Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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DAAAM Symposium

A STUDY OF FATIGUE IN MULTIPLE SCLEROSIS USING A NEW WIRELESS MEDICAL SENSOR MEASUREMENTS SYSTEM

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Abstract: *Fatigue is reported as the most common symptom of Multiple Sclerosis. However, its mechanism is not clear understood. This paper presents our study protocol that we try to find the cautions of fatigue by using a new wireless medical sensor measurements system to measure the physiological parameters of patients continuously for 24 hours. The measurements includes ECG module, EMG module, Motion detection, Skin temperature module, and wireless data acquisition module. LabView is used for signal processing and data analysis. This paper presents the brief procedures of developing the wireless medical sensor devices and the experience of the pilot test. We conclude that the measurement devices do not disturb participants' normal daily routines, and it is suitable for the study of fatigue in multiple sclerosis.*
Key words: *medical sensors, fatigue, LabView*

1. INTRODUCTION

Fatigue is the most common symptom of Multiple Sclerosis (MS). It is reported that up to 97% of MS patients complained of symptomatic fatigue (Freal et al., 1984; Krupp et al., 1988, Fisk et al., 1994). Many studies have attempted to reveal its physiopathology. Most of the medical researches concentrated on the disease mechanisms of MS. Magnetic Resonance Image (MRI), functional MRI, Positron Emission Tomography and electrophysiology techniques combined with questionnaires were used on the studies of fatigue (Kos et al., 2008). They found various defined anatomical areas in the human brain that may be associated with fatigue. But its causations are still unclear. Other researchers found that some secondary factors might contribute to fatigue, such as sleep disorder, depression, psychological factors, medication, or other medical factors. On the other hand, there are only few publications regarding to the study of physiological parameters across time among MS patients. Therefore, our research, which is based on the cooperation between health science and engineering departments, concentrates on the less researched physiological parameters of MS patients across a continuous time span. We hypothesize that we could find more factors indicating fatigue that cannot be perceived following the ordinary procedures by measuring a battery of physiological parameters continuously among MS patients. We have developed a wireless medical sensor measurements system for this study. The paper will present brief developing procedures of the system and the experience from the pilot testing of the first patients group.

2. WIRELESS MEDICAL SENSOR MEASUREMENTS SYSTEM

Considering the measurements system will be used for acquiring data from patients continuously, it has to be a portable wireless device. Fig. 1 indicates the functional diagram

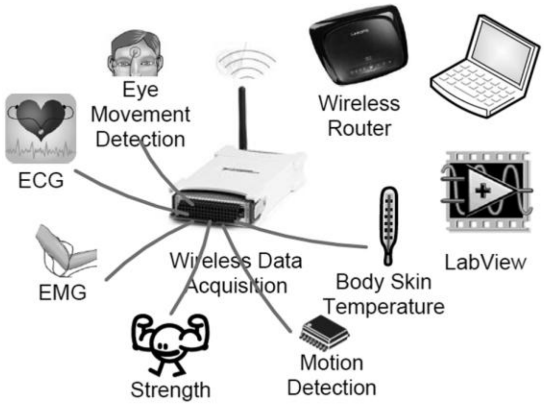

Fig. 1. Functional diagram

of the system. In the centre, it is a wireless data acquisition device that is used for acquiring signals. It converts the analog signal to digital and sends the data via a wireless router to the computer. Connecting to it, these are measurements devices of Electrocardiograph (ECG) module, Electromyograph (EMG) module, Eye movement detection, strength module, and Body skin temperature module. We use LabView for signal processing and data analysis.

2.1 Wireless Data Acquisition

We chose National Instruments (NI) devices for wireless data acquisition. NI WLS-9205 supports IEEE 802.11b/g wireless and Ethernet communication interfaces, which has 32 single ended or 16 differential analog inputs with 16-bit resolution and 250kS/s aggregate sampling frequency. A 15V battery with 2.2Ah, which can keep it running for 8 hours, powers the device.

2.2 Electrocardiograph and Electromyograph Module

Fig. 2.a. shows a small ECG box for continuously measuring ECG signals from patients. Texas Instruments INA321 CMOS instrumentation amplifier is chose to pre-amplify the ECG signals. It is a single-supply amplifier with a high common mode rejection ratio of 94dB. Three electrodes connects to the ECG box, where two of them detect ECG signal on chest and one sticks on the right leg for setting the correct potential.

A portable EMG module measures muscle activities, which is indicated in Fig. 2.b.. A pair of surface EMG electrodes detects signals from quadriceps, which should be pasted on thigh. Another one, which is similar as ECG, is for setting the potential. The analog signals will be amplified and filtered before transferred to WLS-9205. Overnight, the EMG module will be used for measuring rapid eye movement. The pair of electrodes is planed to be pasted on face with above and beneath an eye. Another electrode should be closed to temple.

