International Journal of Control and Automation
Vol.9, No.1 (2016), pp.251-258
http://dx.doi.org/10.14257/ijca.2016.9.1.23

Thermal Characteristics Analysis of Moxibustion Apparatus Capable of Controlling Temperature by Applying RS485 Communication

Tae-Gon Kim[1], Yong-Pil Park[2], Min-Woo Cheon[2*], Yang-Sun Lee[3]
Chang-Su Na[4], Dae-Hwan Youn[4], Jung-Chul Lee[5] and Jae-Young Park[5]

[1]*Department of Electrical and Electronic Eng., Dongshin Univ., Naju-si, Korea,*
[2]*Department of Health Administration, Dongshin Univ., Naju-si, Korea,*
[3]*Division of Convergence Computer & Media, Mokwon Univ., Daejeon, Korea*
[4]*Department of korean medicine, Dongshin Univ., Naju-si, Korea*
[5]*Department of Exercise Prescription, Dongshin Univ., Naju-si, Korea*
[1]*ykiki00@naver.com,* [2]*yppark@dsu.ac.kr,* [2*]*mwchoen@dsu.ac.kr,*
[3]*yslee48@gmail.com,* [4]*nakugi@hanmail.net,* [4]*yhuman@dsu.ac.kr,*
[5]*channel365@hanmail.net,* [5]*koungjun1@nate.com*

Abstract

This paper is based on a previous study on the temperature characteristics of thermal moxibustion for clinical trials. Moxa is one of Korea's traditional medical therapies, using thermal and chemical stimulations to cure and prevent diseases. Moxibustion is used by burning a pellet-like moxa cone put on the meridian and affected regions of the body, and the heat and products generated by burning triggers stimulations for treatment. As the previous study was about the quantification of traditional moxa cautery, this study developed a moxibustion apparatus for application to the experimental animal. The developed moxibustion apparatus enabled constant uniform heating by passing the temperature data of heater read through the K-type sensor to MCU by using RS485 communication. As a result, it was found that the temperature of the heater used in a moxibustion apparatus is 120℃; the uniform heat is passed in treatment temperature. It was also found that adjusting the duty rate can help pass the heat of various patterns.

Keywords*: Moxibustion, Traditional Medical, RS485,*

1. Introduction

Moxibustion is used as a treatment by using thermal and chemical stimulation generated when mugwort or other medicinal materials are burnt on the diseased peat or meridian system [1-4]. Even the same moxa cone can generate different kinds of heat and products generated by burning because of its different density and weight [7,8]. Such differences can lead to a difficulty in equal thermal and chemical stimulations, and cause difficult quantitative evaluation, which is a typical problem of traditional medical science. In particular, thermal response takes direct heat transmission to an affected region, so that if the thermal stimulation grows strong, it can cause severe pain and a suppurative scar on the skin [5, 6]. Much research on moxa treatment, which uses thermal and chemical stimulations, has mainly been conducted on heat transfer to supplement side effects like a burn scar. This paper produced a liquefied extract whose chemical stimulation is similar to a burning product's, and made possible quantitative heat transfer to an affected body region. Also, it created a heating system to give thermal stimulation to an affected body region, and designed and developed an apparatus to transmit heat safely and precisely by applying a thermistor.

ISSN: 2005-4297 IJCA

2. Concept

Moxibustion is attached to warm the diseased area directly or indirectly, and mugwort stimulates the diseased area. In order to study the effect of moxa treatment, we developed a small moxibustion apparatus with which the uniform heat can be applied to the affected area. Also, as treatment by a burning material, we selected the method of applying extracted liquid from a mugwort used as a medicinal substance to the affected area. The moxibustion apparatus is composed of a heating section, which can directly transfer heat to the diseased area, and the control device. Moxibustion apparatus was designed to control temperature simultaneously or individually, to apply 6 heaters to a number of affected areas. In this study, moxibustion apparatus to transfer an extract to an affected body region for thermal and chemical stimulations used a micro-controller for precise control. Figure 1 shows the composition diagram of a moxibustion apparatus.

