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RESEARCH ARTICLE

Test-retest reliability of the pediatric clinical test of sensory interaction for balance in 4-6 years old children

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Abstract

Background and Aim: The pediatric clinical test of sensory interaction for balance (P-CTSIB) evaluates the functional maturity of vestibular, visual, and proprioceptive systems and the quality of sensory interactions between these systems. This test is a simple and inexpensive tool used in the clinical tests of balance performance. The current study aimed at examining the internal consistency and test-retest reliability of the P-CTSIB test in preschool children.

Methods: The present study was performed on 38 children aged 4 to 6 years in preschools and kindergartens of Tehran, Iran. The test consists of 12 positions including visual positions (eyes open, eyes closed, and wearing a visual-conflict dome), support surface (standing on a hard surface and a foam) and the position of the feet (feet together and heel-toe position). The subjects were evaluated in each of the P-CTSIB test positions twice.

Results: Cronbach's alpha coefficients for standing duration, antero-posterior sway, and lateral sway were 0.92, 0.77, and 0.84, respectively. The intraclass correlation coefficient (ICC) ranged from 0.70 to 0.92 for standing duration, 0.27 to 0.89 for antero-posterior sway, and 0.31 to 0.87 for lateral sway.

Conclusion: The results of this study showed that the internal consistency of the P-CTSIB test in 4-6-year-old children was significant. This test has a high reliability in the feet together position. Therefore, the P-CTSIB test with feet together is suggested as a reliable clinical measure to assess children's balance.

Keywords: Balance; postural control; preschool children; test-retest reliability

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Introduction

Postural stability or balance is an initial process essential for all functional movements in everyday activities. Balance can be defined as a position in which all forces active in the body interact with one another and maintain one's position in line with the gravity in a balanced state; hence, it does not interfere with everyday activities. Balance in humans is predominantly regulated by dynamic visual interaction, the proprioceptive system, and the vestibular system [1].

There is a growing focus on deficiencies associated with vestibular system in children [2]. Vestibular disorder is the most common cause of dizziness in children with a prevalence rate of 7% to 15%. These defects that emerge during childhood affect children's performance, including their ability to read and performance at

school [3,4]. Vestibular migraine, benign paroxysmal vertigo of childhood, post-concussion dizziness due to head trauma, and viral vestibular neuritis are the most common balance problems in such children [5]. These abnormalities may remain undiagnosed as the symptoms may be misdiagnosed with those of behavioral disorder [6].

The inefficiency of vestibular function in children is often ignored, and no precise examination is available in this regard. There are several reasons why the evaluation is not usually performed in children such as lack of a simple and applicable method for clinical setting. Adult standard assessment methods e.g. electronystagmography (ENG) and caloric test, which detect the unilateral vestibular hypofunction, are challenging and intolerable for children [7,8]. The rotary chair test uses the natural rotation stimulation to detect bilateral vestibular disorder. This test is very costly, and its tool is not available in all clinics [9]. Another test used to assess balance is the assessment of sensory organization in the computerized dynamic posturography test, which is useful in assessing patients with no postural stability. This test provides a more integrated assessment of balance than that of other assessments such as the caloric test, rotary chairs, and ENG, which only examine the vestibulo-ocular reflex. However, it has a more limited use in assessment clinics because it is very costly and time-consuming, and the equipment takes a lot of spaces [9].

The pediatric clinical test of sensory interaction for balance (P-CTSIB) attempts to evaluate the maturity of vestibular, visual, and proprioceptive systems and the quality of sensory interactions between these systems. This test reflects a child's ability in combining and using different information to cope different positions in static balance [1]. It is a useful tool for the assessment of static balance and is a clinical version of the sensory organization test. P-CTSIB does not use the computerized force plate technology and is, therefore, an inexpensive tool and can be easily used in a clinical setting [10,11]. Considering the fact that sensory systems in younger children are not fully developed and act in a different way to maintain the balance [12], and there is no easy and reliable tool to assess the balance of preschool children in Iran, the current study aimed at evaluating the reliability and internal consistency of the P-CTSIB test in 4-6-year-old children in Tehran, Iran. The study was conducted on this age group due to the difficulty in performing other balance tests on children less than 6 years and there were few studies and findings in balance tests on such groups.

