RESEARCH REGARDING SMART DEVICES FOR DIABETIC

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ABSTRACT: Diabetes, as it's commonly called, belongs in a group of metabolic disorders characterized by high blood sugar levels over a prolonged period of time. Symptoms often include frequent urination, increased thirst and appetite. In some cases, patients can even lose their limbs or fingers due to gangrene. In this scientific research I chose to speak about diabetes in general, it's socio-economic impact, showcase two smart devices dedicated for profilaxy treatment, a 3D model followed by a prototipe of one of the devices and a quiz regarding smart devices specifically tailored to gangrene prevention and monitorization of the illness.

Key words: Diabetes, socks, gangrene, Arduino, sensors

1. Introduction

This scientific study attempts to touch a few fine points, theoretical knowledge meant to better understand diabetes and Charcot's foot, discuss the different clinical approaches that apply to this particular complication and also talk about the associated risks involved. A short broaching of electrostimulation , normally used in muscular pathology and a preferred technique in Rehabilitation Medicine.

Based on the subjects listed above we strive to propose the implementation of new assistive devices, that monitors the plantar region of the patient, devices that should complement each-other for maximum efficacity.

Last but not least I have showed a series of statistics for better understanding and explaining the general population's perception of diabetes as a disease and the role of assistive devices in improving the patients quality of life.

2. The state of art.

2.1 Classical clinical approach of Charcot's Foot.

Charcot's diabetics foot represents one of the most important complication that can appear during the progression of diabetes, it is very destructive, through fractures, dislocations, and articular destruction in the affected limb. The active phase of the pathology is frequently erroneously diagnosed, a fact that inevitably leads to permanent deformation, ulcerations, and in the end, amputations. A proper therapeutical approach should manage to diagnose the disease in a time-efficient manner and avoind unwanted complications.

The patients that suffer from diabetic's foot have a shorter life-span of about 14 years mainly because of increased cardio-vascular risk in neuropathy. Clinically speaking, the patients go to the

hospital accusing redness, swelling, a burning sensation in the affected limb. Pain is present in approximately 50% of cases and can be joined by early permanent deformities.

Secondary to a positiv diagnosis, the foot is immobilised so that deformities are avoided (cast or orthosis), the evolution being monitored through specific investigations (MRI/CT) and interdisciplinary collaboration (orthopedics). After a period of three days the cast is removed and refittted (the affected limb returns to initial volume), the procedure is then repeated in 1-2 weeks.

In regards to post-therapeutical management, we must discuss the opposite limb "trap", which, after the first limb is affected must sustain a heightened weight in the following weeks, a fact that can lead to a secondary diabetic's foot, and as such, the patient must be informed about using assistive means for the healthy limb (Canadian crutch, appropriate footwear).

The most important step in post-therapeutical management is the rehabilitation of the patient, which, after prolongued immobilisation can sustain muscle loss, decreased bone density and can accuse articular rigidity. The normal course of action is a combination of physiotherapy and kinetotherapy.

2.2 Electro-stimulation: basic principles and applicability.

For a better understanding of how electrostimulation works, we have to talk about the mechanism on which neuropathy is based upon and the specific way it affects the nerves.

The main mechanism responsible for neuropathy is hypoxia, or better, a change in the physiological cellular metabolism that leads to a lack of oxygen intake, which in turn increases the neuronal gap and the distance a nervous impulse must travel, all this leads to a decrease of impulse capability and a lowered sensitivity in the affected area.

Initially, the felt sensation resembles a tickle in the affected territory because some impulses manage to reach said area, this phase is followed by more negative developments and as such, the sensation turns into one of pain, after which, in the end the entire segment is completely numb. Secondary to this process are muscle weakness, reduces blood flow (specific to diabetic angiopathy), deficiency in posture and mobility. .[5] [6]

Fig. 1 Positioning the electrodes during an electrostimulation session

3. Case study.

3.1 A new approach in home-care management of neuropathy afflicted patients.

Following the discussion above, which helped us better understand some basic physiopathology , we can now focus our attention on the applicability of said knowledge in an efficient and beneficial way for the neuropathy patients .

