

## **INFLUENCE OF 3-MONTH THERAPY USING THE NEURO-ORTHOPAEDIC SUIT ATLANT ON GAIT CHARACTERISTICS IN PRESCHOOL CHILDREN WITH SPASTIC CEREBRAL PALSY**

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### **ABSTRACT**

Different kinds of physical therapy are used in medical rehabilitation of neurological patients with motor deficiency: partial body weight-supported treadmill training, driven gait orthosis, neuromuscular electrical stimulation and neuro-orthopaedic suit therapies. Neuro-orthopaedic pneumosuit (NOPS) Atlant (Dynaforce, Russia) creates a muscle framework by dynamic proprioceptive stimulation, stabilizing the trunk and the extremities, reducing pathological synergies and normalizing patient's motor activity. The aim of the present study was to investigate the influence of 3-month therapy using the NOPS Atlant on gait characteristics in preschool children with spastic form of cerebral palsy (CP). Six CP children with spasticity of lower extremities with (mean±SE) age of 5.2±0.8 years participated in the present study. Children had NOPS Atlant therapy sessions during three months, supervised by an experienced physiotherapist. The kinematic and kinetic characteristics of gait were measured using 3-D movement analysis system Elite Clinic (BTS S.p.A., Italy). After 3-month therapy using the NOPS Atlant, significant increase (7.9%) of the stride length of gait was found as compared with the initial data. Children with spastic CP demonstrated significant improvement of range of motion of hip joint abduction, decrease of knee joint external rotation, as well as positive changes in foot progression angle during gait. In conclusion, motor function re-activation during gait in preschool children with spasticity caused by cerebral palsy was noted after 3-month therapy using the NOPS Atlant. However, future research is needed to elucidate mechanisms of neurodynamic therapy effect on motor ability in children with CP.

**Keywords:** *cerebral palsy; spasticity; physical therapy; walking*

## INTRODUCTION

Cerebral paralysis (CP) causes numerous impairments of neuromuscular and skeletal systems like spasticity, dystonia, joint contractures, abnormal bone growth, body balance and selective motor control impairments [9]. CP is a frequent cause of motor impairments in childhood, it occurs in 2–3 children per 1000 livebirths [21]. Most frequent motor impairment in CP children is spasticity [6], which is characterised by increase of velocity-dependent tonic reflex accompanied by overnormal stretch-reflex and produced by hyperirritability of stretch-reflex due to higher motor neuron syndrome [14]. A recent study on Australian population-based CP register identified 2956 individuals (1658 males, 1298 females, born in 1970–2003) with spastic CP [17]. The results showed that among individuals born <32 weeks, 48% had diplegia, whereas for children born ≥32 weeks the respective number was 24%. An increased proportion of spastic diplegia in relation to quadriplegia and wide variations across studies in the proportion of diplegia (range 34–90%) and bilateral spastic CP (range 51–86%) were revealed.

Children with hemiparesis began to walk at the age of 18–21 months, 75–85% of children with spastic diplegia walked at the age of 4 years, but only 10% of children with spastic tetraparesis walked at the age of 7 years [22]. Despite the fact that a significant part of children have good cognitive abilities and have independent social life, numerous children remain dependent on additional motion devices such as rulators or crutches [1]. Study of Harvey et al. [10] found that children at Level III according to Gross Motor Function Classification System (GMFCS) who had undergone multilevel surgery, showed more changes in mobility as compared with children at Level I/II at home and in school activities. Wheelchairs were most commonly used in the community before and after single-event multijoint surgery.

Different modalities of physical therapy are used in medical rehabilitation of neurological patients with motor deficiency: partial body weight-supported treadmill training [4, 16], driven gait orthosis [3], neuromuscular electrical stimulation [12] and neuro-orthopaedic suit therapies [2, 8, 19]. Neuro-orthopaedic pneumosuit (NOPS) Atlant (Dynaforce, Russia) creates a muscle framework by dynamic proprioceptive stimulation stabilizing the trunk and the extremities, reducing pathological synergies and normalizing patient's motor activity. Previously, the effect of the NOPS Atlant has been studied in adult patients with different neurologic or orthopaedic pathologies [13]. To our knowledge, the present research includes data of the first study where NOPS Atlant has been used in physical therapy for children with CP, aged 3–7 years. The aim of the present study was to investigate the influence of 3-month therapy using the NOPS Atlant on gait characteristics in preschool children with spastic CP.

## MATERIALS AND METHODS

### Subjects

Six CP children (five girls and one boy, GMFCS level II–III) with spasticity of lower extremities aged 3–7 years participated in the present study before and 3 months after therapy using the NOPS Atlant (Table 1).

