Effect of Hyberparic Oxygen Therapy on Angular Joints Displacements During Initial Contact of Gait Cycle in Spastic Diplegic Cerebral Palsied Children

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ABSTRACT

Purpose: *The purpose of this study was to investigate the effect of Hyberparic Oxygen Therapy on Angular joints displacements during initial contact of gait cycle in spastic diplegic cerebral palsied children.* ***Subjects:*** *Thirty spastic diplegic children from both sexes (16 boys, 14 girls) ranged in age from four to eight years participated in this study. They were divided randomly into two groups of equal number (15 patients in each group) (control and study groups).* ***Procedures:*** *The control group (GI) received a traditional physical therapy treatment program directed towards improving gait pattern. While children in the study group (GII) received the same physical therapy program in addition to hyperbaric oxygen therapy (one hour session for 20 sessions). Evaluation procedure was carried out before, after one month and after three months of treatment application for both groups by using motion analysis system with six proreflex cameras to evaluate angular joints displacement including the right and left hip, knee and ankle joints.* ***Results:*** *Results showed a statistically insignificant difference among both groups before and after the first month of treatment while at the end of the third month the results revealed a statistically significant difference of joints angles displacement among both groups.* ***Conclusion:*** *Hyberparic Oxygen Therapy can be used to improve lower limbs joint angles in diplegic cerebral palsied children.*

Key words: *Spastic diplgia, hyperbaric oxygen therapy, gait cycle.*

INTRODUCTION

Cerebral palsy (CP) is a range of non-progressive syndromes of posture and motor impairment. The disorder results from various insults to different areas within the developing nervous system that cause variability of clinical findings[11]. Spastic diplegia is a common form of cerebral palsy, especially among preterm infants. It is characterized by bilateral hypertonic involvement, primarily of the lower limbs, and is generally caused by peri-ventricular infarction and/or hemorrhage in both hemispheres[3]. The term diplegia is used when the legs are more affected than the arms and it produce any or all of the following symptoms: increase muscle tone, loss of selective muscle forces across the joints, particularly in the lower extremities, imbalance of muscle function in those children, that result in abnormal gait pattern which is typically described as crouch gait. This type of abnormal gait is characterized by increased trunk, hips and knees flexion and ankles planterflexion, there is potential risk of increasing hip and knee flexion contractures, which may ultimately result in the loss of independent ambulation[5,7].

Hyperbaric oxygen therapy (HBOT): refers to intermittent treatment of the entire body with 100-percent oxygen at greater than normal atmospheric pressures[15,19]. The availability of oxygen is essential to promote

healing of damaged tissues, decrease swelling and to improve circulation[4]. As children with CP had experienced to some from of injury to their brain before, during or shortly after their birth HBOT may be used to treat them as it is suggested to alleviate hypoxia at cellular level, oxygenate the cells of the body and relieves the oxygen starvation of the brain through increase the amount of oxygen carried to the hypoxic brain tissues, produce long term improvements in both brain and clinical function with improvement of micro-circulation and relief of any brain swelling. A patient can experience a reduction in spasticity and an improvement in cognitive ability, vision, hearing and speech[13,18].

So this study was conducted to detect the effect of alleviating hypoxia through the use of HBOT on changing lower limbs angular joints displacement during initial contact of the gait cycle.

SUBJECTS AND PROCEDURES

Subjects

Thirty spastic diplegic children of both sexes were selected from "Pediatric outpatient clinic of Faculty of Physical Therapy", Cairo University and from "Hyperbaric Oxygen Therapy Laboratory" in Nasser Institute Hospital. All of them subjected to the following criteria:

1- Their ages ranged from four to eight years.
2- They had mild degree of spasticity according to Modified Ashworth Scale (grade 1 to +1) and they were able to walk independently.
3- They had no contractures or fixed deformity in both lower limbs.
4- They had no ear, nose, visual, heart or thoracic defects.
5- They had no history of previous or recent thoracic surgery, seizures, cancer, and/or chronic asthma.

Children were divided into two groups of equal number (15 patients in each group) they represented control and study group GI & GII respectively.

Procedures

A- Instrumentation used for evaluation:

Motion analysis system with six Pro-Reflex cameras, a wand kit was used for calibration of the system. A personal computer with the Q Trac software installed. ACB- 530 serial interface adapter, which is a communication card that is mounted in the PC (Figures 1 & 2). Eighteen reflected dots, walkway of eight-meter length and 120cm width.