This paper first described the possibility of using SMART socks for monitoring plantar temperature and detection of small variations that appear during Charcot's foot active phase. I propose to enhance the design and offer patients the possibility of both prophylaxis and rehabilitation in a autonomous and cost efficient manner.

I propose a new idea, that of adding a stocking accessory so that it may perform a group of functions together with the sock, more specifically, to offer small electrotherapy sessions following pre set guidelines established by the physician.

We will be using a structure made up from a normal stocking like fabric on which we will apply a number of PMT electrodes that will stimulate the main nervous branches (Sciatic Nerve, Tibial Anterioris, Sural Nerve), this stimulation has a double purpose: it stimulates the patients nerves (metabolic and neurotrophic role) in the latent period of the disease and it offers a analgesic effect for those patients that are in the active phase of the disease. [8]

There will be added a number of band-like electrodes for the main muscular groups (quadriceps femoris, biceps femoris, semimembranosus, semitendinosus, tibialis anterior). These bandlets will initialise the program using low-frequency currents (5-20V, Alternative Current) that are meant to relax the muscles and stimulate venous circulation in the lower extremities. Two specific electrodes will be appointed to each nervous fascicle, one that has rapid conductivity (for bridging the electrical neuronal gap) and one that has slow conductivity (for physiological-like stimulation). The electrodes described will begin their cycle after the bandlets end their activity [7].

Fig. 2. Visual representation of the positioning of the electrodes on the surface of the lower limb

At the end of the procedure we will introduce a combined stimulation of the two electrode types with a frequency of 7.83Hz, that should manage to generate a post-procedural secretion of endorphins that directly help with the patients pain management.

In practical terms, the stalking works as a prophylactic type of therapy for diabetic patients at risk of developing Charco's foot and as pain management system for those that have the active disease. We use the supposition that one daily session should be enough for prophylactic purposes and two daily sessions for those suffering of Charco's Foot, these sessions are adjusted according to the physician and the associated pathologies.

Bearing in mind the technical limitations of this paper, the project is still in early stages but has the potential of being an assistive device of reduced cost, easy to use and with a high safety profile. This

concept has the potential of enhancing the meaning of the term assistive device, managing to bring rehabilitation techniques in the homes of our patients, giving it a enormous value both socially and economically.

3.2 CAD Prototype and functionality testing.

Within this paper I have managed to construct a 3D simulation in CATIA V5 and a physical prototype meant to showcase the functionality of one pair of socks and it's ability to monitor plantar temperature. The CAD simulation and the physical prototype contain the same components as to facilitate the viewing of the whole process, from beginning to the end.

