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A verification on the physical effectiveness of therapeutic horseback riding exercise: Focused on the EMG analysis

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Abstract : Various studies related to therapeutic horseback riding have been reported to be positive for the therapeutic effect of patients with cerebral palsy; however, most of the previous studies focused on to muscle development with training period related to the physical effects of therapeutic horseback riding. To identify the causes and phenomena of muscular activation of the body through actual therapeutic horseback riding exercise and to promote the excellence of physical effects of therapeutic horseback riding. This study was a nonrandomized prospective positive-controlled trial design. Twelve teenaged males with cerebral palsy were selected who had experienced riding exercise for 8-12 months. This study measured 8 muscle activities of the pectoralis major muscle (PM), biceps brachii (BB), rectus abdominis muscle (RA), latissimus dorsi muscle (LD), spinal erector muscle (SE), rectus femoris muscle (RF), anterior tibial muscle (AT), and external gastrocnemius muscle (EG) by using electromyography (EMG). Muscle activity was significantly higher in horse riding position than sitting on the common chair in all muscles (PM, BB, RA, LD, SE, RF, AT, and EG). The activity of the body muscles according to the difference of horse walking method (walk: WA; sitting trot: ST; and riding trot: RT) of therapeutic horse riding showed the highest muscle activity in the PM muscle at ST, and the highest activity at BB, RA, LD, SE, and AT muscles at ST and RT, and showed the highest muscle activity in RF and EG muscle at RT. The results of this study suggest that intervention for the treatment of cerebral palsy patients can use therapeutic riding exercise as a rehabilitation method.

Keywords : Therapeutic horseback riding, Rehabilitation, Walk, Trot, EMG

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1. Introduction

Therapeutic horseback riding is one therapeutic method among rehabilitation sports for the disabled and it induces overcoming emotional, social, and physical disability for the better life [1]. Therapeutic horseback riding plays a role in the overall balance and harmony in the human body rather than treating only one part of the disorder and especially, therapeutic horseback riding is widely used as a treatment and management tool in cerebral palsy, learning disability, amputation, autism, spinal cord injury, neurological disorders, and emotional disorders [2].

Cerebral palsy is a type of physical lesion that occurs in the developing fetal period or early childhood brain tissue and has a permanent limitation on the development of movement such as walking disorder, movement disorder, and sensory disorder [3]. It is a chronic disease that causes physical disability in various parts of the body movement [4], and requires physical and occupational therapy during lifetimes [5]. It also causes other health problems such as sight, hearing, speech, and language disorders and the most usual form is rigid paralysis and 70-80% of rigid paralysis patients are classified as hemiplegia, quadriplegia, and paraplegia [6].

In 21stcentury, as a sporting method for improving performance of patients with cerebral palsy, therapeutic horseback riding is being actively promoted to stabilize the posture and to stimulate a part of the body using horse [7-10] and previous studies reports that the treatment effect of patients with cerebral palsy is positive [8,11]. One previous therapeutic horseback riding study [12] reported that patients with cerebral palsy, who conducted therapeutic horseback riding for 1 time per week for 18 weeks, showed decreased muscle tone and thus therapeutic horseback riding has been reported to be effective in relaxing abnormal stiff muscles. Silva, et al [13] also mentioned that therapeutic horseback riding usually gives riders to experience the pressure of the sensory nerves, which is similar to the pattern of movement that occurs in the pelvis when a person is walking, so that the body temperature and movement of the horses delivered at this time improve the circulation of the passenger and helps to relax the rigid muscles.

Various studies related to therapeutic horseback riding have been reported to be positive for the therapeutic effect of patients with cerebral palsy; however, most of the previous studies focused on to muscle development with training period related to the physical effects of therapeutic horseback riding and were only related with the identification of the cause of muscle development on how much muscle of the body was mobilized during actual therapeutic horseback riding exercise [14,15]. Therefore, the purpose of this study was to identify the causes and phenomena of muscular activation of the body through actual therapeutic horseback riding exercise and to promote the excellence of physical effects of therapeutic horseback riding in patients with cerebral palsy.

