading (RSS analysis); Temperature Range: -4^oF to $+248^oF$ (-20^oC to $+120^oC$).

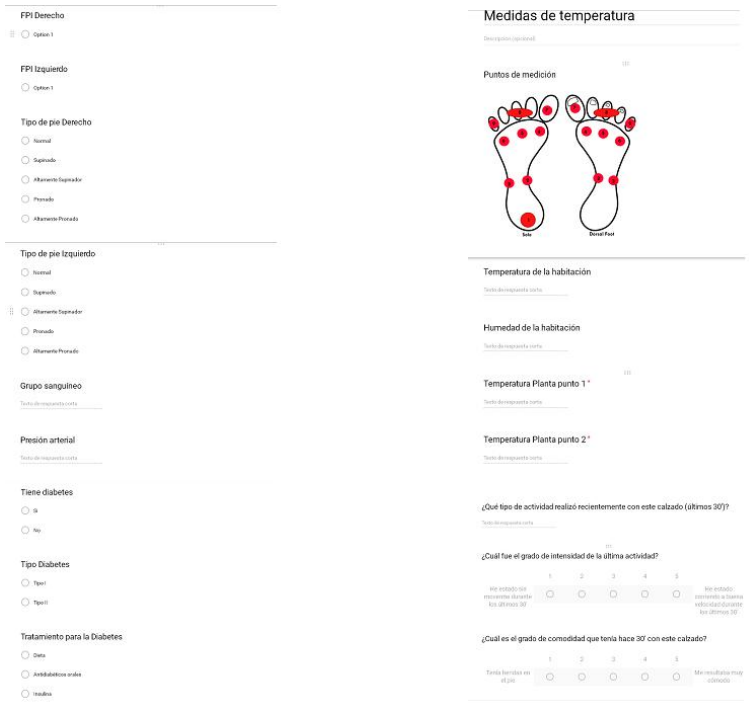

Figure 1: Several screenshots display the main types of questions on the survey.

Acknowledgements

The authors acknowledge support from the Fundación Memoria D. Samuel Solórzano Barruso, through the grant FS/14-2016.

References

[1] A. Q. Dios, J. B. Pérez, A. H. Encinas, J. Martín-Vaquero, A. M. Navas, and J. T. González. Skin temperature monitoring to avoid foot lesions in diabetic patients. *Advances in Intelligent Systems and Computing (submitted)*.

[2] N. I. of Health et al. National institute of diabetes and digestive and kidney diseases. *Diabetes in America, 2nd edition. NIH Publication*, (95-1468), 1995.