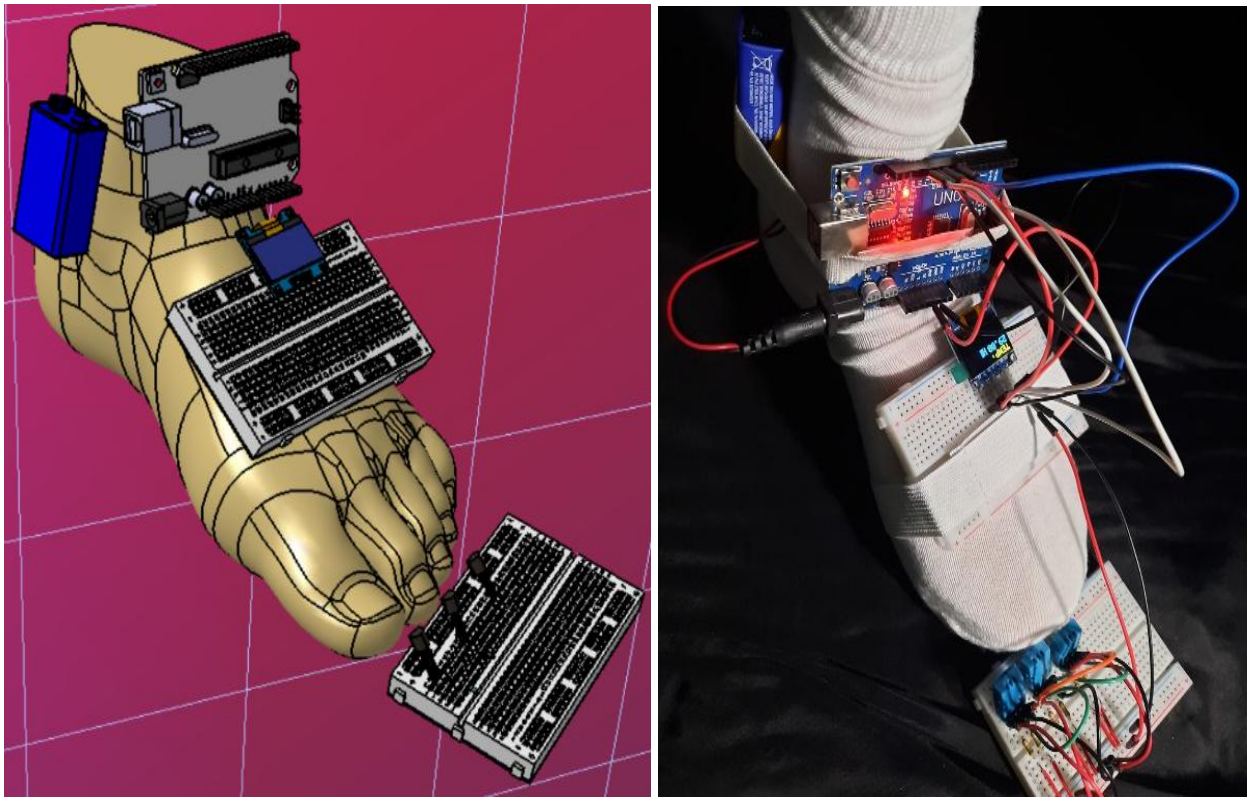

Fig 3. CATIA V5 Simulation (left) together with the physical prototype of the temperature monitoring assistive device

The ensemble is made up from one Arduino Nano R3 board, one OLED display and three temperature and moisture sensors (we will not be using the moisture function in our study), adjecant to these components there are also a number cables and connection devices (jumper cables).

The final result is an avarage of the three temperature measurements, avarage that should fluctuate to no more than 2 degrees in comparison to the healthy limb. If the device registers a fluctuation of more than 2 degrees than it alerts the users , such variation in temeperature is an important prognosis factor in Charco's foot diagnosis and stand to reason that it could prevent the onset of gangrene and eventual amputations. [2] [3] [4].

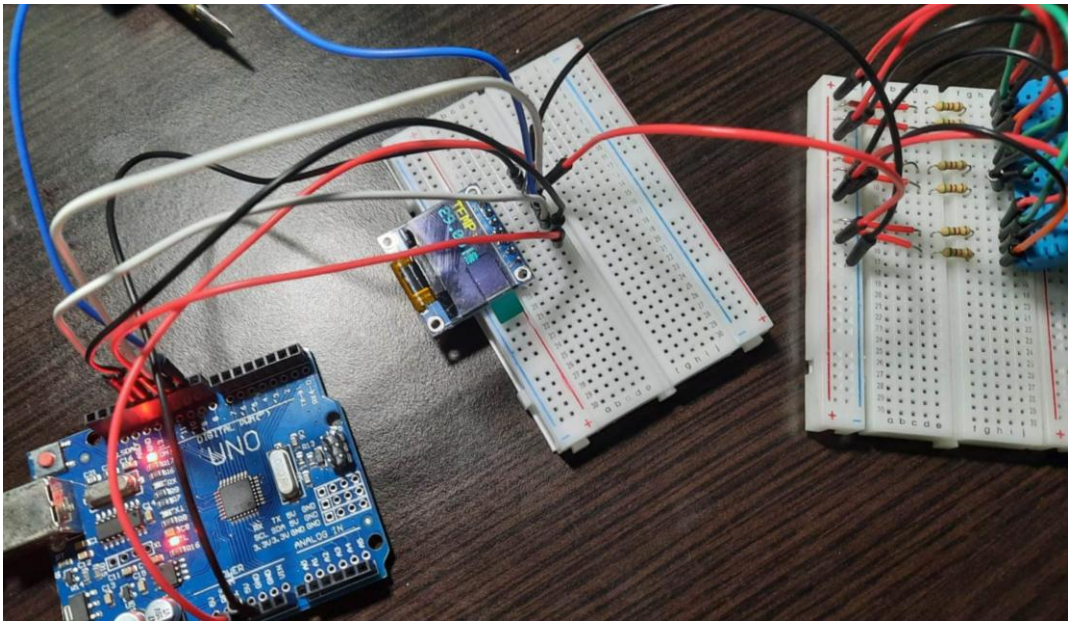

Fig. 4 The Arduino assembly that reads the temperature and displays it

3.3 Discussions regarding an opinion poll related to the population's general knowledge of SMART devices for diabetes patients.

