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Original Article

A study on muscle activity based on the ankle posture for effective exercise with indoor horse riding machine

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Abstract. [Purpose] Although much researches have been conducted on the hippotherapy, the intervention methods of the previous studies focus on the pelvis posture. Thus, this study analyzed the electromyogram (EMG) of trunk muscle and lower limb muscle to analyze the kinetic factors. Based on the analysis, this study aims to compare the muscle load and suggest effective exercise method. [Participants and Methods] This study checked the muscle activity of Rectus abdominis (RA), Erector spinae (ES), Rectus femoris (RF), Adductor magnus (AM) during the exercise using horse riding machine in dorsiflexion position by bending 20 degrees and in neutral position. Each position was performed for 5 minutes and the speed of the horse riding machine was set to medium speed. [Results] Rectus abdominis showed higher muscle activity in dorsiflexion position and the groups had significant differences. Elector spinae showed higher muscle activity in dorsiflexion position and the groups had significant differences. Rectus femoris showed higher muscle activity in dorsiflexion position and the groups had significant differences. Adductor magnus also showed higher muscle activity in dorsiflexion position and the groups had significant differences. [Conclusions] The study result showed that exercise with horse riding machine in dorsiflexion position activates trunk muscle and thigh muscle effectively. Thus, the study suggests more effective posture for the modern people who exercise with horse riding machine for strengthening physical health.

Key words: Hippotherapy, Electromyography, Electrogoniometer

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INTRODUCTION

With the increasing desire for health and advent of various exercises, modern people are having more awareness on importance of exercise for their health. Hippotherapy has long been world-widely recognized as the whole-body exercise with excellent effects. The hippotherapy allows people to experience physical movement and the 3-dimentional movements (front and back, left and right, up and down motion) make people feel as if they are walking. As the movement of a horse resembles how people walk, such 3-dimensional movements offers exercising effect[1)]. Furthermore, people exercise by keeping a balance on a horse. The muscle used to keep balance stimulates the deep muscle that cannot be reached by the existing therapy. Such stimulation activates muscle and joints and enhances blood circulation to restore the impaired function[2)]. The hippotherapy uses the movement of horse to enhance the neuromuscular function and it is reported that hippotherapy promotes vestibular sense, somesthetic sense, and visual feedback and that hippotherapy is a treatment effective in enhancing bodily alignment, developing bilateral muscle, improving symmetry, stabilizing posture, and enhancing balance and flexibility[3, 4)]. Furthermore, hippotherapy is an animal assisted therapy and it uses the movements of a horse to induce orientation response and balance response. It also improves physiological parts, sense of balance, muscular strength, eye-hand coordina-

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tion, muscle tension, range of joint motion, weight bearing, posture while enhancing the walking of patients with neurologic disorders[5]. In addition, since hippotherapy is an animal assisted therapy, it has positive influence on psychological parts[6]. By having a time with horse, people can restore their confidence and people can improve their ability to express their opinion by having a conversation with accompanying person[7]. However, although hippotherapy holds various advantages, hippotherapy has a problem of insufficient horse-riding infrastructure, high expense, insufficient therapist specialized in rehabilitation, and accidents of falling off from horse[8]. Due to such problems, there have been studies on the whether horse riding machine exercise has the same effect of hippotherapy[9]. Horse riding simulator is also effective in storke patients as well as cerebral palsy. To improve stroke patients' balance ability, diverse uses of horse riding simulation training should be considered[10]. When observing the movement of the lower limb joints in kinetic chain, the movements of the lower limb joints are connected with close kinetic chain[11]. Thus, the changes in exercise of angle joint will have influence on the joint movement of trunk and lower limbs. The study of Nakano et al.[12] studied the effect by setting the different body-leg angle by 110 degrees, 130 degrees, and 140 degrees in the horse riding machine exercise and reported that exercise posture and muscle activity. However, there are lack of studies on how ankle joint posture influences on the muscle activity of trunk and lower limb in exercising horse riding machine. Thus, study divides the posture in dorsiflexion position and neutral position to analyze the muscle activity of trunk muscle and lower limb muscle during the horse riding exercise and to analyze the kinetic factors. Through the analysis, this study aimed to compare the muscle load of trunk muscle and thigh muscle based on the ankle position during the horse riding machine exercise to suggest effective exercise method.

