Effects of Elastic band Exercise on Foot Pressure, Balance and Gross Motor Function in Children with Cerebral Palsy : Case Study

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Purpose This study examined the influence of elastic band on foot pressure, balance and gross motor function in children with cerebral palsy. ***Methods*** This study participate 5 subjects were diagnosed children with spastic cerebral palsy. Baseline and pre-test period were not exercise, during intervention period performed for 30 minute, 2 times a week, for 3 months. All subjects were measured with the foot pressure, Gross Motor Function Measure(GMFM) and Pediatric Balance Scale(PBS). ***Results*** After intervention, the significant changes were seen in foot pressure($p<.05$), there were no significant difference change in the result of PBS and GMFM according to the period. Nevertheless, PBS score increased after intervention and decreased slightly in follow-up. Likewise, in GMFM, the score increased after the intervention, and it was higher than before the pre-test. ***Conclusion*** Elastic band exercise was effective in improving foot pressure, balance and gross motor function in children with cerebral palsy.

Key words Elastic band, Foot pressure, Balance, GMFM, Cerebral palsy

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Ⅰ. Introduction

Cerebral palsy is a non-progressive disease that is accompanied by poor movement and postural development, as well as problems with sensation, perception, behavior, and secondary musculoskeletal development.[1)] Cerebral palsy involved musculoskeletal deformities, muscle shortening and dystrophic changes, and weakness throughout the entire body.[2)] Thus, muscle control becomes difficult, which eventually affects functional performance,[3)] limits joint range of motion, and causes abnormal body alignment, leading to decreased balance ability and function.[4)] Compared to ordinary children of the same age, physical activities such as independent movement or stair climbing appear to be limited in children with cerebral palsy,[5)] and because these children sit or lie down for a long period, they also lack exercise experience.[6)]

Davids[7)] suggested that children with cerebral palsy experience decreased lower extremity muscle strength over time, and that this effect is less pronounced in children with independent gait. Various physical therapy methods can elicit latent motor skills and solve secondary problems.[8)] However, there are always limitations in children, who have difficulty understanding and controlling their movement due to immature body cognition.[9)]

Elastic band is a resistance exercise in which tension is generated by pulling a band or tube made of elastic material, to create a load against which muscle strength is exerted.[10)] Elastic band is used in various fields as an effective method to provide sufficient resistance to improve muscle strength. It can provide consistently appropriate resistance in many directions, and is effective for controlling functional movement.[11)] TheraBand consecutive Loops(CLX) is equivalent to weight training in terms of strength curve, muscle activation, perceived exertion, and strength gain. The loops provide multiple unique grip and anchor options for open and closed hand grips, holding objects

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with resistance, no-grip-required exercise, and other exercise that connect the upper and lower body work. Elastic band exercise acts as an external force and differs from existing methods that suffer from limited problem solving and movement control capacity in children. However, its effects have rarely been stuided, especially in children with cerebral palsy. Therefore, the objective of this study was to investigate the effect and persistence of elastic band exercise application on children with cerebral palsy. We conducted a case study involving several children and collected data with the goal of developing function enhancement and intervention strategies.

II. Materials and Methods

1. Subjects

We enrolled five children diagnosed with cerebral palsy at S Hospital in Suwon City, Gyeonggi-do, South Korea; they were all undergoing rehabilitation (Table 1). The parents provided written informed consent. Table 1 lists the general characteristics of the subjects. The study period was about 5 months: from Janunary 2 to June 1, 2019.

2. Methods

Assessments were performed at baseline, pre-test after 4 weeks, post-test after 12 weeks, and follow-up after 4 weeks. This study is a case study and assessments were baseline, pre-test after 4 weeks, post-test for 12 weeks, and follow-up after 4 weeks. The 4 weeks period between baseline and pre-test, these designs provide good control of extraneous factors by enabling the researcher to determine whether the hypothesized change occurs each time the treatment is applied or withdrawn.