**Table 1.** Anthropometric data of subjects (mean  $\pm$ SE)

Characteristics	Before therapy	After therapy
Age (year)	5.20 $\pm$ 0.80	5.40 $\pm$ 0.75
Body mass (kg)	20.70 $\pm$ 2.11	21.76 $\pm$ 2.41
Body height (m)	1.13 $\pm$ 0.04	1.15 $\pm$ 0.04
Body mass index (kg/m <sup>2</sup> )	15.90 $\pm$ 0.65	16.24 $\pm$ 0.86
Lower extremity length (m), R	0.58 $\pm$ 0.03	0.59 $\pm$ 0.03
Lower extremity length (m), L	0.58 $\pm$ 0.03	0.59 $\pm$ 0.03

Note: R – right, L – left;  $p > 0.05$

All participants were recruited from one nursery school of Tartu, Estonia. Organizers of the study excluded the recruitment of children with severe speech and language disorders or problems in their mental or physical development. Inclusion criteria were: spastic diplegia syndrome, ability to walk at least 20 m with or without additional devices, absence of epileptic cramps, good cognitive ability, and absence of Botox injections during the recent 3 months.

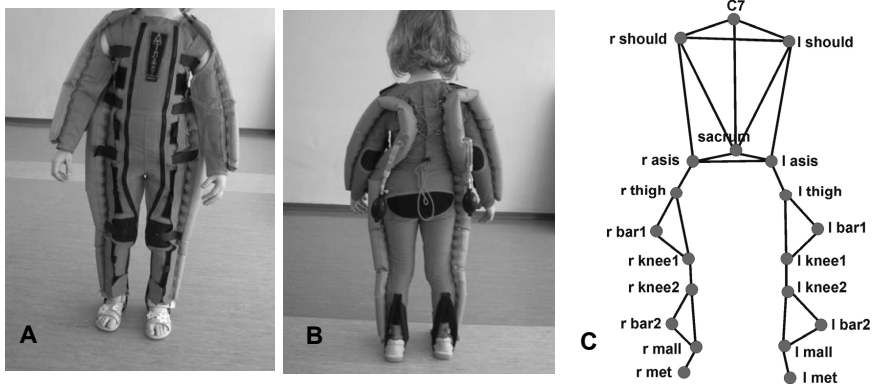
The study carried the approval of the Ethics Committee of the University of Tartu. A written informed consent from the children's parents and each child's assent were obtained for participation in the present study.

Measurements were performed partly in the nursery school and partly at the Laboratory of Kinesiology and Biomechanics, University of Tartu. All assessments were carried out in the mornings to minimize the possibility of fatigue. All tests were performed individually, by appropriately qualified therapists, who were unaware of the children's group assignment. The subjects were given instructions before data collection and the testing procedures were demonstrated, followed by practice session to familiarize the subjects with the procedures.

### Intervention

The children received physical therapy and exercise therapy using the NOPS Atlant (Figures 1A and 1B) during the period of three months in nursery

school, supervised by an experienced physiotherapy specialist. Suits have been used in accordance with height and chest dimensions of each child individually.



**Figure 1.** Neuro-orthopaedic pneumosuit Atlant – anterior (A) and posterior (B) view and biomechanic model of trunk and lower extremities (C).

The mean ( $\pm$ SE) number of therapy sessions using the NOPS Atlant was  $12.2 \pm 1.9$  during the treatment period, and each session increased progressively from 10 min at the beginning of therapy to 35 min at the end of the therapy period. Therapy sessions using the NOPS Atlant were planned individually and aimed at improving body balance, the symmetry of movements and posture, as well as increasing muscle strength, influencing muscle tone and gait pattern improvement.

## Methods

The kinematic characteristics of gait were measured using 3-dimensional movement analysis system Elite Clinic (BTS S.p.A., Italy). Twenty passive reflecting markers were attached to the selected points of the body according to the Helen Hayes protocol using the Davis biomechanical model [5] (Figure 1C). Gait temporal (stance time, swing time, double support time, stride time, cadence) and distance characteristics (step length, stride length, step width, velocity for each leg, mean velocity) as well as range of motion (ROM) of hip, knee and ankle joints were calculated. Three to six trials of gait with comfortable velocity for each child were recorded and the best trial was taken for analysis [7]. All studies were performed in same time of day (from 10 to 12 a.m.).

## Statistical analysis

Data are means and standard error of mean (SE). Student's paired t-test was used to find differences of data before and after 3-month NOPS therapy. A level of  $p < 0.05$  was selected to indicate statistical significance.

