Efficacy of Biofeedback Training on Compensatory Scoliosis in Hemiparetic Cerebral Palsied Children

Manal S. Abd- Elwhab*, Nashwa Sayed Hamed and Amaal HM. Ebrahim*****
* Department of Physical Therapy for Growth and Developmental Disorders in Children and its Surgery.
** Department of Physical Therapy for Neuromuscular Disorder and its surgery.
*** Department of Basic Sciences Assistant professor.. Faculty of Physical Therapy. Cairo University.

ABSTRACT

Background and purpose: *scoliosis is one of the most common problems that encountered physical therapists in the rehabilitation field. The purpose of this study was to investigate the effect of biofeedback training on changing the degree of scoliosis that occur as a result of unequal weight bearing, disturbed standing balance and lack of protective reactions of the involved side in spastic hemiparetic cerebral palsied children.* ***Subjects and procedures:*** *thirty hemiparetic cerebral palsied children ranged in age between 8 and 10 years were selected from outpatient clinic of faculty of physical Therapy Cairo University. All children were selected having non-bony structural postural scoliosis ranged between 20 to 30 degrees Cobb's angle. Children were divided randomly into two groups of equal number (fifteen patients in each group). The first group (control group) received traditional treatment program directed towards improving scoliosis while the second group (study group) received the same traditional treatment program in addition to biofeedback training on the of the scoliotic curve. Evaluation of changing in degree of scoliotic curve through measuring the Cobb's angle was done before and after three successive months of treatment application. Each child in both groups received his/her individual routine physical therapy program directed towards improving the physical condition.* ***Results:*** *data that was collected and statistically analyzed before and after three months of treatment application showed a statistically insignificant difference between the two groups before treatment application. There was statistically significant change in the measurement of Cobb's angle in both groups and between the two groups after three months of treatment in favor to the study group ($P<0.05$).* ***Summery and conclusion:*** *biofeedback stimulation can be used in improving the scoliotic curve in spastic hemiplegic cerebral palsied children.*

Key words: *Hemiparetic cerebral palsy, Biofeedback and scoliosis.*

INTRODUCTION

Spinal deformities develop in 25% of patients with cerebral palsy[1]. Scoliosis in hemiparetic cerebral palsied children may compensate for the body weight being distributed to one side only. This asymmetry may or may not have been seen in other weight bearing positions as sitting, kneeling or four foot kneeling. Sometimes, it is postural fixation mechanisms of the pelvis in standing only which fails, but which may be able to cope at lower levels of development[2].

Ratliffe[3], reported that the children with hemiplegia have many problems one of them is difficulty with balance because of poor muscle control in the arm and leg on one side of the body. Protective responses of catching oneself when falling toward the involved side can be impaired and because of the asymmetrical muscle pull on the spine as well as postural asymmetries in sitting and standing scoliosis may become a problem in those children.

A symmetrical muscle pull that results from imbalances in muscles around the vertebrae are possible causes of physical abnormalities that may cause imbalances in bones that would lead to scoliosis. Some research suggests that imbalances in the muscles around the vertebrae may make children susceptible to spinal distortions as they grow. Science the pelvis is the link between the entire upper structure of the body and the legs, any shifting of its position necessitates considerable readjustment in all body segments above and below. Changes in position of the pelvis results in automatic realignment of the spine[4].

Biofeedback technology was introduced in 1960 in the rehabilitation field. This technique allows subjects to gain conscious control over a voluntary but latent neurofunction by alerting, with an auditory or visual clue, that their efforts have activated a targeted neuromuscular pathway[5]. The original use of biofeedback to train single muscle activity in static positions or movement unrelated to function did not correlate well to motor function improvements in patients with central nervous system injuries. The concept of task-oriented repetitive training suggests that biofeedback therapy should be delivered during functionally related dynamic movement to optimize motor function improvement[6].

Biofeedback is a technique of making certain unconscious or involuntary bodily processes perceptible to the senses in order to learn how to consciously control them. It is taught by a professional who uses special machines which immediately indicate when you have successfully made a desired change. Once the technique is mastered, it can be practiced without the use of the machine. There is some evidence that biofeedback might be useful in correcting spinal curvature or maintaining correction after bracing[7]. Several studies[8,9,10] used biofeedback to provide a contraction to obtain functionally useful movement. From 1960s to the 1990s, many studies investigated the effects of biofeedback therapy on the treatment of motor deficits in the upper[11,12] and lower extremities[13,14] by comparing the effects of biofeedback training with no therapy or with conventional therapy (CT). Patients included those with strokes[13,14,15], traumatic brain injury[13], cerebral palsy[16] and incomplete spinal cord injury[12].

