Commentary

The necessity of developing a Gait Meridian muscle model

Jeong-Woo Seo a, Hyunmin Wie b, Cheol-Hyun Kim b,c, Seyoung Kim b, Sangkwan Lee a,b,c

a Digital Healthcare Research Division, Korea Institute of Oriental Medicine, Daejeon, Korea
b Stroke Korean Medicine Research Center, Wonkwang University, Iksan, Korea
c Department of Internal Medicine and Neuroscience, College of Korean Medicine, Wonkwang University, Iksan, Korea

A R T I C L E   I N F O

Article history:
Received 15 October 2022
Revised 28 October 2022
Accepted 30 October 2022
Available online 4 November 2022

Keywords:
Hemiplegic stroke gait
Meridian muscle model
Muscle activation
Long-short term memory

Abnormal gait occurs in the cases of brain damage and neurodegenerative diseases including stroke, Parkinson’s disease, and cerebral palsy, which involve the signal transduction of the central nervous system. Patients with stroke typically show hemiplegic gait and overall asymmetries in many of the measurable metrics. Parkinsonian gait is characterized by small shuffling steps and a general slowness of movement (hypokinesia), or even the total loss of movement (akinesia), and persons with cerebral palsy show jerky and awkward gait.1-3

Gait disorders caused by brain damage and neurodegenerative diseases show different characteristics from normal gait. Therefore, the use of quantitative gait analysis is necessary when evaluating the severity of motor disturbance and the degree of improvements by Korean medicine (KM) clinical practice.

Various treatments such as acupuncture and manual therapy have been actively applied to patients with gait disorders in KM clinical field.4 However, despite the advantage of KM that enables personalized treatment, objective and efficient diagnosis and evaluation methods for gait disorders have not been widely used because it requires a high cost and professional knowledge for securing a large space and operation of an optical three-dimensional motion analysis system consisting of optical cameras, electromyography, and force plate. This can be solved by replacing the measuring equipment with a new biomechanical system, a combined system of Inertial Measurement Unit and Loadcell based insole-type force plate. In this new system, the variance in joint angle and ground reaction force during walking can be measured by the sensors attached to the limbs and feet without reflective markers and space limitation. This system is also much cheaper and simpler than a three-dimensional motion analysis system.

There is a point to be considered to utilize the biomechanical system in KM clinical field. It is not clear whether the meridian muscles can be equally corresponded with the anatomical muscles. However, it is not likely to be a main issue because various movement-related diseases have been theoretically and clinically elucidated by the meridian muscles, and a previous study showed both muscle systems were positionally corresponded to each other in the body.5 According to the theory of meridian muscle, the human body uses the Foot-Taiyang, Foot-Yangming, and Foot-Shaoyang meridian muscles for walking. The Foot-Taiyang meridian muscle, covering the gluteus maximus, hamstring, and gastrocnemius, extends from the little toe, goes up to the outside of the malleolus and the knee, and passes through the outside of the leg to the heel. The Foot-Yangming meridian muscle, covering the rectus femoris and tibialis anterior, extends from the third toe to the dorsum of the foot, the fibular, and the outside of the knee, and splits up into the anterior thigh and the outer thigh. The Foot-Shaoyang meridian muscle, covering the gluteus minimus, vastus lateralis, and tibialis anterior, extends from the fourth toe, passes through the malleolus and tibia, and goes up to the outside of the knee. The muscles in these three meridian muscles are well known to play an important role in walking. Therefore, it is reasonable...
to evaluate the activities of the Foot-Taiyang, Foot-Yangming, and Foot-Shaoyang meridian muscles by measuring the activities of the corresponding lower extremity muscles. To apply the new biomechanical system to gait disorders in KM clinical field, a gait-related Meridian Muscle Model (MMM) should be developed. A surface EMG has been used to determine the activity of these muscles related to the meridian muscles. However, it is inconvenient for clinical use because the number of EMG channels increases as the number of target muscle increases. Recently, an inverse dynamics analysis is often used; the joint force and moment values are calculated from the variance in the joint angle and the values of ground reaction force; then the calculated values are distributed to the corresponding muscles in each segment to estimate the activities of each muscle. Muscle activities can be also predicted with a Recurrent Neural Network (RNN) deep learning model such as Long Short-Term Memory (LSTM). The test-set consists of predictive variables such as joint angle, joint force, and torque of each lower extremity during walking, and response variable such as muscle activity measured by EMG. The EMG activity can be estimated with the variance in the joint angle and the ground reaction force values measured with a simpler and lower-cost combined system of IMU sensors and simplified insole-type sensors. If the MMM is developed through the combined system, it can predict anatomical and meridian muscle activities and serve as the basis for the personalized application of various KM treatments such as acupuncture and Tuina for patients with gait disorders (Fig. 1).

Stoke Korean Medicine Research Center, supported by the Korean government, is also conducting related researches and has a platform that constantly collects data from multiconter to keep the inverse dynamics analysis and deep learning model up to date for more accurate prediction of muscle activities of stroke patients.

There are some limitations. First, the meridian muscles are assigned to anatomical muscles considering only the location in human body. It is not clear if the meridian muscles and the anatomical muscles have the same functions such as contraction and relaxation of agonistic and antagonistic muscles. However, since the anatomical muscles corresponding to the meridian muscles play an important role in walking, this limitation is not a large one. Second, the pattern of muscle activities of stroke patients is divided into four types, and it may bring difficulties in increasing the accuracy of the muscle activity predicted through deep learning. The four types are hyperactive stretch reflex, lack of activation during both shortening and lengthening contraction, stereotyped coactiva-

tion of several muscles group, and combined components of the other three. These difficulties could be solved by classifying them into four types before the prediction of meridian muscle activities.

Author contributions

Conceptualization, S.L.; Writing- Original Draft, J.-W.S.; Writing - Review & Editing, H.W., C.-H.K. and S.K.; Supervision, S.L

Conflict of interest

The authors declare that they have no conflicts of interest.

Funding

This research was supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HF20C0113).

Ethical statement

This article did not have any research ethical consideration as authors did not perform research with human or animal subjects.

Data availability

Not applicable.

References

1. Li S, Franscisco GE, Zhou P. Post-stroke hemiplegic gait: new perspective and insights. Frontiers in Physiol. 2018;9:1021.
2. Okuma Y, Yanagisawa N. The clinical spectrum of freezing of gait in Parkinson's disease. Mov Disord. 2008;23(Suppl 2):S426–S430.
3. Wallard I, Dietrich G, Kerlirzin Y, Bredin J. Effect of robotic-assisted gait rehabilita-
tion on dynamic equilibrium control in the gait of children with cerebral palsy. Gait Posture. 2018 Feb; 60:55–60.
4. Yang A, Wu HM, et al. Acupuncture for stroke rehabilitation. Cochrane Database Syst Rev. 2016;8:CD004131.
5. Mun SJ, Kim SH, Lee SH. Classification of muscles into Meridian Sinew: a literature review. Korean Med Rehab. 2014;24:83–96.
6. Lee MS, Hong SW, Lee SR. A study on muscular system of foot Three Yang Merid-
ian-Muscle. Korean J Acupunct. 2008;25(2):1–32.
7. Akof Khowalled I, Abotabl A. Neural muscle activation detection: A deep learning approach using surface electromyography. J Biomech. 2019;11:109322.
8. Olney SJ, Richards C. Hemiparetic gait following stroke. Part 1: characteristics. Gait Posture. 1996;4:130–148.