ASSESSMENT OF POSTURAL STABILITY IN CHILDREN WITH POSTERIOR FOSSA TUMOR

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ABSTRACT

Objectives: Children diagnosed with posterior fossa tumor are susceptible to neuromuscular and musculoskeletal impairments. This study was designed to address postural stability affection in those children.

Methods: Sixty children treated for posterior fossa tumor in maintenance phase aged from five to twelve years were participated in this study. Postural stability was assessed using HUMAC balance and tilt system to assess both Static and dynamic balance.

Results: There was a significant difference in postural stability in children with posterior fossa tumor as compared to HUMAC balance and tilt system tests norms.

Conclusion: From the obtained study it can be concluded that there is an affection of postural stability in children with posterior fossa tumor. Periodic evaluation along the course of treatment could identify specific impaired motor domains providing the base for a successful rehabilitation program.

Keywords: Posterior fossa tumor, Medulloblastoma, HUMAC, children, Postural stability, Balance.

I. INTRODUCTION

Primary brain tumors account for nearly 20% of all malignant diseases in children and adolescents worldwide, with an age-standardized incidence rate of 28.2 per million persons.1

These tumors rank second among all childhood cancers, second only to leukemia, and are the most common solid tumor in children.2

Posterior fossa tumor is a type of brain tumor that occurs in or near the lower part of the skull. The posterior fossa is a small space in the skull that borders the brain stem and cerebellum. The cerebellum is the part of the brain responsible for balance and coordination. The brain stem is responsible for controlling important body functions, such as breathing. When a tumor grows in the posterior fossa, it can block the flow of cerebrospinal fluid and cause increased pressure on the brain and spinal cord. Posterior fossa tumors are primary cancers of the brain. They start in the brain and will not spread from any other part of the body. There are no known causes or risk factors for posterior fossa tumors.3

About 400 new patients are diagnosed every year, slightly a lot of typically in males than females. Medulloblastoma is the common malignant tumor in children aged 4 and younger, and the second common in children ages 5-14. The median age of diagnosis is 7 and more than 70% of all pediatric medulloblastomas are diagnosed in children under age 10.4
The main treatments are surgery, radiation therapy and chemotherapy. Treatment is generally recommended to be surgical excision without adjuvant therapy. Studies have shown that this usually resolves the patient’s seizures unless the tumor is sub-totally resected. Even sub-totally resected tumors are thought not to recur in the sense of progressive growth, although experience remains limited and so this conclusion should be stated with caution. Gross total resection is considered the treatment of choice, but failure to achieve gross total excision may justify radiation therapy.5

Poor posture control and balance disorders are common impairments that occur after surgical resection of brain tumors. The systems theory of neural control of posture and balance indicates that the musculoskeletal system and the nervous system work together to maintain normal postural control through the interaction of the individual with tasks and the environment.6

Control of balance is important for the most functional skills performance that helps children to regain from unexpected balance disorders. The functional goals of balance system include facilitation of some voluntary movement like transitions between postures, maintenance of certain posture, such as sitting or standing and restoring the equilibrium after external disturbances like a slip or self-induced instability.7

The HUMAC balance and tilt system is a computerized measurement and training system. Under static conditions, the HUMAC balance and tilt system discovered a quite regular and relatively small margin of displacement error.8

The error analysis of static and dynamic conditions shows that the measurement systems are affected by different error levels due to different application fields and different data collection methods. While the HUMAC balance and tilt system revealed the lowest margin of error, the necessity of a calibration of the HUMAC balance and tilt systems is a must.9

So, this study was conducted to assess balance in these children in comparison to normal children of similar age, height and weight by using the HUMAC balance and tilt system.

II. METHODS

2.1 Participants

Sixty children with posterior fossa tumor of both sexes were enrolled in this study. The study was conducted at Children’s Cancer Hospital Foundation 57357, Cairo over a period of 5 months from September 2020 up to January 2021. They were put in one group in comparison with HUMAC balance and tilt system tests 'norms.

Children with posterior fossa tumors during follow up and aged between 5-12 years old, time elapsed since the start of treatment more than 4 months in order to be in maintenance phase, they can understand verbal command, children with no visual, auditory or perceptual disorders were eligible to participate. Children were excluded from the study if they had a genetic disorder or mental retardation, a chronic lung disease, sever cardiomyopathy, or a neuromuscular disease not related to tumor.

