Functional balance tests in 7-10 year-old children: reliability and relation to anthropometric parameters

Mahboobeh Dehnavi[1]*, Heidar Sadeghi[2], Mehdi Taghva[3]

[1] Department of Physical Education, Central Tehran Branch, Islamic Azad University, Tehran, Iran; m.dehnavi@gmail.com

[2] Department of Physical Education, Kharazmi University, Tehran, Iran; heidar.sadeghi@gmail.com

[3] Department of Physical Education, Central Tehran Branch, Islamic Azad University, Tehran, Iran; m.taghva@gmail.com

* Correspondence: Mahboobeh Dehnavi; m.dehnavi@gmail.com

ABSTRACT

Objectives: This study aimed to examine the reliability of functional balance tests in 7-10 year-old children, as well as the relation between the functional balance tests and anthropometric parameters.

Methods: The study sample was composed of 80 7-10 year-old children (40 boys and 40 girls) from Nishapur (Iran). The participants were selected randomly with the approval of the Nishapur Education Department. Romberg's test and Sharpened Romberg Test were used to assess static balance. Y Balance Test was used to assess semi-dynamic balance. Timed Up and Go Test and Tandem Gait Test were used to assess dynamic balance. The following anthropometric parameters were measured: weight (kg), height (cm), leg length (cm), arch of the foot (cm), upper body length (cm), lower body length (cm), upper limb length (cm). The statistical analysis was performed with SPSS 20.

Findings: Romberg test was not reliable. Sharpened Romberg Test was reliable in girls. Timed Up and Go Test and Tandem Gait Test were reliable in boys. Y Balance Test was reliable in boys and girls. The analysis of the correlation between functional balance tests (static and dynamic) and anthropometric parameters according to sex showed that there was only a significant negative correlation between arch of the foot and Sharpened Romberg Test in girls (r=-.43; p=.00).

Conclusions: Sharpened Romberg Test is reliable in Iranian 7-10 year-old girls. Timed Up and Go Test and Tandem Gait Test are reliable in Iranian 7-10 year-old boys. Y Balance Test is reliable in 7-10 year-old Iranian children. Static balance has a significant and negative correlation with the arch of the foot in Iranian 7-10 year-old girls.

KEYWORDS

1. INTRODUCTION

Nowadays, the awareness of the importance of physical activity is constantly increasing [1-3]. The experts and physical education specialists encourage people of different ages to do sports activities and share the knowledge about the role of exercises in health care [4,5]. They also offer possible solutions to the problems caused by side effects of over exercising and improper or poor training practices that discourage people from physical activity [6].

One of the potential undesirable symptoms that may be caused by exhausting and improper sport practice are body imbalances [7]. Balance is related to the body's dynamic, complex movement ability which prevents it from falling [8]. The ability to keep the body in balance is essential in doing daily sport activities [9]. In biomechanics, balance is the ability to maintain one's center of gravity with minimal postural sway [10]. Balance is an important factor in preventing the body's vulnerability, hence the decline in balance can lead to loss of the body functions [11].

Controlling the human balance depends on the integrity of the vestibular, visual, and sensory-somatic systems [12]. If one of the involving systems in postural control mechanisms declines, or loses its activity, the functions of other mechanisms in this process will be decreased or lost [13]. The balance is kept by the movements of the ankle, knee and hip and it may be disturbed if these movements are not coordinated. These three balance systems work in combination and all of them are significant in keeping the body in a correct and coordinated manner [14].

Hosseini [8] states that two weeks backward running training has a positive impact on static balance. In addition, muscles of the hip, knee and ankle are a strong base for the body and help to keep its upright position. In order to improve balance there is a wide range of sports equipment that can be used, for example: twist boards, rocker boards and balancing balls.

There is a low correlation among the static, dynamic and semi-dynamic balance tests. Therefore, special tests are applied in evaluating and measuring balance [15]. Some factors such as age, gender and anthropometric parameters (leg length, lower body length) affect balance.

There are no sufficient research studies taking into account the above mentioned factors. Hence, this study aimed to examine the reliability of functional balance tests in 7-10 year-old children, as well as the relation between the functional balance tests and anthropometric parameters.

