Effect of Vestibular Stimulation on Balance in Obese Children

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ABSTRACT

Background: Childhood obesity has significant impact on both physical and psychological health. Changes of body geometry in obese children leads to biomechanical disorders in static and dynamic balance.
Objective: To investigate the effect of vestibular stimulation on balance in obese children.
Design: Randomized control trial. The study was conducted between November 2015 to December 2016.
Setting: Outpatient clinic, National research Center, Egypt.
Participants and interventions: Fifty obese children of both genders with age ranging from 6 to 10 years participated in this study. They were selected from outpatient clinic, National research Center. They were allocated randomly into two groups of equal numbers, control and study groups. Children in the control group received a designed balance exercises for 60 minutes. While those in the study group received vestibular stimulation exercises for 20 minutes in addition to the same designed balance program given to the control group for 40 minutes.
Main outcome measures: Before and immediately after six successive months, dynamic balance was assessed by the Biodex balance system and the body weight in kilograms.
Results: Comparing pre and post-treatment mean values of stability indexes showed a statistically significant improvement of all measured variables in both groups. While, post treatment significant difference between the two groups was recorded in all variables in favor of the study group.
Conclusion: Vestibular stimulation in conjunction with a designed balance program is effective in improving dynamic balance in obese children

Key Words: Vestibular Stimulation Exercise, Childhood Obesity, Dynamic Balance, Whole Body Vibration.

eIJPPR 2018; 8(1):27-32

HOW TO CITE THIS ARTICLE: Ahmed Hussein Mashaal, Emam Hassan El-Negmy, HodaAbd El- Azim Al-Talawy, Suzette Ibrahim Helal, Wafaa Kandil, Hebatallah Sherrif Abd ElHady. (2018). "Effect of Vestibular Stimulation On Balance in Obese Children" , *International Journal of Pharmaceutical and Phytopharmacological Research, 8(1), pp.27-32.*

INTRODUCTION

Balance can be defined as controlling the center of gravity in relation to the supporting surface in order to prevent falling down and maintain balance. It is achieved by integration between the visual, vestibular and somatosensory system [1]. The somatosensory systems appear to develop at 3 to 4 years old, while the visual and vestibular system achieve mature level at 15 to16 years old [2]. Vestibular system provides the central nervous system with necessary information about the head position and movement in respect to gravity and inertial forces which play an important role in maintaining balance [3].

Obesity has achieved worldwide plague extents with high prevalence. It is associated with various metabolic, cardiovascular, musculoskeletal and respiratory disorders as obstructive sleep apnea [4]. Childhood obesity is a complex, multifactorial

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 02 November 2017; **Revised:** 22 January 2018; **Accepted:** 15 February 2018

condition influenced by hereditary and social factors as race/ethnicity, and the physical performance [5]. Those children have difficulties to participate in physical exercises and tend to pick exercises with low energy expenditure. Such a condition causes variable consequences as postural changes, muscle weakness, dyspraxia and poor balance [6].

The aim of the current study was to investigate the effect of vestibular stimulation on balance in obese children.

MATERIALS AND METHODS

Origin of plant material

Study design: Randomized control trial, conducted at the period from November 2015 to December 2016.

Ethical considerations

The study was approved by the ethical committee of the Faculty of Physical Therapy, Cairo University, Egypt. A written informed consent form was signed by the children's parents giving agreement to participation and publication of results.

Subjects

Fifty obese children participated in this study. They were selected according to the following criteria; 1) age ranged from six to ten years; 2) both genders; 3) obesity level was equal to or greater than the 95th percentile, according to percentile body mass index-for-age for children; 4) stability level five on Biodex balance system. The exclusion criteria were; 1) mental retardation; 2) visual and auditory problems; 3) uncontrolled epilepsy; 4) neurological or neuromuscular disorders.

Eighty-six obsess children, were initially screened and assessed to determine inclusion and exclusion criteria. Only 58 children fulfilled the inclusion criteria and had no exclusion criteria, three parents refused to participate in the study while five children did not follow the designed program and were excluded from the study. Thus, of the original pool, 50 obese children were included in this study.

