Effect of Modified Splinting on Crouch Gait in Spastic Diplegic Children

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ABSTRACT

Back ground: term "cerebral palsy" includes a variety of non-degenerating neurologic disabilities caused by abnormal central nervous system (CNS) development, particularly to those areas that affect motor function. It is the most common neuromuscular problems in children. The purpose of this study was to investigate the influences of splinting as therapeutic procedures to improve gait pattern in spastic diplegic children (nine girls and eleven boys) ranging in age from 3 years old to 5 years old, their mean age was 5.26±1.43 and 5.40±1.52 years for the control and the study group respectively. They were subdivided randomly into two groups of equal number, each comprised 10 patients. Evaluation of spasticty by Ashworth scale and gait pattern by foot print were conducted for each child of both groups individually before and after three months of treatment. All patients were subjected to the designed physical therapy program, three times/week. The control group received the designed physical therapy program, while the study group received the designed physical therapy program given to the control group in addition to modified splint. The results of this study revealed a statistically significant improvement in all measured variables in both groups. However, high significant improvement was observed in the study group when comparing the pre and post treatment results of both groups. Discussion: Improvement in the study group may be attributed to an improved ability to shift weight, manage abnormal muscle tone and decreased exaggerated tonic foot reflexes with subsequent facilitated achievement of improved functional skills. From the obtained results in this study, it can be concluded that, splinting is a beneficial therapeutic procedures to improve gait pattern in spastic diplegic cerebral palsy children.
Key words: *Cerebral Palsy, Splint, Gait.*

INTRODUCTION

Children with cerebral palsy (C.P) usually have many neurological deficits which interfere with motor function. These impairments include neuromuscular and musculosketal problem such as sparticity, dystonia, muscle contracture, bony deformities, in-coordination, loss of selective motor control and weakness[4].

Bleck[8] stated that, cerebral palsy is a non progressive disorder of motion and posture due to brain insult or injury occurring in the period of early brain growth generally under three years. Most broadly patients with C.P can be divided into those with spasticity due to pyramidal tract involvement and those with extra-pyramidal involvement including a variety of movement disorder.

Spasticity is defined by a movement disorder that, developed gradually in response to a partial or complete loss of supra-spinal control of spinal cord function. It is characterized by altered activity pattern of motor units occurring in response to sensory and central command signals which lead to co-

contraction, mass movement and abnormal postural control[1,5]. In spastic hypertonia there was an increased resistance to passive movement found during bedside examination represent changes in (1) musculo-tentineous unit and (2) the segmental reflex arc[7]. The increased hypertonus causes over development of spastic muscle groups, with agonistic and antagonistic imbalance, leading to deformities of the major joints such as hips, knees and ankles[3].

Diaplegic children suffer from several motor problem as limitation of movement, increased resistance to passive movement, muscle spasm, clonus, exaggerated deep tendon reflexes[10]. In such cases, unequal pull leads to deformities in the form of flexion, adduction and internal rotation at the hips, flexion at the knees & equino-varus or valgus of the feet[2,6].

Spastic diplegia is a common manifestation of cerebral palsy. It affects both legs although there may be considerable asymmetry between the two sides. There are considerable variations between individuals but the commonest pattern consists of:

Hips flexion, internal rotation, knee flexion, equines of the foot and eversion of the hind foot[11,14,16].

In individuals suffering from the commonest pattern of spastic diplegia, excessive flexion of the hips leads to an increased lumbar lordosis in order to get the femur as vertical as possible. The knee is held almost fixed by co-contraction of the hamstrings and quadriceps. Since the hamstrings are more powerful, the knee remains flexed & its angle varies between 30 and 40 degrees. The equines deformity of the foot causes a primary toe strike and loss of all three “rockers”-plantar flexion following heel strike, dorsiflexion in mid stance & plantar flexion in late stance[12].