2. Materials and Method

2.1. Participants

This study was a non-randomized prospective positive-controlled trial to investigate the physical effectiveness of therapeutic horseback riding exercise. In this study, 12 teenaged males with dyskinetic cerebral palsy participated in the experiment after receiving consent to participate in the experiment by their caregivers and their physicians. The characteristics of this study participants are shown in Table 1. This study participants were selected as cerebral palsy patients who had experienced riding exercise for 8-12 months, and their functional classification was classified as athetoid (slow

Table 1. Physical characteristics of participants

N	Age (yrs)	Body Mass (kg)	Height (cm)	BMI (kg/m^2)	Career (mon)	functional classification	GMFCS
12	16.83±0.37	65.42±0.77	168.42±0.69	23.07±0.30	9.58±0.23	athetoid	level 2

Values are mean ± SE
GMFCS, gross motor functional classification system

torsional motion type) among dyskinetic (movement ideal) of global involvement, and the gross motor functional classification system (GMFCS) level was limited to GMFCS level 2. Informed consent from each participant with parental agreement and physicians' consent were obtained before conducting this study.

2.2. Experimental approach to the problem

Experiments to collect the data required for this study were conducted at the "T" horse riding area in Cheongju city. In consideration of the validity of the measurements at the time of the experiment, the horse for this study was limited to the same species of Shetland pony. Before starting the experiment, participants were informed about the anatomical position, sitting position (SP), horse riding position (HP), walk (WA), sitting trot (ST), and riding trot (RT) and all participants fully practiced those with the help of a guardian, a horse leader, and two side walkers to ensure smooth movement. The mean speed for each method was 100-110m/min for WA and 220-240m/min for trot (ST and RT) [16], and 12 steps were performed at one time, and the values of 6 motion cycles excluding the first 3 steps and the last 3 steps were extracted for each horse walking method [17, 18]. With 5 tests for each horse walking method, the measurement results of 30 strides (6 strides × 5 times) were analyzed.

For the analysis of electromyography (EMG), a surface electrode was fixed on the muscle surface to be measured. To eliminate the measurement error, the hair protruding from the muscular part was removed with a razor and the medical alcohol (Hitech bio Pharm, Busan, Korea) and then the surface electrode was attached. Based on the previous study [19], all surface electrodes were attached on pectoralis major muscle (PM), biceps brachii (BB), rectus abdominis muscle (RA), latissimus dorsi muscle (LD), spinal erector muscle (SE), rectus femoris muscle (RF), anterior tibial muscle (AT), and external gastrocnemius muscles (EG), which was representative muscles of right trunk, upper limb, and lower extremity.

The experimental procedure of EMG according to the therapeutic horseback riding method was applied by counterbalanced design. One Life Cam VX-5000 digital video camera (Microsoft Corporation, WA, USA) was used to synchronize all data with each anatomical position, SP, HP, image data, and EMG data. For EMG measurement, myo MUSCLE 3.8.2 program (Noraxon USA Inc., AZ, USA) was used. The surface electrode was connected to a Model 542 DTS EMG sensor (Noraxon USA Inc., AZ, USA) with a small surface electrode T 246 H (Bio-Protech Inc., Wonju, Korea) with a diameter of 20 mm. The electrodes were placed in a 2cm distance and the electrodes were connected to the TeleMyo ™ Desktop Direct Transmission System (Noraxon USA Inc., AZ, USA). The EMG signal processing method sets the bandwidth to 10-350 Hz and the sampling rate to 1,024 Hz. EMG signals were rectified and then smoothed with a root mean square (RMS) of 200 ms.

2.3. Procedures

In this study, the standardization process was performed to compare EMG signals between subjects and between the muscles. The EMG signal standardizing method assumes that the muscle contraction of the specific motion is standard voluntary contraction (RVC) and the% RVC method was used [19]. The baseline RVC was defined as the duration of each subject's anatomical position for 10 seconds, and the data value for 10 seconds was subjected to RMS, and the average EMG signal level during the middle 4 seconds except for the first and last 3 seconds were used to standardize the EMG signals of each muscle with % RVC.