Using a statistical model which includes 123 people, we can observe that 87% of subjects have a acquaintance that suffers from diabetes. The participants believe that diabetes affects the quality of life for diabetic patients, 84.5% believe that the drop in quality of life is significant. 65% of subjects have stated that their acquaintances suffer from complications. 31.3% have mentioned diabetic retinopathy as the most common complication, soon followed by Charco's foot and diabetic neuropathy with 21.3%.

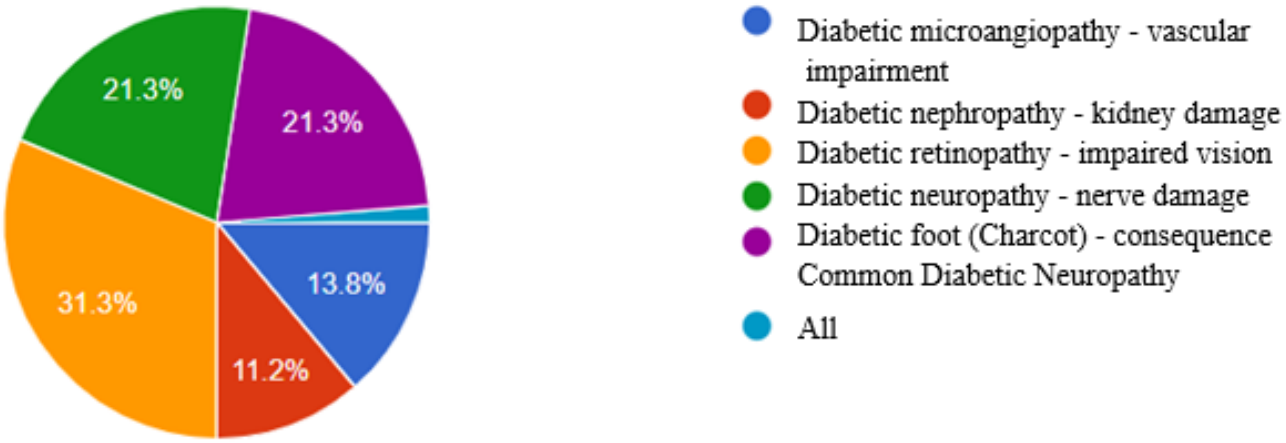

Fig. 5 Statistical representation of the most common complications in diabetes and their frequency

If we were to discuss the most important variable to our current paper, 38.2% of subjects have stated that they know at least one person that suffered amputation secondary to the progression of diabetes.

As for the the frequency of assistive devices in the households of our subjects, 83.7 have stated that they do not use or have relatives/acquaintances that use them. The most popular device chosen when asked if they would buy one such device is the physical assistance device.

Speaking specifically of assistive devices destined for diabetic patients, the most familiar device is the blood-sugar monitor device (45.5%) followed shortly by the insulin dosage monitoring device (19.5%).

Statistics speak for themselves, most patients in our country do not use assistive devices but 74.8% of subjects think they would benefit the diabetic patient and 97.6% of them would recommend one of the the devices mentioned in our query.

As for the plantar temperature monitoring socks, 70.7% of subjects would consider them useful and 82.1% would recommend them to an acquaintance.

Conclusions

This study can offer a broader view into a frequent and important pathology that has a high prevalence nationally and internationally. The purpose, is not informative, strictly speaking but also perspective as it can imagine the possibility of one device combining both prevention and long term conservatory treatment, we can then observe how a real public health issue can be easily monitored and approached, managing to increase both life span and life-quality in those affected by diabetes.

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