2. METHODS

2.1. Participants

The study sample was composed of 80 7-10 year-old children (40 boys and 40 girls) from Nishapur (Iran). The participants were selected randomly with the approval of the Nishapur Education Department. All subjects gave assent and their parents provided their informed consent for inclusion before they participated in the study.

2.2. Procedures and instruments

Participants completed a researcher-made questionnaire about their personal information and general health. The following anthropometric parameters were measured: weight (kg), height (cm), leg length (cm), arch of the foot (cm), upper body length (cm), lower body length (cm), upper limb length (cm). Romberg's test and Sharpened Romberg Test were used to assess static balance. Y Balance Test was used to assess semi-dynamic balance. Timed Up and Go Test and Tandem Gait Test were used to assess dynamic balance. All tests were conducted 3 times after providing full instructions about the procedure and protocol.

Romberg's test

- Purpose: to measure the static balance.
- Instruments: stopwatch and score sheet.
- Procedure: the subject stands on a flat surface with bare feet; the arms are hang down at the sides of the body and the ankles are together. The eyes are closed.
- Scoring: the period the subject can maintain this position is measured as his/her score (i.e. if the subject can perform the test up to 60 seconds, the score will be 60).
- Note: this test is implemented 3 times and there is one-minute rest between each time.

Sharpened Romberg Test

- Purpose: to assess the static balance.
- Instruments: stopwatch and score sheet.
- Procedure: the subject stands on a flat surface. The dominant foot must be in front of the non-dominant one, so that the heel of the forefoot sticks to the toe of the back foot. The arms are crossed and the palms are put on the opposite shoulder. The eyes must be closed.

- Scoring: this test lasts for 60 seconds. The subject will lose 1 second if one of the following errors happens: over swinging; loss of balance; eye opening; shaking hands.
- Note: this test is implemented 3 times with one-minute break after each performance.

Y Balance Test

- Purpose: to assess the semi-dynamic balance.
- Instruments: score sheet.
- Procedure: this test (Figure 1) is implemented on both legs. The subject stands on the center of the board with a single bare foot (this foot must be behind the Red Line) and the other foot is on the ground next to the board. This test requires the subject to balance on one leg whilst simultaneously reaching as far as possible with the other leg in three separate directions: anterior, posterolateral, and posteromedial. When the test has been performed 3 times and in three directions then it is performed by the other foot. After doing the test 3 times with both feet in each direction, the test is finished. Before running the test, the subject practices this procedure 6 times on each foot in each direction to master the procedure. The test is repeated if one of the following errors happens: 1) the subject loses its balance while standing on one foot, 2) the subject touches the ground with the foot that is trying to reach as far as possible, 3) the subject places the foot on top of the reach indicator, 4) the subject does not turn the foot back to the original position after each time.
- Scoring: the distance from the touch point to the center of the board.
- Note: the test is repeated 3 times with 2-minutes rest between each performance.
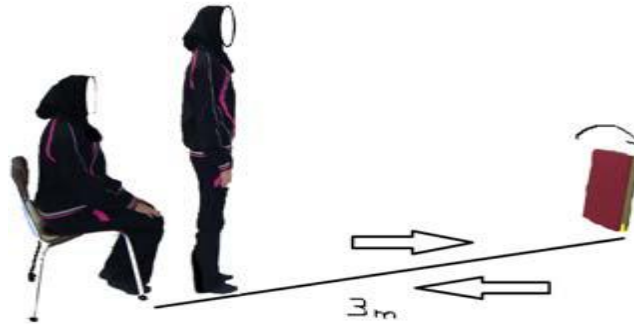

Figure1. General view of the Y Balance Test

Timed Up and Go Test

- Purpose: to measure the dynamic balance.
- Instruments: 41 cm high chair, cone, stopwatch and score sheet.

- Procedure: this test consists of 6 steps that must be done continuously. First, we put a chair and a cone at a distance of 3 meters (Figure 2). Then, the subject is asked to do the test as fast as possible and without running. The steps are as follows: 1) rising from a chair, 2) walking three meters, 3) turning around a cone, 4) turning back the same way, 5) turning around a chair. 6) sitting on a chair.


Figure 2. Timed Up and Go Test

- Scoring: the time of implementing the test by the subject is considered as his/her score.
- Note: the test is repeated 3 times with 2-minutes rest between each performance.