2.4. Statistical Analysis

All data was expressed as the mean and standard error (mean ± SEs) and calculated by analyzing the experimental results with IBM SPSS Statistics 23 (IBM Corporation, NY, USA). Paired t-test was used to compare the difference of muscle activity in SP and HP. One-Way RM (repeated-measures) ANOVA was used to compare the difference of muscle activity according to various walking method of the horse (WA, ST, and RT) and if there was a statistically significant difference, Bonferroni method was used as a post analysis method. Statistical significance was set at $p<.05$.

3. Results

Table 2 shows the results of muscle activity of 8 muscles in comparison with SP and HP. Measurement of muscle activity in PM, BB, RA, LD, SE, RF, AT, and EG resulted that HP showed higher muscle activity than SP in all the muscles and each results are as follows; (t=−5.30, p=0.000), (t=−9.38, p=0.000), (t=−11.92, p=0.000), (t=−8.66, p=0.000), (t=−23.17, p=0.000), (t=−3.91, p=0.002), (t=−5.33, p=0.000), and (t=−3.21, p=0.006).

During therapeutic horseback riding, 8 muscle activity changes of the WA, ST, and RT are shown in Table 3. The ST showed the highest activity in PM than RT and WA, and the statistical result was ($F_{(2,118)}$=22.70, p=0.000). At ST and RT, the highest muscle activity was found in BB, RA, LD, SE, and AT than in WA and each results are as follows; ($F_{(2,118)}$=6.21, p=0.004), ($F_{(2,118)}$=14.02,

Table 2. Comparison of average rectified variable muscle activity during SP and HP (Unit: %RVC)

	SP	HP	p-value
PM	148.97±22.56	613.87±97.58	0.000
BB	511.86±109.91	3083.12±168.38	0.000
RA	373.41±85.13	3032.03±298.59	0.000
LD	126.16±11.94	950.41±103.83	0.000
SE	219.05±36.09	428.66±34.01	0.000
RF	410.58±106.46	628.08±98.12	0.002
AT	227.28±18.45	577.10±67.10	0.000
EG	101.75±10.67	155.20±13.28	0.006

Values are mean ± SE

%RVC, percentage of reference voluntary contraction; SP, sitting position; HP, horse riding position; PM, pectoralis major muscle; BB, biceps brachii; RA, rectus abdominis muscle; LD, latissimus dorsi muscle; SE, spinal erector muscles; RF, rectus femoris muscle; AT, anterior tibial muscle; EG, external gastrocnemius muscle

Table. 3. Comparison of average rectified variable muscle activity during WA, ST, and RT

(Unit: %RVC)

	WA	ST	RT	p-value	Post-hoc
PM	1041.57±133.30	2771.03±230.03	2024.74±169.56	0.000	WA<RT<ST
BB	10235.23±1129.53	20563.06±1878.15	17957.36±3022.67	0.004	WA<RT, ST
RA	3710.50±659.93	10118.22±943.20	10076.68±1259.15	0.000	WA<RT, ST
LD	2341.47±302.42	8750.24±1401.11	6692.57±756.31	0.000	WA<RT, ST
SE	1720.60±273.59	6115.22±1305.74	9645.75±3373.14	0.036	WA<ST, RT
RF	719.96±122.13	3018.49±199.09	5008.63±317.18	0.000	WA<ST<RT
AT	2147.16±300.41	4331.27±763.76	4135.56±471.03	0.012	WA<RT, ST
EG	359.96±78.98	636.22±74.97	1258.02±122.22	0.000	WA, ST<RT

Values are mean ± SE

%RVC, percentage of reference voluntary contraction; SP, sitting position; HP, horse riding position; PM, pectoralis major muscle; BB, biceps brachii; RA, rectus abdominis muscle; LD, latissimus dorsi muscle; SE, spinal erector muscles; RF, rectus femoris muscle; AT, anterior tibial muscle; EG, external gastrocnemius muscle

p=0.000), ($F_{(2,118)}$=12.23, p=0.000), ($F_{(2,118)}$=3.59, p=0.036), and ($F_{(2,118)}$=4.89, p=0.012). Lastly, at RT, RF, and EG showed the highest muscle activity than in ST and WA and each results are ($F_{(2,118)}$=89.06, p=0.000) and ($F_{(2,118)}$=23.69, p=0.000).