Children with diplegia may find difficulty with the following movements:

1- Transfer weight laterally when standing from one leg to the other.
2- Flex the moving leg while keeping the supporting leg extended.
3- Take the moving leg forward, without allowing the pelvis to come forward on that side and at the same time leave the supporting leg behind. They may compensate for their difficulties by using their trunks, either by bending sideways to alternate sides or by bending their trunks back words, then flexing them forwards[16]. The speed of walking may be affected. The child may fall faster than normal, reflecting some element of dys control and lack of extensibility of soft tissues. The increased speed may make it easier to balance. It is seen in diplegic children, whose stiff short hip adductor and calf muscles cause then to take small steps with a small base of support[13].

The most frequently used technique for the spastic diplegic child is neurodevelopmental therapy, which aims at reduction of abnormal reflexes and postures and at helping the child to attain more normal movement patterns[15]. Physical therapy consists of traditional exercises like passive range of motion to the lower extremity joints and practice of gross motor skills at a level as age appropriate as possible. The therapist also should emphasized active trunk extension, increased trunk and pelvic mobility, which can lead to improved posture and balance[23].

King[18] suggested that splinting techniques can improve the range of motion in a joint due to hypertonic contracture and positioning the limb in a tonic stretch has been observed to decrease reflex tone.

Mayer[22] mentioned that, application of casts for diplegic patients revealed a better

improvement of gait pattern as compared with medication and ice application on the spastic muscles. He added that tone inhabiting casts and orthotic devices including splints limit the effect of the positive support reaction on gait.

SUBJECTS, MATERIALS AND METHODS

Subjects

Twenty diplegic cerebral palsied children were selected from the out-patient clinic of the Faculty of Physical Therapy, Cairo university. They were 9 girls and 11 boys, with age ranged from 3 to 5 years old (mean age of 5-26±1.43 and 5.40±1.52 years). They were divided randomly into two groups of equal number, each comprised 10 patients (control and study group). The children were considered to be appropriate candidates according to the following criteria:

- Medical diagnosis of spastic diplegic cerebral palsy since birth.
- Degree of spasticity was ranging between grade 1 and grade 1+, according to the Modified Ashworth scale (Form 1).
- Ambulatory, having the crouch gait, characterizing their walking patterns.
- No contractures at any joint of the lower limbs.
- Intelligence quotient (I.Q) within the level that enables the child to follow instructions of the exercises accurately.
- No fits was recorded.
- No surgical correction has been done.
- They had no other associated disorders.

Materials

1- Materials for evaluation

- Modified Ashoworth Scale, was used to determine the degree of spasticity (Form 1).

Form (1): Modified Ashworth scale for grading spasticity (adopted from Bohannon and smith)[9].

Crade	Description
0	No increase of muscle tone
1	Slight increase in muscle tone, manifested by a catch and relax or by minimal resistance at the end of range of motion when the affected part moved in flexion or extension.
1^{+}	Slight increase in muscle tone, manifested by a catch, followed by minimal resistance through the remainder (less than half range of motion).
2	Marked increase in muscle tone through out most of range of motion but affected part(s) easily moved.
3	Marked increase in muscle tone, passive movement is difficult.
4	Affected part(s) rigid in flexion or extension.

- Kalk paper, 4 meters length was taped to the floor on which the child performed his gait pattern.
- Tray, 45 cm length by 35 width and 13 cm height was used to accommodate both patient's feet.
- Tamper, a powder paint to cover the bottom of the tray.
- Water in order to moisten the subject's feet.
- Tap measurement to measure stride length, stride width & step length.
- Alcohol soaked in a piece of cotton was used to clean patient's feet.

- Stop watch to measure time.
- Protractor to measure foot angle.

2- Materials for treatment

- Therapeutic equipment: Balls of different sizes, wedges, parallel bars, walking aids like walkers, rolls and gymnastic mats were utilized to conduct the designed physical therapy program.
- Splint: consists of below knee night splint, two leg rotation control splint & pelvic band. It is designed from light plastic. It's ankle fixed in 5o dorsiflexion. It was applied for both legs.
- Ties: Manufacture from Velcro, one at the top of the splint, one at the distal part of the splint and one at the front of the ankle joint.
- Straps: Each consists of a pelvic belt with Velcro fastener and two elastic straps with boot hooks aiming to assist in the correction of the excessive internal rotation by pulling the leg toward external rotation.