Ninety-two children with posterior fossa tumor participated in the study, but only sixty children treated for posterior fossa tumor met the eligibility criteria as illustrated in Fig. 1. The study was approved by the institutional review board (IRB) at the Children’s Cancer Hospital Egypt 57357 (CCHE 57357) (CCHE-IRB:6/2020), the ethics committee in the Central Directorate for Research and Health Development, Ministry of Health and Population (IORG0005704/IRB0000687) and the Research Ethical Committee, Faculty of Physical Therapy, Cairo University (P.T.REC/012/002490). Informed consent was obtained from parents of all participants before starting the assessment procedures.
2.2 Measures and procedures

HUMAC balance and tilt system has been validated in comparison with conventional force plate. It is based on the WII Balance Board technology, the Nintendo WII Balance Board (WBB), which functions not only as a diagnostic tool, but also as a training program. The validity and reliability of the system's quantitative posture control has been tested in a variety of ways and a large number of studies.\textsuperscript{10-16}

HUMAC balance and tilt system was used to assess both Static and dynamic components of balance. Balance was evaluated on the force platform through the utilization of three tests:

1. The modified clinical test of sensory integration of balance (mCTSIB):

This test was used to assess the sensory integration of balance in the conditions of eyes open and eyes closed, firm surface and foam surface. First the child was instructed to stand on the platform firm surface which was placed about 3 feet from the wall, the therapist start the test, after determining the position of the two feet the child was instructed to look at a target on the wall placed at the level of his eyes and to stare at this target for 30 seconds (as it was proved that 30 seconds to 60 seconds were enough duration for data analysis)\textsuperscript{17}, then the child was instructed to close his eyes for another 30 seconds. The procedure was repeated again one time with eyes open and another time with eyes closed but this time on foam surface. Each condition was repeated for three times and after the results was viewed of each trial the highest value was taken from these results for each condition.\textsuperscript{18}

2. The center of pressure test (COP):

This test was used to assess the static balance ability of the child. For performing this test, the child was instructed to stand on the platform and after determining the foot position the child was taught that the purple point on the screen simulates the movement of his body and he is instructed to maintain this point stable at the center between the X and Y axis by stopping his body movement and remain as stable as possible. The test
procedure lasts for 30 seconds, and the test was repeated for three times and the highest value was taken which appears in the form of percent of stability in each trial.\(^{19}\)

3 Limits of stability test (LOS):

This test was used to assess the postural control. At first the child was instructed to stand on the platform, before running the test the child had the chance to train first to make sure that he understood the test before the measurement, he had taught that the movable purple point represents his body and it is moving by his own body’s movement. Then he was instructed to follow the lighted target by his body and to remain stable at it for one second until another target was lighted then he had to move to catch it and also to remain stable at it till another target was lighted and so on for one minute, targets represent the movement of the body in eight different directions: front, front/right, right, back/right, back, back/left, left, front/left. The test was repeated for three times and the highest value of overall stability was taken from their results.\(^{20}\)

2.3 Statistical analysis

SPSS version 24 was used for statistical analysis. Descriptive statistics for patients’ characteristics were reported as medians and interquartile ranges for quantitative variables, frequencies, and percentages for qualitative ones. Significance level of \(<0.05\).

III. RESULTS

3.1 Participants

Demographic and clinical characteristics are summarized in Table 1.

<table>
<thead>
<tr>
<th>TABLE 1 Demographic and clinical characteristics</th>
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<tbody>
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<td>N (%)</td>
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<td>Gender</td>
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* One Non-biopsied SOL case and the other Choroid Plexus tumor.

3.2 Postural stability scores compared with normal scores

Eyes Open Firm Surface (EOSS) has a median score of 82 (IQR=10) and statistically significant from normal value (92) \([p<0.001]\). Eyes Closed Firm Surface (ECSS) has a median score of 75 (IQR=11) and statistically significant from normal value (90) \([p<0.001]\). Eyes Open Foam Surface (EOFS) has a median score of 62 (IQR=15) and statistically significant from normal value (88) \([p<0.001]\). Eyes Closed Foam Surface (ECFS) has a median score of 40.50 (IQR=21) and statistically significant from normal value (79) \([p<0.001]\). Center of pressure (COP) has a median score of 82 (IQR=7) and statistically significant from normal value (100) \([p<0.001]\). Limits of stability (LOS) has a median score of 24 (IQR=8) and statistically significant from normal value (65) \([p<0.001]\). (Table 2, Fig. 2)
TABLE 2 Postural stability scores compared with normal scores