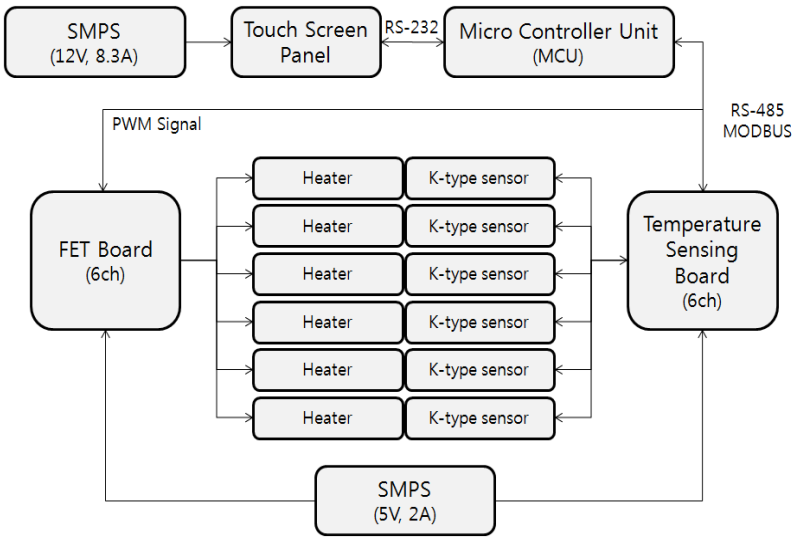

Figure 1. Diagram of a Moxibustion Apparatus

The produced device used a touch screen panel to check and enter the temperature status and operating time of heater, etc. [9]. For operation of the touch screen panel, a separate 12V SMPS (Switching Mode Power Supply) was used. Control signals could also be transferred by using MCU (Micro Controller Unit) and RS232 communication. In case of MCU used for overall control of the device, MPC82G516 with 8 bit RISC (Reduced Instruction Set Computer) was used. MCU operation speed is fast and can communicate with the touch screen panel used and temperature sensing module because it has 2 UART (Universal Asynchronous Receiver Transmitter) ports. The temperature of the heater was controlled by PWM (Pulse Width Modulation) and designed to be controlled by 1 ºC up to 300 ºC. The cylindrical ceramic heater with a diameter of 3.7mm was applied as a heater used in the device in order to indirectly transfer heat to the affected area by using a cauterizing plate commonly used in clinical treatment. A K-type sensor is attached to the outside of each ceramic heater and the thermal can be measured up to -100 ~ 550 ºC through AT command in the temperature sensing module designed to measure the thermal of 6ch. The thermal of heater measured in real time in temperature sensing module is transferred to MCU by using RS485 communication and can be maintained uniformly.

3. Experiment

3.1. Moxa Cone

Traditional moxa treatment includes a direct-heating method to burn the materials directly on the skin, and an indirect-heating method to allow some space between the skin and moxibustion and not to allow direct skin contact [10]. Moxa cautery used in clinical treatment uses the method of directly transferring heat by burning a moxa cone made by drying mugwort, and then compressing it into pellet form. In this study, we checked thermal characteristics passed to the contact surface by using a cauterizing plate that can burn 1 moxa cone in order to apply it to experimental animals. In order to measure the characteristics of the thermal reaching the actual affected area, the experiment was carried out at 22 ± 1 ºC of outside temperature. To measure the surface thermal, temperature changes for 20 minutes after the start of combustion reaction were measured 5 times by creating OPP (Oriented polypropylene) film on the bottom of cauterizing plate and using an infrared thermometer. Figure 2 shows surface temperature changes occurring during the combustion reaction of moxa cone.