Methods

1- Methods for evaluation

A- ***Muscle tone evaluation:*** passive movement of both lower limbs was applied to determine the degree of spasticity according to Modified Ashworth Scale, while the child was completely relaxed in supine position.

B- Gait evaluation

Preparation of the patients

- Each patient was as ked to wear shorts before starting the evaluation.
- Demonstration of the testing measures was carried out for each child in order to gain maximum cooperation.
- Each patient had to sit on a chair before carrying out the test. Feet were moistened with water, the child was asked to stand on the tray containing the powder paint & let his sole thoroughly covered with it, then he was allowed to walk on the paper walkway.

Recording method

A Kalk paper, 4 meters long and 75 cm wide, was tapped to the floor to form a paper walkway.

Three trials were performed for each subject separated by 15 minutes rest & the average was calculated.

Measurements

Inform of both distance parameters [stride length (cm), step length (cm), stride width (cm) and foot angle (degrees)] and temporal parameters [velocity (cm/sec)](Fig.1)

2- Methods for treatment

The control group received a designed physical therapy program. While the study group received the designed physical therapy program given to the control group in addition to modified splint.

- **Designed physical therapy program consisted of:**

(1) Positioning
- Abduction position on horse back riding.
- Prone position on a specially designed pillow.
- Standing position through standing frame or through parallel bars.

(2) Passive stretching exercises to spastic muscle of hips (adductors, flexors and internal rotators), to knee flexors and to ankle planter flexors of both feet.

(3) Balancing exercises during sitting & standing.

(4) Proper gait training between parallel bars or walking aids.

(5) Proper family counseling to a good handling of the child at home after the end of treatment program.

Each patient was treated for 3 successive months, three sessions week for 1 hour.

