CASE STUDY

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EFFECT OF ORTHOTIC SUBTALAR ALIGNMENT WITH CO-ACTIVATION EXERCISE FOR ALTERATION IN GAIT ENDURANCE IN A CHILD WITH CEREBRAL PALSY-SINGLE CASE STUDY

[*1] K. Vadivelan., M.P.T, Paediatric Neurology
[2] T. Manikandan
[3]Prof. V. P. R Sivakumar., M.P.T Orthopaedics

ABSTRACT

Background: Energy cost of walking is two times higher in children with cerebral palsy when compared with normal children; this may be due to gait abnormalities.There is a negative influence on physical activity and early onsets of fatigue in activities of daily living are evident in cerebral palsy children and the reason for this is increase in energy cost of walking. Therefore, the treatment techniques which targets on correction of gait abnormalities and Energy conservation during walking are important to maintain orimprove independent functioning.The aim is to find out the effects of using Supra Malleolar Orthosis (SMO) along with co-activation exercise in the increase of gait endurance and also to encourage independent skills and abilities in cerebral palsy child.

Methods: A 14 years child with spastic hemiplegic cerebral palsy was treated with custom made supra malleolar orthotic which was designed with an orthotic support followed with specific exercises, co-activating dorsiflexors and plantar flexors actively and with assistance. The subject was made to do the co-activation exercises 3 days per week for 8 weeks. Step length, stride length, cadence, navicular drop test, medial arch height and calcaneal eversion were measured before starting the treatment and at the end of 8th week.

Results: the results of treatment shows that there is an improvement in 2 minutes' walk test from 7(pre-test) to 13, step length from 22 (pre-test) to 32,stride length from 36(pre-test) to 47,cadence from 39 (pretest) to 37 after the use of Supra Malleolar Orthosis (SMO) and a co-activation exercises intervention. There was a clear and significant improvement noted in navicular drop test, medial arch height and calcaneal eversion after a period of 8 weeks use of orthosis and exercise intervention when compared with pre-test value.

Conclusion: Orthotic subtalar alignment with co-acticvation exercises for alteration in gait endurance in a child is showing significantly good results in this case study of a child with cerebral palsy. The Co-activation exercise with Supra Malleolar Orthotic support reduces the intensity of symptoms and improved gait parameters in cerebral palsy child.

Keywords: Cerebral Palsy, Supra Malleolar Orthosis, Co-activation exercises, gait.

Received 08th August 2016, revised 18th September 2016, accepted 01st October 2016

www.ijphy.org

10.15621/ijphy/2016/v3i5/117447

[2]Student, SRM College of Physiotherapy,
SRM University, Kattan kulathur-603202.
[3]Dean, SRM College of Physiotherapy,
SRM University, Kattan kulathur -603202.

CORRESPONDING AUTHOR

[*1] K. Vadivelan., M.P.T, Paediatric Neurology

Associate Professor,
SRM College of Physiotherapy,
SRM University, Kattan kulathur-603202

INTRODUCTION

Cerebral palsy is due to reduced blood supply for developing brain, which is a group of motor disorders with permanent disability [1]. Symptomatology is too diverse in Cerebral Palsy [2]. The dysfunctions in cerebral palsy vary greatly and the severity also ranges from slight clumsiness to loss of co-ordinated movements which is impossible to treat. Generally, at the developmental stage of six and half to nine months and when the baby is starting to move, in which mobilization process, preferential use of limbs, asymmetry, or gross motor developmental delay can be observed.

The most widespread form of cerebral palsy, is spastic diplegia, which is characterized by motor in-coordination, essentially in the lower end, that impairs many functional abilities, most particularly ambulation which is resulted from brain damage at birth that averts proper development of the pyramidal tract whose meaning is that certain spinal nerve receptors are unable to properly absorb the gamma amino butyric acid which results in improperly regulated tone in the affected areas. People with this disorder (spastic diplegia), have difficulty in their daily schedule where they walk slowly and have difficulty in walking up and down stairs on foot or running. Weakness of the ankle plantar flexors, knee extensors, and hip extensors are the common gait patterns which also have been known by intensive knee and hip flexion. Spasticity in the legs is so rare and not stops ambulation totally; people with spastic diplegia can walk in most of the cases. Regardless, spastic diplegia does result in the signature "scissoring gait". The person with spastic diplegia cerebral palsy, his gait is typically characterized by a crouched gait.

