J. Phys. Ther. Sci.
26: 1667–1669, 2014

Original Article

The Effect of Exercise Using a Sliding Rehabilitation Machine on the Gait Function of Children with Cerebral Palsy

Yang-soo Lee, MD, PhD[1)], Won-bok Kim, MD, MS[2)*], Joo-wan Park, PT, MSc[3)]

[1)] Department of Physical Medicine and Rehabilitation, Kyungpook National University Hospital, Republic of Korea
[2)] Department of Physical Therapy, College of Rehabilitation Science, Daegu University: 201 Jilyang, Gyeongsan-si, Kyeongbuk 712-714, Republic of Korea
[3)] Department of Physical Therapy, College of Rehabilitation Science, Graduate School, Daegu University, Republic of Korea

Abstract. [Purpose] The purpose of the present study was to examine the effect of strength training using a sliding rehabilitation machine (SRM) on the gait function of cerebral palsy children. [Subjects and Methods] Thirteen children aged 6–18 years participated in the SRM training for 8 weeks (30 min/day, 2 times/week). The SRM is designed for the performance of a closed-kinetic chain exercise in which a tilt table is moved up and down using wheels on the table. Participants began in a position of flexion of the 3 lower joints (hips, knees, and ankles) on the SRM. In each exercise session, they extended and flexed the 3 joints. The level of exercise was set by changing the inclination of the tilt table. Functional gait ability was measured with the 6-minute walk test (6MWT), 10-m walk test (10MWT), and timed up-and-go test (TUG) before and after the training. Muscle strength was also measured using an isokinetic dynamometer. [Results] Nine of the thirteen children completed the entire study. The peak torques of the knee extensor and flexor group muscles significantly improved after training with the SRM. The total distance of the 6 MWT significantly increased after training. The times of the 10 MWT and the TUG significantly improved after training. The changes in muscle tone were also investigated using the MAS (Modified Ashworth Scale) and Tardieu scale, but no significant changes were found in muscle tone between the pre- and post-test measurements. [Conclusion] The findings demonstrate the effect of the SRM intervention which resulted in improved muscle strength and functional gait.

Key words: Cerebral palsy, Sliding rehabilitation machine, Gait

(This article was submitted Feb. 26, 2014, and was accepted Apr. 26, 2014)

INTRODUCTION

Cerebral palsy (CP), which is the most common physical developmental disability in childhood, describes a group of disorders in the development of movement and posture that cause activity limitations, and are attributed to non-progressive disturbances that occur in the developing brains of infants[1, 2)]. The impairment in cerebral palsy, including secondary impairments such as spasticity, muscle contracture, bone deformity, muscle weakness, and coordination disorders, is multifactorial and is characterized primarily in the lower extremities, which account for most of the functional impairments seen in CP, such as deficits in walking ability[3, 4)]. Improvement in gait function is a primary concern of patients and their caregivers. Thus, it has naturally become the most important aim of treatment[5)]. To treat impaired gait, strengthening exercises, such as sit-to-stand (STS) exercises have been attempted. In a study using electromyographic analysis, Berger and Olney reported that muscle weakness is the principal component of limited or decreased gait ability in children with cerebral palsy[6, 7)]. Hua-Fung Liau et al. reported that loaded sit-to-stand exercises improved basic motor abilities, functional muscle strength, and walking efficiency[8)]. However, the application of STS exercises is limited to patients who have sufficient power to maintain a standing position or who do not have severe contractures of the plantar flexor. Therefore, in this study, a sliding rehabilitation machine (SRM) was used because the SRM can provide partial body weight support by adjusting the inclination of the supporting carriage. It is also possible to allow the patients' feet to make full contact with the plate by adjusting the inclination of the footplate. Furthermore, the SRM can facilitate the performance of forced use exercise by removing the footplate of the unaffected side, and it can also provide weight bearing exercise by controlling center-of-gravity movement, with the trunk fixed on the carriage[9)]. In addition, in SRM, the angle of

*Corresponding author. Won-bok Kim (E-mail: ak090700@gmail.com)

knee flexion can be better controlled than in the sit to stand exercise. Lee reported that sit-to-stand performance at different angles of knee flexion by individuals with hemiparesis changed the peak value of plantar pressure and the symmetry of the gait pattern[10].

Therefore, this study was designed to determine the effect of strength exercises, using SRM, on the muscle power and gait function of children with CP.

SUBJECTS AND METHODS

Subjects

Thirteen children who visited an outpatient clinic for treatment were recruited for this study according to the inclusion and exclusion criteria (Table 1). The inclusion criteria of this study were as follows: GMFCS levels I-III; age from 6 to 18 years old; and ability to follow verbal instructions. Children who were not able to walk independently, or with an orthosis, or who had any disease that might have had a negative effect on the results were excluded. Children who had undergone surgery or who had received Botox treatment within the previous 6 months were also excluded. All the subject's parents or guardians understood the purpose of this study and gave their prior written consent to their children's participation, in accordance with the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from our local university and hospital research ethics boards.

