Efficacy of Vestibular Stimulation on Down's Syndrome Children

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ABSTRACT

Back ground: *Motor skills in children with Down's syndrome have been studied in details, Investigators have determined that infants with Down's demonstrate are delayed in achieving gross motor milestones such as walking. Furthermore, a positive association has been identified between delays in achieving gross motor milestones and delays in the development of postural reaction as: The righting, equilibrium and protective reactions.* ***The purpose*** *of this study was to investigate the efficancy of vestibular stimulation on walking pattern in Down's syndrome children. The study included twenty patients from both sexes (eleven boys and nine girls) with age ranged from 7 to 10 years,* $\bar{X}$ *8.8±1.03 years and 8.3±1.06 years respectively. The patients were randomly and equally divided into control and study groups. Evaluation of gait parameters including stride length, step length, velocity and cadence were carried out for each patient before and after three months of treatment. All patient were subjected to the postural reaction program, three time's per weerk. Furthermore, patients belonging to the study group only received vestibular stimulation.* ***Results*** *of the present study revealed significant improvement in the study group versus the control in step length stride length, cadence and velocity.* ***Discussion*** *Improvement in the study group may be attributed to the effect of vestibular stimulation and postural reaction on modulate input from the pyramidal system, improve cerebellar function, automatic reactions, head righting reflex, equilibrium reactions and protective responses.* ***Conclusion:*** *According to this study, supported by results of previous studies, it could be concluded that vestibular stimulation is an effective and safe modality in the treatment of Down's syndrome children.*
Key words: *Down's syndrome, vestibular stimulation, postural reaction.*

INTRODUCTION

DOwn's syndrome, the most common single cause of mental retardation, compromises a major problem to the patients and their relatives. Beside the mental retardation, there is retardation in gross and fine motor development[4]. Researchers have studied the motor skills in Down's syndrome children in details and have found that, the general rate of motor skill development has been below that of normal children[8].

The clinical diagnosis of the syndrome depends on the presence of mental retardation in association with other manifestations of disordered growth of skeletal system[1]. The mental retardation ranges from moderate to severe. Most patients are considered trainable but not educable[6].

Hypotonia may be the first abnormality noticed in the new born. In addition, the patients are short in stature and have brachycephally, with a flat occiput. The neck is short, with loose skin on the nape, the nasal bridge is flat, the ears are low set and have a brush-field around the margin of the iris, and the mouth is opened often showing the furrowed, protruding tongue. The hands are short and broad, with a single transverse palmar crease, and incurved fifth digit. The feet show a wide gap between the first and the second toes[10,14].

The postural reactions (righting, equilibrium and protective reactions) have been identified as the underlying responses that are related, most functionally to motor milestones. Postural reactions provide automatic support and stability to the head, trunk and extremities and facilitate normal weight shifts and mobility. There reactions function to keep the head aligned vertically during movement, to provide balance and postural shift mechanisms when the center of gravity is disturbed and to prevent a fall during rapid movements[9,13]. Postural control problems have been identified in children with Down’s syndrome. The postural responses to loss of balance are slowing in young children (1-6 years of age) with Down’s syndrome and these responses are inefficient for maintaining stability. Children with Down’s syndrome, who were between 7 and 14 years of age, scored consistently low on agility and balance tasks when compared with matched control group[5,12].

Barbara et al.,[3] mentioned that, children with down’s syndrome who were involved in an early intervention programming (EIPs), had significantly higher scores on measures of intellectual and adaptive functioning than children of comparable ages with Down’s syndrome who did not participate in an EIPs.

O’sullivan[23] stated that, fast vestibular stimulation can be used to facilitate postural tone, promotes head righting and increased arousal level and attention, also he added that vestibular stimulation is a useful therapeutic modality for treating hemiplegia and Down's syndrome.

Kelly[18] recommended that, ten days of rotator vestibular stimulation produced a marked improvement in motor performance of children with Down's syndrome. This improvement was explained by two mechanisms. The first mechanism provides an improvement in retinal image stability by more accurate function of the vestibulo-ocular reflex arc. The second involves the development of excitatory mechanisms associated with habituation that generalized to other spheres of central nervous system function.