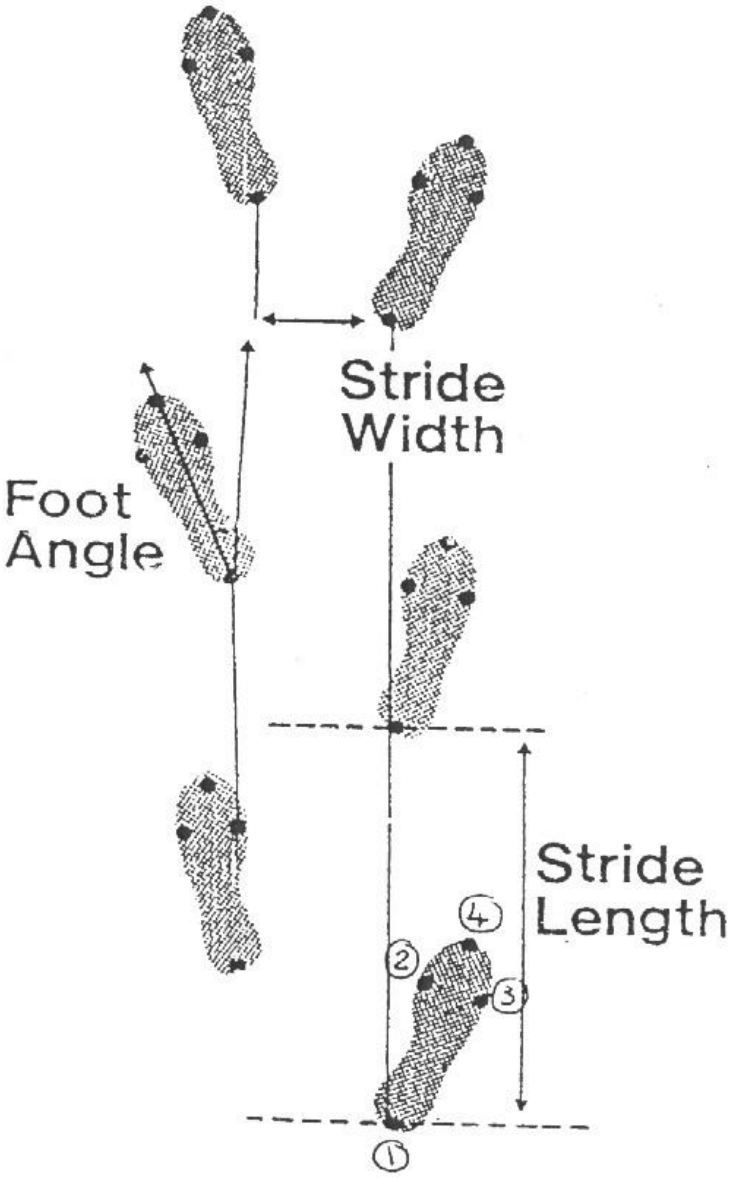

Fig. (1): Measurement from foot Prints.

RESULTS

The pre and post-treatment mean values of muscle tone (grades) for the control group were 1.7±0.55 and 1.4±0.65 respectively with mean difference -0.3, which revealed a significant improvement (P<0.05).

While, the pre and post-treatment mean values of the same parameter for the study group were 1.8±0.53 and 1.2±0.32 respectively with a mean difference of -0.6, which indicate a significant improvement (P<0.01).

Table (1): Mean values of muscle tone (grades) before and after treatment in both groups.

Groups	Pre	Post	Difference	t	P
Control	1.7±0.55	1.4±0.65	-0.3	1.977	<0.05 (S)
Study	1.8±0.53	1.2±0.32	-0.6	3.000	<0.01 (S)

S = Significant

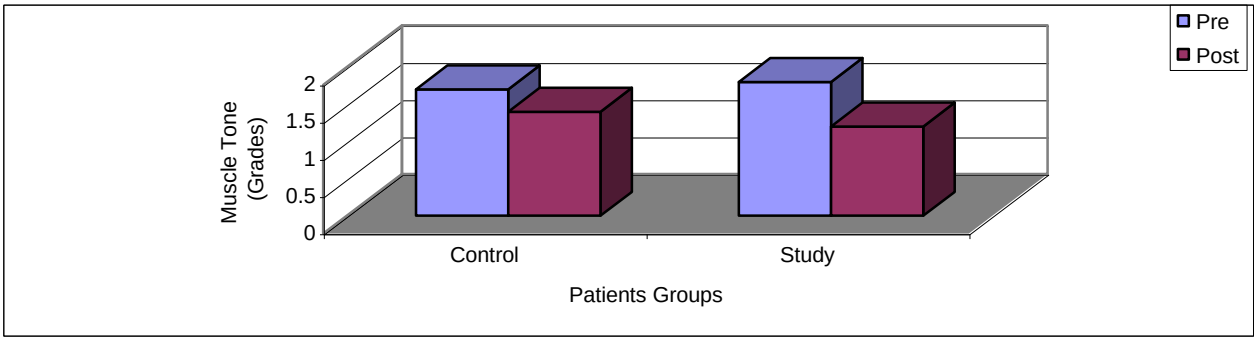

Fig. (2): Mean values of muscle tone (grades) before and after treatment in both groups.

The pre and post-treatment values of stride length (cm) for the control group were 40.30±4.05 and 44.6±4.70 respectively with mean difference of 4.30, this revealed a non significant improvement (P>0.05). On the other hand, the pre and post treatment of the same parameters for the study group were 38.5±1.90 and 58.2±1.30 respectively with mean difference of 19.50 which indicated a high significant improvement (P<0.0005).

Table (2): Mean values of stride length (cm) before & after treatment in both groups.

