DEVELOPMENT OF HOME USE ANKLE REHABILITATION DEVICE USING FORCE SENSOR

CHEOK YAN QI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

2018/2019

UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Development Of Home Use Ankle Rehabilitation Device Using Force Sensor

Sesi Pengajian : 2018/2019

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DEDICATION

Specially dedicated to,

My beloved parents CHEOK CHING CHOON and TAN SIEW WANG,

My sister CHEOK YAN HAN, CHEOK YAN YING and CHEOK YAN ROU,

My brother CHEOK YAN KAI,

Cousins and Friends,

&

Supervisor Dr. Khairuddin Bin Osman

ABSTRACT

Injuries to the ankle's lateral ligaments are the most common in sports and life in general. This statement has been proved by researcher K. Pasenan from his studies to investigate the injuries during the international floorball tournament from 2012 to 2015. A simple, less costly ankle rehabilitation device which can communicate with PC is being developed for home use. The device allows the patients to exercise their ankle in four movements which are dorsiflexion, plantar flexion, inversion and eversion. While exercising ankle, the force applied by ankle in those 4 movements are detected by force sensor, FSR402 that attached below an insole and send to Arduino UNO R3 board. The data is displayed in spreadsheet of Microsoft Excel by using Parallax Data Acquisition (PLX-DAQ), an add-on for Microsoft excel. Lastly, two dynamic graphs are plotted by using the offset function. Analysis of data is carried out in order to investigate the force applied by ankle in four movements for female and male. The force applied by female and male in the four movement for the same category of weight are similar.

ABSTRAK

Kecederaan ligamen buku lali sisi ini adalah yang paling biasa dalam sukan dan kehidupan secara amnya. Kenyataan ini telah dibuktikan oleh penyelidik K. Pasenan dalam pengajiannya untuk menyiasat kecederaan semasa pertandingan bola lntai antarabangsa dari tahun 2012 sampai tahun 2015. Sebuah peralatan pemulihan buku lali yang lebih murah dan boleh berkomunikasi dengan computer telah dicipta untuk digunakan di rumah. Pearalatan ini membolehkan pesakit untuk menjalankan latihan buku lali berdasarkan empat pergerakan, iaitu dorsifleksi, akhiran plantar, penyongsangan dan eversi. Semasa menjalankan latihan buku kali, daya yang dikenakan berdasarkan empat pergerakan tersebut dikesan oleh sensor kuasa yang dilekatkan di bawah kasut insole dan dihantar ke Arduino UNO R3. Data dipaparkan dalam lembaran sebaran Microsoft excel dengan menggunakkan Parallax Perolehan Data (PLX-DAQ), sebuah peralatan tambahan bagi Microsoft excel dan dua graf dinamik diplotkan. Analisis data dijalankan untuk menyiasat daya yang dikenakan oleh buku lali dalam empat pergerakan untuk wanita dan lelaki. Daya yang digunakan oleh wanita dan lelaki bagi empat gerakan buku lali untuk kategori berat badan yang sama adalah sama.

ACKNOWLEDGEMENTS

First of all, I would like to express my gratitude to my supervisor, Dr. Khairuddin Bin Osman for his advice, guidance and suggestions. He lends a hand in guiding me on the right track to do my project and motivating me when facing circumtances.

Secondly, I would like to express my deepest gratitude to my family members for their support and motivation. Moreover, I would like to thank my housemates from FKEKK because they give me support during my research. They give also suggestions and pieces of advices about my project.

Lastly, I am very thankful to Dr. Hazli Rafis Bin Abdul Rahim who always give me the useful information about the final year project.

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LIST OF SYMBOLS AND ABBREVIATIONS

PLX-DAQ	:	Parallax Data Acquisition
VE	:	Virtual Environment
LED	:	Light Emitting Diode
PC	:	Personal Computer
RICE	:	Rest, Ice, Compression, Elevation
AREF	:	Analog Reference
USB	:	Universal Serial Bus
I/O	:	Input/ Output
DOF	:	Degree of Freedom
FSR402	:	Force Sensitive Sensor 402

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CHAPTER 1:

INTRODUCTION

In this chapter, the project background is discussed in order to describe the development of idea for the project. Besides, the problem statements, objectives, scope of project and thesis structure will also be discussed in this chapter.

1.1 Project Background

Injuries to the ankle's lateral ligaments are the most common in sports and life in general. A prospective study is done by K. Pasenan to investigate the injuries during the international floorball tournament from 2012 to 2015 [1]. The study found that the ankle and knee ligament were the most common injury sites for body. The percentage for ankle injury was the highest (24%), followed by the head injury (18%) and knee injury (18%). 23% of the injuries were severe and causing athletes absence from sports for more than 28 days. Thus, rehabilitation regimens aim to promote healing and

prevent repeat injuries. Besides, another research done by K. Linnea Welton indicates that the ankle joint (22.3%) accounted the highest proportion of the recurrent injuries in his study, followed by the head or face (17.4%), knee (16.4%) and shoulder (7.2%) [2].Thus, rehabilitation after sports injury by following a biopsychosocial approach is very important [3]. Patients must often enhance their flexibility and strength beyond prior-injury levels in order to prevent repeat injuries.