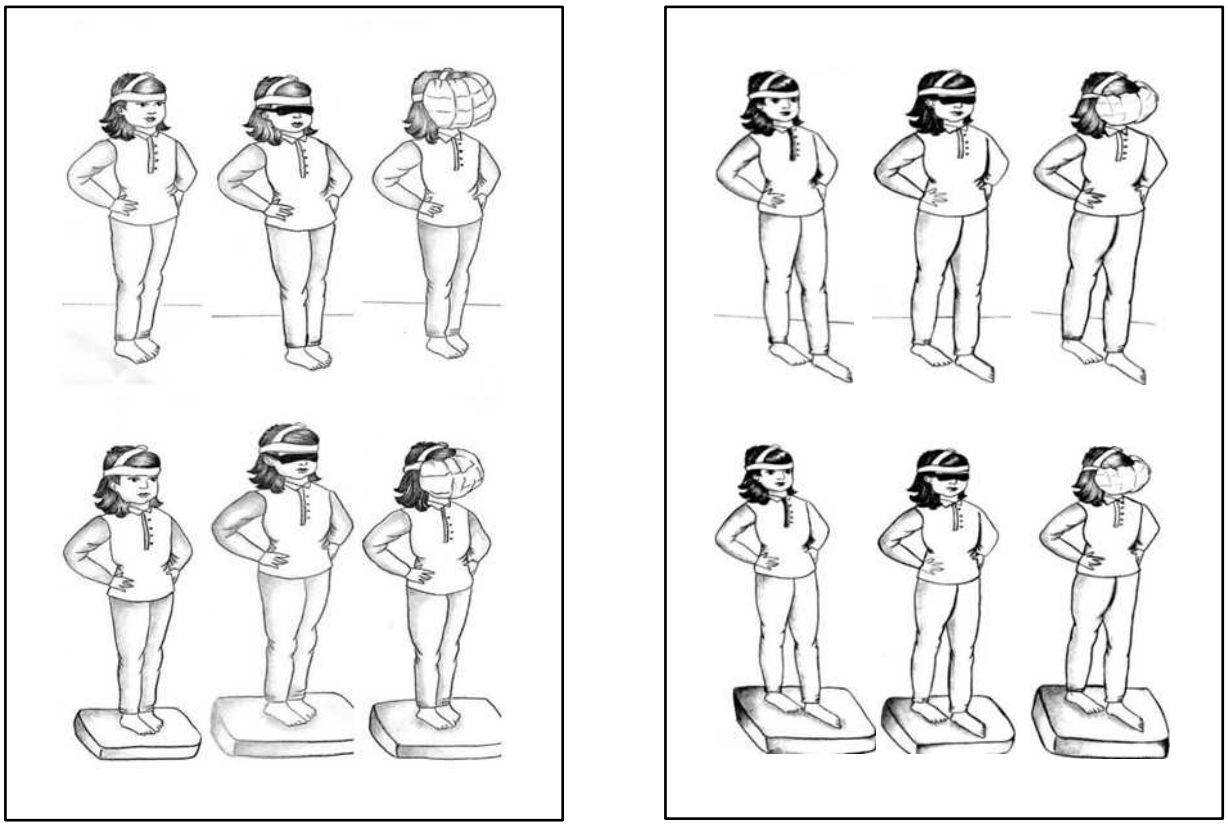
Methods

A total of 38 children aged 4 to 6 years from 4 preschools and kindergartens in Tehran participated in the current study. The children were selected using the random cluster sampling method; parents were explained about the objectives and content of the study, and signed the written informed consent. The inclusion criteria were age ranged 4 to 6 years, based on parental report no history of neurological problems, vision disorder, motor developmental disorders, educational problems, not doing regular exercises, as well as no use of medication that effect on nervous system, balance and the ability to cope with the test. The data were collected during winter 2016 in 4 kindergartens in different areas of Tehran (one in the North, two West, and one South).