Groups	Pre	Post	Difference	t	P
Control	40.30±4.05	44.6±4.70	4.30	1.6	>0.05 (NS)
Study	38.5±1.90	58.2±1.30	19.50	3.000	<0.0005 (HS)

NS = non Significant HS = High Significant

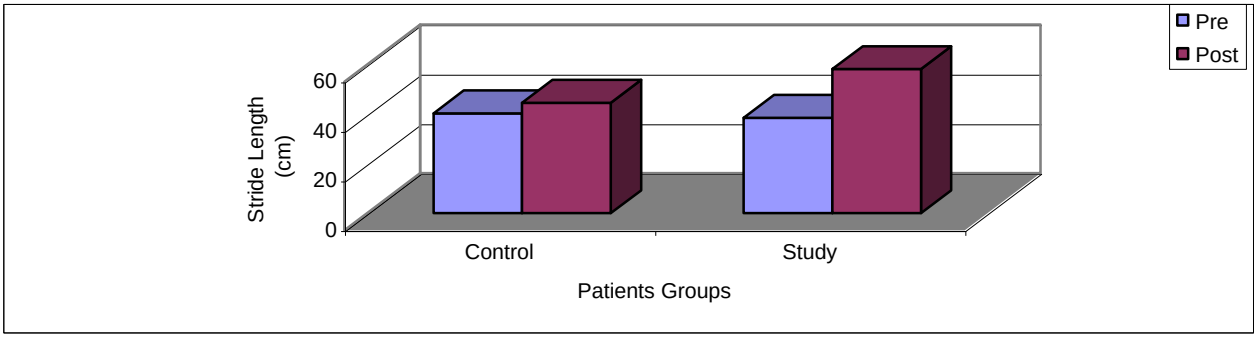

Fig. (3): Mean values of stride length (cm) before & after treatment in both groups.

The pre and post-treatment mean values of step length (cm) for the control group were 20.70±2.50 and 23.1±2.80 respectively with mean difference 4.30, which revealed a non significant improvement (P>0.05). While, the pre and post-treatment mean values of the same parameters for the study group were 19.6±0.90 and 28.9±1.30 respectively with a mean difference of 0.58, which revealed a high significant improvement (P<0.0005).

Table (3): Mean values of step length (cm) before and after treatment in both groups.

Groups	Pre	Post	Difference	t	P
Control	20.70±2.50	23.1±2.80	2.40	1.4	>0.05 (NS)
Study	19.6±0.90	28.9±1.30	0.58	12.9	<0.0005 (HS)

NS = non Significant HS = High Significant

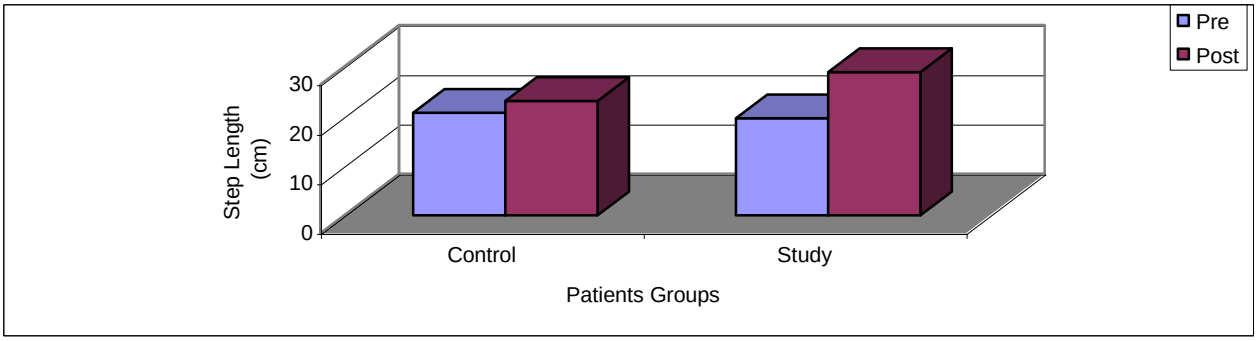

Fig. (4): Mean values of step length (cm) before and after treatment in both groups.

The pre and post-treatment mean values of stride width (cm) for the control group were 14.60±1.14 and 13.0±2.00 respectively with mean difference of 1.60 which indicated a significant improvement (P<0.05). On the other hand, the pre and post treatment mean values of the same parameter for the study group were 13.2±2.04 and 10.2±1.48 respectively with mean difference of 3.00 which revealed a high significant improvement (P<0.0005).