## RESULTS

No significant differences in subjects' anthropometric data as compared before therapy and after three months were observed (Table 1). After 3-month therapy using the NOPS Atlant the temporal characteristics of gait did not differ significantly ( $p > 0.05$ ) as compared with the pre-therapy period (Table 2). A significant ( $p < 0.05$ ) increase (7.91%) of the stride length of gait was found as compared with the initial data (Table 3). Decline of difference in gait velocity between right and left leg was noted – from 5.10% before therapy to 0.98% after 3-month NOPS Atlant therapy.

**Table 2.** Temporal characteristics of gait (mean  $\pm$ SE)

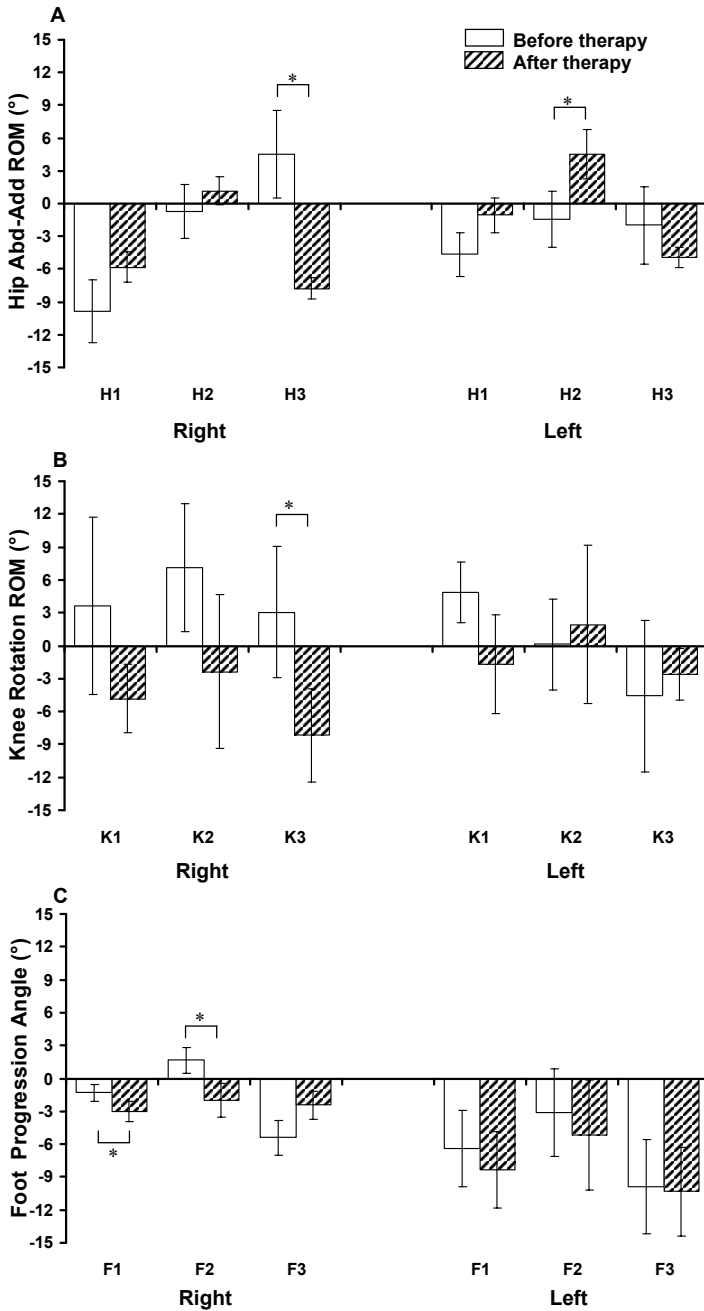
Characteristics	Before therapy	After 3-month therapy
Stance time (%), R	60.98 $\pm$ 1.59	61.26 $\pm$ 0.85
Stance time (%), L	59.10 $\pm$ 1.47	57.96 $\pm$ 0.86
Swing time (%), R	39.02 $\pm$ 1.59	39.02 $\pm$ 1.59
Swing time (%), L	40.90 $\pm$ 1.47	42.04 $\pm$ 0.86
Double support time (%), R	10.34 $\pm$ 1.04	11.02 $\pm$ 1.05
Double support time (%), L	9.44 $\pm$ 1.36	9.46 $\pm$ 0.66
Cadence (step/min)	137.74 $\pm$ 10.37	148.52 $\pm$ 13.34

Note: data are % of gait cycle; R – right, L – left;  $p > 0.05$

**Table 3.** Distance characteristics of gait (mean  $\pm$ SE)

Characteristics	Before therapy	After 3-month therapy
Step length (m), R	0.39 $\pm$ 0.04	0.42 $\pm$ 0.04
Step length (m), L	0.98 $\pm$ 0.14	1.02 $\pm$ 0.15
Velocity (m/s), R	0.93 $\pm$ 0.13	1.03 $\pm$ 0.15
Velocity (m/s), L	0.98 $\pm$ 0.14	1.02 $\pm$ 0.15
Stride length (m), R	0.75 $\pm$ 0.06	0.82 $\pm$ 0.07*
Stride length (m), L	0.76 $\pm$ 0.07	0.82 $\pm$ 0.07*
Step width (m), R	0.10 $\pm$ 0.01	0.10 $\pm$ 0.01
Step width (m), L	0.10 $\pm$ 0.01	0.09 $\pm$ 0.01