<table>
<thead>
<tr>
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<th>Median (IQR)</th>
<th>Normal scores</th>
<th>P value</th>
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<tr>
<td>EOSS</td>
<td>82 (10)</td>
<td>92</td>
<td>&lt; 0.001</td>
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<tr>
<td>ECSS</td>
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<td>&lt; 0.001</td>
</tr>
<tr>
<td>LOS</td>
<td>24 (8)</td>
<td>65</td>
<td>&lt; 0.001</td>
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</table>

mCTSIB=modified clinical test of sensory integration of balance, EOSS=Eyes Open Firm Surface, ECSS=Eyes Closed Firm Surface, EOFS=Eyes Open Foam Surface, ECFS=Eyes Closed Foam Surface, COP=Center of pressure, LOS=Limits of stability.

FIGURE 2 Box and Whisker Plots for postural stability scores
IV. DISCUSSION

The current study was designed to investigate postural stability affection in children with posterior fossa tumor during the maintenance phase of treatment, aiming to create a clear and precise understanding of their impairments. The present study included posterior fossa tumor that constitutes a major classification among brain tumor types. This was supported by Packer (1999) who stated that Medulloblastoma is the most common malignant brain tumor in pediatric patients and is a significant cause of cancer morbidity in children.

In the current study, choosing the age of children between 5 and 12 years old was in agreement with Eccles (1999) who reported that child starting to have a good performance like adult between the age of 5 and 12 years. More attention had to be paid to understand the potentially presenting side effects resulting from the administrated treatment or the disease itself, especially the postural stability problem which was one of the least investigated problems among posterior fossa tumor patients.

Poor performance in children with posterior fossa tumor can result from treatment procedures. This may be explained by numerous side effects to cancer treatment, which often include muscle wasting or atrophy, reduced physical functioning, unfavorable changes in body composition, depression, and fatigue. A decrease in physical activity levels associated with other side effects, such as loss of appetite, can intensify muscular wasting and consequently loss of overall body strength, leading patients to experience a negative spiraling effect that further exacerbates the sense of fatigue. This loss of muscle strength, together with a decline in aerobic exercise capacity, makes it difficult to perform simple daily activities, which significantly reduces the quality of life of cancer patients and leads to higher mortality rates. Weakness was the second most common deficit reported in patients with brain tumors. Muscle weakness may be related to an isolated limb weakness, hemiparesis, steroid-induced myopathy or other neurological impairment, for example ataxic hemiparesis. It may be also related to sensory loss, cranial nerve palsy, dysarthria, dysphagia, aphasia, ataxia, diplopia and general debilitation.

Balance or postural stability is a multidimensional notion refers to the body’s ability to avoid falling, to move freely, and to interact to disruptions. It is the ability to maintain or regain the location of the body’s center of gravity (COG) perpendicularly within the base of support (BOS) and consequently facilitating the performance of smooth coordinated movements safely and correctly. Balance can also be defined as the body capability to activate muscles with the suitable force and time to control body movements like sitting, standing, walking and running as well as specific sports activities.

Balance requires multisystem feedback in addition to intact cerebellar and cognitive functions for achieving proper balance, cognitive processing is essential in the process of postural control even in simple tasks like quiet standing as the motor movement needs expectation, attention, intention and experience, it is believed that the harder the task the more cognitive ability it would need.

Postural control, the ability to control the position and orientation of the body in space, is a requirement for maintaining balance during different activities. Adjustments in posture are necessary for maintaining one’s center of gravity within base of support especially when performing tasks with the extremities. Therefore, a child’s postural control system needs to mature as the child develops. Clumsiness, which is often observed in pediatric cancer patients, may be related to impaired postural control. Impaired postural control can preclude the child from exploring the world and developing functional abilities. Medulloblastoma is the commonest malignant tumor in children aged 4 and younger, a critical time in the development of postural control. As a result, these children are potentially at higher risk for developing associated functional deficits as a result of diminished postural control.

From the obtained results of the current study, it can be concluded that children with posterior fossa tumor have affection of postural stability concerning both static and dynamic components of balance control when compared with normal age and gender matched children.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES


FIGURE 2


FIGURE LEGENDS

FIGURE 1 Flow chart illustrating participants entered the study

FIGURE 2 Box and Whisker Plots for postural stability scores