J. Phys. Ther. Sci.
27: 3023–3025, 2015

Case Study

Whole-body vibration training improves the walking ability of a moderately impaired child with cerebral palsy: a case study

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Abstract. [Purpose] Strength training is recommended for children with cerebral palsy. However, it is difficult for moderately impaired children with cerebral palsy, who require crutches for ambulation, to participate in this type of training. The purpose of this study was to investigate whether whole-body vibration training is an effective method of strengthening in a moderately impaired child with cerebral palsy. [Subject and Methods] This report describes an 8-year-old Japanese boy with cerebral palsy, who was ambulatory with crutches. The subject participated in physical therapy twice a week for 5 weeks. Whole-body vibration training was selected to complement the standing practice. The patient's crutch-walking ability, gross motor function, and spasticity were evaluated. [Results] The number of steps and walking duration were reduced in a 5-m walk test with crutches and gross motor function was improved. Further, the spasticity was reduced. [Conclusion] Whole-body vibration training is an effective physical therapy intervention in moderately impaired children with cerebral palsy, who are unable to walk without crutches.
Key words: Cerebral palsy, Whole-body vibration, Walking ability

(This article was submitted Apr. 14, 2015, and was accepted Jun. 3, 2015)

INTRODUCTION

School-aged children with cerebral palsy (CP) tend to slow down or exhibit decreased ability to walk; strength training is therefore recommended for this age group. However, CP children with moderate impairment of gross motor ability [Gross Motor Function Classification System (GMFCS) level III] cannot perform some of the strength training tasks such as squatting exercises, although previous studies have reported that strength training and circuit training are suitable for mildly impaired children with CP (GMFCS levels I and II)[1–6)]. The appropriate training method for a moderately impaired child has not yet been determined. Among moderately impaired children with CP, who have limited exercise participation, muscle weakness following disuse caused by the lack of movement occurs from an early age. Muscle weakness caused by changes in the physique also reduces the child's ability to walk.

Whole-body vibration (WBV) training is performed on a platform vibrating at a finely tuned high speed. The vibration increases the weight-bearing load on the child's muscles, and physiologically, it stimulates the proprioceptors. WBV training has been shown to be effective in improving range of motion and balance ability[7–11)].

Even among children with CP, who are able to walk with crutches, there is a risk of reduced walking ability if the child has limited opportunities for walking on a daily basis. In this study, training using WBV-stimulation was investigated to establish whether it improved the subject's walking ability. In addition, changes in spasticity, the main factor limiting the subject's walking ability, were assessed.

SUBJECT AND METHODS

The participant was an 8-year-old boy with CP (spastic diplegia), who had no intellectual disability or epilepsy and no history of surgery. He was able to walk with crutches, but he uses a wheelchair for everyday living activities for improved safety and speed of movement. He attends a special support school. He was provided physical therapy

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Table 1. Walking ability of the subject (5-m walk test with crutches)

	1	2	3	4	5	6	7	8	9	10	r
Duration (sec)	91.0	54.2	51.5	37.5	45.7	43.7	37.4	36.2	37.4	32.8	0.93
Number of steps	43.5	37.5	35.5	33.5	36.0	35.5	32.0	30.0	30.0	29.5	

The values represent the average of 2 measurements
r: regression coefficient of the duration and number of steps

Table 2. Modified Tardieu scale (ROM°: deg)

	1	2	3	4	5	6	7	8	9	10
V1	20.0	35.0	32.5	32.5	20.0	30.0	17.5	10.0	20.0	20.0
V3	−15.0	−5.0	−7.5	−2.5	−7.5	−2.5	2.5	−2.5	−2.5	0.0
R2–R1	35.0	40.0	40.0	35.0	27.5	32.5	20.0	12.5	22.5	20.0

Joint angle of ankle (Average of the left and right sides)
V1: As slow as possible (slower than the natural drop of the limb segment under gravity)
V3: As fast as possible (faster than the rate of natural drop of the limb segment under gravity)
R2–R1: The difference between slow (V1) and fast (V3) ankle dorsiflexion

Table 3. Changes in the gross motor function measure (GMFM) before and after intervention

Domain	Before	After
C: Crawling and kneeling	33/42 (78.6%)	36/42 (85.7%)
D: Standing	14/39 (35.9%)	17/39 (43.6%)

(PT) at another hospital from infancy and at our rehabilitation center at the age of 8 years. During his first visit, his impairment was graded as GMFCS III, and his Gross Motor Function Measure (GMFM) exercise capacity scores were 33/42 points (78.6%) for dimension C (crawling and kneeling) and 14/39 points (35.9%) for dimension D (walking). The present study was conducted with the approval of the Medical Review Board of Gifu University Graduate School of Medicine (approval number: 26-58). In addition, the study aim and procedure was explained to the subject and his parents, and written informed consent was obtained.