Note: R–right, L–left; \* $p < 0.05$  as compared before therapy



**Figure 2.** Hip abduction-adduction ROM (A), knee joint rotation ROM (B) and foot progression angle (C) during gait before and after 3-month neuro-orthopaedic pneumosuit Atlant therapy in children with spastic CP (mean±SE). 1 – initial contact of the foot with the ground, 2- maximal angle in stance, 3 – maximal angle in swing; \* p<0.05.

Significant increase ( $p < 0.05$ ) of right hip abduction ROM (Figure 2A) and knee joint external rotation ROM (Figure 2B) in swing phase as well as increase of foot progression angle (Figure 2C) in stance phase during gait were noted after 3-month NOPS therapy as compared to the pre-therapy period.

No significant differences emerged in kinematic characteristics of other joints between pre- and post-therapy period.

## DISCUSSION

The main results of the 3-month application of the NOPS Atlant in preschool children with moderate level of CP were: (1) children demonstrated significant improvement of ROM of hip abduction and knee external rotation as well as increase of foot progression angle, and (2) stride length of gait was increased as compared to the initial data.

The qualitative classifications of gait in children with spastic diplegia have been more widely used and different classifications have been applied for this aim. Main concerns have appeared about the validity of classifications, which are not based on quantitative data [18]. The results of the present study are based on standard gait instrumental kinematic analysis and improvement of gait characteristics have been found in preschool children with CP after using NOPS Atlant. In the study of Bailes et al. [2] the influence of 3-week *TheraSuit*<sup>TM</sup> method on gait in two children with spastic diplegia syndrome was analysed. The patients performed trainings five days a week and the duration of the one training was 3–4 hours. After training, improvement of gait characteristics (speed and cadence, movement pattern) and of posture was noted. Sologubov [20] investigated a 20-day orthopaedic suit therapy that was performed using Adeli-92 load suit in children with spastic diplegia syndrome aged 10 to 18 years; each session lasted for one hour. After Adeli suit therapy the improvement of postural steadiness and increase of ROM and length of step during gait were noted. Other studies [8, 19] demonstrated decrease of stride width during gait and toe-off phase duration and increase of swing phase duration in children with spastic diplegia aged 6 to 10 years after three-week treatment using Adeli suit. The present study differed from research mentioned above by its longer duration and younger age of children as well less intensive therapy. Another study compared the effect of the conventional therapy program and modified (individualized) therapy with Adeli suit in 36 CP children [15]. It was found that in case of modified therapy where the child was guided to use more functional and primary-task movements and exercises, the treatment effect was better as compared with the conventional therapy programme.

A special physical therapy programme using the NOPS Atlant has been elaborated for children with a more enhanced level of CP in Kazan University of Medicine by Isanova [11] but the proposed programme could not be used in the studied group of preschool children with moderate-level CP. Therapy using the NOPS Atlant is based on individual tasks. This aspect supports the study of van den Broeck et al. [21], where gait and mobility in 3-10 year-old children was analysed. The authors found that individual training programme is most effective for improvement of spastic muscle function and gait characteristics [21].

One factor influencing the results of the study could be a number of therapy sessions per week. According to Isanova's results [11], maximum effect of the therapy with the NOPS Atlant is attained in case it is applied for three times per week and additionally in home environment. In the present study it was not possible to give Atlant suits for home use because the parents had not performed a course of therapy rules.

The present study had some limitations. The number of subjects was small, due to having to consider numerous criteria for including the subjects in the study. On the other hand, it decreased the homogeneity of the studied group. The therapy process was planned during a 3-month period with children participating twice a week, however, diseases or other reasons caused frequent absence of children from therapy lessons. The total time for physical therapy lesson was 40 minutes and the time of wearing the NOPS Atlant increased gradually in accordance with methodology, but we did not compare data with groups of CP children with lower limb spasticity who did not receive NOPS Atlant therapy.

In summary, children with spastic CP demonstrated significant improvement of range of motion of hip joint abduction, decrease of knee joint external rotation, as well as changes in foot progression angle during gait. Motor function re-activation during gait (lengthening of stride) in preschool children with spasticity caused by cerebral palsy was noted after 3-month therapy using the NOPS Atlant. However, future research is needed to elucidate mechanisms of neurodynamic therapy effect on motor ability in children with CP.

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