Children were randomly allocated to one of two groups, control and study, 25 children each, on two stages. Stage one involved instructing two physical therapists, working in the outpatient clinic, National research Center, to report all children who fulfilled the inclusion criteria of the study and had no exclusion criteria. The second stage involved random allocation of the children to one of the two groups by using sealed envelopes. The randomization process was carried out by a registration clerk who was not involved in any part of the study.

The treatment procedures were conducted three sessions per week for six successive months. The session was conducted as follows:

- Children in both groups received treadmill gait training for 45 minutes.
- Control group: Children in this group received a designed balance exercises for 60 minutes.
- Study group: Children in this group received the same designed balance exercises as in control group for 40 minutes in addition to 20 minutes' vestibular stimulation in form of whole body vibration (WBV) and mini trampoline.

MATERIALS

Materials for assessment

Assessment of dynamic stability and body weight were conducted for all children in the two groups before and after 6 months of treatment. The assessment procedures were conducted at Biodex balance lab, Faculty of Physical Therapy, Cairo University. While the treatment procedures were conducted at the outpatient clinic, center of clinical research excellence, National research Center.

Universal weight and height scale

It was used to measure weight and height.

Percentile body mass index chart

The percentile body mass index chart was used to calculate obesity level for inclusion criteria.

Biodx balance system:

It is a unique tool used as dynamic postural control assessment and training system. It consists of a movable balance platform which can be set at variable degrees of instability. This system is connected with computer software monitored through the control panel screen that provides instantaneous feedback [7]. The test estimates overall stability index (OASI), represents the variance of foot platform displacement in degrees, from level, in all motions during a test. It is the best indicator of the patient to balance the platform. Anterior/posterior stability index (APSI): represents the variance of foot platform displacement in degrees, from level, for motion in the sagittal plane medial/lateral stability index (MLSI): represents the variance of foot platform displacement in degrees, from level, for motion in the frontal plane. A high stability index score indicates high postural sway and shows poor stability [8].

Materials for treatment:

1- Different sizes of balance and rocker boards.

Balance and rocker boards were used for conducting the designed balance exercises. These boards were made of wood with different sizes to allow wide variety of exercises. In the current study balance boards dimensions used were 60x60 and 60x150 centimeters and rocker board demotions were 60x60.

2- Twisting stepper.

The Twisting stepper is a devise widely used for rehabilitation purposes. It is often described as a low-impact exercise. It consists ofsteel base with two separate parts for foot placement. The exercises are performed during standing. Subjects who are not familiar with the device may be allowed to use support at the early beginning of the training sessions. The device allows exercises that are similar to walking as it involves stereotyped reciprocal alternating movement of the lower limbs [9].

3- Mini-trampoline

It is a type of rebound therapy that has been widely used in sports and for therapeutic purposes. The parts and dimensions were suitable for the children. The bounce was 40 inches in diameter while the height was 12 inches from the floor. Children were allowed to use support, once they could control the task no more support was allowed.

4- Whole body vibration device:

The Galileo 900 platform (Galileo Fitness, Novotec, Germany) is a unique device for applying whole-body vibration/oscillatory muscle stimulation. It consists of a platform and a hand support. The subject stands on a rocking platform, which alternately thrusts the legs upwards and downwards, thereby promoting the lengthening of the extensor muscles of the lower extremities. The reaction of the neuromuscular system is a chain of rapid muscle contractions. This type of training provides reflex muscle stimulation with no serious adverse events.

5- Treadmill machine:

EnrafNonius, EN-TREAD, made in Germany was used in the current study. Its speed, inclination and timer are adjustable, and it also provided with control panel to display the exercise parameters. The entire treadmill apparatus is a steel structure 2.4 meters long, and ½ meter width. The unit is formed of a belt, two cylinders, and two arm support. This unit is adjusted for uphill walking (maximum 16 degrees). The treadmill belt is a loop of synthetic rubber and nylon 3.75 meters long that passes around 2 cylinders of 0.31 meters in diameter.

METHODS

Methods for assessment:

Demographic data:

It was recorded including name, age, weight, height and PBMI.