Ernst[17], stated that feedback seems a promising approach in hemiplegic rehabilitation. It is particularly favorable when initiated early in only mild affected patients. This therapy is not costly or work intensive and can be performed on outpatients.

Cheng et al.,[18] assessed the balance function of hemiplegic patients and investigated whether visual feedback rhythmic weight-shift training can decrease falls among patients with hemiplegia. They concluded that visual feedback rhythmic weight-shift training may improve dynamic balance function for hemiplegic patients and the occurrence of falls decreased in training group.

This study was conducted to investigate the effect of biofeedback on changing the degree of spinal lateral curvature (scoliosis) which occur as a compensatory mechanism to poor muscle pull between both sides of the vertebral column and unequal weight bearing in spastic hemiparetic cerebral palsied children.

SUBJECTS AND PROCEDURES

Subjects

Thirty spastic hemiparetic cerebral palsied children (18 boys and 12 girls) suffering from non-bony structural scoliosis secondary to the effect unequal weight bearing on both lower limbs due to affection with hemiplegia ranged in age between 8 to 10 years ($\bar{X}$ 9.2 ±0.92) participated in this study. They were selected from the outpatient clinic of faculty of Physical Therapy Cairo University.

Children participated in this study were chosen with mild degree of spasticity ranged between 1 and 1^+ according to modified Ashwarth's scale. All subjects were able to walk independently even with abnormal pattern and were able to maintain balance during walking. Each child had a degree of scoliosis ranged between 20º to 30º as determined by the Cobb's angle, through the use of plain stress X-ray films taken from standing position.

Children participated in this study were divided randomly into two groups of equal number (I and II). Evaluation for each child was conducted before and after three months of treatment.

Instrumentation

For evaluation:

X-ray apparatus: Bennet X-ray apparatus with tubstand (S-82 RMIO) and upright wall structure (V79 M17) was used to take X- ray films that used to determine the degree of the spinal curvature through measuring Cobb's angle. Protractor and ruler were used for measuring the Cobb's angle from X-ray films.

For treatment:

Biofeedback apparatus (Biofed 901 apparatus), with three surface electrodes. P-203 amplifier speaker system.

Procedures

For evaluation:

Stress X-ray film was taken for each child participated in this study from upright standing position to detect the degree of the lateral curvature of the spine through measuring the Cobb's angle.

Detection of Cobb's angle: from the X-ray film the cephalic and caudal (most upper and lower vertebral bodies respectively) were detected. Then two perpendiculars were extended from lines drawn through the superior end of the highest vertebral body and the inferior end of the lowest identified vertebral body of the curve. The acute angle formed by the intersection of the two perpendiculars is termed the Cobb's angle.

For treatment:

Treatment procedures for group I (control group): children in this group received the traditional treatment program directed towards improving the scoliotic curve in a form of stretching exercises for the muscles in the concave side from different positions as prone position, kneeling, side-lying and standing. Strengthening exercises for the muscles on the convex side, abdominal and back muscles.

Treatment procedures for group II (study group): children in this group received the same exercises given to children in the study group in addition to application of biofeedback on the concave side of the scoliotic curve as a source of augmented feedback to provide both audible and visible feedback signals about the degree of the muscle contraction to encourage the child's active participation. Before electrodes placement, the skin was cleaned with alcohol to decrease the skin resistance. Then the two active electrodes were placed on the child's back on the belly of the paraspinal muscles (1.25 cm lateral to the spinous process of both the cephalic and caudal vertebral bodies of the scoliotic curve). The ground electrode was fixed on the spinous process of the apex of the scoliotic curve[19].

Rising from prone with head and trunk while the arms were kept above the head and the child was asked to bend laterally away from the concavity. Bending towards the convex side from sitting position, raising arms above the head while standing against wall were done with 30 seconds of contraction and one minute for relaxation after demonstration of the child that green color means relaxation, yellow color indicates moderate contraction and red color indicates highest contraction, also the sound he/she hears will be louder when the degree of contraction increased.

Children in both groups were treated three times per week for three successive months and they received their individual physical therapy treatment directed towards improving the physical abilities of the child.

Statistical analysis

Raw data was collected and statistically analyzed using graph pad prism version (4.01) to show the mean values and standard deviation. T-test was performed before and after treatment application in each group as well as between both groups before and after treatment.