PARTICIPANTS AND METHODS

This study examined healthy 29 students of Daegu Catholic University from July 2014 to August 2014. The participants included 17 female students and 12 male students. The average age was 24.4 ± 1.5, the average height was 168.9 ± 7.2 cm, the average weight was 61.9 ± 13.0 kg, and the average foot length was 250 ± 16.5 cm (Table 1). Research purpose and method were explained to all the participants prior to participating in the study, and all participants provided written informed consent according to the ethical standards of the Declaration of Helsinki and agreed to participate in the study. This study used Panasonic EU7805 for indoor horse riding machine and the machine is designed to experience 3 dimensional movements (front and back, left and right, up and down) like the movements of a live horse and to experience various movements. When the participants sat on a saddle during the test, the participants were instructed to put two arms on a chest and maintain the tension on cervical vertebrae. With such position, the participants rode the horse riding machine while using the thigh muscle. In regard to order of position, the participants were asked to perform in the order of neutral position and ankle dorsiflexion position. In the neutral position test, the participant's ankle and stirrup were parallel. On the other hand, the participant's ankle dorsiflexion was set to 20 degrees with electro goniometer in before the ankle dorsiflexion test. Because dorsiflexion range of motion influneces dynamic balance[13]. During the ankle dorsiflexion test, the participants were told to "Maintain the angle" repeatedly and the participants were alerted on maintaining the position. In the test, the machine speed was set to medium speed.

All participants performed neutral position and ankle dorsiflexion position for 5 minutes respectively and the participants were allowed to rest for minutes between the position change in order to prevent the muscle fatigue.

For muscle activity measurement, this study used wireless surface EMG device, WEMG-8 (Laxha,US), and this study measured the muscle activity in four muscles including Rectus abdominis (RA), Erector spinae (ES), Rectus femoris (RF), Adductor magnus (AM). The electrodes were placed parallel to muscular fiber and this study used disposable Ag/Agcl monitoring electrode (2223H,3M,Korea) for electrodes. The electrodes of EMG device were placed between the umbilicus and pubis, midway muscle belly for the rectus abdominis (RA), and the electrodes were placed above and below the L1 level, midway muscle belly for erector spinae (ES)[14, 15]. The electrodes for rectus femoris (RF) was placed between vastus medialis and vastus lateralis[16], and the electrodes for adductor magnus (AM) was placed on line between tuberculum pubis and medial epicondyle[17]. The reference electrode was placed on 1/3 point of inner elbow. For the parts where electrodes were placed, this study removed the keratin layer by rubbing with thin sandpaper and removed the skin grease with rubbing alcohol to reduce the skin resistance to EMG signal. After taking the measures, this study grounded the electrodes on the muscle parts and the distance between the two electrodes were maintained below 2.5 cm[18]. The EMG measurement result was recorded with uV and the wires connecting the electrodes and EMG device were well organized to minimize the noise for movement. In regard to sampling rate for signal collected through electrodes, this study set the sampling rate to 1,024 Hz. For EMG analysis, this study set band pass filter to 10 Hz–450 Hz and conducted notch filter on 60 Hz, 120 Hz, and 180 Hz which may influence on the band pass filter. Among the surface EMG signal, each one minute of the first and last signal

Table 1. General characteristics of the participants

	Gender	Age (years)	Height (cm)	Weight (kg)	Foot length
Participant (n=28)	12 males / 17 females	24.4 ± 1.5	168.9 ± 7.2	61.9 ± 13.0	250 ± 16.5

All values are means ± standard deviation (SD).

was excluded from the analysis and the analysis was conducted after root mean square (RMS). In addition, this study used maximal voluntary isometric contraction (MVIC) to standardize the action potential for each muscle. In regard to manual muscle position for measuring maximum isometric contraction, this study referred to manual muscle testing of Daniels and Worthingham[19]. For measuring the average of maximum isometric contraction value, the maximum isometric contraction was measured for 3 times[20]. The maximum isometric contraction was measured for 5 seconds and after excluding the one second for the first and the last part, the average EMG signal for 3 seconds were used as the maximum voluntary isomeric contraction (%). The electro goniometer used on this study was composed of two electrical potentiometers and springs connecting them. With two electrical voltage dividers, the analog signal generated by the voltage difference from bending and stretching of ankle was delivered to wireless Telemyo DTS (Noraxon Scottsdale, AZ, USA) through TEL100C (4-Channel Telemetry) and converted to digital signal. The data unit was expressed in Volt and the it was measured identical to the angle of actual ankle movement. The sampling rate for each signal was set to 500 Hz. For the statistical analysis, this study used SPSS version 18.0. In addition, this study used matching sampling of t-test (paired t-test) to compare the muscle activity of trunk muscle and thigh muscle based on the ankle position. Also, all the values were expressed in average ± standard deviation and the statistical significance level was set to α=0.05.