Majority parents of children with CP has a concern which is the ability to walk, and the primary focus of most therapeutic interventions addressing the motor problems seen in children with spastic diplegia also improving or maintaining this ability is often considered. The stability of knee joint during stance is a challenging task in cerebral palsy children, due to the weakness of quadriceps and loss of knee joint control. They will adopt compensatory stance with hyper flexed knee joint which can be treated with quadriceps strengthening programs.

The joint contractures and muscle weakness may lead to challenging situations to the cerebral palsy child to walk and the amount of energy expenditure to overcome the restraints is also more. So the treatments should concentrate energy expenditure techniques and promotion of independent function. To prevent deformities in cerebral palsy children orthotics have been used from long time. Application of ankle and foot orthosis of various designs has effectively altered the biomechanics of gait in individuals without neurological impairments. The effectiveness of orthosis in quadriplegic cerebral palsy was proved in several studies, but the effect of same on hemiplegic and diplegic cerebral palsy is not having evidence.

Measuring the neutrality of subtalar joint is difficult so that the controversy exists to study its functions during walking. Subtalar joint usually aids the tibial rotation and takes part in mobility component of lower limb. When the subtalar joint is in mid position, neither supinated nor pronated and the knee is tracked over the second toe, the joint is said to be in neutral [3]. If the subtalar joint is pronated, the tibia to rotate internally due to anatomical arrangement of the tibia and the talus, moving the knee medial to the foot and hip and knee joints will flex. These variations in subtalar joint position from supination to pronation will lead to some compensation while bearing weight.

The tibia moves medially with the medial movement of the talus. The legs go for compensation by flexing at the hips and knees with tibial internal rotation and foot pronation. The reverse compensatory changes occur during supination which includes that the talus goes for laterally and the tibia externally rotates with the hips and knees in extended position. During walking the subject holds the foot in supinated or pronated position in which compensations occur due to lack of mobility. It is important that the foot and ankle be aligned correctly even in the child's first orthoses, to allow more typical growth and development because the subtalar joint is so influential for the superstructure.

If subtalar joint is maintained in neutral position, the supination and pronation can be achieved without excessive tibial rotation.When the lower limb cast for orthotic mold is applied to cerebral palsy child it is important to hold the subtalar joint in neutral position.When subtalarjoint is moved from pronation to neutral position, the size and shape of the medial and lateral sides of the foot will also change and there exists a difficulty to adjust the mold to duplicate the natural contour of ankle.So the controversy of the fabrication of ankle and foot orthotics is focused on the subtalar joint neutrality.

To control inversion and eversion of the foot the Supra Malleolar Orthoses (SMO) are commonly prescribed devices for young children who present with benign hypotonia and excessive pronation, or flexible pes-planus. Flexible pes-planus presents with abnormally low or absent of arch withgeneralized ligamentous laxity in the foot. This results in compensatory changes in which the heel presents with excessive eversion during weight bearing, and the forefoot goes for abduction, producing midfoot sag with lowering of the longitudinal arch, so that navicular bone is participating excessively during weight bearing and the talar head and navicular tuberosity appear to be in contact with the floor.

The Supra-MalleolarOrthosis (SMO) is the small and shortest Ankle foot orthoses (AFO). The Supra-MalleolarOrthosis (SMO) is prescribed for flat foot and patients who have soft, flexible arches. The medical conditions leading to flat foot may be pronated subtalar joint, pes-planus, pesplano-valgus, and hyper-pronated foot. The Supra-Malleolar Orthosis (SMO) is designed to support three arches of foot and to maintain a vertical or neutral heel and the standing balance and walking will be improved [4].