First, the child's preparation and precise explanation was made to understand how the test process and how he/she must cooperate. Due to the different stages of the test, before each stage children were instructed again about procedure of the test, if necessary.

The duration of the static balance, the amount of antero-posterior sway, and lateral sway of the body were assessed under six different sensory states and two different standing positions (feet together and the heel-toe position) a total of 12 positions (Fig. 1).

Combining three levels of visual variables (eyes open, eyes closed, and wearing a visual-conflict dome) and three levels of the support surface variable (standing on a hard surfaces and a foam) made up six levels of the sensory position of the test. These six positions were as follows:



a **b**

Fig. 1. Different conditions in a) feet together, and b) heel-toe positions of pediatric clinical test of sensory interaction for balance test.

1) eyes open, standing on a hard surface
2) eyes closed, standing on a hard surface
3) eyes open, and wearing a visual-conflict dome, standing on a hard surface
4) eyes open, standing on a foam
5) eyes closed, standing on a foam
6) eyes open, and wearing a visual-conflict dome, and standing on a foam

In all of the test position, the child was asked to standby placing hands on the pelvis until he/she maintains balance for 30 seconds or a new postural adjustment occurs. The postural adjustment function is defined as the removal of hands from the pelvis, the movement of one or both feet from the original position, opening the eyes during the closed-eye position, or the need for the examiner's assistance to prevent from falling [13].

The duration of standing and the amount of lateral sway and antero-posterior sway were recorded. Duration of standing is defined as the time when the child removes his or her hands from the pelvis, removes one or both feet from the original position, opens his/her eyes if the test needs closed eyes, or needs the examiner to prevent from falling [13], which was measured using a chronometer in seconds. The maximum standing time was 30 seconds.

A plate in millimeter sizes was placed behind the child to measure the amount of sway in a 1×1 m space. The total amount of sway was recorded on both sides and on the vertical and horizontal plates.

To determine the amount of movements on a millimeter plate, a laser beam was placed on child's head using a headband. The child's sway rate was determined by a laser mounted on the plate behind him/her and marked by the

Table 1. Cronbach's alpha for duration, anterior-posterior and mediolateral sway

Variable		Cronbach's alpha
Duration		
	Feet together	**0.82**
	Heel-Toe	**0.93**
	Total (12 position)	**0.92**
Anterior-posterior sway	**Feet together**	**0.86**
	Heel-toe	**0.51**
	Total (12 position)	**0.77**
Mediolateral sway	**Feet together**	**0.85**
	Heel-toe	**0.69**
Variable	**Total (12 position)**	**0.84**

examiner. In positions 3 and 6, a conflict dome, made by a paper and a series of horizontal and vertical lines inside it, limited the child's sight from the opposite, up, and down, as well as right and left sides [14].

Two examiners performed the test procedure [13]. The first one determined the sway rate in different directions on the plate behind the child. The other one directed the child and regulated his/her position correctly, was ready to prevent him/her from falling, and also recorded the time.

In all of the 6 positions for the feet together and heel-toe position, the best response with the longest duration was recorded for the analysis. Between each test position, one minute rest was given to the child in order to prevent the impact of fatigue. The subjects were evaluated in all P-CTSIB positions in two rounds.

It took about 30 minutes to complete the test. The test was conducted in an environment with minimal distraction factors so that the child could concentrate on the balance duty.

The results were statistically analyzed using SPSS 22. Cronbach's alpha and intraclass correlation coefficient (ICC) were used to examine the internal consistency and test-retest reliability.

