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Case Study

Clinical usefulness of Adeli suit therapy for improving gait function in children with spastic cerebral palsy: a case study

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Abstract. [Purpose] The purpose of this study was to determine the effects of Adeli suit therapy (AST) on gross motor function and gait function in children with cerebral palsy. [Subjects and Methods] Two participants with spastic cerebral palsy were recruited to undergo AST. AST was applied in 60-minute sessions, five times per week, with 20 sessions total over 4 weeks. Assessments of gross motor function, spatiotemporal parameters, and functional ambulation performance for gait were conducted. [Results] Gross motor function, cadence, and functional ambulation performance improved after the intervention in both cases. [Conclusion] Although additional follow-up studies are required, the results demonstrated improved gross motor function and functional ambulation performance in the children with cerebral palsy. These findings suggest a variety of applications for conservative therapeutic methods that require future clinical trials in children with cerebral palsy.

Key words: Cerebral palsy, Adeli suit, Gait function

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INTRODUCTION

The Adeli suit was originally designed for the Russian space program in 1971. The suit was developed for the maintenance of muscle tone in a weightless environment, such as that of a spaceship worker[1)]. It was designed to create a normal framework of forces on the body for stabilizing the torso to allow for more fluent and coordinated movement of all limbs. It uses a system of elastic bands and pulleys that create artificial forces against which the body can work in order to prevent muscular atrophy. The Adeli suit treatment (AST) has been proposed as an intensive exercise protocol for use in the management of cerebral palsy (CP) and other neuromuscular disorders[1)]. The suit is composed of a cap, a vest, shorts, knee pads, shoes with attached auxiliary equipment, and a bungee cord to connect auxiliary equipment. The pieces are laced together with bungee-type cords. The cords are adjustable for the application of varying degrees of tension to the child's different muscle groups. The bungee cords are positioned to keep the body properly aligned and to forcibly encourage movement within a normal range of motion[2)]. To reposition the limbs in order to correct for abnormal muscle alignment, the bungee cords are adjusted by therapists to mimic normal flexor and extensor patterns of the major muscle groups[1)].

The mechanism behind the Adeli suit is that through active movement therapy, the brain is stimulated and thus is retrained to recognize, and eventually initiate, correct movement of the muscles. Once the body is in proper alignment, aggressive movement therapy that will reeducate the brain to recognize correct movement of the muscles can be performed. The suit enhances communication between the brain and peripheral muscles, particularly, the head and trunk control muscles, and the locomotor functions of the legs[1, 3)]. Rehabilitative gains in motor control through Adeli suit treatment are typically retained after the intensive course is completed. Studies on groups of children with AST have shown long-term retention of skills after the completion of the therapy program. AST is often used as part of a comprehensive physical therapy program and might

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improve mechanical efficiency without a corresponding gain in gross motor skills, especially in children with higher levels of motor function[4].

In this study, we compared changes in gross motor function, spatiotemporal parameters, and functional ambulation performance score (FAPS) in children with CP who were assigned to receive AST and underwent training for a period of 4 weeks. The results suggest the importance of the development of AST programs to improve gait ability in children with CP.

SUBJECTS AND METHODS

The subjects consisted of a 6-year-old boy (height, 112 cm; weight, 18 kg; Gross Motor Function Classification System [GMFCS], level II) and a 3-year-old boy (height, 89 cm; weight, 10 kg; GMFCS, level II) with spastic diplegic CP recruited from an S rehabilitation center in Korea. The subjects with CP had no history of newly developed neurological problems, musculoskeletal disorders, or botulinum toxin injections in the previous 6 months. The study was approved by the Sahmyook University Institutional Review Board (SYUIRB2015-109). The objective of the study and its requirements were explained to the subjects, and all of the participants' parents provided written consent, in accordance with the ethical principles of the Declaration of Helsinki.

AST was applied in two subjects for a period of 4 weeks, 5 times per week, in 60-minute sessions per day. AST included intensive multiple movements combined with the wearing of a fitted garment (Adeli suit), which provided resistance during the multiple movements. This suit comprised a vest, shorts, knee pads, and specially designed shoes. It was connected by hooks, rings, and elastic bands that could be adjusted to provide pressure and support to joints and muscle groups. The bungee-like cords were adjusted by a physical therapist to mimic normal flexor and extensor patterns of the major muscle groups in an attempt to reposition limbs in order to correct abnormal muscle alignment. Each session included multiple movements based on the children's abilities and included standing up, sitting, playing with balls while standing, jumping on the trampoline, walking on different geographical features, and climbing stairs or ladders[5].

To assess gross motor function, we used the gross motor function measure (GMFM-88). GMFM is a tool for measuring and recording changes in exercise level during the process of treatment or elapsed time. It is used to measure the level of a child's physical performance[6]. The GMFM-88 consists of 88 items grouped into five domains as follows: domain A (lying and rolling, 17 items), domain B (sitting, 20 items), domain C (crawling and kneeling, 14 items), domain D (standing, 13 items), and domain E (walking, running, and jumping, 24 items)[7, 8]. Each item is worth 3 points, and the points earned from each domain are multiplied by 100 points to obtain a domain score. The final score is obtained by adding each domain score and dividing the sum by 5 to obtain a total score[7].