A novel ankle rehabilitation device which can communicate with PC is being developed for home use. The system includes hardware and software. The system's hardware is a combination of four force sensitive resistors (FSR 402), an Arduino UNO R3 Board, 4 LED and resistors while the system's software contains Arduino IDE and PLX-DAQ (Parallax Data Acquisition), an add-on tool for Microsoft excel to create log excel sheet. The device allows the patients to exercise their ankle in four movements which are dorsiflexion, plantarflexion, inversion and eversion after ankle surgery or injured. While exercising ankle, the four FSR 402 force sensing resistors which attach below an insole in different positions are used to sense the force applied by ankle in those four movements. The readings sensed by sensor are then send to Arduino UNO R3 Board which connect to PC and showed in the PLX-DAQ of Microsoft Excel. Two dynamic line charts are generated by offset function in excel to shows the readings of four FSR402 in analog and force sensed by four FSR 402. This device can work together with the game created through Unity. While exercising, the patients can interact with a game-like virtual environment (VE) and develop strength of ankle in a more enjoyable condition. The PC will run game-like virtual reality exercises that control the movement and output forces of the ankle. An ankle rehabilitation device based on game was presented by Jaime Andres Garcia. The paper focuses on the development of Mobile RehApp^{TM}, an augmented reality based

application for mobile devices designed for therapeutic support that aims to assist physiotherapists and patients on ankle sprain rehabilitation[4].

1.2 Problem Statement

Most ankle rehabilitation system that exists widely on the market are independent and can only work on its own and cannot connect with computer. Besides, those systems cannot carry out data collection and data analysis for the patients. For example, elastic band, roller foam and wobble boards. Thus, to ensure the ankle rehabilitation system is able to interact with PC to collect data, the expansion of excel, PLX-DAQ will be used to transfer data from the ankle rehabilitation system to Microsoft Excel. The data collected can be stored in the Microsoft Excel and sent to other people such as doctor and physiotherapists for analysed.

Usually, the main problem with a health based device is the user will easily get bored with the same routine and interface during rehabilitation, thus when there is an interactive game are meant to be played with the ankle rehabilitation device. The thrill of using the system will be lengthened to a longer period of time, thus making the device to be used for a longer time before the user gets bored of the device. The designed ankle rehabilitation device created in this project can work together with game platform in order to solve this problem.

Besides, the ankle rehabilitation devices in the market are expensive and complexity to use such as bio-inspired soft wearable robotic device, the Biodex Balance System and the Multi-Joint System 3 and ARBOT[5].

1.3 Objectives

The main objectives of this project are:

I. To design an ankle rehabilitation device which can communicate with computer.

II. To develop a simple and less costly home use ankle rehabilitation device.

III. To analyze the data of force applied by four ankle movement for female and male.

1.4 Scope of project

The project is only designed for ankle rehabilitation. The device allows the patient to exercise an ankle each time. The goal of this project is to develop a home use ankle rehabilitation device which provide convenience to the patients and therapists. This project will need to design a prototype of an ankle rehabilitation system using force sensing resistors (FSR 402), Arduino UNO and an insole with length 30cm and width 10cm. The prototype of an ankle rehabilitation system can be only connected to a PC to allow the transferring of required data from Arduino UNO R3 to an add-on tool of Microsoft Excel, PLX-DAQ.

The range of force that can be measured by force sensitive resistor, FSR 402 force sensing resistors are from 0.1kg to 10kg, which means the sensor can only detect the force applied by ankle of patients within this limit. The readings of force that smaller than 0.1kg or larger than 10kg are not accurate when refer to the data sheet of the FSR402. Thus, the patient should start ankle exercises by sitting on a chair with his or her foot flat on the floor, 90º between leg and foot as shown in the Figure 1.1.

Figure 1.1 Sitting posture

1.5 Importance and significance of the project

The device is user friendly because it uses the Microsoft Excel to record data and plot dynamic graph. Microsoft Excel is a popular software program that commonly used by most of the people. It can be used for Windows, Linux, macOS, Android and iOS. By using the Microsoft Excel spreadsheet, the users can save the data easily. The device in this project has the potential in commercialization because the device can be implemented in the hospital or our home to exercise the injured ankle. If the patient does the ankle rehabilitation exercises at home by using this device, he can send the data of rehabilitation to therapists through email without going out. The device can also connect to a PC to work together with a game-like virtual environment. Thus, the patients will not feel bored during ankle rehabilitation. Besides, the project will potentially cut out the cost of ankle rehabilitation instead of buying the expensive ankle rehabilitation device which are available in the market. The device produced in this project are movable, it can be carried easily to from one place to another due to its smaller size and simpler structure. The product will win a place in the market due to its lower price in manufacture and multi-functionality.