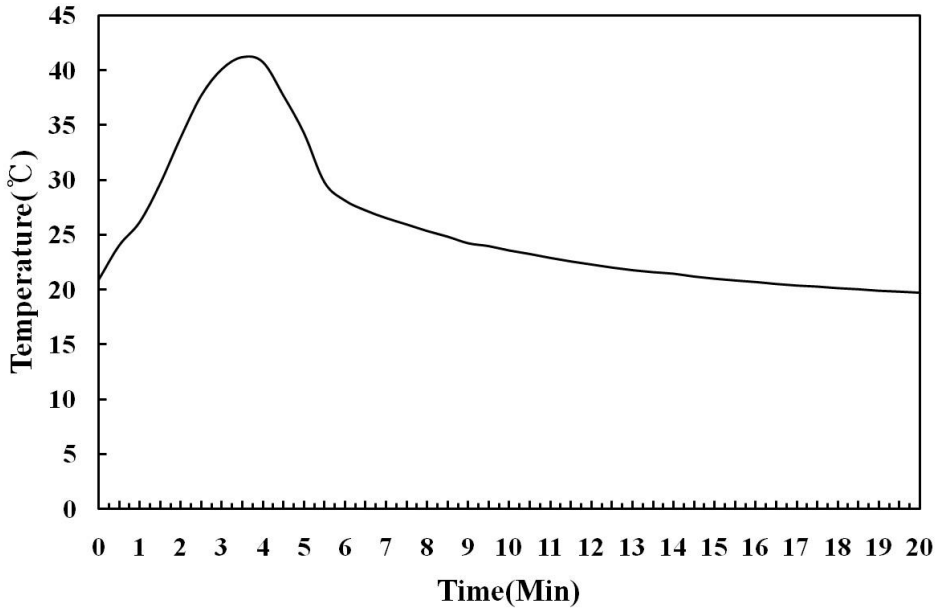

Figure 2. The Temperature Change According to the Reaction Time of the Moxa Cone Combustion

Moxibustion treatment of transferring indirect heat is known to be effective at 40 ºC or more. According to temperature measurement results, the temperature was rising slowly after combustion reaction and reached more than 40 ºC, which was the treatment temperature range in about 3 minutes, and was lowered sharply after maintaining the treatment temperature range for about 1 minute.

3.2. Moxibustion Apparatus

In this study, we measured temperature changes of indirect heat for 20 minutes by applying a cauterizing plate used in a combustion reaction of a moxibustion apparatus. The temperature of the ceramic heater was set to 100 ºC, 120 ºC, 140 ºC and the experiment was carried out after setting to hold for 5 minutes in full duty. Figure 3 shows the changes in indirect heat according to heater setting temperature.

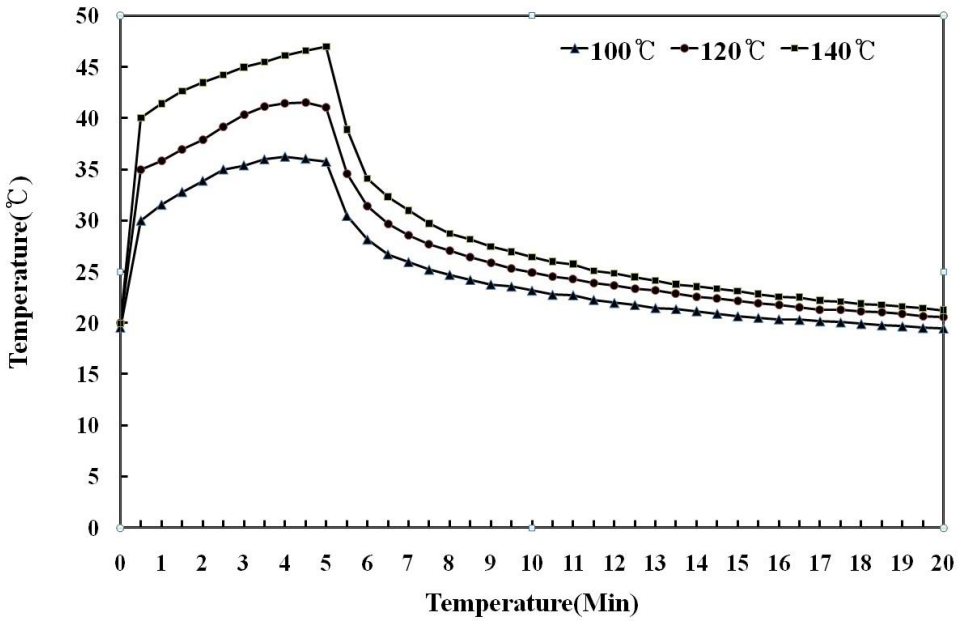

Figure 3. The Changes in Indirect Heat According to Heater Setting Temperature

About 5 to 6 seconds were taken until the heater was heated to the set temperature in full duty. However, as shown in Figure 3, it was found that the temperature of heat transferred indirectly changes rapidly in about 30 seconds after the operation of the equipment. Also, depending on the setting temperature of heater, indirect heat showed rapid changes in temperature for 30 seconds, about 30 ºC in case of 100 ºC, about 35 ºC in case of 120 ºC, and about 40 ºC in case of 140 ºC, and the temperature increased relatively slowly afterward. As with the burning of moxa cone, it reached the treatment temperature in about 3 minutes when the temperature of heater is 120 ºC. Also, it turned out that continuous treatment temperature range could be maintained until 5 minutes of treatment time.

