



Original Article

## Effect of dual-task training on postural stability in children with infantile hemiparesis

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**Abstract.** [Purpose] The aim of this study was to evaluate the influence of using a selected dual-task training program to improve postural stability in infantile hemiparesis. [Subjects and Methods] Thirty patients participated in this study; patients were classified randomly into two equal groups: study and control groups. Both groups received conventional physical therapy treatment including mobility exercises, balance exercises, gait training exercises, and exercises to improve physical conditioning. In addition, the study group received a selected dual-task training program including balance and cognitive activities. The treatment program was conducted thrice per week for six successive weeks. The patients were assessed with the Biodex Balance System. These measures were recorded two times: before the application of the treatment program (pre) and after the end of the treatment program (post). [Results] There was a significant improvement for both groups; the improvement was significantly higher in the study group compared to the control group. [Conclusion] The selected dual-task training program is effective in improving postural stability in patients with infantile hemiparesis when added to the conventional physical therapy program.

**Key words:** Infantile hemiparesis, Postural stability, Dual-task training

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### INTRODUCTION

Postural control is considered an automatic system. However, recent studies suggest the involvement of attentional processes in the regulation of posture during simple or more complex tasks, especially when the latter involves attentional processes<sup>1-3)</sup>.

It is well known that visual information plays an important role in postural control in children; visual inputs are known to require attention, and the execution of eye movements involves attention<sup>4-6)</sup>.

Several structures in the central nervous system, the cerebral cortex (frontal, parietal, and occipital), and the brainstem (paramedian pontine reticular formation and superior colliculus) play an important role in postural control as well as in the programming and execution of eye movements. Consequently, one could expect interferences between oculomotor and postural control. Studies on the effects of eye movements on posture in normal children are nonexistent. The few studies available have focused only on adult subjects, and their results are discordant<sup>7)</sup>.

The body position in space maintained by the postural control for the dual purposes of stability and orientation. Postural

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dysfunction in cerebral palsy is due to the decreased capacity to modulate postural activity in certain situations. Recently, researchers have suggested that postural control requires significant attention<sup>8-10</sup>. Researchers have demonstrated the attentional demands of maintaining an upright posture by using the dual-task paradigm with postural control chosen as the primary task. A dual-task condition is a situation in which a person performs two attention-demanding tasks simultaneously. Most of our environments consist of background noise, obstacles, and distracting visual and auditory stimuli<sup>11-13</sup>).

In our daily life with or without our attention, we perform dual tasks. Typically, developing children are capable of dividing their attention between tasks within a limit, such that neither of the tasks is affected. Dual-task interference occurs due to the conflict arising in resolving the allocation of attention between two tasks<sup>14</sup>). Blanchard along with Pellecchia were the first researchers to demonstrate the interaction between the cognitive process and motor control in the pediatric population<sup>15, 16</sup>). Various studies demonstrate the combined effects of physical and cognitive tasks on postural sway in both adults and children with spastic cerebral palsy. Recently, there have been an increasing number of studies showing the attentional requirements in young and older children during postural tasks and in various neurological conditions<sup>2, 17</sup>).

However, there is a lack of literature examining the postural sway during the attentional demands of a concurrent cognitive task in children with cerebral palsy. These children often encounter numerous dual-task situations in their daily living activities. Therefore, there is a need to identify whether dual-task conditions affect the postural control of children with cerebral palsy to pinpoint the importance of the rehabilitation needs and to decrease the risk of falls<sup>18</sup>). The purpose of this work is to study the effect of dual-task training on postural stability in children with infantile hemiparetic cerebral palsy.

## **SUBJECTS AND METHODS**

Thirty children with spastic hemiparesis (infantile type) between the ages of nine to fifteen years participated in this experimental study. Participants were recruited from our clinic, Faculty of Physical Therapy, Cairo University. The degree of spasticity of all participants ranged from grade 1 to grade 2, measured according to the modified Ashworth Scale. Participants could stand and walk independently and they could understand and follow verbal commands and instructions during both testing and training sessions. We excluded children with fixed deformities of upper and lower limbs or had significant perceptual, cognitive, visual and auditory disorders.

The children were assigned into two groups of equal number, a control group, and a study group. Each group consisted of fifteen participants. Ethical approval was obtained in accordance with the ethical principles of the Declarations of Helsinki.

