Design and development of foot pressure sensing massage stick

Yuting Hsiao, Dengchuan Cai, Chung-Wen Hung
Nation Yunlin University of Science and Technology, Taiwan
123 University Road, Section 3, Douliou, Yunlin 64002, Taiwan, R.O.C

Email: ergoresearch119@gmail.com, caidc@yuntech.edu.tw, wenhung@yuntech.edu.tw

Abstract

There are three key points in the operation of the Foot Massage Stick: sequence, direction and force. However, the force is not easy to be described and not easy to be learned. In order to provide the operator with visualization and information about the force during the operation, a pressure sensing massage stick was developed in this study. The features developed in this study are as follows. 1) The function of the assistive device is in line with the precision level of commercially available instruments. 2) The force and time duration of the operation can be displayed at any time during the execution process. 3) At the end of the execution, the maximum, average, standard deviation, and time duration of the force of the operation can be presented. This visualizes the force of the operation and makes it easy for the learner to check and meet the requirements for use.

Keywords: Foot Massage, assistive device, pressure sensing massage stick, force

1. Introduction

A foot massage is a type of massage that applies pressure to specific points on the feet and can be performed by a professional therapist or at home. There are two types of foot massage, one is Manual therapy (MT) and the other is using massage sticks. However, hand injuries are the second most common work-related musculoskeletal injuries among Manual therapy (MT) professionals [5]. This is because during massage, the hands must maintain repetitive movements and high-velocity forces to accomplish the task [6].

According to Cornwell et al., (2021) in the American Physical Therapy Association, 38.5% of Physical Therapists (PTs) suffered from Work-Related Musculoskeletal Disorders (WRMD). Among them, manual therapy (MT) caused the highest proportion of damage [3].

Albert, Currie-Jackson, & Duncan, (2008) surveyed 502 Canadian Registered Massage Therapists (RMTs) and found that musculoskeletal pain and discomfort was highest in the wrist and thumb, followed by the lower back, neck, and shoulders [1]. To effectively reduce the risk of musculoskeletal injury, preventive measures such as manual treatment or the development of new tools or equipment should be reduced [7].

The use of massage stick can replace the movements that cannot be operated by Manual Therapy (MT), including rolling, pushing, lifting, pressing, etc., and it can also press the acupoints more accurately. Therefore, the effect and operation satisfaction of massage stick is preferred by most of the massage practitioners. It can also reduce the incidence of hand pain and injury [2].

The technique of massage stick operation has three key points: sequence, direction and force [4]. Sequence and direction can be recorded visually, whereas force is less easily described and learned. The aim of this study was to develop a foot pressure sensing massage stick. It allows learners and operators to have visual information to refer to, and the power to record the operation process to assist the operator's learning and operation quality.

2. Methodology

The development of the foot pressure sensing massage stick in this study followed the product development procedure. At first, based on the analysis of market data, the study of existing technology principles and the investigation of usage requirements, the design objectives and specifications are formulated, and the functional design is carried out to achieve the design objectives. In this study, two technical applications such as piezoelectric elements and strain gauge elements are used as the basic components for the design. Secondly, the human factors design of the assistive device should be applied to the operation mode and human factors needs of the employees. Finally, by integrating the aforementioned functional design and ergonomic design, the development and pleasing appearance will meet the proposed design objectives and specifications.

3. Design Results

This study went through 5 designs and revisions, resulting in the development of an assistive device that could record the force exerted and met the design objectives. This model foot pressure sensing massage stick is the result of design 1-3 modifications. The pressure value is sensed by a single point pressure sensor (Fig.1). The internal structure has a pressure sensing

mechanism in three directions: x, y, and z-axis. The topmost structure of a massage stick is utilized to sense pressure in three axes. In order to optimize the effect of the massage stick in transmitting pressure to the sensor, four different shapes of the top part of the massage stick were made for testing (Fig.2). The result of the test was that the top part of the fourth massage stick was the most effective, and could detect the pressure value of each foot massage technique (Fig.3).

Fig. 1 Single Point Pressure Sensor

Fig. 2 Four different shapes of the massage stick top part.

Fig. 3 foot pressure sensing massage stick testing

3.1. Final Design

This pressure sensing massage stick is the final modification result. This design is rechargeable and is charged using the USB connector. The applied data can be displayed on the small display of the massage stick, eliminating the need for an external large screen to display the measured data. During the foot massage, the massage aid itself will display the pressure value and the time of application at any time. When the operation program is completed, the maximum value, average value, standard deviation and total application time of the force applied during this operation will be displayed on the screen(Fig.4, Fig.5). Fig.6 shows the appearance of the final design entity. Fig.7 shows the internal electronics of the pressure sensing massage stick. Fig.8 shows the charging device of pressure sensing massage stick. Fig.9 shows the external dimensions of the final design of pressure sensing massage stick.