RESULTS

Table (1) and figure (1), illustrate the mean values of Cobb's angle before and after the application of traditional program of treatment for group I and traditional treatment with biofeedback for group II. For group I (control group), the results showed a statistically significant change in the mean values of the Cobb's angle after treatment application as mean values before and after treatment were 24.73±2.46 and 22.07±1.16 respectively (P-value <0.05) with a percentage of improvement equals 10.7%. Mean values of the Cobb's angle for the study group (group II) indicated that there was a highly significant difference before and after application of the treatment (<0.0001), as the mean values were 25±2.07 and 18±1.18, before and after treatment respectively. The mean difference was 6.6 and the percentage of improvement equals 25.4%.

Table (1): Mean values of Cobb's angle before and after treatment application for both control and study groups.

	$\bar{X}$ ±SD	MD	t-value	P-value	% of improvement
GI Before After	24.73±2.46 22.07±1.16	2.66	4.3	<0.05*	10.7%
GII Before After	25 ±2.07 18.4±1.18	6.6	12.6	<0.0001**	25.4%

GI: group (1). GII: group (2). $\bar{X}$ ± SD: mean ± standard deviation. MD: mean difference.
* significant **highly significant

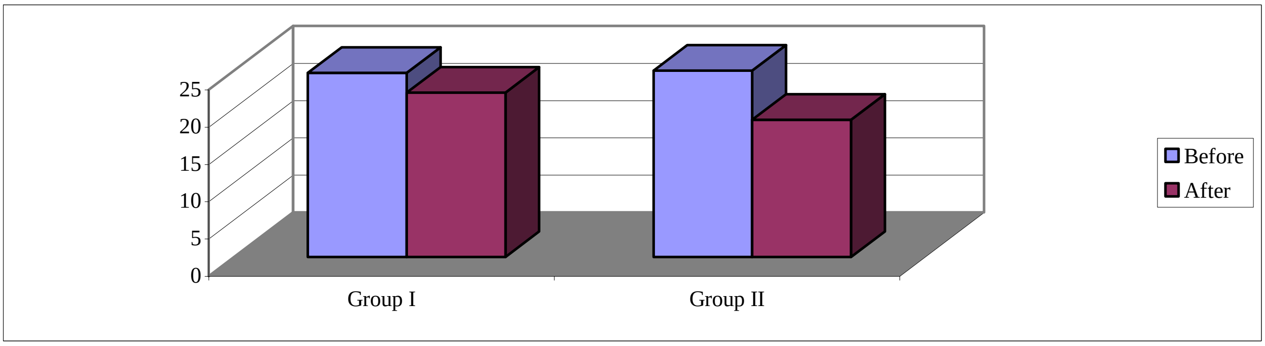

Fig. (1): Mean values of Cobb's angle before and after three months of treatment for groups I and II.

As shown in table (2) and illustrated in figures (2) and (3) the mean values of the Cobb's angle before treatment application for both control and study groups were 24.73 ±2.46 and 25 ±2.07 respectively with a mean difference of 0.32 indicated a statistically non-significant difference between both groups before treatment (P>0.05). Mean values of the Cobb's angle after treatment application for the control group was 22.07 ±1.16 with 10.7% of improvement and 18.4 ±1.08 with 26.4 % of improvement and a mean difference of 3.56 indicated a statistically significant difference after application of the traditional treatment and biofeedback technique (P<0.0001) in favor to the study group as shown in table (2) and figure (3).

Table (2): The mean values of Cobb's angle before and after biofeedback application for both control and study groups.

Variables	$\bar{X}$ ±SD	MD	t-value	P-value	% of improvement
Before GI GII	24.73±2.46 25±2.07	0.27	0.32	>0.05 NS	–
After GI GII	22.07±1.16 18.4±1.18	3.66	8.56	<0.0001***	10.7% 26.4%

$\bar{X}$ ±SD: mean ± standard deviation. MD: mean difference. NS: non significant ** Highly significant