Results

A total of 38 children aged 4 to 6 years old were evaluated in the study in two rounds based on the P-CTSIB test. Cronbach's alpha coefficients were measured for three variables of standing duration, antero-posterior sway, and lateral sway as 0.92, 0.77, and 0.84, respectively; all three variables of the test had good internal consistency (Table 1). As shown in Table 2, in the feet together position, the standing duration variable showed a high reliability (ICC from 0.70 to 0.90) for positions 1 to 6. All children in position 1 were able to stand for 30 seconds in the both rounds of the test. The antero-posterior sway in the feet together position showed a high reliability for positions 1 to 4 (ICC: 0.77 to 0.89); but it was a moderate and a low reliability for positions 5 and 6, respectively. The reliability of the lateral sway variable in the feet together position for positions 1 to 4 was high (ICC: 0.67 to 0.87), whereas it was moderate for position 5 and low for position 6. As shown in Table 3, the standing duration for positions 1 to 6 in heel-toe position had a high reliability (ICC: 0.84 to 0.89). Position 1, 5, and 6 for the antero-posterior sway variable showed a moderate reliability in the heel-toe position, whereas positions 2, 3, and 4 showed lower reliability. The amount of lateral sway in the heel-toe position showed moderate reliability for positions 1 and 4 (ICC: 0.64), but a low for positions 2, 3, 5, and 6.

Discussion

In the current study, the reliability and internal consistency of the P-CTSIB test-retest items were examined in normal children aged 4 to 6 years. The results of this study showed a good internal consistency for P-CTSIB.

The results of the current study also indicated that P-CTSIB items have moderate and high reliability in this age group and in the feet together position. In case of heel-toe position, except for the standing duration item that showed a high reliability, other items including antero-posterior sway and lateral sway showed moderate to low reliability.

The results were in part consistent with those of

Table 2. Intraclass correlation coefficient for duration, anterior-posterior and mediolateral sway in feet together position

	Condition	ICC	95% CI	p
Duration				
	2 Hard surface-eyes closed	0.72	0.84-0.53	<0.001
	3 Hard surface-conflict dome	0.70	0.83-0.49	<0.001
	4 Foam- eyes open	0.91	0.95-0.84	<0.001
	5 Foam-eyes closed	0.92	0.95-0.85	<0.001
	6 Foam- conflict dome	0.92	0.96-0.86	<0.001
Anterior-posterior sway				
	1 Hard surface-eyes open	0.85	0.92-0.74	<0.001
	2 Hard surface-eyes closed	0.89	0.94-0.81	<0.001
	3 Hard surface-conflict dome	0.85	0.92-0.73	<0.001
	4 Foam- eyes open	0.77	0.87-0.60	0.001
	5 Foam-eyes closed	0.51	0.71-0.23	0.001
	6 Foam-conflict dome	0.48	0.69-0.19	0.001
Mediolateral sway				
	1 Hard surface-eyes open	0.87	0.93-0.77	<0.001
	2 Hard surface-eyes closed	0.83	0.91-0.71	<0.001
	3 Hard surface-conflict dome	0.67	0.81-0.45	<0.001
	4 Foam- eyes open	0.75	0.86-0.57	<0.001
	5 Foam-eyes closed	0.59	0.76-0.34	<0.001
	6 Foam-conflict dome	0.33	0.58-0.01	0.020

ICC; intraclass correlation coefficient, CI; confidence Interval

a study by Westcott et al., on 24 four-year-old children with normal growth using the P-CTSIB test. They found that reliability of the test items was high in the feet together position, but lower in the heel-toe position. They suggested more tests on older children to determine the effect of the heel-toe position after further development of balance skills [15]. In present study, the reliability of the test items was also higher in the feet together position than that of heel-toe position. The test-retest differences were fewer in the feet together position. However, the total sway amount indicated a lower reliability for positions 5 and 6, compared with those of other positions, which may be due to the disruption of the visual input and proprioceptive system in these positions and the child's reliance on the vestibular system to maintain balance, which is a justifiable finding for this age group with an incomplete balance maintenance systems. Heel-toe position showed a lower reliability than feet together positions in the current study and the reason can be attributed to its difficulty for the children in this age group. However, the duration of standing in these positions showed a high reliability, but the duration alone does not refer to balance.