Fig. (1): Camera system with six cameras (ProReflex).

Fig. (2): The PC with the Q Trac software installed.

B- Instrumentation used for treatment

1- Chamber of hyperbaric oxygen therapy (multiplace chamber)[9] (Figure 3).

Fig. (3): Multiplace chamber of hyperbaric oxygen therapy.

2- Therapeutic rolls balls, parallel par and balance board.

(A) Evaluation of Joint angle excursion:

1) Skin marker placement:

Before starting capture, specific bony landmarks were marked by reflected dots, markers were fixed to the skin by adhesive straps on both sides of the body. The reflected dots were placed as follows:

1. Knee joints line.
2. Suprapatellar.
3. Tibial tuberosities.
4. Ankles.
5. Feet.
6. Heels.
7. Shoulders.
8. 12th Thoracic vertebrae.
9. Sacrum.
10. Anterior superior iliac spines.

2) Capturing:

Six cameras were used for capturing the child motion; they were arranged on two sides of eight meters long walkway at a height of one and half meters (figure 1). The child was asked to stand midway on the walkway and start walking from a position faraway enough from the measurement volume. The child was allowed to continue walking several meters after the measurement volume. Data collection started just before the child entered the measurement volume and few meters after it.

(B) Treatment procedures for GI: Children in control group received traditional physical therapy program directed towards improving gait pattern including: Neuro-developmental technique, training for active trunk extension, postural control and balance. Exercises for Facilitation of protective reaction, maintaining the optimum length of the muscles especially tendoachilis, hamstrings, hip flexors and adductors of the lower limbs Strengthening exercises for antispastic muscles, back and abdominal muscles exercises to prevent spinal deformities and improve trunk control. Weight bearing on each lower limb. Sideways, forward and backward walking between parallel bars in front of a large mirror and training for ascending and descending stairs was done. Children were generally treated once a day for three days per week and physical therapy treatment conducted for one hour every session for three successive months.

(C) Treatment procedures for GII: Children in study group received the same exercise program given to GI in addition to hyperbaric oxygen therapy. Children were placed into hyperbaric oxygen therapy multiplace chamber and a clear mask was placed around their mouth and nose through which pure oxygen was pumped. Pressure inside the mask was gradually increased and lasted for 10-15 minutes. Once the pressure reached 26 feet below sea level (1.7 ata), it was stabilized and child started to breathe air of 100% oxygen (figure 4). After 60 minutes, pure oxygen pumping was stopped and air saturation pressure was gradually reduced to normal again which took 10-15 minutes. The frequency of treatment were 20 sessions, children were generally treated once a day for five days per week[10].

Fig. (4): Child breaths pure oxygen through mask.

RESULTS

This study was conducted to evaluate the effect of HBOT on angular joint displacement during the initial contact of the gait cycle in spastic diplegic cerebral palsied children. The data was collected and statistically treated before, after one month and after three months of treatment application. Differences among both groups were illustrated as follows:

a) Angular displacement of hip, knee and ankle joints during initial contact before treatment.

Table (1): Mean values of right and left hip, knee and ankle joint angles during initial contact before treatment for both control and study groups.

Joint angle		$\bar{X}$ ± SD	MD	t value	P value	Significance
Rt hip	GI	44.06±4.86	1.07	0.65	P> 0.05	NS
	GII	45.13±4.08				
LT hip	GI	43.2±3.82	1.00	0.72	P> 0.05	NS
	GII	44.2±3.72				
RT knee	GI	40.40±5.17	0.7	0.31	P> 0.05	NS
	GII	39.73±6.48				
LT Knee	GI	40.53±6.33	0.86	0.37	P> 0.05	NS
	GII	39.66±6.33				
RT ankle	GI	28.86±3.56	1.13	0.75	P> 0.05	NS
	GII	27.73±4.55				
Lt ankle	GI	29.66±3.47	2.8	1.6	P> 0.05	NS
	GII	26.86±5.37				

From the previous table it was illustrated that mean difference of angular displacement regarding Rt and Lt hip, knee and ankle joints showed a statistically insignificant difference among both groups before starting treatment (P>0.05) as illustrated in figure (5).