3.2. Thermal Stimulation

In this study, the PWM method was applied for heating the heater. This is intended to apply thermal stimulation of different patterns by adjusting the time required until indirect heat reaches the treatment temperature. According to the results of Figure 3, the heating pattern similar to moxibustion treatment by existing combustion reaction was shown when the setting temperature of the heater is 120 ºC. These results occurred while the heater maintains the temperature constantly and, when lowering the actual duty rate, it takes much time to reach the treatment temperature range. Therefore, in order to analyze reaching of indirect heat to the treatment temperature and heating patterns during a relatively short period of time, we analyzed the temperature characteristics of the heater and indirect heat for 5 minutes by setting the temperature of the heater to 140 ºC and classifying duty rate of PWM into 20% unit from 100 to 20. Figures 4 and 5 show the temperature change of the heater and indirect heat.

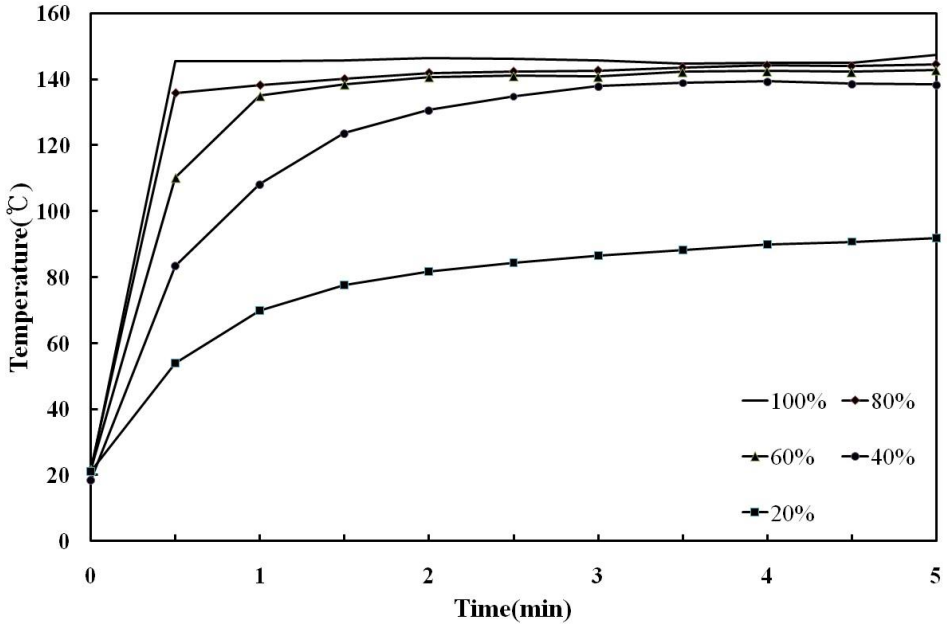

Figure 4. The Temperature Change of the Heater According to the Duty Rate

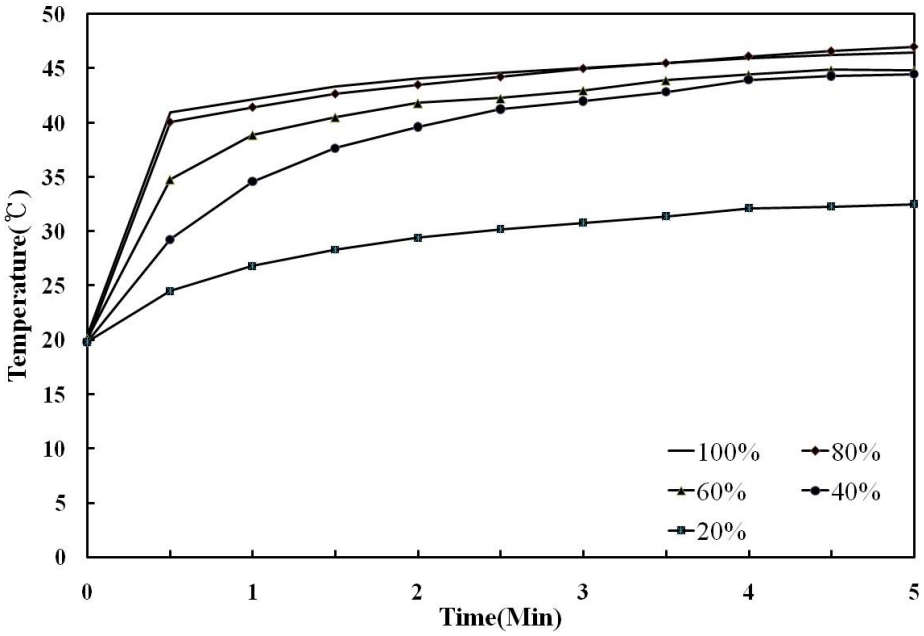

Figure 5. The Temperature Change of Indirect Heat According to the Duty Rate

The heating time of the heater can be controlled depending on duty rate changes, which means that indirect heat transferred actually can also be controlled in the range the user wants.