Figure 1. Elastic band consecutive loops

Thereafter, assessments were performed twice per week for 3 months. Elastic band was applied for 30 min of exercise comprising everyday tasks, which were part of a task-oriented training program consisting of standing, sitting, squatting, and walking.[12, 13]

We used the green TheraBand CLX (Hygenic Corp., OH, USA), which has a resistance level of 4.6–6.7 lbs.; the band was applied to the lower extremities and fixed by hanging it between the feet, and then forming and maintaining an X shape(Figure 1). The femoral band provides resistance to the muscles that stretch the knee, the band behind the knee limits knee hyperextension, and the ankle joint band provides resistance to the plantar flexor.

3. Measurements

(1) Foot pressure

We used a TPScan diagnostic device (Biomechanics

Table 1. General characteristics of the subjects

(N=5)

Subject	Gender	Age (years)	Weight (kg)	Height (cm)	Type of Cerebral Palsy	GMFCS (level)
1	Male	7	33	127	Rt. hemipleia	1
2	Male	7	27	122	Diplegia	1
3	Male	8	26	120	Diplegia	1
4	Female	6	30	124	Lt. hemipleia	2
5	Female	7	25	121	Diplegia	1

GMFCS: Gross Motor Function Classification System

Table 2. General characteristics of the subjects

Task	program
Sit to stand	Activity of standing take place in the chair
Squatting	Activity of bending the knee in a standing position.
Standing	Looping and ball throwing activities in a standing position
Walking	Activity of walking the target between 3m

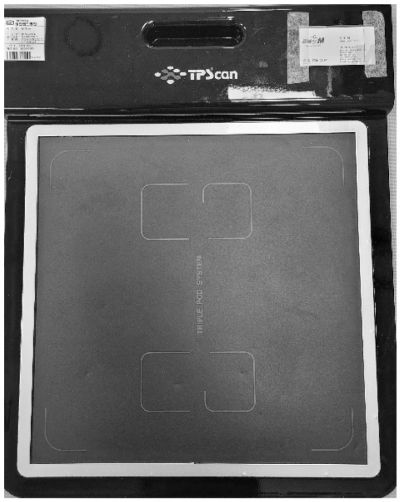

Figure 2. TPScan

Co., Goyang, Korea) to manufacture a thermoplastic styrenic elastomer(TPS) insole with a pressure monitor(Figure 2). Plantar pressure is tested by standing or stepping on the TPS insole, which is composed of a baropedometer comprising 1600 pressure sensing sensors; pressure distribution can be determined from an image of the measurement results (Figure 3).[14)]

Static plantar pressure distribution was measured by having each child stand on a pressure measurement plate with both feet for 10s; the average of three measurements was used. These evaluations were conducted twice: before and after the intervention.[15)]

(2) Balance

The Pediatric Balance Scale (PBS) was used to analyze changes in balance. The 14 items of the revised Berg Balance Scale include the time taken to maintain a sitting posture, the quality of the posture per se, and the ability to maintain head posture for 30s(less than the time of the original Scale). The average of the three attempts was used, and the score ranged from 0 to 4. Balance skills such as sitting, standing and climbing stairs are important in order to perform independent activities stably in activities of daily living. The intra-rater and inter-rater correlation coefficients attained 0.99.[16)] Also, the maximum duration of one-leg standing on the more affected side was measured[17)]; this is an important measure of postural control.[18)] Assessments were baseline, pre-test after 4 weeks, post-test for 12 weeks, and follow-up after 4 weeks.

