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Research Article

Comparative Study of Mobility Quality and Walking Parameters in Children with ADHD and Normal Controls

Behzad Amini,[1] Seyed Ali Hosseini,[2] Akbar Biglarian,[3] Nasrin Amiri,[4] and Ebrahim Pishyareh[5,*]

[1]Occupational Therapy, University of Social Welfare and Rehabilitation Science, Daneshjoo Blvd, Evin, Tehran, IR Iran
[2]Occupational Therapy, Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, IR Iran
[3]Department of Biostatistics, University of Social Welfare and Rehabilitation Science, Tehran, IR Iran
[4]Department of Child Psychiatry, University of Social Welfare and Rehabilitation Science, Tehran, IR Iran
[5]Pediatric Neurorehabilitation Research Center, University of Social Welfare and Rehabilitation Sciences, Tehran, IR Iran

[*]*Corresponding author*: Ebrahim Pishyareh, Pediatric Neurorehabilitation Research Center, University Of Social Welfare and Rehabilitation Science, Daneshjoo Blvd, Evin, Tehran, IR Iran. Tel/Fax: +98-2122180037, E-mail: ebipishyareh@yahoo.com

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Abstract

Background: Children with ADHD suffer from movement disorders in addition to hyperactivity and attention deficits.
Objectives: To investigate specific indices related to mobility factors, static and active mobility factors were studied in children with ADHD and normal controls.
Methods: 32 children, 16 diagnosed as ADHD and 16 normally developed school-age controls, participated in the research. Static and active mobility factors were assessed using a balance master device, and data were analyzed using the repeated test method.
Results: Parameters, including fluctuation, range, speed at center of mobility, and side control under six sensory conditions differed significantly between ADHD and control groups. However, no significant differences were observed between the two groups on the seven mobility factors, including step coordination and frequency range in the walking and tandem walk tests.
Conclusions: Static mobility patterns are the most problematic issues in children with ADHD.

Keywords: ADHD, Walking, Dynamic Mobility Factors, Static Mobility Factors, Balance Master

1. Background

ADHD is a developmental neurological condition characterized by stable patterns of attention deficiency, impulsivity, and hyperactivity (1). Children with ADHD exhibit specific hyperactivity symptoms, including an abnormal amount of running and jumping, restlessness and constant motion, intolerance of being in a constant state, intolerance of waiting and compliance, and impulsive action without anticipating the consequences (2). ADHD is a chronic disorder that occurs mostly at early ages (i.e., before children start school or in the early years of their elementary schooling); its prevalence among elementary school children is 4% - 8% (1, 3). Children with ADHD perform poorly in the educational environment, lack dependency, and are not well accepted by their peers (4). Various studies on the mobility problems of Children with ADHD have been conducted (5, 6). However, there is contradictory evidence on certain topics, including on the relationship between the quality of mobility and walking patterns in children with ADHD and attention and hyperactivity issues (7, 8). It is noteworthy that, although 47% - 69% of Children with ADHD suffer from motor coordination dysfunction (9), researchers have historically focused on other ADHD patterns.

Previous work has investigated the connection between mobility patterns and ADHD symptoms (6, 7). In a study by Fliers et al. (2008), the relationship of fine and gross mobility dysfunctions, motor coordination, and motor control to attention deficiency was significantly stronger than that to hyperactivity and impulsivity (8). Recognizing the factors that influence mobility could be considered a predictive tool for the disorder. In addition, information related to those dysfunctions can be regarded as a reasoning tool, as well as a resource for designing practices in the conception and application of mobility treatment methods based on the Sensory Integration Pyramid as a non-pharmacological treatment approach. In fact, mobility symptoms can be considered both an invaluable resource and an appreciable index during diagnosis, treatment programming, and treatment efficiency evaluation over the course of treatment. Therefore, the present study aimed to assess the quality of both static and active mobility factors, as well as walking, in children with ADHD.

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2. Methods

The present study is a comparative cross–analysis, the aim of which is to compare the quality of mobility and the factors that influence walking in children with ADHD, compared to normal controls. For this purpose, precise and quantitative tools, such as the balance master, were applied. One of the important benefits of using the balance master is to eliminate subjectivity and bias from the instructor. When this device is used, there is no need for the instructor directly to assess and score the factors.

The ADHD and normal children in the present study were between 5 and 12 years old and lived in Tehran, Iran. They were selected via availability sampling. Both the ADHD and the normal group consisted of 16 children each. This number was calculated by considering a test power of 80%, an assurance level of 95%, a maximum precision of 10% for frequency of staying on one leg in both groups, and a standard deviation of 20%. Data on one child in the ADHD group were excluded from the analysis because they were not homogenous.

2.1. Tools

This study used the test included in the balance master (NeuroCom), a device that records a measurement of the amount of force applied to it every ten seconds. The performance and capability of this device have been established (90 - 86).

