

# Difference in balance ability levels in children with Down syndrome compared to those with typical development

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## ABSTRACT

Children with Down Syndrome (DS) experience motor delays due to muscle weakness and hypotonia, especially on the lower extremities. These impairments affect their general physical health and ability to perform daily activities. The aim of the study was to evaluate the ability to perform motor activities that involve keeping the balance of a group of children with DS. This study included 60 children aged 6 to 12 years: 30 with Down syndrome and 30 with typical development. The children were evaluated using the Pediatric Balance Scale (PBS). The scale includes 14 balance-related tasks, each scored from 0 points (lowest function) to 4 points (highest function). The results showed significantly lower scores in children with DS across all assessed activities ( $p < 0.01$ ). The most significant difficulties were detected in tasks such as standing with eyes closed, standing with feet together, standing with one foot in front, standing on one foot, placing alternate foot on stool ( $p < 0.01$ ). The only exception was the standing unsupported test, which had no statistically significant difference ( $p > 0.05$ ). Children with DS performed lower abilities in achieving balance skills compared to typically developing peers. This highlights the need for tailored interventions to improve balance abilities in children with DS.

## KEYWORDS

Down Syndrome; Pediatric Balance Scale; Balance; