Role of Tonic Vibration Reflex on Gait of Hemiplegic Cerebral Palsied Children

Khaled A. Olama, Ph.D. and Gehan H. El-Meniawy, Ph.D.
Department of Physical Therapy for Disturbance of Growth and Development in Children and its Surgery. Faculty of Physical Therapy, Cairo University

ABSTRACT

Background and Purpose: *Gait is the most common means of moving about and is an essential part of daily life. It requires the simultaneous involvement of all lower limb joints, in a complex pattern of movement. The present study was conducted to determine the effect of high frequency vibration on gait pattern of hemiplegic cerebral palsied children.* ***Subjects:*** *Thirty hemiplegic cerebral palsied children (22 Lt. and 8 Rt.) represented the sample of this study. They were chosen from both sexes (18 males and 12 females), from El-Nabawy EI-Mohandis Institute of Poliomyelitis and Physical Medicine at the area of Imbaba, Cairo, Egypt. Their ages ranged from 6 to 8 years (X` 7.24 ± l .49 Yr.). They were free from any associated disorders other than spasticity. The degree of spasticity was determined according to the modified Ashworth's scale to be within the range of l^+ to 2 grades. The children were free from any structural changes in the joints of the lower limbs; however, there was few degrees of tendo-Achilles shortening. They were able to walk independently with an abnormal pattern of gait.* ***Methods:*** *They were divided randomly into two groups of equal numbers: group A (control) and group B (study). Assessment included measurement of changes in gait variables, via measuring distance (step length and step width) and temporal (cadence and velocity) parameters, for each child of the two groups, before and after three months of treatment. Group A received a designed exercise program, while group B received high frequency vibration on the tibialis anterior and hamstring muscles, in addition to the exercise program given to group A, considering that the session time was equal for the two groups.* ***Results:*** *The post-treatment results of this study, after the suggested period of treatment revealed significant improvement in all the gait variables of group B as compared with its pre-treatment results and the post-treatment results of group A. However, no significant difference was observed when comparing the pre and post-treatment results of group A and also the pre-treatment results of groups A and B.* ***Discussion and Conclusion:*** *Improvement recorded in group B may be attributed to the facilitatory effect of high frequency vibration in controlling spasticity of the lower limb muscles, which is manifested by the improvement occurred in the hemiplegic gait pattern.*

Key words: *Tonic Vibration Reflex, Hemiplegic Gait, Cerebral Palsy.*

INTRODUCTION

Cerebral palsy is defined as a life long disorder of the nervous system, which affects muscle control, resulting in spasticity and paralysis. It can strike a child during pregnancy, at birth or any time during the first five years of live[3].

Cerebral palsy is not a disease or an illness, but it is a disability caused by damage to the brain that take place before, during, or in the early period after birth[25].

Cerebral palsy is characterized by aberrant control of movement or posture of a patient, appearing early in life (secondary to central nervous system lesion, damage or dysfunction), and not the result of a recognized progressive or degenerative brain disease[1].

Hemiplegic cerebral palsy is one of the most common type among children born at term and is second only to diplegia among children born pre-term[13].

The hemiplegic problem is not only a lack of muscle power but also, the patient become unable to control isolated or voluntary components of the pattern of movement[6].

Inadequate recruitment of motor units resulting in an inability to generate sufficient force is considered an important reason for poor motor performance in hemiplegic patients[11].

In the presence of hypertonicity, the agonist-antagonist relationship is altered, due to abnormal patterns of activity in the opposing muscle groups crossing a joint[26].

Hemiplegic children do not bear weight equally on both legs. They walk with their affected leg planter flexed at the ankle, knee hyper-extended and hip flexed, to try to get their heel down. They also walk with unequal length strides[2].

Drop foot is one of the problems associated with hemiplegia, leading to an abnormal gait pattern. In such cases, drop foot is thought to be a result of spasticity, which causes poor active control of the anterior tibial muscles, rendering them to be incapable of achieving their normal response in conjunction with the antagonistic group[8].

Persistent equinous foot doesn't only lead to slow and unsafe, but also causes further increase in spasticity[21].

Inhibition of the increased extensor tone of the lower limb of the hemiplegic pattern may improve the whole gait pattern[2].

Tonic vibration reflex (TVR), which is a sustained muscle contraction due to vibration[12], is of enormous value in rehabilitation of motor function, in a wide variety of circumstances. It is particularly useful in the neurological handicapped patients[17].

It has been reported that tonic vibration reflex elicited by a high frequency vibrator (around 100 Hz) and low amplitude (around 1 .8 mm.) has a great effect in patients who can produce a weak voluntary contraction, helping them to produce a much stronger contraction[5].

SUBJECTS INSTRUMENTATION AND PROCEDURES

Subjects

Thirty hemiplegic cerebral palsied children (22 Lt. and 8 Rt. side) represented the sample of this study. They were chosen from both sexes (18 males and 12 females), from EI-Nabawy El-Mohandis Institute of Poliomyelitis and Physical Medicine at the area of Imbaba, Cairo, Egypt. Their ages ranged from 6 to 8 years (X'7.24±1.49Yr.). They were able to understand any command given to them, with an IQ level within normal range. Children participated in the study were free from any associated disorders other than spasticity. The degree of spasticity was determined according to the modified Ashworth's scale[7] to be within the range of 1^{+} and 2 grades. They were free from any structural changes in the joints of the lower limbs; however there was few degree of soft tissue tightness. They were able to walk independently with an abnormal gait pattern. The study sample was divided randomly into two groups of equal number. (A and B).

Group A (control) received a designed exercise therapy program while group B (study) received high frequency muscle vibration, to induce tonic vibration reflex, on the tibialis anterior and hamstring muscles, in addition to the exercise therapy program given to group A, taking in consideration that the session time is equal in the two groups.

Instrumentation

For evaluation

* Instructional sheet:

A straight white Kalk paper (10 meters long and 50 cm wide) was used for recording distance and temporal parameters.

*Colored powder:

For foot print on the white Kalk paper.

*A ruler and fine pen.

*A stop watches for measuring temporal parameters.

For treatment

An electric vibrator unit with a maximum frequency ranging from 90 to 120 cycles / second and amplitude of 2 millimeters was used for treatment.

Procedures

For evaluation

The instructional sheet was located in the gait evaluation walkway area and fixed to the ground from both ends with adhesive tapes, to prevent its slipping. Temporal and distance measurements of gait parameters were then recorded.

Each child was asked to put his / her bare feet in a bowl filled with water then place them in the colored powder and walk in a usual relaxed manner along the walkway.

By using the stopwatch and ruler, the parameters of gait were determined:

- Step length (cm.): the distance between two consecutive contra-lateral heel strikes.
- Step width (cm.): the horizontal distance between a perpendicular line from the center of the heel of one foot to the center of heel of the other foot.
- Cadence (steps/min.): the number of steps divided by the elapsed time for a distance.
- Velocity (m. /sec.): the total distance between the first and last heel strikes divided by the elapsed time for the distance.

Three successive trials were allowed for testing each parameter and the mean values were obtained, for each child of the two groups, before and after three months of treatment.

For treatment

The thirty children representing the sample of this study were divided randomly into two groups of equal number. Group (A) received an designed exercise program of neuro-developmental treatment for inhibition of the abnormal postural and movement patterns, via the use of reflex inhibitory pattern. Facilitatory techniques for the antispastic muscles (anterior tibial and hamstring muscles), via tapping, scratching and brushing, approximation. Prolonged stretch for inhibition of the abnormal spastic pattern and stretching of the soft tissue tightness, and facilitation of righting, equilibrium and protective reactions from different positions.

This program was conducted for one hour, once daily, five days per week for three successive months.

Group (B); in addition to the exercise program given to group A, this group received high frequency vibratory stimulation of the anterior tibial and hamstring muscles as follows;

- Form sitting position, with the knees flexed 90° at the edge of the plinth, the feet were maintained in planter flexion position (to put the anterior tibial muscles in slight stretch, for facilitation of the TVR. The high frequency vibrator was then applied just above the ankle at the lower third of the lower leg, on the musculo-tendinous junction.
- From prone lying position, with extended knee and the feet outside the plinth, the high frequency vibrator was applied on the musculo-tendinous junction of the medial

and lateral hamstring muscles above the knee.

The vibrator was applied on each group of muscles for one minute and switched off for 15 seconds. (to avoid skin burn from friction). This maneuver was repeated for five successive times[4].

RESULTS

The raw data of the measured gait variables for the two groups were statistically treated to show the mean and standard deviation. Student t-test was then applied to examine the significance of the treatment procedures applied in each group. No significant difference was observed when comparing the pre-treatment mean values of the two groups, and also the pre and post-treatment results of group A. The post-treatment results after three months of treatment revealed significant improvement in all the measuring variables of group B as compared with its pre-treatment results and also with the post-treatment results of group A.

1) Step length

As shown in table (1) and fig. (1), there was no significant difference when comparing the pre and post-treatment results of group A. The mean value of step length pre-treatment was 23.47±6.43 cm. and 24.52±4.60 cm. post-treatment (P>0.05), while significant difference was observed in group B where the mean value of step length pre-treatment was 24.31±2.66 cm. and 38.59± 1.37 cm post-treatment (P<0.0001). Highly significant improvement was observed when comparing the post-treatment results of the two groups in the favor of group B.

Table (1): Pre and post-treatment mean values of step length (cm) for groups A and B.

	Group A		**Group B**	
	Pre	Post	Pre	Post
X`	23.47	24.52	24.31	38.59
SD	± 6.43	± 4.60	± 2.66	± 1.37
T	0.289		6.56	
P	> 0.05		< 0.0001	
Sig.	Non-significant		Significant	

X`: mean SD: Standard deviation T: t-test P: level of significance Sig.: significance

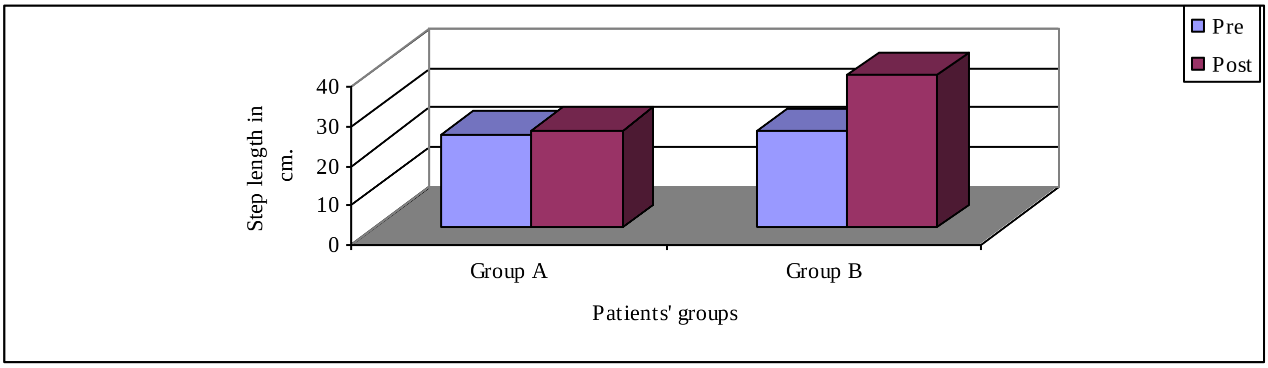

Fig. (1): Illustrating the mean values of step length (cm.) for groups A and B Pre and post-treatment.

2) Step width

As shown in table (2) and fig. (2), there was no significant difference when comparing the pre and post-treatment results of group A.

The mean value of step width pre-treatment was 13.86±4.93 cm. and 11.51±13.47 cm. post-treatment (P>0.05), while significant difference was observed in group B where the mean value of step width pre-treatment was 13.46±3.26 cm. and 5.83±0.88 cm. post-treatment (P<0.0001). Highly significant improvement was observed when comparing the post-treatment results of the two groups in the favor of group B.

Table (2): Pre and post-treatment mean values of step width (cm) for groups A and B.

	Group A		**Group B**	
	Pre	Post	Pre	Post
X`	13.86	11.51	13.46	5.83
SD	± 4.93	± 3.47	± 3.26	± 0.88
T	2.01		7.81	
P	> 0.05		< 0.0001	
Sig.	Non-significant		Significant	

X`: mean SD: Standard deviation T: t-test P: level of significance Sig.: significance

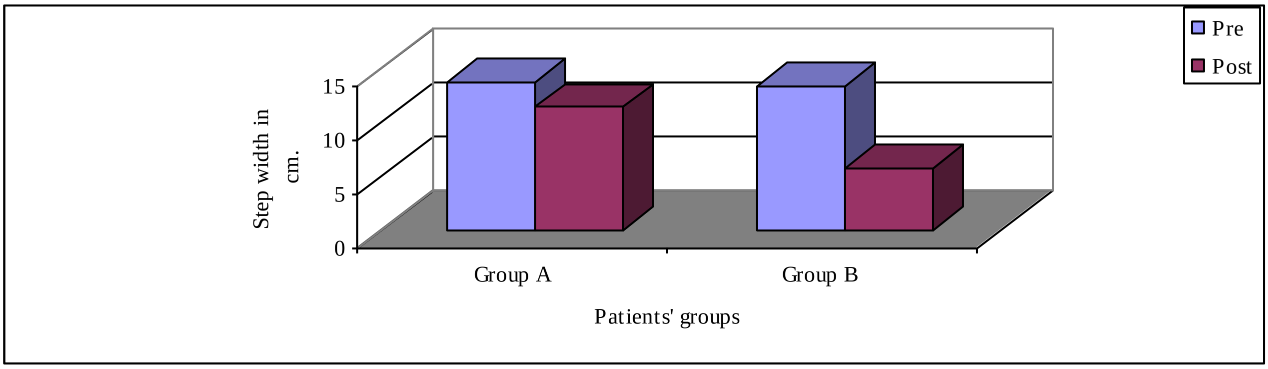

Fig. (2): Representing the mean values of step width (cm.) for groups A and B pre and post-treatment.

3) Gait velocity

As shown in table (3) and fig. (3), there was no significant difference when comparing the pre and post-treatment results of group A The mean value of velocity pre-treatment was 13.24±2.15 m/sec. and 13.66±4.93 m/sec post-treatment (P>0.05), while significant difference was observed in group B where the mean value of velocity pre-treatment was 12.92±1.68 m/sec. and l4.58 ± 2.98 m/sec. post-treatment (P<0.0001). Highly significant improvement was observed when comparing the post-treatment results of groups A and B in the favor of group B.

Table (3): Pre and post-treatment mean values of gait velocity (m/sec.) for groups A and B.

	Group A		**Group B**	
	Pre	Post	Pre	Post
X`	13.24	13.66	12.92	14.58
SD	± 2.15	± 4.93	± 1.68	± 2.98
T	1.667		6.254	
P	> 0.05		< 0.0001	
Sig.	Non-significant		Significant	

X`: mean SD: Standard deviation T: t-test P: level of significance Sig.: significance

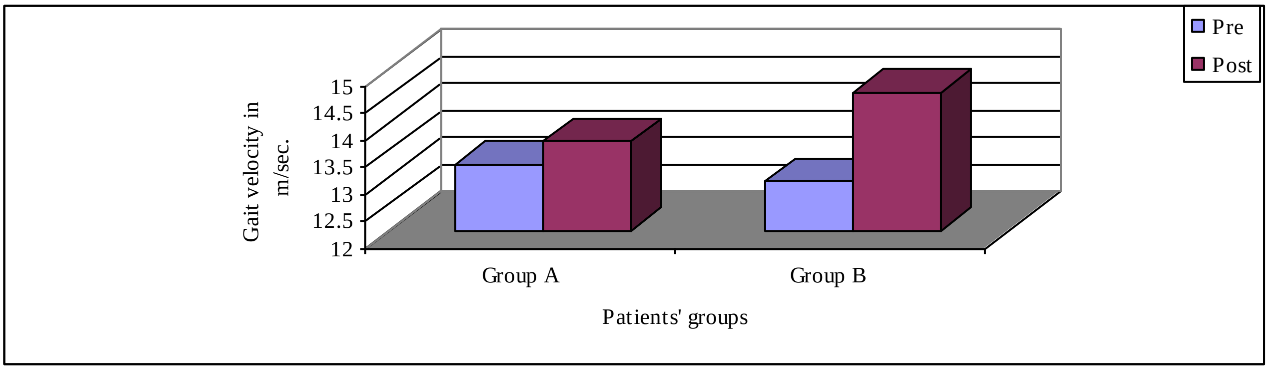

Fig. (3): Demonstrating the mean values of gait velocity (m/sec) for groups A and B pre and post-treatment.

4) Cadence

As shown in table (4) and fig. (4), there was no significant difference when comparing the pre and post-treatment results of group A The mean value of cadence pro-treatment was 28.4±3.15 step/min. and 29.12±4.5 step/min post-treatment (P>0.05), while significant difference was observed in group B where the mean value of cadence pre-treatment was 27.44±1.56 step/min. and 3l.20±2.60 step/min. post-treatment (P<0.0001). Highly significant improvement was observed when comparing the post-treatment results of groups A and B in the favor of group B.

Table (4): Pre and post-treatment mean values of cadence (step/min.) for groups A and B.

	Group A		**Group B**	
	Pre	Post	Pre	Post
X`	28.4	29.12	27.44	31.20
SD	± 3.15	± 4.5	± 1.56	± 2.60
T	1.467		5.65	
P	> 0.05		< 0.0001	
Sig.	Non-significant		Significant	

X`: mean SD: Standard deviation T: t-test P: level of significance Sig.: significance

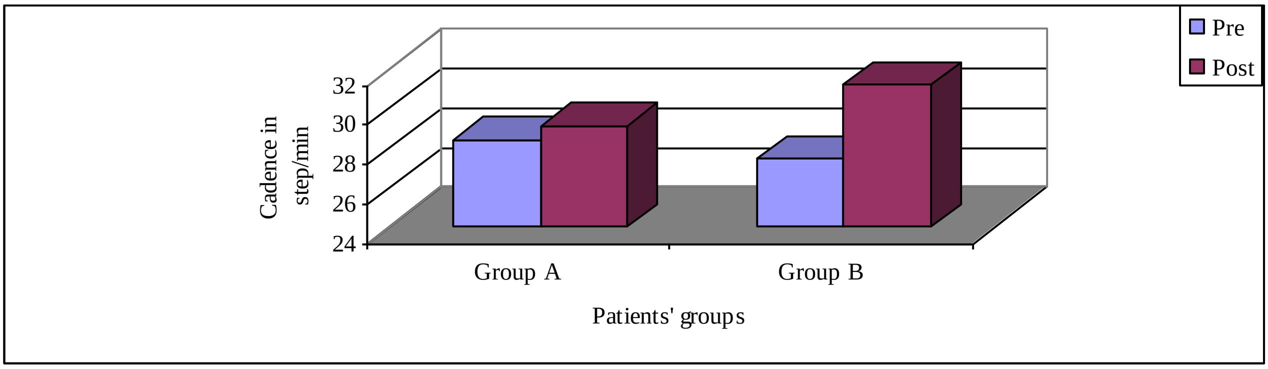

Fig. (4): Showing the mean values of cadence (step/min) for groups A and B pre and post-treatment.

DISCUSSION

The feet play an important role in the process of normal erect walking in human. Provision of a normal ankle with proper phasing of the extensor and flexor muscles, results in achievement of the normal gait[16].

Any affection of one group will lead to dysfunction of the whole process. Spasticity is one of the main problems, which render the anterior tibial muscle group and hamstring muscles, incapable of achieving their normal response in conjunction with the antagonistic group, in spastic hemiplegic cerebral palsied children[19].

The present study was conducted to determine the effect of tonic vibration reflex on hemiplegic gait pattern. Statistical analysis of the post-treatment results of this study revealed that there was significant improvement in the gait variables of group (B), including distance parameters (step length, step width), and temporal parameters (cadence and velocity), when compared with its pre- treatment results and with the post-treatment results of group (A).

Using foot print for quantitative gait analysis for determining step length step width, cadence and velocity come in agreement with Cerny[9], Jacob[18] and Harris and Heriza[14] who recommended the use of foot print method as a quantitative guideline to measure children's gait, clinically and objectively, including stride and step lengths, step width, foot angle and cadence.

The results of the present study after the suggested period of treatment confirm the findings of De Domenico[12] who established that TVR is of great value in the patient who can produce a weak voluntary contraction. It helps the patient produce much stronger contraction and so reciprocally inhibiting the spastic muscle group.

The post treatment results support the findings of Romaiguere et al.,[24] who reported the effect of activation of muscle spindle Ia afferent exerted by muscle vibration on motor unit recruitment. Their results showed that Ia afferent, activated by tendon vibration, exert a strong facilitatory action on their bearing muscles.

The obtained results also confirm the findings of Park and Martin[23] who stated that high frequency, low amplitude TVR activates a large fraction of motoneuron pools and recruits previously inactive motor units into response.

Significant improvement in group (B) receiving TVR agree with Martin and Park[22] who reported that TVR with a frequency around 100 Hz and an amplitude of 1.8 mm. induce more motor unit synchronization, with an increase in the spontaneous firing rate.

The results of the study come in agreement with Herbert and Boucher[15] who emphasized that TVR produces an increase in the neuro- muscular excitability, with facilitation of the excitation-contraction coupling mechanism.

The post-treatment results of the present study support the findings of Cisek et al.,[10] who stated that TVR influence the vibrated muscles to achieve their remarkable efficiency and accuracy in response to wide varying constraints. They added that, the key issue for achieving this efficiency is the influence of the nervous system to cope with a wide variety contexts.

Statistical analysis of the results of the present study after three months of treatment agree with Kavounoudias et al.,[20] who stated that vibration is a powerful stimulus affecting both cutaneous receptors as well as proprioceptive mechanisms. They reported that muscle vibration produce motor improvement in cerebral palsied children, when used in combination with other conventional therapeutic techniques.

Improvement observed in group B may be attributed to the effect of tonic vibration reflex which produce facilitation of the vibrated muscle and simultaneously inhibition of the opposite spastic muscles. Because prolonged spasticity are known to induce gross deformities of the involved joints, so, repetitive interruption of abnormal postures or movement patterns, via application of high frequency vibration may provide a means for preventing or at least delaying the onset of deformities. In addition to these motor benefits, vibration was found to improve the patient's body image and his memory for motor acts.

Conclusion

It can be concluded that TVR may be used in-conjunction with other physical therapy modalities for improvement of gait pattern of the spastic hemiplegic cerebral palsied children by inhibition of the spastic group of the lower limb muscles via activation of their antagonistic group at the lower extremities.

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الملخص العربي

دور الاهتزاز الكهربي عالي التردد على المشي في الأطفال المصابين بالفالج الشقي

تم إجراء هذا البحث لتحديد دور الاهتزاز الكهربي عالي التردد على طريقة المشي في الأطفال المصابين بالفالج الشقي. تم إجراء هذا البحث على ثلاثين طفلا (18 ولدا ، 12 بنتا) ممن يعانون بالفالج الشقي ، وقد تراوحت أعمارهم بين 6 إلى 8 سنوات تم اختيار هؤلاء الأطفال من معهد النبوي المهندس لشلل الأطفال والطب الطبيعي وقد حددت درجة التشنج العضلي على أساس مقياس أشورث لتتراوح بين 1^+ ، 2 درجة ، تم تقسيم هؤلاء الأطفال عشوائيا إلى مجموعتين متساويتين . مجموعة أ (ضابطة) ومجموعة ب (موضوع إجراء البحث) تلقت المجموعة (أ) برنامج خاص من التمرينات العلاجية ، بينما تلقت المجموعة (ب) تطبيق الاهتزاز الكهربي المطبق على المجموعة (أ) تم إجراء تقييم لجميع الأطفال موضوع هذه الدراسة قبل وبعد ثلاثة اشهر من تطبيق العلاج . وقد اشتمل التقييم على تحديد التغيرات في طريقة المشي عن طريق استخدام القياسات المسافية والزمنية . وقد أظهرت نتائج ما بعد العلاج بثلاثة اشهر وجود فروق ذات دلالة إحصائية عالية لقياسات المجموعة (ب) عند مقارنتها ما قبل العلاج لنفس المجموعة وكذلك عند مقارنتها بنتائج ما بعد العلاج للمجموعة (أ) بينما لم تظهر النتائج وجود فروق ذات دلالة إحصائية للمجموعة (أ) عند مقارنتها نتائج ما قبل وبعد العلاج لهذه المجموعة وكذلك عند مقارنة نتائج ما قبل العلاج للمجموعتين (أ ، ب) ويمكن إرجاء هذا التحسن الواضح في نتائج المجموعة (ب) إلى تأثير الاهتزاز الكهربي عالي التردد الذي أدى إلى انقباض العضلات الأمامية للساق وكذلك العضلات الثانية للركبة مما أدى إلى التحكم في زيادة النغم العضلي التشنجي لهذه العضلات والذي تمثل في التحسن الواضح في طريقة المشي لهؤلاء الأطفال .