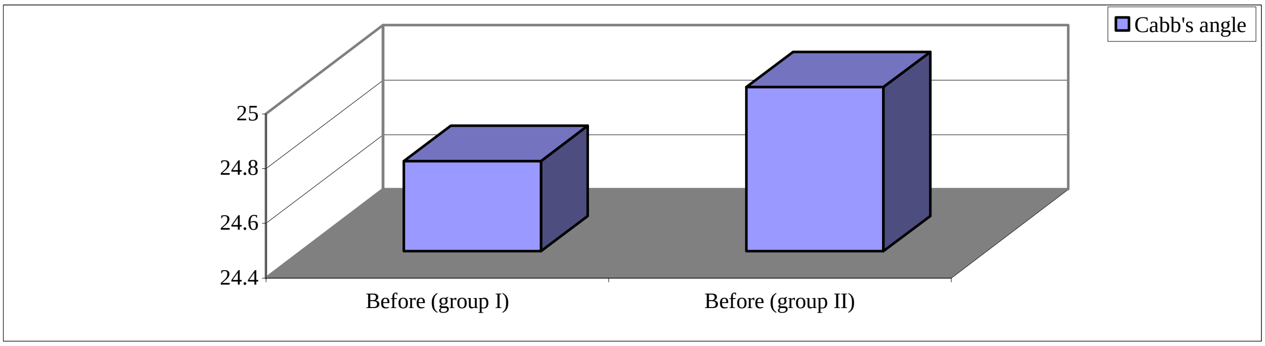

Fig. (2): Illustrates comparison between the mean values of control and study groups before treatment application.

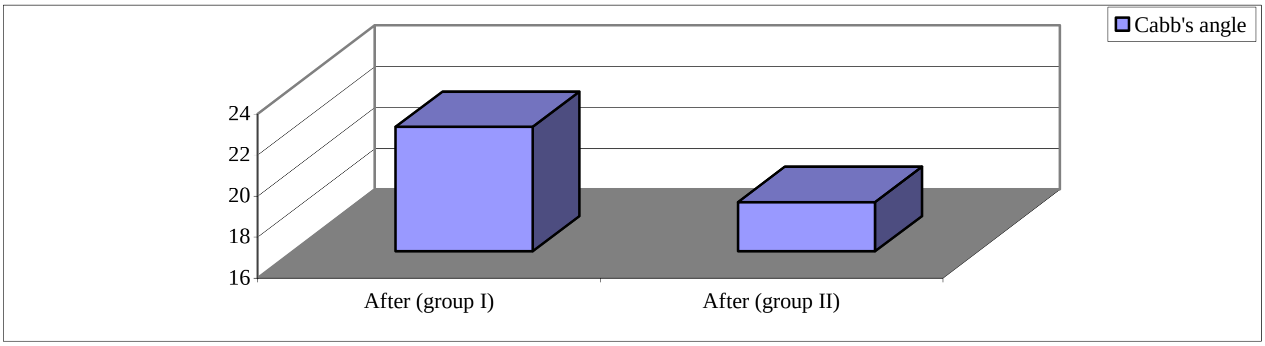

Fig. (3): Illustrates comparison between mean values of both groups (control and study) after three months of treatment application.

DISCUSSION

The present study was conducted to evaluate the effect of biofeedback stimulation on changing the degree of spinal deviation (scoliosis) in spastic hemiparetic cerebral palsied children. The collected data was manipulated and showed a statistically non-significant difference between both groups (control and study) before treatment application indicating homogeny between the collected sample data. Moreover, there was a statistical significant improvement in the degree of the spinal deviation in both groups after treatment application compared with before treatment with marked improvement in the study group. This significant difference may be attributed to the effect of biofeedback stimulation, as repetitive practice through biofeedback may resulted in long term functional gain than an individual practice without a direct biofeedback[20].

Neuromuscular control due to biofeedback application may be attributed to the activity of the parietal cortex that results from sensory feedback and occurs after the initial muscle contraction. The sensory system then assists in controlling motion after becoming aware of the movement. Activity in the motor cortex must precede voluntary movement. In absence of sensory feedback the patient is unaware of this neuromotor activity. With improving of the awareness of the effect of the motor cortex activity, the patient is able to practice and reinforce desired movement patterns[21].

The improvement in the degree of the spinal deviation may also be attributed to the effect of motor learning, as learning is a process associated with practice and leading to improvement in the ability to produce skilled movement. The sensory system gives information about how movement are/ or should be performed and it gives information about how to act to reach the goal that is sated for the motor training. Feedback is beneficial during early training of motor tasks, when the movements are usually slow and performed under mental concentration[22].

The results of the current study come in agreement with Engardt[23], who reported that concurrent, continuous feedback is vital for motor control and skill acquisition and has been very critical of the view that knowledge of result or any form of learning by consequences can be an important determinant of motor learning. Feedback is considered a significant variable for motor learning.