Loss of endurance and muscle weakness is evident in the adolescent cerebral palsy individuals, the reasons to be considered for difficulties in functional upright abilities including ambulation. These individuals also scores low on different indices which measures physical fitness due to "deconditioning" of lower limb muscles. This poor musculo skeletal conditioning and possible interventional strategies are of research interest in today's neuro-rehabilitaion. The positive effects on muscle strength, gait characteristics and some functional abilities are evident with Isotonic and isokinetic strengthening programs, but decreases in energy expenditure have not paralleled these changes in strength [5].

The need of the study is to find out the effects of using Supra Malleolar Orthosis (SMO) along with co-activation exercise in the increase of gait endurance and also to encourage the functional and independent skill development. The interest of this study is also to know whether Supra Malleolar Orthosis (SMO) can prevent deformity, muscles contracture and improved walking pattern.

CASE DESCRIPTION

A child diagnosed with spastic hemiplegic cerebral palsy had a pronated foot on the right side. He was 14 years old. The Range of motion is restricted in inversion and partially restricted in dorsi-flexion and plantar flexion. The foot was everted when sitting and standing. The chief complaint of the patient is regarding his gait function, it was not progressing and he walks with slow steps which may be due to inadequate balance which was caused by subtalar joint displacement and evertion of foot. The patient can walk without support but with great difficulty as he has presented with spasticity. The child can walk only a few steps independently due to muscle weakness.

Sl. No	Movements	Range of motions noted	
		Right side	Left side
1	Knee joint flexion	0-135^0	0-135^0
2	Ankle dorsi flexion	0-12^0	0-20^0
3	Plantar flexion	0-50^0	0-50^0
4	Inversion	0- 20^0	0-30^0
5	Eversion	0-10^0	0-15^0

Table 1: Ranges of motions in both lower limbs

Voluntary control	Balance		Limb length		Gait parameters			Foot examination		
	Static	Dynamic	right	left	Step length (right)	Stride length (right)	Cadence (steps/min)	Navicular drop	Arch height	Calcaneal eversion
Grade 3	Normal	Normal	55.5 cm	57 cm	22cm	36cm	39	2cm	3cm	6 degrees

Table 2: Functional examination of both lower limbs

TREATMENT PROCEDURE

The treatment procedure was clearly explained to the parents. The pre-test assessment such as step length, stride length, cadence, and subjective gait assessment for determining subtalar joint position level and navicular drop was measured using navicular drop scale, medial arch height was measured using a caliper and calcaneal eversion was measured using goniometer.

Step length, stride length and cadence are measured during the 2 minutes' walk test.Navicular height was measured from the floor to the most inferior portion of the navicle, for the baseline outcome. Custom made supra malleolar orthotic was designed with an orthotic support followed with specific exercises, co-activating dorsiflexors and plantar flexors actively and with assistance. The subject was made to do the co activation exercises 3 days per week for 8 weeks. Post-test was taken at the end of 8th week including step length, stride length, cadence, navicular drop test, medial arch height and calcaneal eversion. Child was asked to sit or stand with foot flat on the floor and therapist will encourage tibia to roll on talus whenchild was doing sitting to standing from 90-90 position at hips and knees either using shoes or orthotic boots. Patient asked to attempt to wrinkle up the towel or tissue paper under the foot by keeping the heel on the floor and flexing the toes. Encourage the child to stand on a soft ball with the involved foot allowing to push the ball in and down towards gravity, which will activate dorsi-flexors and plantar flexors.