Table 1. Demographic data of the subjects

Subject	Age	Sex	GMFCS	Type
1	15	Male	3	Quadriplegia
2	11	Male	2	Rt. Hemiplegia
3	13	Female	2	Lt. Hemiplegia
4	11	Male	2	Lt. Hemiplegia
5	16	Male	2	Diplegia
6	18	Male	3	Diplegia
7	15	Male	3	Quadriplegia
8	14	Female	2	Lt. Hemiplegia
9	9	Male	3	Diplegia
10	18	Female	3	Quadriplegia
11	8	Male	2	Diplegia
12	9	Female	2	Rt. Hemiplegia
13	12	Male	2	Rt. Hemiplegia

Fig. 1. SRM training

Methods

The children and their parents were provided information about the purpose, method, advantages or inconveniences, warnings, and the test schedule of this study. A SRM was used in this study. It consists of a patient-supporting carriage, a footplate, and a Velcro safety strap that is connected to the carriage. It also has a rail system, which is designed to allow the patients to perform a closed-kinetic chain exercise by moving the tilt table up and down using the wheels on the table. The wheels, which minimize frictional force, make the exercise easier. In this exercise, participants began in a position of flexion of the hips, knees, and ankles. In each exercise session, the patients extended the hips, knees and ankles from the flexed posture and then returned them to their original flexed posture (Fig. 1). The level of exercise was set according to the level of weight supported by changing the inclination of the tilt table for each patient. Adjusting the inclination of the footplate to produce full contact between the soles and plates made the exercise possible for those patients who had difficulty performing plantar flexion due to severe contracture. During the exercise, Velcro straps were fixed to the patient's trunks and ankles for their safety. All of the children who participated in this study trained with the sliding rehabilitation machine for 30 minutes per day, twice a week for 8 weeks, with concurrent conventional Bobath therapy. The intensity of the exercise was controlled by increasing the inclination of the carriage and by adjusting the number of trials per session. Break times were also provided when the children requested rest, but they were minimized as the training progressed. Every training session was conducted under the supervision of an experienced physical therapist. To confirm the effects of the training with the SRM, functional gait ability was measured with the 6-minute walk test (6MWT), 10-m walk test (10MWT), and timed up-and-go test (TUG). Muscle strength was measured using an isokinetic dynamometer (Cybex International, Inc., USA). The peak torque was measured during flexion and extension exercises of the knee joint before and after the training. Furthermore, tests for possible adverse effects, such as changes in muscle tone, were performed the pre and post-test. Statistical analysis was conducted using SPSS 18.0 for Windows. Non-parametric tests were used as not all data were normally distributed. To identify the changes in each parameter between before and after the training with the SRM, Wilcoxon's signed rank test was used. Significance was accepted for values of $p<0.05$ in the statistical analysis.

RESULTS

Nine of the thirteen children completed the entire study, and 4 children withdrew before the completion of this study because the children or their parents did not want to continue due to academic problems or conflicts in scheduling. Subject 4 started the SRM training during his school vacation. As a new semester started, however, he could not continue the SRM training because of regular school classes and additional private lessons. Subjects 1 and 3 were excluded from the analysis because their attendance rates were low during the 2-month training period. Subject 2 was transferred to another hospital because her parents wanted whole-day treatment, so she also could not continue the SRM training. The remaining children completed the entire training and all of the tests.

The peak torque of the knee extensor muscles had significantly improved after the training with the SRM ($p<0.05$); the mean value increased from 31.11±7.42 to 40.55±10.37 Nm. The peak torque of the knee flexor also significantly improved after the training ($p<0.05$); the mean value increased from 20.22±16.2 to 26.33±19.11 Nm. The total distance of the 6MWT significantly increased after the training ($p<0.05$); the mean value increased from 227.14±42.93 to 260.951±48.71 meters. The times taken for the 10MWT and the TUG had significantly decreased after the training, compared with before training ($p<0.05$). The mean values of these tests decreased from 16.42±3.71 to 14.14±3.52 sec and from 25.17±7.53 to 21.79±6.43 sec, respectively. No adverse effects, such as seizures or pain, occurred during the intervention. In addition, the changes in muscle tone were also investigated using the MAS and Tardieu scale, but no significant changes were found in muscle tone between the pre- and post-test measurements.