4. Conclusions

The proposed moxibustion treatment has emphasized safety against thermal stimulation. In this study, we developed a small moxibustion apparatus capable of indirect and uniform thermal stimulation, and analyzed heat characteristics for quantifying moxibustion used in Oriental medicine. The developed moxibustion apparatus used the method of creating indirect heat by applying a cylindrical silicon heater with a diameter of 3.7mm to a cauterizing plate used in the clinical treatment. Also, in order to apply it to a number of affected areas or animals, it was designed to operate independently on 6 heating bodies. In addition, the temperature can be controlled by transferring the temperature detected through the K-type sensor attached to the outside of the heater, as well as various patterns of thermal stimulation to MCU with RS485 communication by applying PWM method to heating the ceramic heater. It was found that indirect heat transferred when burning 1 moxa cone lasts for about one minute at more than 40 ºC, the treatment temperature range in 3 minutes. In order to implement a heating pattern which is similar to combustion reaction, we analyzed thermal characteristics for 20 minutes by varying the heater temperature conditions of the device produced. As a result, like the burning of moxa cone, when operated at 120 ºC, it reached the treatment temperature in about 3 minutes, and the treatment temperature can be constantly maintained up to 5 minutes, which is the set treatment temperature. In order to induce a variety of heating patterns, we controlled the temperature of the heater by applying PWM method to temperature control of the heater. As duty rate is controlled, indirect heat reaching the actual affected area could also be controlled.

References

[1] J. R. Peterson, “Acupuncture in the 1990s, A review for the primary care physician”, Arch. Fam Med., vol. 5, no. 4, **(1996)**, pp. 237-240.
[2] T. G. Kim, Y. M. Lee, Y. P. Park and M. W. Cheon, “Development of the Electronic Moxibustion Device for Realizing the Heatingof the Moxa cautery”, Transactions on Electrical and Electronic Materials, vol. 15, no. 1, **(2014)**, pp. 28-31.
[3] C. J. Chen and H. S. Yu, “Acupuncture Treatment of Urticaria”, Arch. Dermatol., vol. 134, no.11, **(1998)**, pp. 1397-1399.
[4] K. R. Shin, S. A. Kwak, J. B. Lee and H. R. Yi, “The effectiveness of hand acupuncture and moxibustion in decreasing pain and “coldness” in Korea women who have had hysterectomy: a pilot study”, Applied Nursing Research, vol. 19, no. 1, **(2006)**, pp. 22-30.
[5] G. M. Lee, Y. S. Yang and G. H. Lee, “Experimental study on the stimulating Effect of Commercial Moxa Combustion through the Measurement of Temperatre: Focuson Combustion time and Temperature”, Journal of Kor. Acupu. Moxibustion, Soc., vol. 19, no. 2, **(2002)**, pp. 114-127.
[6] K. H. Whang, "A Review of Studies and Experimental Methodologies on Moxibustion in Korea for an Establishment of Application Standard", Korean Journal of Phys. Anthropol., vol. 24, no. 3, **(2011)**, pp. 155-163.
[7] M. F. Marquardt, S. Pollak and U. Schmidt, “Cigarette burns in forensic medicine”, Forensic Science International, vol. 176, no. 2, **(2008)**, pp. 200-208.
[8] A. Bensoussan, S. P. Myers and A. L. Carlton, “Risks Associated With the Practice of Traditional Chinese Medicine”, Arch Fam Med., vol. 9, no. 10, **(2000)**, pp. 1071-1078.
[9] D. M. Won and H. W. Kim, “Touch screen sensing circuit with rotating auto-zeroing offset cancellation”, Journal of Inf. Commun. Converg. Eng., vol. 13, no. 3, **(2015)**, pp. 189-196.
[10] M. W. Cheon, T. G. Kim, D. H. Youn, K. W. Nam, C. S. Na, Y. E. Kim and J. C. Lee, “Comparison of Temperature in the Deep Part of the Dummy by the Electronic Moxibustion and the Gu-Gwan Moxibustion”, Lecture notes in electrical engineering, vol. 180, no.1, **(2012)**, pp. 35-40.