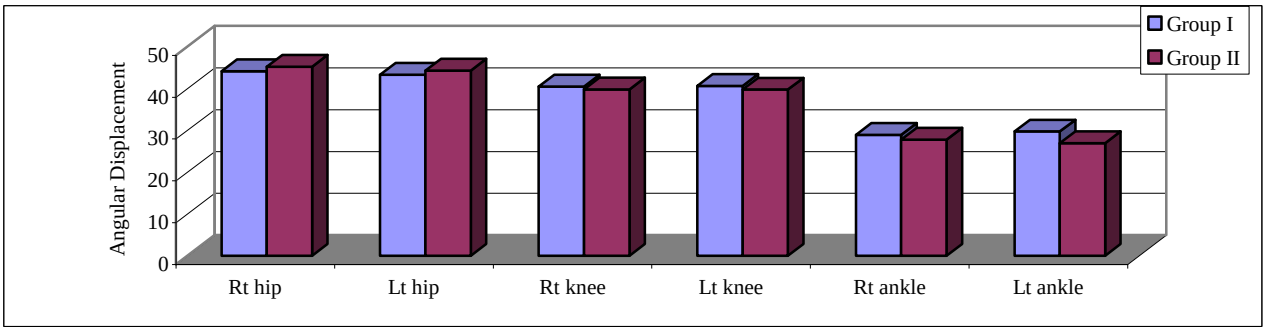

Fig. (5): Mean values of angular displacement of right and left hip knee and ankle joints during initial contact before treatment for both control and study groups.

b) Angular displacement of hip, knee and ankle joints during initial contact after 1st month of treatment.

Table (2): Mean values of right and left hip, knee and ankle joints angle during initial contact phase after one month of treatment for both control and study groups.

Joint angle		$\bar{X}$ ± SD	MD	T value	P value	Significance
Rt hip	GI	43.86±4.96	0.8	0.45	P> 0.05	NS
	GII	44.66±4.68				
LT hip	GI	42.93±3.91	o.93	0.66	P> 0.05	NS
	GII	43.86±3.72				
RT knee	GI	40.53±6.33	0.6	0.27	P> 0.05	NS
	GII	39.66±6.33				
LT Knee	GI	40.33±6.46	0.87	0.37	P> 0.05	NS
	GII	39.46±6.37				
RT ankle	GI	28.66±3.67	1.4	0.94	P> 0.05	NS
	GII	27.26±4.43				
Lt ankle	GI	29.46±3.46	2	1.58	P> 0.05	NS
	GII	27.46±3.46				

This table illustrates that there was statistically insignificant difference among both groups after the 1st month of starting treatment as illustrated in figure (6).

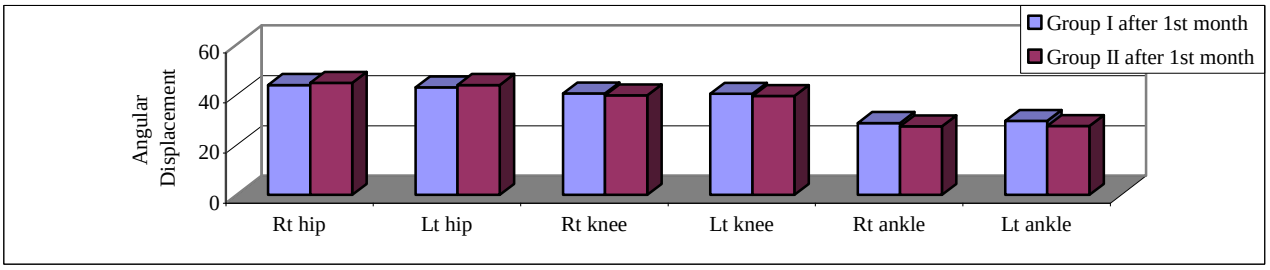

Fig. (6): Mean values of angular displacement of right and left hip knee and ankle joints during initial contact after 1st month for both control and study groups.

c) Angular displacement of hip, knee and ankle joints during initial contact phase aftert 3rd month of treatment.

Table (3): Comparison between mean values of right and left hip, knee and ankle joints angle during initial contact after three months of treatment for both control and study groups.