Tandem Gait Test

- Purpose: to measure the dynamic balance.
- Instruments: stopwatch and score sheet.
- Procedure: the subject walks a straight line with the toes of the back foot touching the heel of the front foot at each step.
- The feet are bare, the arms are hang down at the sides of the body (Figure 3).
- Scoring: the subject runs the test for 60 seconds. One second is lost if one of the following errors happens: 1) over swinging, 2) loss of balance.
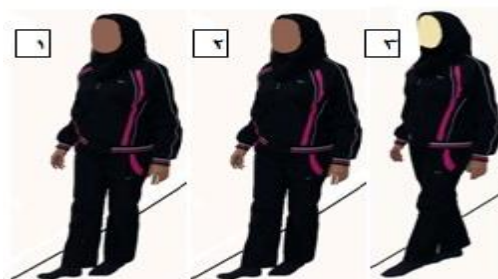
Figure 3. Tandem Gait Test

- Note: this test is repeated 3 times with 2-minutes rest between each performance.

2.3. Statistical analysis

Intraclass correlation coefficient (ICC) was used to determine the reliability of the tests. Pearson correlation coefficient was used to determine the correlation between the balance tests and the anthropometric parameters. The statistical analysis was performed with SPSS 20. The level of statistical significance was set at $P < 0.05$.

3. RESULTS

The general characteristics of the participants (average age and anthropometric parameters) are presented by sex (boy and girls) in Table 1.

Table 1. General characteristics of the participants by sex

Items	Boys		Girls	
	M	**SD**	**M**	**SD**
Age	8.50	1.13	8.50	1.13
Weight (kg)	28.22	10.104	27.10	5.97
Height (cm)	127.23	18.033	132.3	8.54
Leg length (cm)	20.86	1.63	21.28	1.52
Arch of the foot (cm)	20.58	1.79	20.95	1.53
Upper body length (cm)	29.96	2.92	29.43	2.30
Lower body length (cm)	77.52	9.01	80.21	6.39
Upper limb length (cm)	59.38	4.59	60.71	4.98

M=Mean. SD=Standard deviation.

Based on the findings of the ICC test in analyzing the reliability of the tests in question, the Romberg test in both boys and girls and the Sharpened Romberg Test in boys were not reliable but the latter was reliable in girls. Moreover, based on the findings of the ICC test in analyzing the reliability of the Timed Up and Go Test and the Tandem Gait Test, both were reliable in boys (Table 2).

<div align="center">Table 2. Average values and reliability by sex of
Romberg, Sharpened Romberg, Timed Up and Go, and Tandem Gait tests</div>

Test	Sex	First time		Second time		Third time		Reliability		
		M	**SD**	**M**	**SD**	**M**	**SD**	**ICC**	**P**	**Reliability**
Romberg	**Boys**	45.36	18.55	51.85	14.10	52.28	13.27	.583	.001	**No**
	Girls	49.72	16.065	56.30	8.50	55.57	10.67	.193	.209	**No**
Sharpened Romberg	**Boys**	14.22	15.63	11.70	12.11	12.55	10.52	.346	.056	**No**
	Girls	20.68	19.34	23.37	20.36	19.85	16.51	.805	.001	**Yes**
Timed Up and Go	**Boys**	6.78	.9	6.32	.61	6.54	.53	.617	.001	**Yes**
	Girls	6.9	.91	6.76	.52	6.59	.99	.629	.001	**No**
Tandem Gait	**Boys**	57.03	9.22	57.28	9.1	59.02	1.52	.739	.001	**Yes**
	Girls	58.28	2.06	58.81	1.64	58.89	1.52	.458	.013	**No**

<div align="center"><i>M=Mean. SD=Standard deviation.</i></div>

The findings of the ICC test in analyzing the reliability of Y Balance Test showed that this test has reliability in all situations (Table 3).