MATERIALS AND METHODS

Subjects

Twenty Down's syndrome children were selected from Out-patient clinic of the Faculty of Physical Therapy, Cairo University. They were eleven boys and nine girls, with age ranged from 7 to 10 years, the mean age was 8.8±1.03 years and 8.3±1.06 years respectively.

They were randomly divided into two equal groups (control and study groups) each comprised 10 patients, they enrolled in this study fulfilled the following criteria:

- All had mild to moderate degree of mental retardation with IQ (50-61).
- They were investigated by a physician to exclude the possibility of any other illness that might interfere with the treatment program such as hearing loss, congenital cardiac anomalies, atlanto-axial subluxation, dislocation of hip or knee or subluxated patella.
- They had a delay in the areas of walking and postural reaction.

Materials

I- Materials for evaluation

- **Walking sheet:** A straight plastic walking, with l0 meters length and 50 cm width. The middle 6 meters of this walkway was divided into equal segments, each was 1cm long and numbered from 0 to 60o. The walking sheet was located in gait. The evaluation area was fastened from both ends with a masking adhesive tape to prevent slipping off the ground.

- **Recording and displaying systems:**

1- Video camera: A portable video camera used from recording the temporal and distance gait parameters during the patient's gait.
2- Video tapes: sensitive video tapes were used during recording and playing back.
3- Colour T.V: It was used for displaying the recorded video tapes during determination of temporal and distance parameters of the patients gait.
4- Stop watch: A stop watch capable measuring duration up to one tenth of a second.
5- Tape measure: It is graded from 1 to 150cm, used to measure the long measurements for distance gait parameters.

II- Materials for treatment

- **Vestibular stimulator:** Electro-Mechanical motorized apparatus (weight 150kg), was used. It moves in several directions to provide angular and linear acceleration, its rotational velocity 21 r-p.m. The apparatus was provided with an electro-automatic timer. The timer can adjusted every 20 second (Kanter)[17].
- **Therapeutic equipment:** Balls of different sizes, parallel bars and gymnastic mats were utilized to conduct the tradition al physical therapy program inform of facilitator techniques for postural mechanics and gait training.

Methods

I- Methods for evaluation:

Gait evaluation

The walking sheet was put on the floor of the gait evaluation area and fastened on both sides by adhesive tapes. Subjects were asked to wear shorts, so that the majority of the legs were visible. The subject was allowed to stand at least two strides infront of the walkway, then he or she was told to look straight a head and to walk as he or she normally did to the end of the walk way. The video camera was adjusted to show a close up of the body from the waist down including the walking sheet. The subjects were photographed by the video camera along 10 meters of the sheet. This was repeated 3 times for each subject. The video tape was then played back on the T.V. for the evaluation of temprol and distance gait parameters. This was done for each subject of both groups before and after treatment.

Gait parameters were calculated as follows

- Stride length: Distance between two successive placements of the same foot was measured (two step lengths, left and right).
- Stride length (cm) = distance (cm) x 2/steps counted[29].
- Step length: Distance between two consecutive contra lateral heel strikes was measured[29].
- Velocity: Distance covered by the whole body in a given time in a particular direction was calculated. Velocity (m/s) = distance (m/time(s)[29].
- Cadence: Cadence is the measurement of the number of steps taken per unit of time (steps/min). Cadence (step/min) = step counted x 60/times[29].

II- Methods of treatment

Patients of both groups practiced postural reaction facilitation program (righting, equilibrium, protective reaction), based on:

1- Exercises to support the body weight against gravity and to improve stability.

2- Exercises for balance during motion.
3- Righting or rising reactions.
4- Tilt off the horizontal plane and adjust the trunk to perverse balance.
5- Exercise to save from falling.

Vestibular stimulator

Patients belonging to the study group were subjected to vestibular stimulation.