(3) Gross Motor Function

We used a Gross Motor Function Measure (the GMFM-66) appropriate for children with cerebral palsy aged 0–18 years. The GMFM-66 includes five groups

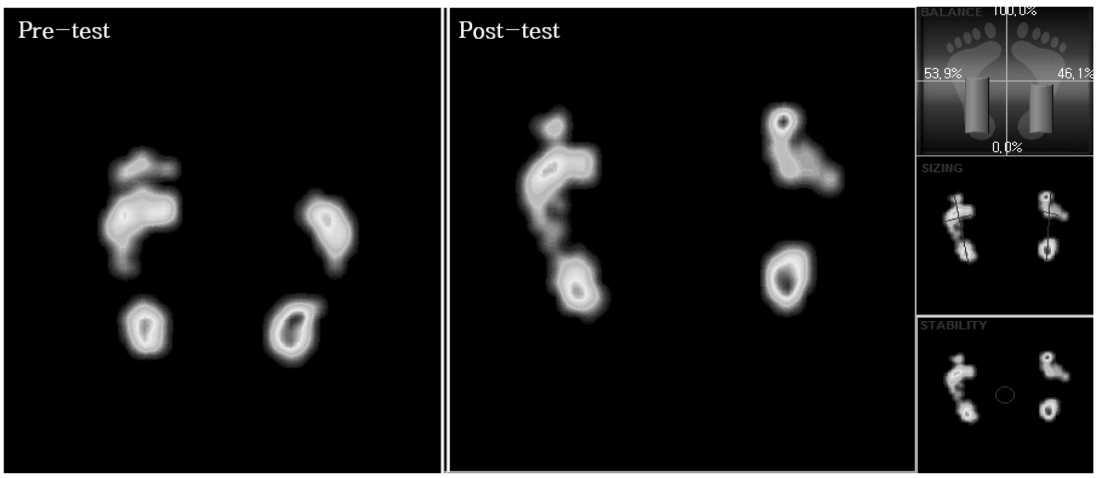

Figure 3. Foot pressure measurement image

of items, with 66 items in total, thus fewer than the GMFM-88; scores can be obtained without evaluating all items. In addition, responses are ranked in terms of difficulty; functional ability is readily assessed.[19] The scores for each item ranged from 0(failure) to 3(complete success); the test-retest reliability was 0.99.[20] In other studies, the test-retest reliability was 0.97 and the interlaboratory reliability 0.98.[21] All scores were estimated using Gross Motor Ability Estimator (GMAE) software and were calculated at baseline, pre-test after 4 weeks, post-test for 12 weeks, and follow-up after 4 weeks.

4. Statistics analysis

Statistical analyses were performed using the SPSS v. 22.0 software for Windows. Nonparametric statistics were used for all tests. Foot pressure measurements before and after intervention were compared using the Wilcoxon signed rank test, where the significance level(α) was corrected to .008 (.05/8). The Freidman test was used to assess differences in the probability of bivariate superiority (PBS) and gross motor function measurement (GMFM).

Ⅲ. Results

1. Foot pressure

Table 3 lists the differences in the static plantar pressure distribution of both feet before and after the intervention. In most children, plantar pressure was in the anterior direction. Plantar pressure was significantly lower before the intervention ($p<.05$), and the distribution was slightly higher on the right side.

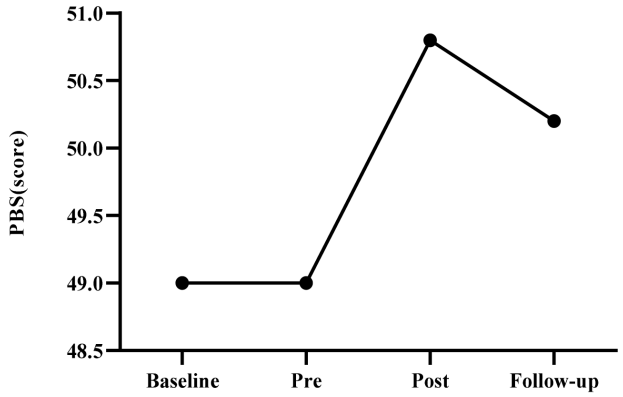

Figure 4. A comparison of PBS, *p<.008

2. PBS

The baseline PBS score improved following the intervention, but dropped markedly after the intervention(Table 3). A significant difference was observed between baseline and post-test scores, but not between those of adjacent periods(Figure 4).

3. Gross Motor Function

Table 3 lists the major outcomes of this study. GMFM scores increased from baseline to the pre-test assessment, and then again after the intervention, but decreased slightly at the post-test assessment; none of these differences was statistically significant(Table 4).