Joint angle		$\bar{X}$ ± SD	MD	T value	P value	Significance
Rt hip	GI	40.4±5.23	3.34	1.99	P< 0.05	S
	GII	37.06±3.8				
LT hip	GI	38.73±3.63	3.07	2.04	P< 0.05	S
	GII	35.66±4.51				
RT knee	GI	38.8±6.67	5.54	2.14	P< 0.05	S
	GII	33.26±7.43				
LT Knee	GI	37.46±6.92	5.66	2.00	P< 0.05	S
	GII	31.8±8.46				
RT ankle	GI	26.46±3.68	3.2	2.27	P< 0.05	S
	GII	23.26±4.02				
Lt ankle	GI	26.6±5.09	3.87	1.96	P< 0.05	S
	GII	22.73±5.65				

From the previous table it was illustrated that mean difference of angular displacement regarding Rt and Lt hips, knees and ankles showed a statistically significant difference among both groups after the 3rd month of starting treatment (P<0.05) as illustrated in figure (7).

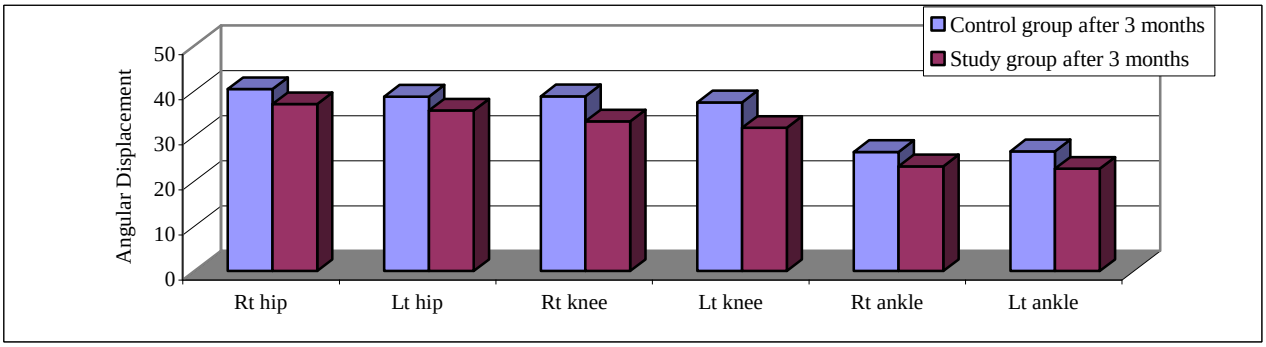

Fig. (7): Mean values of angular displacement of right and left hip knee and ankle joints during initial contact after the 3rd month for both control and study groups.

DISCUSSION

The present study was conducted to evaluate the effect of hyperbaric oxygen therapy on angular joints displacements during initial contact of gait in spastic diplegic children as motor deficits and spasticity in diplegic CP children produce a walking pattern characterized by exaggerated hip and knee joints flexion during stance phase of gait with ankle plantar flexion[1].

The results of the current study showed a statistically insignificant difference after the 1st month of treatment while there was a statistically significant difference among both groups after the 3rd month of treatment.

This insignificant difference among both groups after the 1st month of treatment may be attributed to the residual effects of the brain impairment as increase energy expenditure, spasticity, abnormal extensibility, disturbed reflexes and limitation of movement which led to abnormal weight bearing also fear of the child to fall and loss of complete maturation of balance and equilibrium reactions. That led to non-improvement of balance of the child during gait or due to spinal immobility and poor coordination which led to inability to use righting reflexes and equilibrium reactions.

Improvement after the 3rd month of treatment may be attributed to the effect of HBOT which is suggested to increase attention and intelligence of the child in addition to the main effect of damping spasticity. It was suggested that HBOT could increase the endurance of the child in addition to child's cooperation during physical therapy session[12].

The results of the present study could be explained by the fact that the beneficial effects of HBOT would continue beyond treatment endpoint. Heuser and Uszler[8], showed that tissue oxygen partial pressure measurements that rose from near zero to 50 mmHg after some months long course of HBOT were retained without further treatment for at least three years. They thought that continues improvement is due to re-canalization of atrophied vessels or growth of neovasculature.

The mechanism of improvement after application of HBOT may helps the body to heal itself by making oxygen available to tissues that are not receiving an adequate supply. Also hyperbaric oxygenation has a positive effect on the central nervous system as it reduces swelling, repairs the blood-brain barrier, and stabilizes cell membranes. It increases the ability of white blood cells to clean up damaged areas and also damaged tissue in the brain due to an inadequate supply of blood[6,14].

HBOT can stimulate idling neurons (that survived after hypoxia but have not resumed their former electrical activity) to function more efficiently, producing long term improvements in both brain and clinical function. With the improvement of micro circulation and relief of any brain swelling, a patient can experience a reduction in spasticity and an improvement in cognitive ability, vision, hearing and speech[16].