The Biodex Balance System (AESULAP-MEDITEC GMBH, Holland) was used to measure postural stability parameters of all participants. The study procedure was explained to each patient. Informed consent was filled and signed by the father or the mother. Care was taken not to interrupt the recording procedure to maintain the child in a relaxed position. Each child was instructed to take off their shoes before standing.

To ensure the safety of every patient, the session started with the balance platform in the “locked” or static position. Before beginning the evaluation on the Biodex system, the supporting structures above and below the examined joints were adequately fixed to stabilize the balance device. We positioned the display at the patient’s eye level to ensure comfort and safety. To protect the patient against sudden or unexpected movement on the platform, the patient was asked to stand in the center of the platform and grasp the support handle, then progress to standing without grasping the support handle. Three trials were performed before testing. For static balance testing, the “default settings” were preselected with three trials per side. The pre-trial testing assists with the learning curve and provides a better average of the data. The system’s microprocessor-based actuator controls the degree of surface instability.

The assessment of postural stability was performed pre and post treatment program for each participant in both groups. The Postural Stability test emphasizes a patient’s ability to maintain their center of mass. The patient’s score on this test assesses deviations from the center; thus, a lower score is more desirable than a higher score. In this study platform, stability was selected to be at one level (i.e.) level eight. The testing menu screen was selected from the main menu. The patient setup information screen was displayed on Postural Stability. The patient’s name, age, and range of height were selected. The foot position and angle for each patient was recorded on the control display by using the alpha numeric grid on the platform. The foot position and angle for each patient were constant during pre- and post-test. The stance type was adjusted at a two-leg stance. The start button was pressed to activate the cursor, and the patient was asked to move the cursor to the center point on the grid. The record button was pressed to bring up the patient position entry screen. Using the keypads, the patient’s left foot, left heel, right foot, and right heel positions were entered with the midline of the foot and the platform grid as reference points. The stance button was touched at the postural stability testing screen to scroll through the three stance positions provided: left, right or both. The test trial time was set at 20 seconds. The initial and ending platform stability settings were entered at level eight, with three trials for each patient. The (OK) button was touched to confirm selections and to return to the postural stability testing screen. With the patient ready to begin the test, the collect data button was touched. The screen provided a three-second countdown before beginning the first of three test trials. The display screen showed total trial time, platform setting, and stance to the left of the grid. This displayed the trial number and score to the right of the grid. After the first trial, the screen displayed “Trial 1 Complete,” the platform returned to the locked position, and a ten-second rest countdown began for the second trial. The data were collected and the second test trial started and continued. After completing the test, a “Test Complete” message was displayed. The Results button was touched to advance to the postural stability

test results screen. The Print button was touched to automatically generate a printed report at the postural stability test results screen. The (Save Results) button was touched to save the test data and then (OK) was touched in response to the “Save Results for later reporting or export”. The data generated from this test were in the form of a balance index. This included the overall balance index, which represents the patient’s ability to control his balance in all directions. High values mean balance disturbance (increase rate of body swaying during the test). In addition, the results included the anterior/posterior (A/P) index, which represents the patient’s ability to control his balance in a front to back direction. High values indicate balance disturbance. Moreover, the medial/lateral (M/L) index represents the patient’s ability to maintain his balance from side to side. High values indicate balance disturbance. The (Home) button was touched to return to the opening menu from the postural stability test results screen.

Children in the control group received a specially designed exercise program based on balance activities while those in the study group received the same program in conjunction with selected cognitive activities (Table 1). Each treatment session lasted one hour and was conducted five times/week for six successive weeks, approximately 30 sessions.

Data analyses were performed using SPSS 17 for Windows. The collected data of demographic and other baseline charac-