The child's position

The child chair was fixed on the top of the apparatus with three safety straps (around the chest, around the pelvis and around the legs) to avoid any inclination during movement. The child was vertically seated on the chair with trunk and lower limbs fixed. (Figure 1)

Fig. (1): The child position on the apparatus.

Procedures

- Spinning movement in two directions, clockwise and counter clockwise[17].
- Bending forward and backward from vertical axis about 30°[17].
- Bending from vertical axis to right and left side to 30°[17].

Every child was received 10 stimulus in rotation 5 in clockwise and 5 in counter clockwise followed by interval relaxation. Also 10 stimulus in bending, 5 forward and 5 backward with interval relaxation, also side to side.

Precautions

Each patient was observed carefully while using vestibular stimulation to avoid signs resulting from over stimulation such as fainting, vomiting.

Each patient was treated for 3 successive months, three sessions weekly.

The statistical analysis of this work was carried out by using t-test in order to calculated the difference between the two groups and its level of significance.

RESULTS

Mean difference values of all measuring parameters in both groups before starting of treatment were statistically non-significant ($P>0.05$).

As revealed from table (1), changes in the mean values of stride length/cm and step length/stride (%) in the control group, 3 months after treatment were statistically non-significant ($P>0.05$). Mean values of str/cm in the study group before and after treatment were 82.26±3.13 and 88.31±3.74, respectively. Mean difference value were 6.05cm, which revealed significant change ($P<0.0025$). The corresponding values of st/str% were 38.687±2.915% and 43.19±3.037% respectively. Mean difference value was 4.503%, which was statistically significant ($P<0.005$).

Table (1): Changes in mean values of stride length (str/cm) and step length / stride length ratio (st/str%) in both control and study groups before and after treatment.

		Control		Study	
		Pre	Post	Pre	Post
Stride length (cm)	$\bar{X}$	83.16	84.01	82.26	88.31
	±SD	3.115	3.89	3.13	3.74
	MD	0.85		6.05	
	t	0.1223		4.0356	
	P	>0.05		<0.0025	
		NS		S	
Step length/stride (%)	$\bar{X}$	38.940	39.687	38.687	43.190
	±SD	2.999	3.0	2.915	3.037
	MD	0.747		4.503	
	t	0.134		3.0241	
	P	>0.05		<0.05	
		NS		S	

As indicated from table (2), changes in mean values of cadence (c)/min and velocity (V) cm/sec in the control group, 3 months after treatment were statistically non-significant (P>0.05). Mean values of Cs/min in the study group, before and after treatment were 92.63±4.132and 98.63±4.831 s/min, respectively. Mean difference value was 6.00s/min, which showed a significant change (P<0.0025). The corresponding mean values of (V) cm/sec were 62.312±5.83 and 69.560±5.12 cm/sec, respectively. The mean difference value was 7.248 cm/sec, which indicated significant improvement (P<0.0005).

Table (2): changes in mean values of cadence (c)/min and velocity (v)cm/sec in both control and study groups pre and post treatment.

		Control		Study	
		Pre	Post	Pre	Post
Cademce (s/min)	$\bar{X}$	93.060	94.135	92.63	98.63
	±SD	4.86	3.95	4.132	4.831
	MD	1.075		6.00	
	t	0.1023		3.3216	
	P	>0.05		<0.0025	
		NS		S	
Velocity (cm/sec)	$\bar{X}$	62.687	63.375	62.312	69.560
	±SD	5.044	6.111	5.83	5.12
	MD	0.688		7.248	
	t	1.0121		4.9201	
	P	>0.05		<0.05	
		NS		S	

As indicated from table (3) and Fig (2), the mean values of str/cm in both control and study groups at the end of treatment were 84.01±3.89 and 88.31±3.74 cm respectively. Mean difference value was 4.3cm, which indicated a significant difference (P<0.05).