Table 3. Variations of foot pressure

(unit: %)

	Pre-test			Post-test			Difference
	Rt	Lt	Difference	Rt	Lt	Difference	Z(p)
Foot pressure	55.36±12.28	44.64±12.28	20.64±14.65	55.83±7.00	44.16± 7.00	11.67±14.00	-2.023(.043)*

Value are mean±SD, *p<.05

Table 4. Variations of Outcome

	Baseline	Pre-test	Post-test	Follow-up	χ^2(p)
PBS(score)	49.00±3.39	49.00±3.39	50.80±3.56	50.20±4.26	10.286(.016)*
GMFM(%)	78.37±5.25	78.37±5.25	81.69±8.62	80.23±7.57	5.400(.145)

Value are mean±SD, *p<.05

Ⅳ. Discussion

Children with cerebral palsy lack stability and balance due to muscle weakness, abnormal muscle tone and difficulty in motor control.[22] Cerebral palsy affects daily life including participation in school, and society, and can be an important factor in determining the quality of life.[7]

In this study, we examined how elastic band exercise applied to the lower extremities of children with cerebral palsy effected gross motor function. To reduce asymmetry between the sides of the body and restore walking ability, it is necessary to maintain a balanced standing posture and allow weight transfer to both lower limbs.[23] Analyzing foot pressure in relation to gait is useful way to observe the treatment and progress of children with cerebral palsy or stroke patients with foot problems.[24]

The results of this study showed that elastic band exercise reduced the difference in weight distribution to both lower limbs, by. 20.64±14.65 at the pre-test assessment, and by 11.67±14.00 after the intervention. The symmetry ratio in children with cerebral palsy is very different compared to normal children, and irregular symmetry makes it difficult to secure stability.[25] Other studies also indicated that asymmetrical lower extremity weight support was found in children with cerebral palsy,[26] and that limitation of weight transfer could affect balance control.[27] It was reported that bilateral weight transfer training promotes balance control, and that even weight bearing is important in preventing secondary deformation and reducing abnormal patterns.[28] The exercise through elastic bnad in this study maintains the distribution of bilateral weight transfer symmetrically, and it is thought that it can help to control balance and improve function by reducing weight transfer restriction.

PBS showed significant difference in the amount of change over time, but there was no period that satisfied the significance level in the post-test. However, it was increased from 49.00±3.39 before intervention to 50.80±3.56 after intervention, and it was also maintained at baseline and at an increased level than before intervention in follow-up. In a study of normal adults showed that the CLX exercise in combination with the PNF pattern had a positive effect on enhancing the balance ability of the normal adult and performing the functional mobility of the lower limb.[29]

There was no significant differences in the amount of change over time for GMFM. However, the increase was 81.69±8.62 after the intervention than 78.37±5.25 before the intervention, and it was shown that the follow-up was maintained at an increased level compared to the baseline and before the intervention. In a study of in 12 children with cerebral palsy, it was reported that the Theraband exercise showed significant differences in the standing and walking areas of the gross motor function.[30] Kim[29] study also showed improved single limb hop function when elastic band was applied with exercise.

The increase in symmetrical weight support shown in this study also reduces the compensatory pattern and improves balance. Furthermore, it will be of great help in activities where weight support and movement are essential, such as walking and climbing stairs. Gross motor function is an intervention goal of children with cerebral palsy and is a factor that influences activity and social participation,[31] prior to improving the quality of life, emphasis should be placed on enhancing gross movement ability,[32] and the improvement of gross movements through this study can be said to be a meaningful result.

The limitations of this study are that it is difficult to generalize the study results due to the small number of subjects, and that various variables were not identified in the foot pressure test. In addition, the intervention and evaluation showed limitations in that the degree of participation varies depending on low concentration, emotion, and condition, and it is believed that a study on the intervention method for the weight distribution pattern of children with cerebral palsy with many variations in the foot is needed.

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