Table (4): Mean values of stride width (cm) before and after treatment in both groups.

Groups	Pre	Post	Difference	t	P
Control	14.60±1.14	13.0±2.00	1.60	1.90	<0.05 (S)
Study	13.2±2.04	10.2±1.48	3.00	6.5	<0.0005 (HS)

S = Significant HS = High Significant

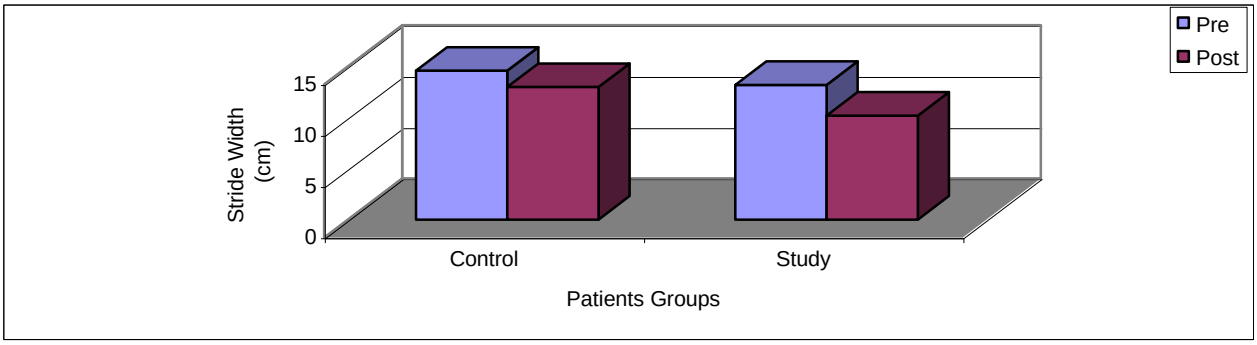

Fig. (5): Mean values of stride width (cm) before and after treatment in both groups.

The pre and post treatment mean values of foot angle (degrees) for the control group were 20.0±5.90 and 20.2±5.20 respectively with mean difference of 0.80, which indicated a non significant improvement (P>0.05). While, the pre and post-treatment mean values of the same parameters for the study group were 19.8±3.70 and 12.2±2.16 respectively with mean difference of 5.60, which revealed a high significant improvement (P<0.0005).

Table (5): Mean values of foot angle (degrees) before & after treatment in both groups.

Groups	Pre	Post	Difference	t	P
Control	20.0±5.90	20.2±5.20	0.80	0.23	>0.05 (NS)
Study	19.8±3.70	12.2±2.16	5.60	4.60	<0.0005 (HS)

NS = non Significant HS = High Significant

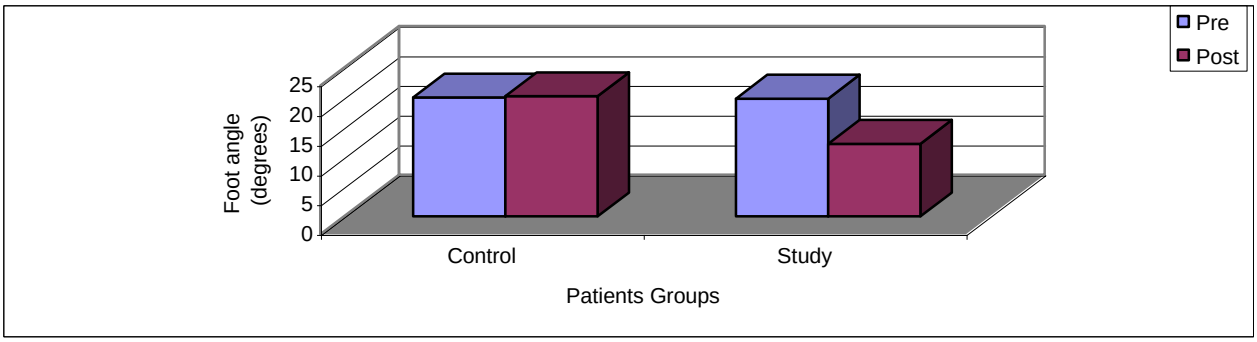

Fig. (6): Mean values of foot angle (0) before and after treatment in both groups.