4. Discussion

Major findings of this study are as follows; 1) muscle activity was significantly higher in HP than SP in all muscles (PM, BB, RA, LD, SE, RF, AT, and EG), 2) The activity of the body muscles according to the difference of horse walking method (WA, ST, and RT) of therapeutic horseback riding showed the highest muscle activity in the PM muscle at ST, and the highest activity at BB, RA, LD, SE, and AT muscles at ST and RT, and showed the highest muscle activity in RF and EG muscle at RT.

Cerebral palsy is accompanied by various paralysis of the body caused by brain lesions, so it is necessary to cope with the problems such as reduction of joint motion range, paralysis due to muscle tension, walking ability disorder, and motor dysfunction [12]. Particularly, due to the nature of cerebral palsy, it is very important to intervene to relieve the developmental delay because it affects the physical development and has difficulties in maintaining the daily life. This is because it can be a management to minimize the inconvenience of daily life even if it is not a fundamental treatment, and the key to rehabilitation is to maximize the individual's potential [20]. As one of these intervention methods, therapeutic horseback riding exercise has been reported to show many effects on patients with cerebral palsy [21,22]. In the case of studies on the excellence of physical characteristics by performing therapeutic horseback riding exercise for patients with cerebral palsy, Alfredson, et al. [23] reported that the group that performed rehabilitation riding exercise increased bone mass due to weight load and strength of hamstrings and quadriceps femoris was significantly increased as a result of examining the strength of 20 adolescent female professional riders who exercised for 7 hours a week and 20 adolescent females who did not exercise. McGibbon, et al. [11] investigated the effect of exercise on the group of rehabilitation riding exercise group and the group that stretched in the round barrel for the same time. They used EMG and 47 children with spastic cerebral palsy were participated. Results showed that the group of children who underwent a rehabilitation riding exercise program had higher muscle strength.

Hodges and Richardson [24] mentioned that the activity of the trunk muscles plays a major role in the movement of the pelvis and the movement of the lower limb, and is an essential factor in maintaining the lumbar stability. This study compared muscle activity at SP and HP and found that PM (412.07 %), BB (602.33 %), RA (811.98 %), LD (753.33 %), SE (195.69 %), RF (152.97 %), AT (253.91 %), and EG (152.53 %) showed significantly higher muscle activity in HP compared to SP. During therapeutic horseback riding, PM (266.04 %), BB (200.90 %), RA (272.69 %), LD (373.70 %), SE (560.60 %), RF (695.68 %), AT (201.72 %), and EG (349.48 %) showed significantly higher muscle activity in ST and RT compared to WA. These findings proved that physical exercise is excellent even if only the HP is performed rather than the SP and trot (ST or RT) is more effective than WA during therapeutic horseback riding exercise. These results may be consistent with the goal of rehabilitation riding therapy, which is to optimize the strength of the body, by decreasing the stiffness pattern of patients with cerebral palsy by maintaining proper posture while sitting on the horse. In addition, this study also proved that the actual rehabilitation riding therapy approach, which has been avoided clinically in the treatment of patients with cerebral palsy, is an effective treatment method.

A study for the effect of rehabilitation riding therapy through EMG on the symmetry in muscle activity of the trunk and upper legs [25], it reported that children aged 4-12 years with rigid cerebral palsy had significantly higher symmetry in muscle activity in WA compared to HP. Similarly, this study result ssupports higher muscle activity of PM (169.67 %), BB (331.97 %), RA (122.37 %), LD (246.36 %), SE (401.39 %), RF (114.62 %), AT (372.06 %), and EG (231.93%) in WA compared to HP. This suggests that therapeutic horseback riding exercise is effective in improving general physical exercise function of cerebral palsy patients.

5. Conclusion

HP and trot (ST and RT) had a significant effect on the muscle activity of patients with cerebral palsy, and it was found that the physical effect of the therapeutic horseback riding was positive for the improvement of muscle strength of cerebral palsy patients. If patients with cerebral palsy can successfully perform WA, the basic course of therapeutic horseback riding exercise, we recommend the trot (ST and RT) method, which is more helpful in improving physical strength. The results of this study suggest that the method of intervention for treatment of cerebral palsy patients can use therapeutic horseback riding exercise as a rehabilitation method. In future research, it would be expected that the physical effects of therapeutic horseback riding exercise should be studied according to several types of disability, gender, and age.

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