Dynamic balance assessment:

Platform firmness (stability level) was set on stability level 5 for all children. The child was instructed to focus on the feedback screen while the platform advanced to an unstable state and attempt to maintain the cursor in the middle of the screen (centered). The test duration was set for 30 seconds. The child's ability to control the platform variance was recorded. At the end of each test trial, a printout report was obtained. This report included information as regard to OASI, MLSI and APSI. High values indicated of a lot of movement therefore less stability.

Methods for treatment:

Control group

1. Designed balance exercises

The exercises were conducted gradually from easy to more difficult positions according to the child's abilities. It was performed on land and on balance board as follows:

The child was instructed to use wide base in the starting of the program. The suitable base was achieved by standing with both feet apart (equal to his shoulders width). He/she was asked to keep balance against external forces such as unexpected pushing the child with different force magnitude and in different directions and catching and throwing balls.

As in exercise 1 but with both feet together.

As in exercise 1 standing on one foot alternatively.

As in exercise 1 while standing with both knees 30^{o} flexed while the back was erect.

Squatting position on toes trying to keep balance against unexpected pushing the child with different force magnitude and in different directions.

2. Twisting stepper exercise:

The exercises started with slow and regular rhythm that increased as the child felt more stable during exercises. Children were instructed to keep back erect and look forward.

3. Treadmill training:

Whole session time was 45 minutes of aerobics, started with five minute warming, zero inclination and low speed for warming-up 1.7 kilometer/hour (km/h). The speed increased gradually up to 2.8 km/h with zero inclination for 35 minutes. The speed increased when the children could move their feet independently without dragging their feet for more than 5 seconds. Manual support holding the hand rails by 2 hands then by one hand till he/she gained the self-confidence to walk on it without support. Finally cooling down for five minute with zero inclination and low speed (1.7 km/h).

Study group

Children in the study group received the same previously described program as in control group including treadmill training for 45 minutes and designed balance exercises for 40 minutes in addition to vestibular stimulation for 20 minutes as follows:

1. Mini-trampoline exercises

The child stood at the trampoline with his/her feet at the shoulder width and the therapist stood behind the child for controlling the rhythm. Different exercises were performed [10] as follow:

- Bounce up and down with maintaining a steady balance.
- The rate and rhythm of bouncing was controlled by holding the child's legs or feet for guidance (hand free manner).
- Stand on one leg trying to control balance.

2. Whole body vibration:

The Galileo was used in the current study. Low frequencies and amplitudes are more effective in improving balance and muscular performance. The frequency, amplitude and time for WBV were based on the treatment schedule detailed in table (1) according to Gonzalez-Aguero et al. [11] as follows:

1. Stand with 30^{o} flexion of both knees while both feet were at level of the shoulders width.
2. Single limb stance with 30^{o} knee flexion
3. Squat position on toes the child was allowed to hold on support if needed.

Data analysis

All statistical measures were performed through the statistical package for social sciences (SPSS) version 19 for windows. Descriptive statistics and t-test were conducted for comparison of the mean age, weight, and height between both groups. The paired and unpaired t-test was used to compare the pre-and post-treatment values of APSI, MLSI, OASI, and body weight, within and between the groups The level of significance for all statistical tests was set at $p < 0.05$.

Table 1. Treatment schedule for whole body vibration [11].

Month	Sessions	Frequency (Hz)	Amplitude (mm)	Duration seconds	Rest seconds	Repetition	Vibration Total Time, minutes	Training Total Time, minutes
1	12	25	2	30	60	10	5	15
2	12	25	2	30	60	10	5	15
3	12	28	2	45	60	10	7.5	17.5
4	12	28	2	45	60	10	7.5	17.5
5	12	30	2	60	60	10	10	20
6	12	30	2	60	60	10	10	20

General characteristics of the subjects

Comparing the general characteristics of the children in the two groups revealed no significance difference in the mean age, weight, height and gender ($p > 0.05$) as represented in table (2).

Stability index

As represented in table (3) the pretreatment comparison of APSI, MLSI and OAST showed no significant difference ($p > 0.05$). While within group comparison (table 4) revealed significant improvement in both groups. Moreover, post-treatment comparison showed significant improvement ($p < 0.05$) in favor of the study group (table 5).