2.3 Body Skin Temperature, Module Motion Detection and Muscle Strength Measurement

We chose a low cost, linear and low self-heating centigrade temperature sensor LM35 (Fig. 3.c.) to monitor body skin temperature. METEK Calibration Instruments ATC-156A is used for calibration. Considering we want to account the steps of the patients during the test, we chose two single axes accelerometers to detect the motion of both legs, which are shown in Fig. 2.d.. If single axes accelerometer is not sufficient, we will consider 2-axes or 3-axes accelerometers combined with gyroscope for precise motion detection in future work. Besides, we have made a muscle strength measurement based on Z6FC3 load cell, which contains a pedestal, a load cell and a handle. It can measure strength of biceps with a maximum capacity of 75Kg or approximately 750N.

2.4 Program in LabView

We use LabView for signal processing and data analysis. Because all channels share one AD converter, there may have influences between channels. To limit the influences, an additional channel that measures ground is added to isolate signals between two border channels. Fig. 2.f. shows an example of the program in LabView, when the system was acquiring data. It contains four parts including Step measure, EMG signal, ECG signal and Temperature. Considering the system runs for continuously 24 hours, we do not implement advanced signal processing during the measuring. The data will be saved in a file that named by the ID of participants for further analysis.

3. STUDY DESIGN

In this study of fatigue in MS, we plan to recruit three groups of participates including 10 fatigue MS patients, 10 non-fatigue MS patients and 10 age-matched healthy controls. Participants should be aged from 20 to 65 with normal mobility, but does not have depression, severe pain or cognitively handicapped. Each participant will carry the measurements for continuously 24 hours covering one day and night. By starting of the test, they need to complete a form of their information, and following a series of tests including a short memory test, chair rise test, 10-meters walk test and 6-mins walk test. Besides their daily activities will be recorded in a notebook for further data analysis. We expect to find the differences of physiological parameters among three groups, further more we hypothesize that we can discover more cautions of fatigue or indicate fatigue following this study design.

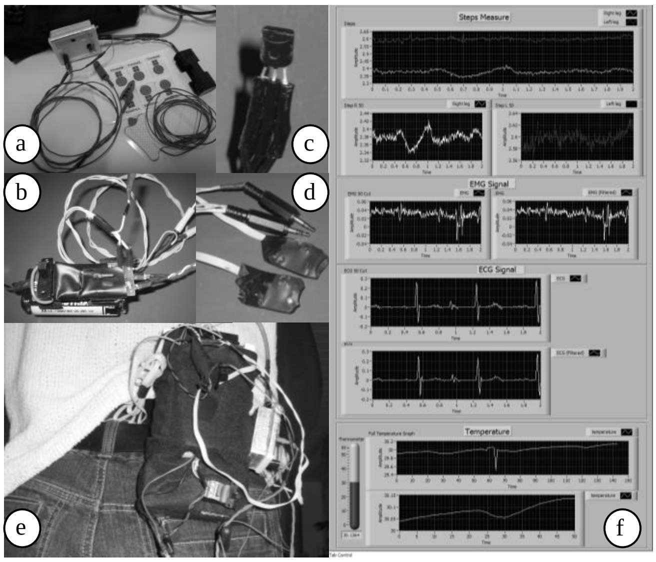

Fig. 2. Wireless medical sensor measurements system

4. RESULTS AND CONCLUSION

The study is still in processing. We have tested among 10 MS patients. Each of them carried the devices for 24 hours including day and night, which can continuously measure ECG, EMG, body skin temperature, eye movement and motions signals. Participants did not complain any inconvenience with carrying the measurements. All data have been saved for further analysis. Therefore, we conclude that the measurements system does not disturb participants' normal daily routines, and it is suitable for the study of fatigue in multiple sclerosis.

4. FUTURE WORKS

We are currently working on getting more data from other participants. After we collect all the data, we will implement the advanced signal processing procedure to extract useful information. A similar algorithms from our previous work of developing an intelligent electronic stethoscope (Yu et al., 2008) can be used for analyzing ECG signals. Furthermore, data analysis algorithms and bio-statistical theorems will be used for finding the association between fatigue and the physiological parameters.

Besides, we have a parallel project on developing the measurements device in embedded system. A series of microcontrollers and flash memory are used for acquiring the signals and saving data separately. It covers the drawback that participant are limited by the distance of the wireless router, but cannot be used for real time monitoring.

5. ACKNOWLEDGEMENT

Big thanks for the financial support from the Faculty of Engineering and Faculty of Health Science. We are very thankful for the participants at Sønderborg Hospital and Mads Clausen Institute. Thanks to Susanne Aabling and Helle Aabling for arranging the meetings with the patients and showing the information of medical instruments. Special thanks to Egon Stenager for his expert support in MS.

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