The corresponding mean values of st/str% in both the control and the study groups were 39.687±3.049 and 43.90±3.037% respectively. Mean difference value was 3.503%, which showed a significant value (P<0.05). Mean value of (c)/min in both the control and study groups at the end of treatment were 94.135±3.95and 98.63±4.831 s/min, respectively. Mean difference value was 4.495 s/m, which showed a significant difference (P<0.05). The corresponding mean values of (V) cm/sec in both the control and study groups were 63.375±6.111 and 69.560±5.12 cm/sec, respectively. Mean difference value was 6.185 cm/sec, which indicated a significant difference (P<0.05).

Table (3): comparison between mean values of stride length (str/cm), step length / stride length ratio (st/str%), cadence (s/min) and velocity (cm/sec) for both control and study groups at the end of treatment.

	Control		Study		MD	t	P
	$\bar{X}$	±SD	$\bar{X}$	±SD			
Str/cm	84.01	3.89	88.31	3.74	4.30	2.2513	<0.05
St/str%	39.687	3.049	43.90	3.037	3.503	2.3046	<0.05
(c)s/min	94.135	3.95	98.63	4.831	4.493	2.0525	<0.05
(v)cm/sec	63.375	6.111	69.56	5.12	6.185	2.2010	<0.05

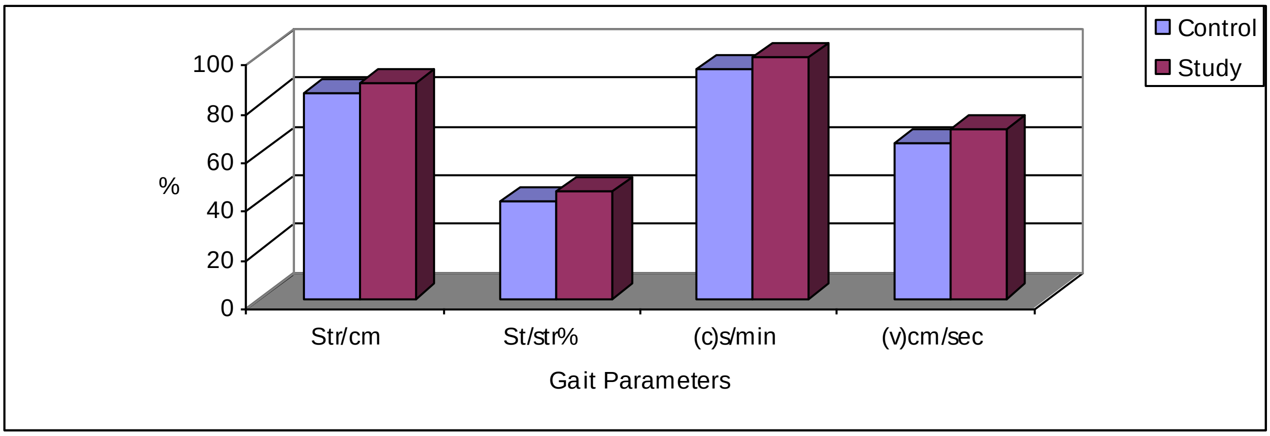

Fig. (2): Precentage of improvement in mean values of stride length, step length / stride length ratio, cadence and velocity of the study group at the end of treatment.

DISCUSSION

Physical therapy is concerned with the restoration of function, quantifing functional progress by assessing clinical changes in motor function in children with Down's syndrome. The accurate detection of change in function is the essential purpose of an evaluative out come measure[2]. The quantitative method of gait analysis is a part of assessment of child's movement patterns demonstrated by Cerny[7], as an important evaluation component in the early management of handicapped children.

In respect to the results of the present study, there were significant improvements in the mean values of all measured parameters (step length, stride length, step length/stride length ratio, cadence and velocity), when comparing the post treatment results of both groups. However, no significant difference was presented when comparing the pre-treatment results.

The effect of early intervention programs on the developmental skills of children with Down's syndrome has been of interest to researchers for a number of years. Early intervention programming are usually focused on the stimulation of developmental skill in the child, as well as, the facilitation of parent-child interaction[11].

Postural reaction facilitation program is also one of the methods used to improve the quality of life of handicapped children who have poor postural reactions like those with Down's syndrome[15]. The postural reactions are the intrinsic part of motor skills. When they are abscent or abnormal, they lead to abnormal motor skills[30].