The subject participated in PT twice a week for 5 weeks. WBV training was selected to complement the standing practice (30 Hz, low (1–3 mm) amplitude, 1 min × 5–6 sets, interval 1 min). For the WBV training, a vibrating platform (Powerplate®, Performance Health Systems UK Ltd., UK) was used. Walking ability was evaluated using a 5-m walk test with crutches in terms of the number of steps and walking duration. As spastic diplegia of the lower limbs was the limiting factor, spasticity was also evaluated using the Modified Tardieu Scale (MTS) and the Modified Ashworth Scale (MAS), which have been used to evaluate spasticity of the ankle[12)]. Walking ability and spasticity were evaluated before and after every PT intervention. GMFM was measured before and after the 5-week intervention.

RESULTS

As shown in Table 1, the number of steps and walking duration in the 5-m walk test with crutches decreased after the 5-week intervention.

As shown in Table 2, there were no changes in the MAS scores, but the MTS (V3) scores showed a trend of increasing joint range of motion after the intervention.

As shown in Table 3, the subject's GMFM scores increased by 7.1% in the C domain and by 7.7% in the D domain.

DISCUSSION

In a previous study, 45% of children with CP were reported to have lost their ability to walk[13)]. Children with CP, who present with moderate motor dysfunction, are at a high risk of reduced exercise capacity because of infrequent opportunities to stand or walk. WBV training can quickly and effectively increase muscle activity during the standing training.

In this study, WBV training improved the walking ability and gross motor function of a moderately impaired child with CP. The study also showed that the subject's spasticity was reduced by WBV training.

Previous reports on strength training in children with CP have provided evidence of improvement in gross motor function with increase in lower limb muscle strength; however, the effects on stride and walking speed have not yet been reported[3–5)]. The walking ability of a subject has been shown to improve with WBV training, suggesting the possibility that in addition to increased leg strength, this method also improves function, flexibility, and balance to some extent. In addition, WBV training is a more useful method of strength training in children with CP compared to other previously used methods. In other studies[2–5)], circuit training and an incremental load training program have been reported to be as effective as strength training techniques for ambulatory children with CP. Adjusting the load on the vest that is used often can provide a uniform weight-bearing load distribution; this method is used in circuit training, step-lifting to the side (lateral step-up and step-down), and sit-to-stand, with a gradual increase in the load[2–4, 14]. For children with CP, who have moderate impairment, such training is very difficult. However, with WBV, there is no need to attach a weight to the child's muscles to perform weight-bearing exercises. The vibration allows a child who is unable to perform the exercise to experience increased muscle activity while maintaining a desired posture. The training posture can be set by the therapist to suit the needs of the child. In this case, it was determined that WBV would be added to maintain the standing posture being practiced by the child to increase the amount of muscle activity. After 5 weeks, the child showed improved strength, and WBV training is believed to have led to his improved walking ability and gross motor function.

This study showed that WBV training is useful for reducing spasticity in a child with CP. This is not observed with other strength training methods. In this case, the level of spasticity was evaluated using the MTS and MAS before and after each PT session; this showed that MTS (V3) was increased and R2–R1 was reduced after WBV training. Increased ankle dorsiflexion was observed, as was inhibition of spasticity. The inhibitory effect of WBV training on spasticity has also been observed among elderly stroke patients. In this case, reducing spasticity led to an improvement in the child's walking ability[15].

Lower limb strength generally decreases among wheelchair users because of disuse. Increased activity of the lower limbs in children with CP, who use wheelchairs, is important for improved strength and mobility, and WBV training may be an effective method for this purpose. However, the training frequency (the speed of the vibration as well as its amplitude) and the ideal weight-bearing load are not known. In children with a history of surgery or epilepsy, which is common among those with CP, the safety and effectiveness of WBV training needs further clarification. There are reports on the usefulness of WBV training in the treatment of central nervous system diseases other than CP. In recent years, WBV training has been shown to be an effective strength training approach for individuals affected by spinal cord injury, Parkinson's disease, and stroke[16–20].

In moderately impaired children with CP, who use a wheelchair on a daily basis, WBV training may prevent muscle weakness caused by disuse. Furthermore, WBV may improve mobility by reducing spasticity.

ACKNOWLEDGEMENT

We would like to thank the Himeyuri children's rehabilitation center staff (Sakai RPT, Tama RPT, Abe RPT, Takahashi OTR, and Usami OTR) for providing assistance in the training and measurements.

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