Two tests of static mobility factors and two tests of walking were applied. These tests were selected for their simplicity, minimal tool requirements, and easy conceptuality for children. The tests were as follows:

- Unilateral stance (US)

This test measures the frequency range of a person's posture when he/she stands on his/her foot and under two conditions: with eyes open and eyes closed.

- Rhythmic weight shift (RWS)

This test evaluates the characteristics of mobility, direction control, and frequency range in relation to the person's ability intentionally to move his/her center of gravity and weight to the left and the right in a rhythmic pattern.

- Walk across (WA)

This test assesses the characteristics of a person's way of walking from one side to another, including step width, step length, speed, and symmetry.

- Tandem walk (TW)

This test evaluates the characteristics of walking the patient exhibits as he/she walks on a rope, including speed, step width, and end point of the frequency range.

2.2. Experiments

Participants and their parents were invited to a briefing of the method of the experiments. The weights and heights of the children were recorded, and the devices to be applied in the study were shown to both the children and their parents. The balance master repeats a test thrice based on its default setting. Each test lasted ten seconds. In the first test, children were told to stand on one foot (leg) with their eyes open for ten seconds and then with their eyes closed for another ten seconds. In the next test, the children were told to move their weight first to the left and right sides of the body and then back and forth. The walking test was also conducted, as was the walk-across test. The number of tests and the way they were performed were based on the device manual and were similar for all children. SPSS software was used to apply the K-S test to assess the data distribution overlap between the results of the study and the normal distribution. To determine whether the difference in demographic variables between the two groups was significant, an independent sample t-test was performed. The results, as shown in Tables 1 and 2, indicate no significant difference. In addition, the performances of the groups on each test were compared using a repeated measures test.

3. Results

The two groups were matched for age and laterality. The following results were achieved after analyzing the data obtained from the experiments.

3.1. Walking Factors (Dynamic)

3.1.1. Walk-Across Test

In this test, the children's walking patterns were statistically analyzed in terms of step width and length, speed, and symmetry. Based on the results, the performance of the children with ADHD did not differ significantly from that of the control group. Table 1 presents the results of the walk-across test (step width and length, speed, and walking symmetry).

3.1.2. Tandem Walk Test

This test evaluated the factors step width, speed, and end sway as the children moved on the balance master plate similarly to the way an acrobat walks on a tightrope. No significant difference was observed in the performances of the two groups. The results are presented in Table 2.

Table 2 shows the results of the tandem-walk test. No significant difference was observed in step width, speed, and swing measures between the two groups.

Table 1. Walk Across Test

Evaluated Components	Type III Sum of Squares	df	Mean Square	F	P Value
Step width	51.181	1	51.181	1.236	0.277
Length step	459.869	1	459.869	1.399	0.248
Speed	1685.476	1	1685.476	2.273	0.142
Step symmetry	131.868	1	131.868	0.190	0.666

Table 2. Tandem Walk Test (Here)

Evaluated Components	Type III Sum of Squares	df	Mean Square	F	P Value
Step width	53.700	1	53.700	1.452	0.238
Speed	154.027	1	154.027	.958	0.336
Swing	241.365	1	241.365	1.881	0.181

3.2. Static Mobility Factors

3.2.1. Unilateral Stance

This test evaluated the sway velocity while standing on each foot and under eyes-open and eyes-closed conditions. The results for the unilateral stance on the left and the right foot with eyes open differed significantly between the two groups. Although similar results were not observed when the children's eyes were closed, the results relating to the other foot while their eyes were closed were significantly different.

Table 3 shows that the results of three of the four tests differed significantly. The results for swing rate while standing on one leg (with eyes open or closed) considering group, laterality, and both group and laterality, are presented in the Table 3.

The results of the unilateral stance test were analyzed thrice: for group, laterality, and both group and laterality. As shown in data, a significant difference was observed between the two groups.

Weight shifting in the frontal and sagittal planes

In this test, the on-axis velocity and directional control during weight shifting in both the frontal and sagittal planes were evaluated. Table 4 consists of two general parts: 1 for sway and 2 for directional control.

As seen in data the recorded degrees of on-axis velocity during weight shifting in the frontal and sagittal planes indicate a significant difference of $P \leq 0.047$ and $P \leq 0.042$, respectively, between the groups. However, no significant difference in the results for directional control during weight shifting in the frontal plane were observed between the two groups ($P \leq 0.001$).

4. Discussion

From the medical point of view, the lack of a significant difference in active mobility factors between ADHD and normal children can be considered an important result. In the present work, the results of the experiments on active mobility factors can be evaluated in terms of the task aspect. Additionally, other factors can be considered, including the degree of task clarity, the ratio of mobility factors to conceptual task factors, the time interval between educating the children and their taking the tests, and the distance of the field in which the tests were taken. It should be mentioned that, in the area of active mobility, the given tasks were clear and appreciable, and the factors were definitely higher than those in conceptual mobility. Also, the length of the field in which the tests on active mobility were taken was adequately short, and the tests were performed directly after educating the children.