The results of the present study came in agreement with those of Kreutzberg[19] who reported that, children with Down's syndrome who received vestibular stimulation exhibited greater gains in motor skills. Also supported by those of Maclean and Baurneister[21] who mentioned that, vestibular stimulation can have beneficial effect on balance, posture and gait through improvement in initiation of movement. In another study, it was reported that through input by rapid spinning, muscle tone is enhanced and increased facilitatory effect on the intrafusal fibers of the muscle spindle prepares the nervous system for easier activation in subsequent activity[16].

The significant improvement in the study group after the suggested period of treatment with vestibular stimulation and postural reaction facilitation confirmed the findings of Ottenbacher[24] who demonstrated that, the importance of vestibular stimulation for modulation of different types of afferent, for increasing visual attentiveness and visual orientation, as well as for increasing motor and exploratory ability.

The results of our study revealed an improvement of balance in Down's syndrome children may be due to:

Modulate discharge to neuronal connection of the motor cortex which in turn improved co-ordination and mental concentration and this in turn may modulate input from the pyramidal system, improve cerebellar function, automatic reactions, head righting reflex, equilibrium reactions and protective responses. Also it may modulate input from spinal, medualla, mid brain and cortical level that regulate posture of the body and makes movement more co-ordinated and possible[17,27]. It may increase the function of feedback circuit from priopriceptive to basal ganglia and lateral portion of cere bellum to the pre motor and motor cortex which is concerned with planning and organizing voluntary movement[20].

This may activate synapses that previously have been dormant and improve co-ordinated eye movement by increasing efferent from vestibulo-occular reflex which help to maintain a stable retinal image that help the subject to make and adjust the movement in space[26]. Increase input from vestibular and visual cues which increase orientation to space and it improve vestibular information which is used by the C.N.S. in providing reflex responses to movement of the head in space and position of head in respect to gravity[22].

Significant improvement may also be due to the effect of vestibular reflex to produce kinetic contraction of muscles for maintenance of equilibrium and stability during movement[28]. Another explanation to this improvement may also be attributed to the effect of interaction for vestibular system with other systems. As the control centers in the brain use the signals to develop a subjective awareness of head position in relation to the environment[25]. Vestibular stimulation also may increase visual skills (attention, orientation), in addition to alertness, language skills, eye-hand co-ordination, integrating postural reflexes, developing exploratory behavior, socio-emotional development and regulating arousal level[17].

Conclusion

According to the results of this study supported by other related studies, it can be concluded that vestibular stimulation is an effective and safe modality in treatment of Down's syndrome children.

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الملخص العربي

مدى فاعلية تنبيه عصب الاتزان عند الأطفال المنغولين

الهدف من البحـث : تقييم مدى فاعلية تنبيه عصب الاتزان على نموذج المشي في الأطفال المنغولين .
مود البحث وأساليبه : قد تم إجراء هذا البحث على عشرون طفلاً منغولياً من الجنسين تراوحت أعمارهم من سبعة إلى عشرة سنوات، وقد تم تقسيمهم عشوائياً إلى مجموعتين متساويتين (ضابطة وتجريبية) ضمت كل منها عشرة أطفال، وقد خضعت المجموعة الأولى إلى إجراء برنامج تمرينات التحكم في القوام، بينما المجموعة الثانية تلقت تنبيه الاتزان بالإضافة إلى العلاج السابق للمجموعة الأولى، وقد استمر العلاج ثلاثة أشهر متصلة بواقع ثلاثة أيام أسبوعيا وقد تم قياس عناصر المشي قبل وبعد العلاج بثلاثة أشهر.
النـتـائـج : وقد أظهرت النتائج في نهاية فترة العلاج إلى تحسن ذو دلالة إحصائية في عناصر المشي التي تم قياسها ، ووفقاً للنتائج يوصي باستخدام تنبيه الاتزان بالإضافة إلى تمرينات التحكم في علاج الأطفال المنغولين .