Since full blood circulation to specific areas of the brain is impaired, increasing the rate at which oxygen diffuses into all of the body's fluids, increases the amount of oxygen carried to the hypoxic brain tissues. Oxygen enriched cerebrospinal fluid will help to repair any recoverable brain tissue that is intact but not functioning normal[4].

This improvement may also attributed to the effect of HBOT on microcirculation, cerebral metabolism as it reduces cerebral edema by vasoconstrictive effect, increases the permeability of the blood-brain barrier and preservation of partially damaged tissue and prevention of further progression of secondary effects of cerebral lesions[15,17,19].

Effects of hyperbaric oxygenation on the brain are that it reduces cerebral edema, deactivates platelets, reduces lactate peaks and toxic amines, restores the integrity to the blood brain barrier and cell membrane, enhances the delivery of oxygen to DNA and mitochondria, neutralizes free radicals, and delivers oxygen to the cells for immediate metabolic use without energy exchange even in the absence of circulation[2].

The results of the current study comes in agreement with Williams[20] who stated that there is significant improvements in aspects of gross-motor and fine-motor functioning, as well as reductions in spasticity in hip adductors, hamstrings, and ankle plantar flexors. Significant improvements in walking and sitting after treatment with hyperbaric oxygen therapy.

Conclusion

From the obtained results it can be concluded that HBOT could be used in addition to traditional methods of treatment to improve lower limbs angular joints displacement in diplegic cerebral palsied children.

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الملخص العربي

تأثير العلاج بالأكسجين تحت الضغط على زوايا انحراف مفاصل القدم عند لمس الأرض في بداية المشي عند الأطفال المصابين بالشلل المخي التشجي

تهدف هذه الرسالة إلى تقييم تأثير العلاج بالأكسجين تحت الضغط على زوايا انحراف مفاصل الحوض والركبة والكاحل عند لمس الأرض في بداية المشي عند الأطفال المصابين بالشلل المخي التشجي . تم إجراء هذا البحث على ثلاثين طفلاً من المصابين بالشلل المخي التشنجي تراوحت أعمارهم من أربعة إلى ثمانية أعوام . وقد تم اختيار عينة البحث من العيادة الخارجية – كلية العلاج الطبيعي جامعة القاهرة ومعهد ناصر. وتم تقسيمهم عشوائيا إلى مجموعتين متساويتين (خمسة عشر طفلاً لكل مجموعة). وشمل البرنامج العلاجي للمجموعة الضابطة العلاج الطبيعي التقليدي ويشمل التمرينات الآتية : (تمرينات إطالة لعضلات ثني الحوض والركبة والكاحل بالإضافة إلى تمرينات تقوية لبعض العضلات وتمرينات للتدريب على المشي) بينما أشتمل البرنامج العلاجي للمجموعة التجريبية على نفس البرنامج العلاجي للمجموعة الضابطة بالإضافة إلى العلاج بالأكسجين تحت الضغط . وقد تم تقييم الأطفال قبل العلاج وبعد شهر ثم بعد ثلاثة أشهر من العلاج باستخدام التصوير الحركي ثلاثي الأبعاد لقياس: زوايا حركة ثني مفاصل الحوض والركبة والكاحل أثناء المشي عند لمس الأرض وذلك عن طريق ست كاميرات للأشعة تحت الحمراء متصلة بجهاز كمبيوتر محمل عليه برنامج للتحليل الحركي ثلاثي الأبعاد. وقد أظهرت النتائج وجود تحسن ذو دلالة إحصائية لمرضى المجموعة التجريبية بالمقارنة بمرضى المجموعة الضابطة بعد ثلاثة أشهر من العلاج .. وقد استنتج من هذه الدراسة أن تطبيق العلاج بالأكسجين تحت الضغط بالإضافة إلى برنامج العلاج الطبيعي التقليدي يفيد في تقليل زوايا انحراف مفاصل الحوض والركبة والكاحل أثناء المشي عند لمس الأرض عند الأطفال المصابين بالشلل المخي التشنجي عنه من استخدام برنامج العلاج الطبيعي فقط.

التوصيات : وفقاً للنتائج السابقة نوصي بإضافة العلاج بالأكسجين تحت الضغط عند علاج الأطفال ذوى الشلل المخي التشنجي .

الكلمات الدالة : (الشلل الدماغي، التصوير ثلاثي الأبعاد ، العلاج بالأكسجين تحت الضغط) .