Body weight

As represented in table (6) the pretreatment comparison of body weight between the two groups showed no significant difference ($p > 0.05$). Within group comparison revealed significant reduction of body weight in the two group. Furthermore, post-treatment comparison revealed significant difference between the two groups in favor of the study group ($p < 0.05$).

Table 2. Demographic characteristics of children in both groups.

Variable	Control group	Study group	MD	- value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Age (years)	8.41 ± 1.49	8.45 ± 1.47	-0.04	-0.09	0.92	NS
Weight (kg)	44.54 ± 7.3	45.98 ± 5.28	-1.44	-0.8	0.42	NS
Height (cm)	124.92 ± 10.2	124.84 ± 9.52	0.08	0.02	0.97	NS
Gender Girls Boys Total	 15 (60%) 10 (40%) 25 (100%)	 15 (60%) 10 (40%) 25 (100%)				

$\bar{X}$	: Mean	MD	: Mean difference	p-value	: Probability value
SD	: Standard deviation	t-value	: Unpaired t-value	S	: Significant
Kg	Kilogram	Cm	Centimeter	NS	: Non-significant

Table 3. Statistical analysis of pretreatment mean values of stability indexes between groups.

	Control group	Study group	MD	t- value	p-value	Sig
	$\bar{X}$ ±SD	$\bar{X}$ ±SD				
APSI	1.9 ± 0.54	2.03 ± 0.51	-0.13	-0.85	0.39	NS
MLSI	2.05 ± 0.53	2.13 ± 0.86	-0.08	-0.39	0.69	NS
OASI	1.86 ± 0.5	1.96 ± 0.36	-0.1	-0.77	0.44	NS

$\bar{X}$	: Mean	MD	: Mean difference	p-value	Probability value
SD	: Standard deviation	t-value	: Unpaired t-value	NS	Non-significant
ALSI	Antrolateral stability index	MLSI	Mediolateral stability index		
OASI	Overall stability index				

Table 4. Statistical analysis of stability indexes within group before and after treatment.

Variable		Pre	Post	MD	t-value	p-value	Sig
		$\bar{X}$ ±SD	$\bar{X}$ ±SD				
APSI	Control group	1.9 ± 0.54	1.46 ± 0.56	0.44	9.46	0.0001	Sig
	Study group	2.03 ± 0.51	1.08 ± 0.29	0.95	15.37	0.0001	
MLSI	Control group	2.05 ± 0.53	1.47 ± 0.51	0.58	10.28	0.0001	Sig
	Study group	2.13 ± 0.86	1.1 ± 0.49	1.03	10.84	0.0001	
OASI	Control group	1.86 ± 0.5	1.37 ± 0.39	0.49	8.08	0.0001	Sig
	Study group	1.96 ± 0.36	1.05 ± 0.33	0.91	13.85	0.0001	

$\bar{X}$	: Mean	MD	: Mean difference	p-value	Probability value
SD	: Standard deviation	t-value	: Unpaired t-value	NS	Non-significant
ALSI	Antrolateral stability index	MLSI	Mediolateral stability index		
OASI	Overall stability index				

Table 6. Statistical analysis of body weight of the two groups before and after treatment:

		Pre	Post	MD	t- value	p-value	Sig
		$\bar{X}$ ±SD	$\bar{X}$ ±SD				
Weight (Kg)	Control group	44.54 ± 7.3	36.94 ± 6.73	7.6	13.29	0.0001	S
	Study group	45.98 ± 5.28	32.55 ± 6.85	13.43	12.77	0.0001	S
	MD	-1.44	4.39				
	t- value	0.42	0.02				
	p- value	NS	S				

$\overline{X}$	:Mean	SD :Standard deviation	p-value :Probability value
t-value	:Paired t-value	S :Significant	

DISCUSSION

The current study was conducted to investigate the effect of vestibular stimulation on balance in obese children. The main findings in the present study were that obese children who received vestibular stimulation (study group) showed a significant reduction of stability indexes and body weight compared with those who received a selected balance program only (control group).

The significant improvement of balance and reduction in body weight could be attributed to the effect of the designed balance exercises and treadmill training which allow safe exercises which is considered as an effective tool that can be beneficial in improving proprioceptive feedback, physical activities, muscle strength, weight reduction and energy expenditure. This explanation matches the opinion of Janiszewski and Ross [12] who stated that physical activity is the backbone of weight reduction techniques for obese and overweight individuals, as it increases energy consumption, enhancing cardiopulmonary fitness and balance, even without weight reduction.