The pre and post-treatment mean values of velocity (cm/sec) for the control group were 45.38±3.87 and 52.05±8.85 respectively with mean difference 4.00, which revealed a non

significant improvement (P>0.055). While, the pre and post-treatment mean values of the same parameter for the study group were 46.14±2.64 and 63.56±2.87 respectively with mean difference of 17.42, which indicated a high significant improvement (P<0.0005).

Table (6): Mean values of velocity (cm/sec) before and after treatment in both groups.

Groups	Pre	Post	Difference	t	P
Control	45.38±3.87	52.05±8.85	4.00	1.54	>0.055 (NS)
Study	46.14±2.64	63.56±2.87	17.42	17.40	<0.0005 (HS)

NS = non Significant HS = High Significant

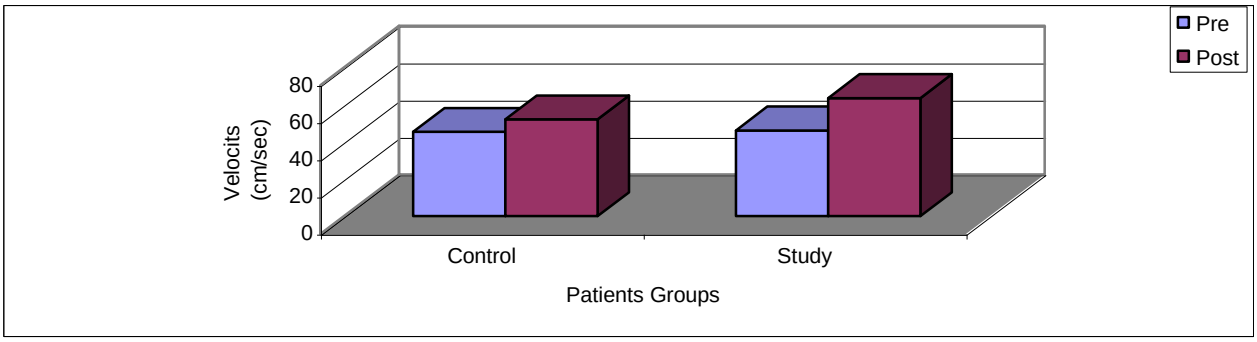

Fig. (7): Mean values of velocity (cm/sec) before and after treatment in both groups.

DISCUSSION

The ability to walk is a major concern of the parents of children with cerebral palsy. Improving or maintaining this ability is often considered to be the primary focus of most therapeutic interventions addressing the motor problems seen in children with spastic Diplegia[17].

In the present work the effect of splinting combined with designed physical therapy program on facilitation of normal gait patterns of diplegic cerebral palsied was the subject of this investigation.

The results obtained from this work clearly demonstrated the evidence of facilitatory effects of both splints and physical therapy program on gait pattern when applied simultaneously in twenty diplegic cerebral palsied patients.

In respect to the results of study group after treatment there was significance improvement in stride length (cm), step length (cm), stride width (cm), foot angle (degrees) and velocity (cm/sec), these improvements were measured by foot prints methods. The splint used in this study was made of thermoplastic material. It was designed with the ankle in slight dorsiflexion up to 5o to stimulate the normal position of the ankle in standing & in stance phase in early walking. This construction is coincided with the conclusion of Sussman[29].

The results of the present study revealed a significant improvement in all measured parameters concerning the study group, this indicated that modified splint in cerebral palsy contributes to an improved ability to shift weight, manage abnormal muscle tone and decreased exaggerated tonic foot reflexes with subsequent facilitated achievement of improved functional skills. These findings support the findings of Lehmann[19] who emphasized the importance of splinting on

facilitation of cerebral palsied gait. Decreasing of muscle tone was evidenced by increased passive mobility and ability to shift weight, these findings support the result of Perry[24].