To measure gait function, we used the GAITRite Walkway System (CIR system Inc., PA, USA), which consists of an electronic walkway (90 × 460 cm). Data were sampled from the walkway at a frequency of 80 Hz. The spatiotemporal characteristics of the GAITRite system have shown excellent reliability with an intraclass correlation coefficient of between 0.82 and 0.92[9]. The procedure was explained and demonstrated to the child. The child was then instructed to walk barefoot at a self-selected walking speed, with the head facing forward and the eyes looking straight ahead[10]. Data on spatial (step length and stride length) and temporal gait parameters (walking speed and cadence) were obtained by using GAITRitever 3.2b[9, 11]. Velocity was calculated by dividing the distance by the ambulation time and was expressed in centimeters per second. Stride length was defined and measured on the line of progression between the heel points of two consecutive footfalls of the same foot and was expressed in centimeters. Cadence was defined as the number of foot falls in 1 minute[5].

The FAPS is integrated within the GAITRite walkway and is considered to be the gold standard for spatiotemporal gait parameter analysis. The FAPS is commonly used for clinical evaluations. The measurement was performed 3 times, and to eliminate the fatigue of walking, the subjects were allowed a 30-second rest after walking once[12].

All measurements were performed twice, before intervention and after 4 weeks of intervention. The spatiotemporal gait parameters and the FAPS for gait function were measured three times, and the average of the three measurements was used in the analysis. All of the data were codified and analyzed with SPSS Statistics for Windows version 17.0.

RESULTS

The gross motor function of case A as assessed by GMFM increased from 87.2% at pretest to 94.37% at post-test; for case B, GMFM increased from 71.17% at pretest to 73.0% at post-test. The gait velocity of case A increased from 78.57 cm/s at pretest to 80.705 cm/s at post-test, while the cadence increased from 135.63 to 136.97 steps/min, the right-sided step length decreased from 39.01 to 37.03 cm, the left-sided step length increased from 31.76 to 37.27 cm, the right-sided stride length increased from 70.08 to 77.52 cm, the left-sided stride length increased from 70.08 to 76.85 cm, and the FAPS increased from 81 to 84 (Table 1).

The gait velocity of case B decreased from 71.26 cm/s at pretest to 62.27 cm/s at post-test, while the cadence increased from 152.9 to 157.6 steps/min, the right-sided step length decreased from 28.70 to 28.55 cm, the left-sided step length decreased from 23.50 to 22.11 cm, the right-sided stride length decreased from 52.18 to 51.25 cm, the left-sided stride length increased from 52.27 to 52.94 cm, and the FAPS increased from 75 to 84 (Table 1).

Table 1. Gross motor function and gait function scores

Parameter		Case A		Case B	
		Pretest	Posttest	Pretest	Posttest
GMFM (%)		87.2	94.4	71.2	73.0
Velocity (cm/s)		78.6	80.7	71.3	62.3
Cadence (step/min)		135.6	137.0	152.9	157.6
Step length (cm)	Right side	39.0	37.0	28.7	28.6
	Left side	31.8	37.3	23.5	22.1
Stride length (cm)	Right side	70.1	77.5	52.2	51.3
	Left side	70.1	76.9	52.3	52.9
FAPS (score)		81	84	75	84

Values represent means.
GMFM: gross motor function measure, FAPS: functional ambulation performance score

DISCUSSION

The current neurodevelopmental treatment of CP focuses on maintaining or improving function in patients with CP. Various treatments may help children with CP to hold an upright body alignment, strengthen muscles, prevent complications, and improve their daily functions. Although several treatments of CP exist, adjustments to existing and new treatments are still needed. AST has been used recently to treat and facilitate active movement in CP. Many families and clinicians are interested in the outcomes of treatment using the Adeli suit, but the rehabilitation community does not have adequate scientific support for its use as a generally accepted treatment of CP[1].

This study focused on children with CP who received AST for a period of 4 weeks, in order to examine changes in GMFM, spatiotemporal parameters, and the FAPS. An important finding is improvement in gross motor function, as assessed by GMFM, in both cases. The applied AST involved multiple movements based on the children's abilities and included standing up, sitting, playing with balls while standing, jumping on the trampoline, walking on different geographical features, and climbing stairs or ladders. Proprioceptive stimulation by multiple movements has a profound effect in the treatment of CP because proprioception stimulates the nervous system at the onset of damage, thus creating a better basis for successful rehabilitation. For this reason, gross motor function was increased in both cases. Regarding gait function, the cadence and FAPS improved after the intervention in both cases. Step length increased on the left side and decreased on the right side in case A, resulting in a decreasing tendency of asymmetries in step length after the intervention.

Studies on the effect of AST for rehabilitation of CP are scarce. However, AST has been proposed as a treatment of CP. The results of previous studies on AST suggest that the subject relies on changes in proprioceptive information from muscles, tendons, and joints. An increase in the input of proprioception and significant information from the vestibular organs can affect body position, balance, and posture tension. Through active movement therapy with AST, the brain is stimulated and, thus, is retrained to recognize, and eventually initiate, the correct movement of the muscles, resulting in the improvement of body alignment through trunk stability, along with improved walking patterns[1, 5].

Body deformation due to a disability prevents patients from maintaining good posture or weight support in comfortable standing positions. The location of the elastic bands in the Adeli suit is similar to the position of antagonistic muscle pairs. Motor improvement of the joints in the lower extremities in antigravity situations was associated with resistance to the muscles that occurred when patients moved each part of their body that is connected to a bungee cord. AST controls each movement in response to the constantly acting gravitational force, particularly for the head, trunk, and locomotor functions of the legs.

A limitation of this study is that only two children with CP participated in the study. However, the results show that AST improved gross motor function and functional ambulation performance in these subjects. These findings suggest that AST should be recommended for treatment of CP, as a properly executed intervention would bring more benefits, particularly for functional improvements in CP.

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