Therefore, it can be concluded that children with ADHD are able efficiently to perform tasks that do not require stable attention, response inhibition, and long focus on the object. Also, children with ADHD can properly handle given tasks similar to the above-mentioned ones, in which the focus is mostly on mobility and specific patterns with specified objectives. In fact, such practices increase the children's confidence and self-esteem, which could be regarded as a way for them to become independent.

When they are required to answer a question rapidly, children with ADHD are unable to handle the situation. In addition, they experience difficulty with walking patterns when performing dual tasks. One of the problems observed during walking tests is a dysfunction of walking speed, exhibited when children are confronted with complex mobility patterns (10).

Table 3. Unilateral Stance Test (Here)[a]

Test		Type III Sum of Squares	df	Mean Square	F	P Value
Test1	Group	0.904	1	.904	4.058	0.054
	Laterality	0.007	1	.007	0.030	0.865
	Group * laterality	0.005	1	.005	0.021	0.886
Test2	Group	1.879	1	1.879	11.913	0.002
	Laterality	0.104	1	.104	0.661	0.423
	Group * laterality	0.006	1	.006	0.037	0.849
Test3	Group	0.976	1	.976	9.571	0.005
	Laterality	0.000	1	.000	0.002	0.963
	Group * laterality	0.001	1	.001	0.009	0.923
Test4	Group	31.641	1	31.641	0.861	0.363
	Laterality	20.012	1	20.012	0.545	0.468
	Group * laterality	15.869	1	15.869	0.432	0.517

[a]Test 1: Standing on the left foot with eyes open; Test 2: Standing on the left foot with eyes closed; Test 3: Standing on the right foot with eyes open; Test 4: Standing on the right foot with eyes closed.

Table 4. Weight Shifting Test (Here)[a]

Test	Type III Sum of Squares	df	Mean Square	F	P Value
Test1	63.238	1	63.238	4.511	0.042
Test2	21.911	1	21.911	4.349	0.047
Test3	21.393	1	21.393	.068	0.797
Test4	6248.025	1	6248.025	24.454	$\leq$ 0.001

[a]Test 1: Weight shifting velocity in the frontal plane; Test 2: Weight shifting velocity in the sagittal plane; Test 3: Weight shifting directional control in the frontal plane; Test 4: Weight shifting directional control in the sagittal plane.

In the following, the results on static mobility in this study, which were found to differ significantly between the ADHD and control groups, are discussed in relation to neuroanatomy, psychology, and sensory-motor function.

4.1. Neuroanatomy

Volumetric disorders have been reported in the brains of children with ADHD, including in the performance and volume of the cerebellum, basal ganglia, and vestibular nucleus. The changed volume and impaired function of the basal ganglia and the decreased size of the cerebellum in children with ADHD have been reported in neuroimaging studies (11, 12). In fact, these two organs play important roles in controlling movement and balance (12). Further, the basal ganglia play a crucial role in postural control and in coordinating posture and movement. Previous imaging studies have shown that the cerebellum is active in analyzing the proprioceptive information rooted in active and passive movements. Indeed, functional interconnectivity of the basal ganglia and cerebellum is required for accurate perception of the state of bodily organs (11, 13).

The results of the present work in the existence of specific disorders in static mobility factors of children with ADHD are anticipated given the above-mentioned disorders in the brains of children with ADHD, the vital role of each brain region in postural control and daily activities, and the importance of the cerebellum in balance control.

4.2. Psychology

High levels of stress could contribute towards the development of mobility disorders. Considering that children with ADHD experience stressful conditions, stress may be considered a decisive factor in this issue (14).

4.3. Sensory Motor Function

Interactions among the major senses and the mechanisms of sensory integration are important in controlling postural fluctuation. The prevalence of sensory integration deficiency in children with ADHD reportedly ranges from 40% - 84%; the rate in normal children is only 16% (5). One of the disorders common in children with ADHD is sensory-related mobility dysfunction, including postural dysfunctions, such as specific disorders of core stability and apraxia. The results imply that children with ADHD who suffer from specific dysfunctions in the frequency of the center of gravity of their bodies under static conditions, could benefit from postural practices. Thus, it seems that the connection between the mobility aspect and the attention and hyperactivity aspects of ADHD should be regarded as important, and should be considered from a medical perspective, too.

The results of the present study are consistent with those of Ren et al. (2003) and Zang Yu Feng et al. (2002) (15, 16). In both studies, the balance master was applied to compare the performances of children with ADHD in terms of balance (stability) ((15, 16). Our results indicate that children with ADHD are unable efficiently to handle tests of static mobility factors, particularly frequency range, directional control, and on-axis velocity, compared to children in the control group. Knowledge of these differences could be helpful in recognizing ADHD during its early stages, determining the roots and the foundation of the disorder, and understanding the possible effects of its symptoms on the occurrence of unacceptable behavior in children with ADHD.

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