The inhibitory effects of splinting as an adjunct to the physical therapy program were obviously demonstrated in the obtained mean values of study group after treatment results in prolonged stretch in fully elongated range which may lead to stimulation of neurotendinous spindle (Golgi tendon organs) by the inhibition 1a receptor intrufusal muscle fiber in the stretched muscle, which appreciably inhibit the spastic muscle. These results were in agreement with Maclean[20] and Rosenthal[26] who stated that sustained increase in the initial muscle length, suppress the tonic stretch reflex in spastic muscles.

The results of this study indicated that splinting has beneficial effect in improving ankle mobility. This come in agreement with Marris and Riffle[21] who reported that splinting technique can improve the range of motion. According to these results, it could be stated that, the rationale for splinting repositioning of the spastic foot in the child with cerebral palsy may decrease the strength of abnormal strong tonic foot reflexes such as extensor thrust, positive support and tonic toe grasp, this concept come in agreement with Rose et al.,[25] concluded that extension of the toes inhibits extensor thrust, which subsequently reduces extensor muscle hypertonus through out the extremities and the trunk.

Sarno[27] recommended that using of appropriate splint in addition to physical therapy program from the beginning of treatment of spastic children can protect them from the surgical intervention. The previous results also agree with the suggestion of Zachazewski et al.,[30] who stated that usage of splint in treatment of spastic diplegic children can cause inhibition of abnormal reflexes and facilitation of normal postural reaction that help in improving the normal developmental sequences.

Slaton[28] showed that the neuro-developmental treatment approach is more effective if the families well trained how to handle their children and put them in proper positions during their activities of daily living through chairs, splints, corrective shoes. Also Rosenthol[26] stated that ankle foot orthoses are commonly used in the treatment of spastic cerebral palsy to hold the foot in a position conductive to a more functional gait.

According to the results of this work, it was found that splints adjunct with physical therapy program, facilitated heel-toe gait in dipligic cerebral palsied children thus improving gait pattern as a result of decreasing muscle tone through out the extremities, increase trunk mobility and inhibit abnormal postural reflexes.

Conclusion

From the obtained results in this study, it can be concluded that, splinting is a beneficial therapeutic procedure, when combined with exercise program to improve gait pattern in spastic diplegic cerebral palsy children.

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الملخص العربي

تأثير الجبيرة على المشية الجاثمة في الأطفال ذوي الشلل المخي التشنجي

الهدف من البحث : تقييم تأثير الجبيرة كوسيلة علاج على المشية الجاثمة في الأطفال ذوي الشلل المحني التشنجي .
مواد البحث وأساليبه : قد تم إجراء هذا البحث على عشرون مريضاً من الأطفال المصابين بالشلل المخي التشنجي تتراوح أعمارهم من ثلاثة إلى خمسة سنوات ، تم تقسيمهم إلى مجموعتين متساويتين (ضابطة وتجريبية) ضمت كل منها عشرة أطفال ، وقد خضعت المجموعة الأولى لبرنامج علاج طبيعي معين ، بينما المجموعة الثانية إلى الجبيرة بالإضافة إلى العلاج السابق للمجموعة الأولى ، وقد استمر العلاج ثلاثة أشهر متصلة بواقع ثلاثة أيام أسبوعياً وقد تم قياس درجة النغمة العضلية ، وكذلك عناصر المشي قبل وبعد العلاج بثلاثة أشهر .
النتائج : وقد أظهرت النتائج وجود تحسن ذو دلالة إحصائية في جميع القياسات لدى مرضى المجموعة التجريبية / أما المجموعة الضابطة فقد أظهرت تحسن في بعض القياسات دون الأخرى .
ووفقاً للنتائج نوصي بإضافة الجبيرة إلى العلاج التقليدي لعلاج المشية الجاثمة في الأطفال ذوي الشلل المخي التشنجي .