Lucca and Recchiuti[24], reported that adding biofeedback to isometric exercise has been shown to produce greater gains in peak torque than isometric exercise alone. Feedback monitored information concerning proprioceptors in the joint and muscles as well as extroceptors in the skin. These receptors signaled sensory information concerning the length of the muscle, amount of tension developed and tactile sensation.

The results of this study also agree with the findings of Lewthwate[25], who investigated the research that had been performed on motivation and its relationship to the physical activity. She looked at the effects of personal, social and environmental motivation influences and found that strategies can be developed to benefit performance using effective motivational features.

Researchers have investigated biofeedback on the premise that people receiving a signal to improve posture when slumping may in some cases reduce their spinal deformities. (Some experts believe that braces work only because the young patients self-correct their curves by retraining their posture to avoid the discomfort of the brace).

The improvement in the post treatment results comes in agreement with Colborne and Olney[26], who stated that feedback is known to be essential for ordering changes, monitoring errors and enhancing corrections that are needed in the motor program.

Conclusion

This study investigated the effect of biofeedback on changing of the scoliosis degree in hemiparetic children with cerebral palsy. The results revealed a steady significant decrease in the Cobb's angle for both control group and study group. The study proved that the biofeedback is more effective when combined with other traditional physical therapy techniques than using traditional techniques only.

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الملخص العربي

تأثير التغذية الحيوية الرجعية على تعديل الانحناء الجانبي (الجنف) للعمود الفقري التعويضي عن الشلل المخي النصفي

الخلفية والغرض : الانحناء الجانبي للعمود الفقر ي أحد المشاكل الأكثر شيوعا الت ي صادفت أخصائي العلاج الطبيع ي في مجال التأهيل.الغرض من هذه الدراسة هو معرفة تأثير تحفيز التغذية الحيوية الرجعية على تغيير درجة الانحناء الجانبي للعمود الفقري الذي حدث كنتيجة للتوزيع الغير متساوي لوزن الجسم واضطراب أتزان الوقوف وقلة رد الفعل الوقائي للجانب المتقلص عند الأطفال المصابين بالشلل المخى الطولي . العينة : تم إجراء هذه الدراسة على ثلاثين طفلاٍ يعانون من انحناء في العمود الفقري (الجنف) الناتج من الإصابة بالشلل المخى الطولي تراوحت أعمارهم بين 8-10 عام اختيرت من العيادة الخارجية لكلية العلاج الطبيعي-جامعة القاهرة . على أن يكون جميع الأطفال لديهم درجة متوسطة من التقلص العضلي وفقا لمقياس أشور وكانوا يستطيعون المشي ولو بطريقة غير صحيحة. وقد حددت درجة انحناء العمود الفقري بين 20 - 30 درجة.الطريقة. تم تقسيم الأطفال عشوائيا إلى مجموعتين متساويتين في العدد (15 طفلا في كل مجموعة) المجموعة الضابطة والتي تلقت البرنامج التقليدي موجها لتحسين اعوجاج الجنف للعمود الفقري . بينما تلقت المجموعة الدارسة نفس برنامج المعالجة التقليدي بالإضافة إلى التنبيه الكهربي عن طريق استخدام جهاز التغذية الحيوية الرجعية على الجانب المقعر لمنحنى العمود الفقرى . تم تقييم زاوية كوب قبل وبعد ثلاثة شهور من تطبيق العلاج . النتائج البيانات التي جمعت وحللت بشكل إحصائي قبل وبعد ثلاثة أشهر من تطبيق العلاج أظهرت عدم وجود اختلاف إحصائي بين المجموعتين قبل تطبيق العلاج كما أظهرت النتائج وجود فروق ذات دلالات إحصائية للمجموعة الضابطة قبل وبعد تلقى العلاج. ويمكن إرجاع هذا التحسن إلى تأثير استخدام جهاز التغذية الحيوية الرجعية على زيادة قدرة الطفل على المشاركة الايجابية في قبض العضلات المشدودة على الجانب المحدب للعمود الفقري مما أدى بدوره إلى بسط العضلات في العضلات في الجانب المقعر والذي انعكس على تقليل زاوية انحناء العمود الفقري .

الخلاصة : تحفيز التغذية الحيوية الرجعية يمكن أن يستعمل في تحسين الانحناء الجانبي للعمود الفقري في الأطفال المصابين بالشلل المخى النصفي .

الكلمات الدالة : الشلل المخى النصفي (الطولي)- التغذية الحيوية الرجعية- تحدب (جنف) العمود الفقري .