Figure 1: Co-activation exercise in Standing position

Figure 2: Measurement of calcaneum eversion

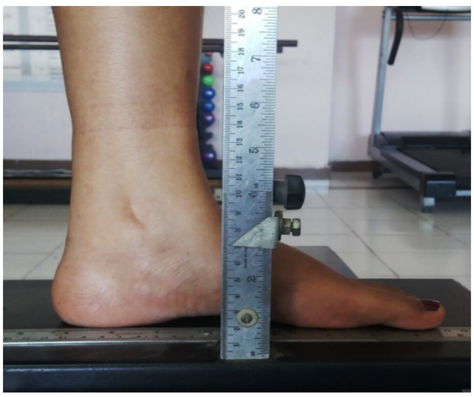


Figure 3: Measurement of navicular drop

Figure 4: Co-activation exercise by using ball

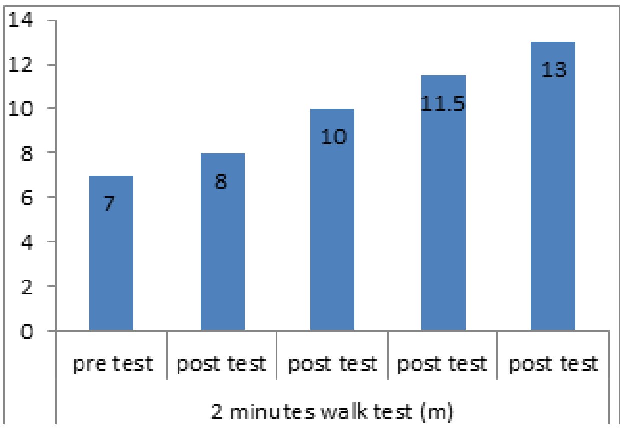
DATA PRESENTATION AND ANALYSIS

NO	Variables	Base line week (pre-test)	2nd week Post-test 1	4th week Post-test 2	6th week Post-test3	8th week Post-test4
1	2 minutes' walk test (m)	7	8	10	11.5	13
2	Step length (cm)	22	25	27	29	32
3	Stride length(cm)	36	39	42	45	47
4	Cadence (no. Of steps/min)	39	42	41	38	37

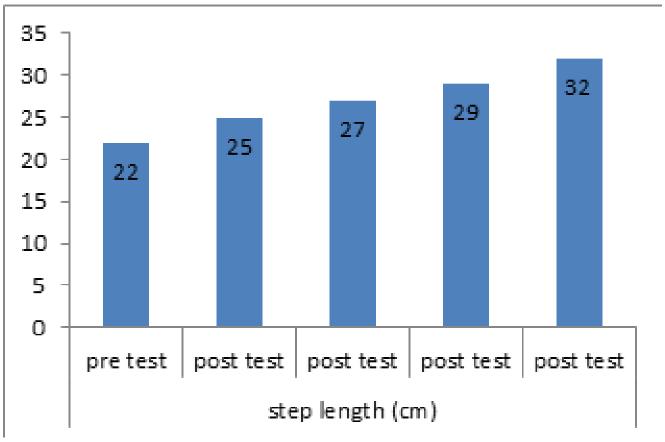
Table 3: Pre and post-test values of 2 minutes' walk test, step length, stride length and cadence.

NO	Variables	Base Line Week (Without Orthosis)	2nd Week Post Test1	4th Week Post Test2	6th Week Post Test2	8th Week Post Test3
1	Navicu-lar Drop	2	2.2	2.4	2.5	2.7
2	Medial Arch Height	3	3.2	3.4	3.5	3.7
3	Cal-caneal Eversion	6º	5.8º	5.6º	5.4º	5.3º

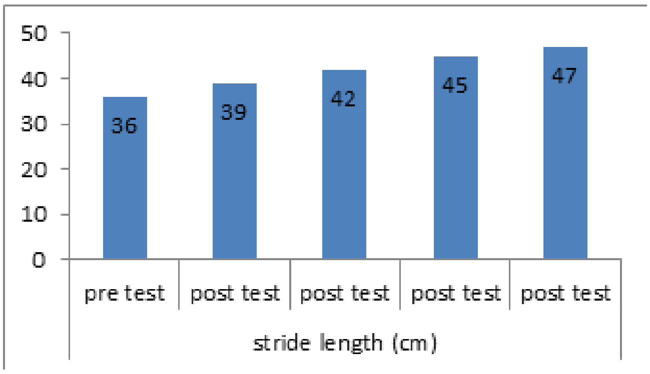
Table 4: Pre and post-test values of navicular drop test (measured by navicular drop scale), arch height (measured by caliper) and calcaneal eversion (measured by goniometer).