<div align="center">Table 3. Average values and reliability by sex of Y Balance Test</div>

Test	Sex	First time		Second time		Third time		Reliability		
		M	**SD**	**M**	**SD**	**M**	**SD**	**ICC**	**P**	**Reliability**
Anterior right foot	Boys	62.6	9.35	62.4	9.58	63.27	9.81	.953	.001	**Yes**
	Girls	65.87	12.97	65.8	12.74	67	12.54	.982	.001	**Yes**
Anterior left foot	Boys	62.42	7.94	62.7	8.75	62.47	8.47	.939	.001	**Yes**
	Girls	65.5	13.33	65.9	12.63	67.4	13.11	.974	.001	**Yes**
Posterolateral right foot	Boys	75.1	12.66	76.95	12.72	76.92	12.99	.979	.001	**Yes**
	Girls	72.6	12.81	73.42	13.4	72.2	14	.979	.001	**Yes**
Posterolateral left foot	Boys	74.67	13.13	76.65	12.49	77.65	11.98	.976	.001	**Yes**
	Girls	73.87	13.3	73.8	13.2	73.07	13.57	.976	.001	**Yes**

Posteromedial right foot	Boys	70.67	11.73	71.4	11.31	72.6	12.63	.971	.001	**Yes**
	Girls	69.42	11.38	69.1	11.76	69.47	12.18	.978	.001	**Yes**
Posteromedial left foot	Boys	71.92	14.51	73.47	13.52	73.90	11.9	.980	.001	**Yes**
	Girls	69.55	12.21	69.1	11.87	70.22	12.74	.977	.001	**Yes**

M=Mean. SD=Standard deviation

The analysis of the correlation between functional balance tests (static and dynamic) and anthropometric parameters according to sex (Table 4) showed that there was only a significant negative correlation between arch of the foot and Sharpened Romberg Test in girls (r=-.43; p=.00).

Table 4. Correlation between functional balance tests (static and dynamic) and anthropometric parameters by sex

Anthropometric parameters	Sharpened Romberg				Romberg			
	Boys		Girls		Boys		Girls	
	r	p	r	p	r	p	r	p
Age	.10	.53	-.26	.09	.19	.24	.13	.39
Weight	-.07	.64	-.27	.08	.07	.65	.15	.33
Height	.08	.58	-.31	.05	.25	.11	.01	.90
Leg length	-.09	.56	-.22	.16	.12	.43	.08	.59
Arch of the foot	-.05	.71	**-.43**	**.00**	.17	.28	-.12	.45
Upper body length	.04	.78	-.19	.23	.14	.37	.15	.33
Lower body length	-.09	.57	-.27	.09	-.04	.79	.08	.60
Upper limb length	-.06	.67	-.29	.06	.16	.31	.08	.59

Anthropometric parameters	Timed Up and Go				Tandem Gait			
Age	-.07	.66	.01	.96	-.12	.45	.01	.94
Weight	-.05	.78	.07	.68	-.02	.89	-.19	.26
Height	.02	.92	.23	.15	.08	.64	-.07	.70
Leg length	-.16	.32	.17	.28	.15	.35	-.04	.80
Arch of the foot	-.12	.45	.10	.54	.21	.20	-.15	.36
Upper body length	.14	.39	.18	.26	.09	.60	.08	.65
Lower body length	-.07	.66	.19	.23	.09	.58	.01	.97
Upper limb length	.05	.78	.23	.14	.59	.08	.31	.16

4. DISCUSSION

The results of the present study showed that the Sharpened Romberg Test was reliable only in girls. It is probably due to the anatomic differences between the two sexes, and/or the differences in the levels of physical activity in boys and girls.

Our results also indicated that Timed Up and Go Test and Tandem Gait Test were reliable only in boys. These results are consistent with the results of Cattaneo [12] and McLeod et al. [16].

Hammarén et al. [17] indicated that the dynamic balance tests were more reliable than the static balance tests.

In case of the Y Balance Test, according to our results, it was reliable in both boys and girls. These results are consistent with the findings of Ghandili [10].

Finally, regarding the analysis of the correlation between functional balance tests (static and dynamic) and anthropometric parameters according to sex, it was found that that there was a significant negative correlation between the arch of the foot and Sharpened Romberg Test in girls. These results are consistent with the results of Ghandili [10]. It is probably caused by a higher arch of foot that may reduce the foot's contact area with the ground, and this can reduce the ability to keep the balance.

5. CONCLUSIONS

Sharpened Romberg Test is reliable in Iranian 7-10 year-old girls. Timed Up and Go Test and Tandem Gait Test are reliable in Iranian 7-10 year-old boys. Y Balance Test is reliable in 7-10 year-old Iranian children. Static balance has a significant and negative correlation with the arch of the foot in Iranian 7-10 year-old girls.

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AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

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