RESULTS

Rectus abdominis showed higher muscle activity in ankle dorsiflexion position and the groups had significant difference ($p<0.05$). Elector spinae showed higher muscle activity in ankle dorsiflexion position and the groups had significant difference ($p<0.05$). Rectus femoris showed higher muscle activity in ankle dorsiflexion position and the groups had significant difference ($p<0.05$). Adductor magnus showed higher muscle activity in ankle dorsiflexion position and the groups had significant difference ($p<0.05$) (Table 2).

DISCUSSION

The hippotherapy uses the movements of a horse and the people exercise by keeping a balance on a horse. The muscle used to keep balance stimulates the deep muscle that cannot be reached by the existing therapy. Such stimulation activates muscle and joints and enhances blood circulation to restore the impaired function[2]. However, although hippotherapy holds various advantages, hippotherapy has a problem of insufficient horse-riding infrastructure, high expense, insufficient therapist specialized in rehabilitation, and accidents of falling off from horse[8]. Thus, there has been attempts on applying horse riding machine to clinical field to maintain the positive effects of hippotherapy while overcoming such weaknesses. This study changed the ankle position conditions while exercising with indoor horse riding machine to compare and analyze the muscle activity of trunk muscle and thigh muscle and to suggest effective exercising method. Exercising posture is one of the important elements that influences on the kinetic effects. Especially, the structure of lower limb and foot play important role in sports and exercises with various movements as they maintain the balance of dynamic body and allow delicate movements[21]. The ankle and foot are flexible and strong and they are important in weight bearing, walking, and functional activities[22]. Also, in the perspective of kinetic chain, the ankle joint movements are connected with close kinetic chain[23]. Among muscle strengthening exercise, ankle strengthening exercise through close kinetic chain exercise involves movements of hip joint and knee joint and the exercise is largely used in complex treatment of lower limbs[24]. Also, depending on the ankle posture, the pelvic tilt can change[25]. The ankle dorsiflexion is the main movement of ankle joint and as it shows complex movement applied with rotary elements instead of single movement, ankle dorsiflexion is closely related with knee joint[26]. This study results also showed that the ankle position influenced on trunk muscle of rectus abdominis, erector spinae and on lower limb muscle of rectus femoris and adductor magnus. This result verified the previous study's result on how hippotherapy influences on trunk muscle and lower limb muscle to maintain dynamic balance. In consequence, the tension changes based on the change of angle in joint exercise. In this study, the dorsiflexion position had higher significant difference on muscle activity of trunk muscle and lower limb muscle compared to neutral position ($p<0.05$). The limitation of this study is that the test was conducted on the participants without disabilities. Thus, the study result may not be generalized for patients with nerve problem or musculoskeletal problem. And the muscle used for the measurement were limited to the rectus abdominis, erector spinae, rectus femoris, adductor magnus. Also, in the the indoor horse riding exercise, dynamic movements were

Table 2. Comparison of muscle activities according to ankle posture (M ± SD)

Muscle	DF	NP	t	p
Rectus abdominis	6.14 ± 4.56	5.59 ± 4.22	3.491	0.002*
Elector spinae	11.22 ± 13.50	7.73 ± 8.10	3.227	0.003*
Rectus femoris	9.27 ± 6.17	5.00 ± 3.50	4.925	0.000*
Adductor magnus	23.66 ± 16.50	15.80 ± 10.50	4.803	0.000*

*$p<0.05$, DF: dorsi flexion; NP: neutral position.

repeated and the limited data was collected due to noise from such movements. To overcome the limitation, this study taped the EMG wires so that the EMG wire near the electrodes would not shake and each channel was tied with strap to minimize the shaking. In addition, in dorsiflexion position, this study used electro goniometer (Noraxon Scottsdale, AZ, USA) for maintaining the dorsiflexion angle for overcoming the limitation in maintaining the dorsiflexion angle of 20 degrees for 5 minutes while riding the indoor horse riding machine. This study also conducted comparative analysis on muscle activity of trunk muscle and thigh muscle based on the ankle position. However, the participants had issues in maintaining the plantar flexion position in ankle position and the ankle position was limited to neutral position and dorsiflexion position. The future studies may need clinical study on influence of angle position on functional activities such as proprioception, balance, and walking other than muscle activity. Also, the future studies need to conduct tests on patients with ankle sprain caused by sports injury and the effects of hippotherapy and ankle position for such patients. This study result showed that horse riding machine exercise in dorsiflexion position selectively activates trunk muscle and thigh muscle to suggest effective exercise method. Thus, this study on the influence of ankle position on trunk muscle and thigh muscle during the indoor horse riding machine exercise is expected to suggest more efficient posture for modern people who participate in various sports for improving their physical health.

Conflict of interest

None.

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