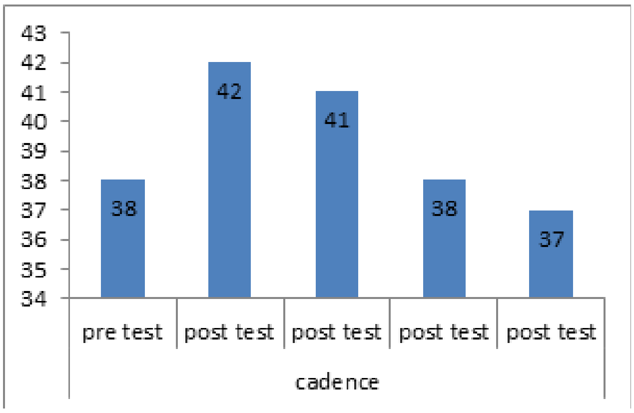
Graph 1: Pre-test and Post-test Values of 2 Minutes-Walk Test



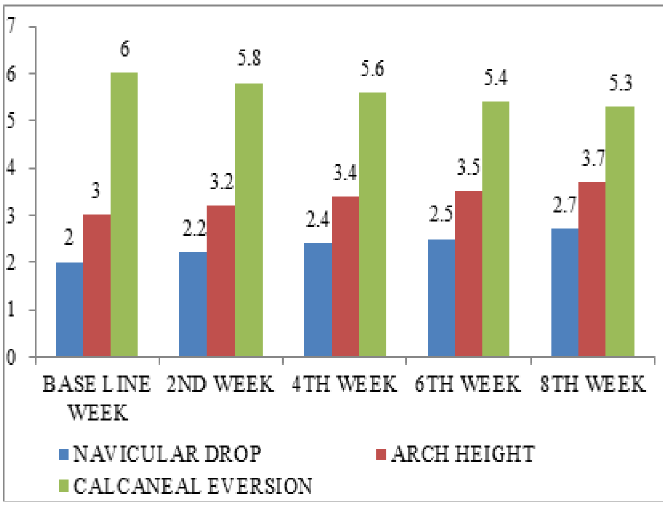
Graph 2: Pre-test and Post-test Values of Step Length



Graph 3: Pre-test and Post-test Values of Stride Length



Graph 4: Pre-test and Post-test Values of Cadence



Graph 5: Pre-test and post-test values of navicular drop test (measured by navicular drop scale), arch height (measured by caliper) and calcaneal eversion (measured by goniometer).

RESULTS

Table 3shows that there is an improvement in 2 minutes' walk test from 7(pre-test) to 13 (post-test), step length from 22 (pre-test) to 32(post-test), stride length from 36(pre-test) to 47, (post-test), cadence from 39 (pretest) to 37 (post-test) after the use of Supra Malleolar Orthosis (SMO) and a co-activation exercises intervention. Table4 shows that there an improvement in navicular drop test, medial arch height and calcaneal eversion after a period of 8 weeks use of orthosis and exercise intervention when compared with pre-test value.

DISCUSSION

The purpose of the study is to show the effect of orthotic subtalar alignment with co-activation exercises for alteration in gait endurance in a child with cerebral palsy. The SMO is prescribed for patients who have soft, flexible, flat feet and is designed to maintain a vertical or neutral heel while also supporting the three arches of the foot. This can help in improving standing balance and walking[6].

In recent studies the researchers proved that Supra MalleolarOrthosis (SMO) will improve the subtalar joint position. Judy Carmick (2012) concluded that orthotic device alignment in the subtalar joint neutral position contributes to beneficial outcomes. This study evaluated the effect of orthotics-Supra-Malleolar Orthosis (SMO) and co-activation exercises on endurance through 2 min walk test on a teenager with spastic hemiplegia. The major finding was that the use of Supra-Malleolar Orthosis (SMO) followed with co-activation protocol results in increase in endurance. The case study also revealed that gait parameters includes step length, stride length, cadence have also shown improvement from the baseline assessment.

The post-test value of 2 minutes' walk test has been increased to 13 meters by the end of eight week of intervention period. Butland et al (1982) have concluded that 2 and 6 min walk test were reproducible as a 12 min walk in patients with respiratory disease and walk test has been considered as an outcome measure for testing patients with disability and also in children and adults with cerebral palsy(CP) [7].