Christy et al., also performed clinical trials to test the reliability of the vestibular functions in children aged 6 to12 years with sensorineural

Table 3. Intraclass correlation coefficient for duration, anterior-posterior and mediolateral sway in heel-toe position

	Condition	ICC	95% CI	p
Duration				
	1 Hard surface-eyes open	0.87	0.93-0.77	<0.001
	2 Hard surface-eyes closed	0.84	0.91-072	<0.001
	3 Hard surface-conflict dome	0.87	0.93-0.76	<0.001
	4 Foam-eyes open	0.89	0.94-0.81	<0.001
	5 Foam-eyes closed	0.89	0.94-0.81	<0.001
	6 Foam-conflict dome	0.86	0.92-0.75	<0.001
Anterior-posterior sway				
	1 Hard surface-eyes open	0.49	0.70-0.29	0.001
	2 Hard surface-eyes closed	0.27	0.04-0.54-	0.045
	3 Hard surface-conflict dome	0.35	0.59-0.03	0.015
	4 Foam-eyes open	0.30	0.56-0.01-	0.029
	5 Foam-eyes closed	0.50	0.72-0.18	0.002
	6 Foam-conflict dome	0.51	0.73-0.20	0.001
Mediolateral sway				
	1 Hard surface-eyes open	0.64	0.79-0.41	<0.001
	2 Hard surface-eyes closed	0.39	0.63-0.09	0.006
	3 Hard surface-conflict dome	0.44	0.66-0.15	0.002
	4 Foam-eyes open	0.64	0.79-0.41	<0.001
	5 Foam-eyes closed	0.31	0.59-0.04-	0.042
	6 Foam-conflict dome	0.32	0.60-0.02-	0.034

ICC; intraclass correlation coefficient, CI; confidence Interval

hearing loss and healthy children. They used the modified clinical test of sensory interaction for balance, which is normally used for adults. In this test, positions 3 and 6 of the P-CTSIB test were removed, and the test was performed only in 4 positions. Their results showed that high reliability for all of the positions (0.78), except position 4 (0.56), had a high reliability. Therefore, they suggested completing all test positions and considering the results together [2]. In our study, in position 5, similar to position 4 in Christy's study, the reliability for antero-posterior and lateral sways in the feet together position was 0.51 and 0.59, respectively, that indicated high reliability of the test that we obtained somewhat similar results despite the younger age of the subjects in this study.

Geldlof et al., studied the test-retest evaluation of static and dynamic balance on 20 children aged 9 to 10 years using a modified CTSIB (mCTSIB) test and the limit of stability test. The results indicated a moderate to high reliability (ICC: 0.62 to 0.80) for all of the 4 sensory states of mCTSIB that was somewhat consistent with the result of the present study [16]. In this study, reliability was lower for difficult positions such as position 5 and 6 (similar to position 4 in the Geldlof's study), which can be attributed to the

lower age of the subjects in the current study and their less cooperation with the test. However, Geldlofet al., [16] only evaluated the feet together position.

Conclusion

The P-CTSIB test with the feet together position has a good reliability in the assessment of the balance in children 4 to 6-year-old and it is recommended as a reliable clinical measure for the assessment of balance performance for such children. Considering that this test, as shown by the research, has a relatively high correlation with other balance tests such as the sensory organization test in the posturography and is an inexpensive and simple test, it can be easily used in children's balance assessment clinics. For the heel-toe positions, which did not show a good reliability in both rounds of the test, more repetitions are recommended to obtain better results.

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Conflict of interest

The authors declared no conflicts of interest.

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