Fig. 4 Pressure value data display

Fig. 5 Pressure value data display

Fig. 6 pressure sensing massage stick final design of the physical appearance

Fig. 7 pressure sensing massage stick internal Electronic Components

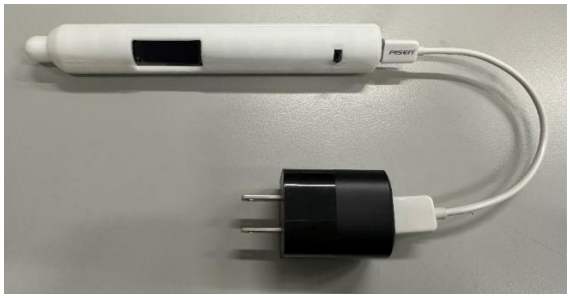

Fig. 8 pressure sensing massage stick charging device

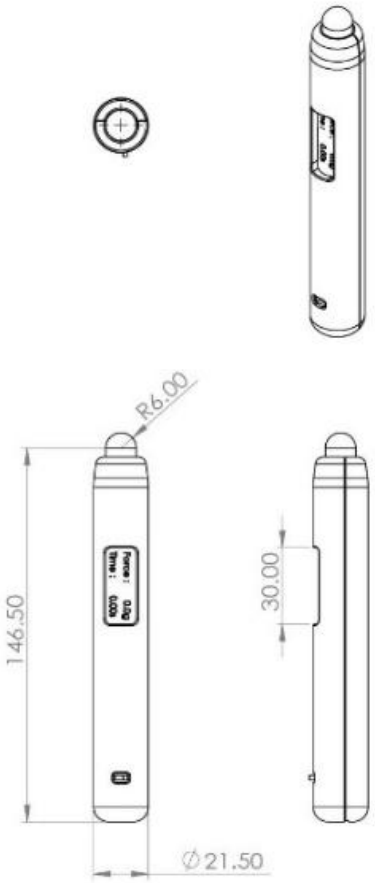

Fig. 9 External dimensions of the final design

3.2. Test and Verification

In order to test the functionality of the pressure sensing massage stick, a compression test was conducted in this study. Pressure tests were conducted using a commercially available pressure measurement device from G-CHEN Technology Corp. and a pressure sensing massage stick produced in this study. The test was conducted by pressing the top end of the pressure sensing massage stick developed in this study down on a G-CHEN Technology Corp. pressure pad and applying a force of 1kg. The results of the measurements were compared to the force values presented by the two devices. The results showed that the force value of 1kg was the same for both devices, confirming their validity. Fig.10 shows the test situation, the left side of the figure shows the pressure value of G-CHEN Technology Corp. equipment, and the right side is the final design of the pressure sensing massage stick applying force of 1kg. Fig.11 applies 1000g (1kg) of pressure to the pressure sensing massage stick. Fig.12 shows the result of pressure sensing massage stick pressure recording. 1kg of pressure is shown on the screen. Fig.13 shows the results of pressure sensing equipment testing by G-CHEN Technology Corp.

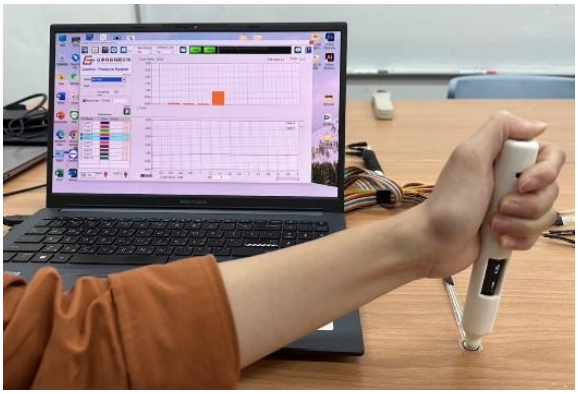

Fig.10 The left side shows the pressure value of the company's software, and the right side shows the 1kg force test of this design.