The posttest values of step length have been increased to 32cm by the end of eight week of intervention period. The results were similar with Wiley and Damiano, which revealed that lower extremity muscle training for 6 weeks with 11 spastic diplegia and 5 with hemiplegia, among those children one child who performed ankle dorsiflexors and plantar flexor co activation exercises showed increase in muscle strength and increase in scores of Gross Motor Function Measure (GMFM) dimension [8].

In our present study 11 steps/ min increment of cadence and about 2cm increase in right foot step length were noticed after Supra Malleolar Orthosis (SMO) and co activation exercise resulting remarkable change in performing endurance in 2 min walk test. This result goes in hand with Gestel 2008, Balaban 2007, Westberry 2007, Romkes 2006, Romkes 2002, Thomas 2002, Thompson 2000, White 2002, Buckon 2001, Hainsworth 1997, and Yokoyama 2005. There is a statistical and clinical improvement noted in many temporal-spatial parameters of gait like velocity, step-length, cadence, stride length, single leg stance, decreased double limb support time, and energy expenditure.

The evidence to support the use of orthoses in the improvement of gross motor skills in both function and quality including stair negotiation skills were available in literature [9] (Thomas 2002, Buckon 2001). In hemiplegic cerebral palsy one side muscle will be week since the use of Supra Malleolar Orthosis corrects the deformity and co-activation exercises strengthens the muscle which are weak. Thus it improves the gait parameters which includes step length, stride length, cadence and in spastic hemiplegic cerebral palsy child.

The goal of orthotic interventions is to correct musculoskeletal alignment in the foot and ankle. The orthosis will maintain Joint alignment and limits the range of motion in applied joints. The radiographic imaging proved the immediate impact of orthosis on changes of bony alignment in the foot. Statistical significance found in calcaneal and talus positions. 25-40% of children achieved a "normal" alignment of joint, when wearing an orthosis (Westberry 2007). This supports the use of orthoses in correcting the bony alignment, and it is proven as a part of holistic and functional approach to improve posture and motor skills.

Objective gait analysis has found to be reliable, particularly when Physical therapy has extensive clinical experience [10]. Outcome measures such as ROM, ankle pronation, muscle strength and gait velocity are important to show changes over time to evaluate progress as to whether the orthotics are functioning better than shoes or boots alone [11]. Natural arch occurs whenSubtalar Joint (STJ) is in neutral and arch height varies in considerable population. However due to difficulty in measuring sutalar joint neutrality, there is still controversy about the function of Subtalar Joint (STJ) orthosis.

Engsberg et al reported that muscle strength of the ankle dorsi-flexors and plantar flexor of children with CP are about 50 and 35% respectively, when compared with that of children with typical development, suggesting that children with cerebral palsy requires co activation exercise [12]. Dod et al 2013 has demonstrated that minimum of 6 weeks program will improve the ability to generate muscle force in children with cerebral palsy. Cerebral palsy children with some voluntary control and mild equinus are benefit more from an orthosis of less restriction (Romkes 2002 [13], Morris 2002). If dorsi-flexors with knee extensors are actively contracting, supramalleolar orthosis of less restrictive style is best to use. It was seen that use of orthotic device and co-activation exercise improves gait and foot abnormalities in spastic hemiplegic cerebral palsy child after 8 weeks period of intervention. So orthotic device and co-activation exercise has a good effect in treating spastic hemiplegic child and also signifies that use of Supra Malleolar Orthosis (SMO) improves the gait pattern in children and is useful in physiotherapy practice.

CONCLUSION

Orthotic subtalar alignment with co-activation exercises for alteration in gait endurance in a child is showing significantly good results in this case study of a cerebral palsy child. The Co-activation exercise with Supra Malleolar Orthotic support reduces the intensity of symptoms and improved gait parameters in cerebral palsy child.

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Citation

Vadivelan, K., Manikandan, T., & Sivakumar, V. P. R. (2016). EFFECT OF ORTHOTIC SUBTALAR ALIGNMENT WITH CO-ACTIVATION EXERCISE FOR ALTERATION IN GAIT ENDURANCE IN A CHILD WITH CEREBRAL PALSY-SINGLE CASE STUDY. *International Journal of Physiotherapy,* 3(5), 603-608.