Similarly, Abdel Rahman and Shaheen [13] reported that, proprioceptive training improves both static and dynamic balance in children with Down's syndrome. Furthermore, Rosendahl et al. [14] added that, weight-bearing exercises enhance reactivation of the proprioceptors input to the central nervous system which is essential for joint position sense and motion awareness and convey greater constant proprioceptive feedback that improves postural adjustments.

Our results came in accordance with Johnston et al. [15] who reported that, treadmill training improves walking speed, endurance, cardiopulmonary fitness and postural adjustments through enhancement of control between agonist and antagonist muscles that functional and static stability. Moreover, LaSala [16] stated that long duration low to moderate intensity treadmill training induces higher fat oxidation, which leads to weight loss and improve health outcomes in overweight and obese subjects. Similarly, Bell et al. [17] studied the effect of an eight-week aerobic and resistance exercise program in in sedentary obese children and adolescents with age ranged from 9 to16 years. The results of their study revealed significant decrease waist circumference measurements.

The results of the current study revealed significant improvement in stability indexes and body weight in both groups. Moreover, the results revealed significant difference between the two groups post treatment in favor of the study group. It could be attributed to the application of WBV which is believed to improve muscle performance, balance and functional performance through repeated and rapid oscillations. It could be also related to the changes of hormonal response following WBV training. Moreover, the improvement may be related to the use of mini trampoline that are considered as rebounding action, that actually provide vestibular as well as proprioceptive stimulation.

The results of the current study came in accordance with Carter [18 2006] who reported that rebounding on mini trampoline offers all of the advantages of other aerobic exercise without the strain effect usually associated with vigorous activity.

Our results came in agreement with Nejadsahebi et al. [19] who studied the influence of an 8-week rebound exercise on the static and dynamic balances of students with Down syndrome, their results revealed significant improvement of balance. They attributed their results to the effect of rebound exercises which produce high sensory stimulation of superficial and deep senses that gives proprioceptive and vestibular stimulation resulting in improving static and dynamic stability. This matches the findings of Mitsiou et al. [20] who studied the effect of mini trampoline training program in children with age ranged from 6 to 11 year with developmental coordination disorders. The results of their study showed significant improvement in static and dynamic balance.

The results match the findings of Cochrane [21] who mentioned that, the WBV has been recognized as one of the most powerful strategies for proprioceptive stimulation that stimulate a moving pattern similar to human gait. These result in the activation of proprioceptive spinal circuits, thus leading to compensatory rhythmic muscle contractions in the lower limbs and trunk. Similarly, Kemmler and von Stengel [22] reported that, vibration has been identified as one of the strongest proprioceptive stimulation methods. Moreover, Rittweger [23] reported that WBV produces repeated and fast oscillations of a vibrating platform which induces continuous eccentric-concentric muscular contraction, with higher oxygen consumption. They recommended that regular WBV training has positive impacts on body composition and muscle strength.

The results of the current study are supported by previous studies of Cardinale et al. [24], Visser et al. [25], and Artero et al. [26] who stated that, combination of resistance and WBV training is effective in lowering total body fats in obese and overweight individuals.

The results of our study matches the opinion of Kraemer and Ratamess [27] who reported that the additional gravitational load that an individual experience when exposed to WBV elicits an anabolic hormonal response. It reduces plasma glucose, possibly by increasing glucose uptake and utilization by contracting muscle. They found a positive relationship between increasing blood levels of anabolic hormones and increased muscle mass and strength.

CONCLUSION

Vestibular stimulation in conjunction with a designed balance program was effective in improving dynamic balance and weight reduction in obese children.

ACKNOWLEDGEMENTS

The authors would like to thank the children and their parents who participated in this study with all content and cooperation and also all the staff and managers of the Outpatient clinic of Faculty of Physical Therapy, Cairo University.

Conflict of Interest

The authors declare that there is no conflict of interest in this study. The manuscript has been read and approved by authors

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for- profit sectors.

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