Authors

Tae-Gon Kim, He received his B.S. and M.S. degrees from the Dept. of Electrical and Electronic Engineering in Dongsin University in 2005 and 2007 respectively. He was a researcher at Bio Artificial Organs Institute, Bioateco Inc. from 2007 to 2008. Since 2009, he has been working on his Ph.D. degree in the Department of Electrical and Electronic Engineering in Dongshin University. His current research interests are bio artificial organs, light therapy, X-ray device and development of medical device.

Young-Pil Park, He was born in Seoul, Korea on June 13, 1957. He received his B.S., M.S., and Ph.D. degrees in Electrical Engineering from Kwangwoon University in 1981, 1983 and 1992, respectively. He performed post-doctoral course as a visiting researcher in Osaka University, Japan, from 1995 to 1996. Since 1992, he has been with the Department of Biomedical Engineering, Dongshin University as a Professor. His current research interest are biomaterials and light therapy.

Min-Woo Cheon, He received his B.S., M.S., and Ph.D. degrees from the Dept. of Electrical and Electronic Engineering in Dongsin University in 2001, 2003, and 2006, respectively. He received his Ph.D. degree from the College of Medicine in Chosun University in 2008. He was a research director at Bio Artificial Organs Institute, Bioateco Inc. from 2006 to 2008. He was also a development director at Eco-ray Inc. from 2008 to 2010. Since 2010, he has been with the Department of Biomedical Engineering in Dongshin University as an Assistant Professor. He was awarded a Paper and a Scholarship at KIEEME in 2007 and 2008, respectively. His current research interests are bio artificial organs, light therapy, rehabilitative medicine and developmental medicine.

Yang-Sun Lee, He received his B.S. and M.S. degrees in Electrical & Electronic Engineering from Dongshin University, and his Ph. D. degree from the Dept. of IT Engineering in Mokwon University in 2001, 2003, and 2007, respectively. He was a Senior Engineer at R&D Center, Fumate Co., Ltd. from 2007 to 2009. He was also a Research Professor at the Dept. of Information Communication Engineering, Chosun University from 2009 to 2011. Since 2012, he has worked as a Full Time Faculty Member in the Division of Computer Engineering at Mokwon University. His current research interests include UWB, Wireless Multimedia Communication, Network Transmission Scheme and Ubiquitous Sensor Networks. He is a member of the KITCS, KICS, KIICE, KIIT and KONI.

Chang-Su Na, He received his Ph.D degree from the College of Korean Medicine in Kyung-Hee University. He was a visiting scholar in the University of California, Irvine (Beckman Laser Institute) from 2005 to 2006. He is currently serving as dean and professor in the College of Korean Medicine in Dong-Shin University. He has also served as president of the Meridian & Acupoint Society and Korean Integrative Medicine Forum since 2014. His current research interests are scientific mechanism of the acupuncture, development of medicinal food & drug, and medical application of the laser therapy.

Dae-Hwan Youn, He is known as Prof. Daehwan Youn (M.D.) in Dongshin University in Korea. He received his M.S. and Ph D degrees from the Dept. of Korean Medicine, Dongshin University in 2003 and 2006. He does research in evaluating the efficiency of acupuncture therapy on either structural or hemodynamics in tissues using optical coherence tomography (OCT). Also, he is currently doing multiple projects such as the mechanism of therapeutic action, and developing a new diagnostic method carried out by the combination of laser and Korean traditional medicine.

Jung-Chul Lee, He received his M.S. and Ph.D degrees from the Dept. of Physical Education in Korea University in 2002 and 2006 respectively. He was an exercise specialist at the Seoul Asan Medical Center from 1999 to 2000. He is currently serving as a professor in the Department of Exercise Prescription from Dong-Shin University. His current research interests are exercise prescription, exercise rehabilitation, sports medicine, and scientific program development of Nordic working.

Jae-Young Park, He received his M.S. and Ph.D. degrees from the Dept. of Sports Biomechanics in Chonnam National University in 2004 and 2008 respectively. He is a professor of the Exercise Prescription Department in Dongshin University. His current research interests are gait analysis, exercise motion analysis, corrective exercise device and development of vertebral column proofreading device.