**Table 1.** Therapeutic intervention for both groups

ITEM	Primary (Balance) activities	Secondary (Cognitive) activities
1st week	<ul style="list-style-type: none"> <li>• Sit to stand</li> </ul>	<ul style="list-style-type: none"> <li>• Counting backward (e.g., by twos, threes): Patients were asked to count backward from specific start number (e.g., from forty) and subtracting three each time. It means patient will count (forty, thirty-seven, thirty-four, thirty-one, twenty-eight and so on).</li> </ul>
2nd week	<ul style="list-style-type: none"> <li>• Stand with narrow B.O.S, with his or her eye closed.</li> <li>• Standing semi-tandem with eye open.</li> <li>• Stand with stepping forward, backward, and sideways.</li> <li>• Sit to stand and walk.</li> </ul>	<ul style="list-style-type: none"> <li>• N-Back task: recite numbers, days, or months backward (December to January).</li> <li>• Tell story: tell any story such as what they did in the morning, what they did on their vacation, and so on.</li> </ul>
3rd week	<ul style="list-style-type: none"> <li>• Standing semi-tandem with eye closed.</li> <li>• Stand on foam, eyes open.</li> <li>• Sit to stand and pick up objects from the floor.</li> <li>• Walk narrow B.O.S.</li> <li>• Walk around obstacles.</li> <li>• Walk narrow B.O.S holding a toy.</li> </ul>	<ul style="list-style-type: none"> <li>• Random digit generation: randomly name the numbers between 0 and 300 (e.g., two hundred seventy four, thirty-nine, eighty-six, seven, and so on).</li> <li>• Tell opposite direction of action: name the opposite direction of their actions. For example, they were required to name “left” when they move their right leg.</li> </ul>
4th week	<ul style="list-style-type: none"> <li>• Stand on foam, eyes open.</li> <li>• Stand and move hip in abduction and adduction.</li> <li>• Stand with stepping forward, backward, and sideways.</li> <li>• Stand narrow B.O.S and reach different directions.</li> <li>• Sit to stand and stop with varied speed.</li> <li>• Walk narrow B.O.S.</li> </ul>	<ul style="list-style-type: none"> <li>• Name things and words: name things such as types of flowers, states, and men’s names (e.g., mention name of men start with digit “M”, So he said “Mohammed”, “Mustafa”, “Mounier”, “Mohsen” and so on).</li> <li>• Subtract or add number to letter: give the letter as result of the equation (e.g., <math>K - 1 = J</math>).</li> <li>• Stroop task: name the color of the ink while ignoring the meaning of the word (e.g., see a paper written on it word “black” but written in red ink, So say “red” and so on).</li> </ul>
5th week	<ul style="list-style-type: none"> <li>• Stand narrow B.O.S, with eyes closed.</li> <li>• Stand semi-tandem, with eye open.</li> <li>• Stepping sideways.</li> <li>• Roll the stick with foot.</li> <li>• Stand narrow B.O.S and reach different directions.</li> <li>• Throw a ball.</li> <li>• Sit on a ball and perturb.</li> <li>• Walk narrow B.O.S.</li> </ul>	<ul style="list-style-type: none"> <li>• Remembering things: memorize telephone numbers, prices, objects, or words (e.g., mention price of last electric bill or grocery).</li> <li>• Visual imaginary spatial task: imagine and tell the road direction (e.g., the road direction from their home to the mosque or supermarket).</li> <li>• Auditory discrimination tasks: identify noises or voices from a compact disc such as identifying voices (man, woman, child) and identifying noises (hand clap, door close, cat meow).</li> </ul>
6th week	<ul style="list-style-type: none"> <li>• Stand and move hip and knee in flexion and extension.</li> <li>• Stepping sideways.</li> <li>• Sit to stand on different chair heights.</li> <li>• Walk with narrow B.O.S.</li> <li>• Walk and kick a ball.</li> </ul>	<ul style="list-style-type: none"> <li>• Spell the word backward: spell a word backward such as “apple,” “bird,” and “television” (e.g., when patient spelling “apple” backward, he will spell “E” then “L” then “P” then “P” then “A”).</li> <li>• Visual discrimination tasks: they were shown the pictures before and after performing the balance tasks. They were asked to memorize the pictures and to respond if the pictures were the same.</li> </ul>

teristics were statistically treated to show mean, range and standard deviation of measured parameters.  $\chi^2$  test and independent t-test were used to compare baseline characteristics between both groups. A repeated measures 2-way analysis of variance (ANOVA) was performed to compare changes in stability indices according to two rehabilitation programs. Post hoc test was conducted following ANOVA when statistical significant differences between data collected before and after treatment within each group and between groups were found. P-value (<0.05) was considered statistically significant.

## RESULTS

Table 2 presents a summary of demographic and other baseline characteristics at entry including age, weight, height, frequency distribution of gender, frequency distribution of affected side, and frequency distribution of spasticity grading. There were no significant differences between both groups ( $p>0.05$ ).

A significant statistical difference was observed in the stability indices, including medio-lateral, antero-posterior and overall indices, after three months of application of the rehabilitation program ( $p<0.05$ ), either when comparing mean values within each group or when comparing mean values between groups concerning post treatment results as shown in Table 3. The interaction between all variables was studied and there was no significant difference.