DISCUSSION

The findings of this study indicate that SRM might provide a useful therapeutic intervention for the improvement of the muscle strength and walking ability of children with cerebral palsy. Several studies have reported that when hemiplegic patients with stroke performed strengthening exercises using a sliding rehabilitation machine, their muscle strength and walking ability significantly improved after the training. In the current study, muscle strength was significantly improved by training with the SRM. This finding is in agreement with those previous studies which reported that the strength of the quadriceps femoris muscle of children with cerebral palsy improved as a result of resistance exercise[11]. Our study subjects showed improvements in walking ability after training using the SRM. We believe that this finding is explained by an increase in muscle strength sufficient to improve functioning. For children with diplegia, weight could be distributed on both the soles by adjusting the inclination of the footplate, and strengthening could be focused on the qaudriceps muscle, by fixing the trunk on the carriage. Consequently, the muscle strength of the quadriceps significantly improved. Furthermore, for the hemiplegic children, it was possible to conduct forced use exercise through concentrating the weight only on the paretic limb by removing the footplate from the opposite, nonparetic side[9]. In addition, increased muscular strength of the quadriceps femoris would make it possible to counteract the hamstring muscle and increase the stride length by decreasing the cadence which results from overcompensatory action[12].

We thought that strengthening of the ankle plantarflexor was improved by enabling full contact of the feet with the plate by adjusting the inclination of the footplate. Ankle plantarflexor strengthening may lead to improvements in the gait function of children with cerebral palsy[13]. Furthermore, it is believed that improved strength can facilitate faster and more stable walking by increasing the angular velocity during extension and by improving the stability of the joints[14].

This study had some limitations. First, the number of patients who participated in this study was somewhat small. Second, the simple design did not include a control group. Third, follow-up testing of the sustainability of the intervention's effectiveness was not performed. However, despite these limitations, this study is meaningful because the effectiveness of the SRM for children with cerebral palsy was objectively confirmed and has been presented for the first time. Additional studies will be needed which address these limitations.

ACKNOWLEDGEMENT

This research was supported by the Daegu University Research Grant, 2011.

REFERENCES

1) Himmelmann K, Hagberg G, Beckung E, et al.: The changing panorama of cerebral palsy in Sweden. IX. Prevalence and origin in the birth-year period 1995–1998. Acta Paediatr, 2005, 94: 287–294. [Medline] [CrossRef]
2) Bax M, Goldstein M, Rosenbaum P, et al. Executive Committee for the Definition of Cerebral Palsy: Proposed definition and classification of cerebral palsy, April 2005. Dev Med Child Neurol, 2005, 47: 571–576. [Medline] [CrossRef]
3) Binder H, Eng GD: Rehabilitation management of children with spastic diplegic cerebral palsy. Arch Phys Med Rehabil, 1989, 70: 482–489. [Medline] [CrossRef]
4) Gormley ME Jr: Treatment of neuromuscular and musculoskeletal problems in cerebral palsy. Pediatr Rehabil, 2001, 4: 5–16. [Medline]
5) Bleck EE EE: Management of the lower extremities in children who have cerebral palsy. J Bone Joint Surg Am, 1990, 72: 140–144. [Medline]
6) Berger W, Quintern J, Dietz V: Pathophysiology of gait in children with cerebral palsy. Electroencephalogr Clin Neurophysiol, 1982, 53: 538–548. [Medline] [CrossRef]
7) Olney SJ, MacPhail HE, Hedden DM, et al.: Work and power in hemiplegic cerebral palsy gait. Phys Ther, 1990, 70: 431–438. [Medline]
8) Liao HF, Liu YC, Liu WY, et al.: Effectiveness of loaded sit-to-stand resistance exercise for children with mild spastic diplegia: a randomized clinical trial. Arch Phys Med Rehabil, 2007, 88: 25–31. [Medline] [CrossRef]
9) Byun SD, Jung TD, Kim CH, et al.: Effects of the sliding rehabilitation machine on balance and gait in chronic stroke patients—a controlled clinical trial. Clin Rehabil, 2011, 25: 408–415. [Medline] [CrossRef]
10) Lee MY, Lee HY: Analysis for sit-to-stand performance according to the angle of knee flexion in individuals with hemiparesis. J Phys Ther Sci, 2013, 25: 1583–1585. [Medline] [CrossRef]
11) Lee JH, Sung IY, Yoo JY: Therapeutic effects of strengthening exercise on gait function of cerebral palsy. Disabil Rehabil, 2008, 30: 1439–1444. [Medline] [CrossRef]
12) Damiano DL, Vaughan CL, Abel MF: Muscle response to heavy resistance exercise in children with spastic cerebral palsy. Dev Med Child Neurol, 1995, 37: 731–739. [Medline] [CrossRef]
13) Jung JW, Her JG, Ko J: Effect of strength training of ankle plantarflexors on selective voluntary motor control, gait parameters, and gross motor function of children with cerebral palsy. J Phys Ther Sci, 2013, 25: 1259–1263. [Medline] [CrossRef]
14) MacPhail HE, Kramer JF: Effect of isokinetic strength-training on functional ability and walking efficiency in adolescents with cerebral palsy. Dev Med Child Neurol, 1995, 37: 763–775. [Medline] [CrossRef]