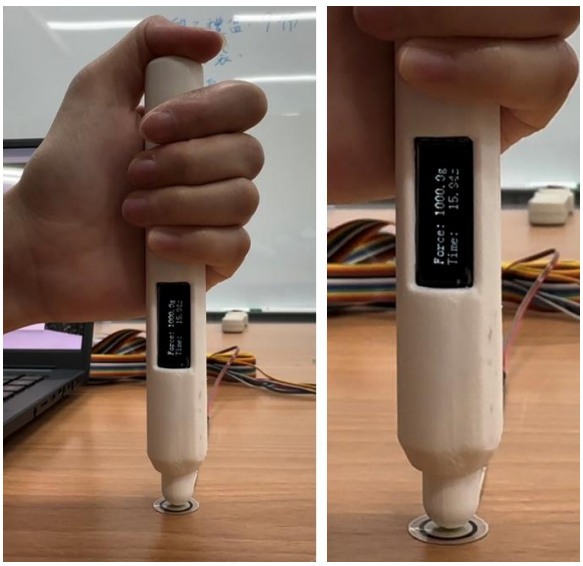

Fig.11 Pressure sensing massage stick applied 1000g of pressure.

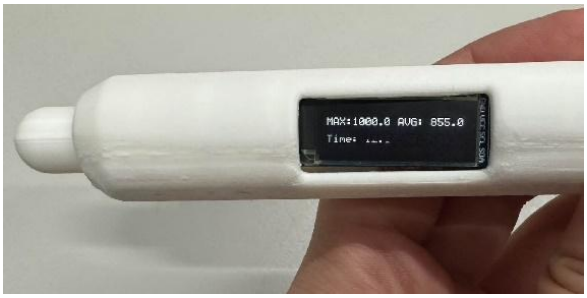

Fig.12 Pressure sensing massage stick test results

Fig.13 G-CHEN Technology Corp. pressure Sensing Equipment Test Results

4. Conclusion

This study went through five designs and revisions to develop an assistive device that could record the force of application and meet the design objectives. The design features are as follows: 1) The function of the assistive device is in line with the precision level of commercially available instruments. 2) The force and time duration of the operation can be displayed at any time during the execution process. 3) At the end of the execution, the maximum, average, standard deviation, and time duration of the force of the operation can be presented. This visualizes the force of the operation and makes it easy for the learner to check and meet the requirements for use.

Acknowledgements

The authors thank the National Science and Technology Council of ROC (NSTC112-2410-H-224-019) for financial support.

References

1. Albert, W. J., Currie-Jackson, N., & Duncan, C. A. (2008). A survey of musculoskeletal injuries amongst Canadian massage therapists. Journal of bodywork and movement therapies, 12(1), 86-93.
2. Caragianis, S. (2002). The prevalence of occupational injuries among hand therapists in Australia and New Zealand. Journal of hand therapy, 15(3), 234-241.
3. Cornwell, L., Doyle, H., Stohner, M., & Hazle, C. (2021). Work-related musculoskeletal disorders in physical therapists attributable to manual therapy. Journal of Manual & Manipulative Therapy, 29(2), 92-98.
4. Eugster, J., & Hu, C.W. (2017). Self-healing Foot Care: Father Josef 's Method of Reflexology. Cosmax Publishing Co., Ltd. New Taipei City.
5. Gyer, G., Michael, J., & Inklebarger, J. (2018). Occupational hand injuries: a current review of the prevalence and proposed prevention strategies for physical therapists and similar healthcare professionals. Journal of integrative medicine, 16(2), 84-89.
6. Glover, W., McGregor, A., Sullivan, C., & Hague, J. (2005). Work-related musculoskeletal disorders affecting members of the Chartered Society of Physiotherapy. Physiotherapy, 91(3), 138-147.
7. Sharan, D., & Ajeesh, P. S. (2012). Injury prevention in physiotherapists-a scientific review. Work, 41(Supplement 1), 1855-1859.

Authors Introduction

Ms. Yuting Hsiao

She received her M.S. degree in design from National Yunlin University of Science and Technology. Currently she is a Ph.D. student in the School of Design of National Yunlin University of Science and Technology.

Prof. Dengchuan Cai

He is a professor in Department of Industrial design, National Yunlin University of Science and Technology, Taiwan. He received his Ph.D. degrees in management from Taiwan University of Science and Technology and M.S. degree in engineering from National Chiao Tung University, Taiwan.

Dr. Chung-Wen HUNG

He received the Ph.D. degrees in Electrical Engineering from National Taiwan University in 2006. Currently he is a Professor in National Yunlin University of Science &Technology. His research interests include the IoT, IIoT, and AI application.