## DISCUSSION

In this study, dual-task training focusing on balance and cognitive tasks may improve postural stability compared with those focusing only on conventional balance training in children with infantile hemiparesis. Postural stability depends on the on appropriate integration of visual, proprioceptive, and vestibular signals, which accordingly leads to the generation of an optimal motor response to counteract a postural perturbation<sup>19</sup>. Swan et al.<sup>20</sup>, proposed that performing a secondary cognitive task directs attention away from balance-related cues, thereby preventing over-corrections.

Cognitive therapy is important to reduce fall risk. Although hemiplegics have complex impairments involving cognitive, sensory, and motor functions, they receive therapies focused on a single aspect at a time. For example, a physical therapist provides treatment for motor impairments or poor balance control, whereas an occupational therapist provides cognitively oriented therapy. However, many tasks in a community setting require an interplay of motor, sensory, and cognitive functions. The interventions that were provided to the dual-task group in this study help patients with stroke adapt to the real-world

**Table 2.** Demographic and baseline characteristics

Item		Control group	Study group
Age (years)	Mean±SD	12.6±1.8	12.73±1.83
	Range	9–15	9– 5
Weight (kg)	Mean±SD	40.07±4.67	41.2±4.74
	Range	33–48	33– 7
Height (meters)	Mean±SD	1.41±0.046	1.42±0.042
	Range	1.35–1.52	1.35–1.48
Frequency distribution of gender	Male	8	9
	Female	7	6
Frequency distribution of affected side	Right side	9	10
	Left side	6	5
Frequency distribution of spasticity grading	Grade 1	4	6
	Grade 1+	5	4
	Grade 2	6	5

**Table 3.** Comparing mean values of stability indices in both control and study groups

Stability index	Control group		Study group	
	Pre treatment	Post treatment	Pre treatment	Post treatment
Medio-lateral	2.03±0.44	1.54±0.52 *	1.96±0.49	1.19±0.38 * #
Antero-posterior	2.28±0.6	1.74±0.53 *	2.2±0.74	1.23±0.36 * #
Overall	2.9±0.73	2.29±0.69 *	2.96±0.86	1.82±0.51 * #

\*Significant difference between pre and post treatment mean values

#Significant difference between post-treatment mean values of both groups in favor of study group

environment. Therefore, our findings that dual-task training focusing on balance control and cognitive function improved postural stability have important clinical implications and suggest that this type of dual-task training might be helpful for reducing fall risk and helping patients with stroke adapt to new strategies<sup>21</sup>).

These results suggest that patients in the dual-task group reduce their risk of falling or becoming unstable during activities that require weight shifts. In addition, significant decreases in sway area and sway length were observed only in the dual-task group during steady standing, which represents steadiness and postural control<sup>22, 23</sup>). Lee et al.<sup>24</sup>), reported that visual feedback training improves sitting balance and visual perception in patients with chronic stroke. The dual-task training we provided was task oriented and of high intensity. Dual-task programs trigger the conscious control mechanisms and attention strategies and reduce automatic control during activities. The automatic control of movement involves the supplementary motor area (SMA) which receives its major input from the basal ganglia (BG)<sup>25</sup>). The potent effect of dual-task programs may be attributed to the efficacy of attention in generating cortical plasticity in the primary somatosensory and motor cortex and improvement in the motor memory<sup>26</sup>). Holschneider et al.<sup>27</sup>), also stated that long-term dual-task programs elicit plastic changes in the brain. These changes result in a combination of increase in the efficiency of neural processing (sensorimotor cortex, striatum, vermis) and enforcement of the cerebellar-cortical circuit.

In the current study, improvement in the postural stability parameters can be explained by the potent effect of the dual-task program on activating an alternate pathway containing the cerebellum, sensorimotor cortex, and lateral premotor cortex. In this pathway, the cerebellum is responsible for movement timing. The premotor cortex may be responsible for scaling the motor activity when facilitated by somatosensory cues related to any task (i.e. walking). This means that recruitment of these structures can compensate for inefficient BG<sup>28, 29</sup>). Chen et al.<sup>30</sup>) compared the between effects of simple versus dual-task training on dynamic balance but in children with attention deficit hyperactivity disorder as they found it effective in favour to dual-task training. Future studies should investigate the effect of various cognitive skills on balance through postural sway<sup>31</sup>). Additionally, future research should investigate the different effects of dual motor task training in patients with neurological deficits from various viewpoints depending upon activities of daily living and gait<sup>32–37</sup>).

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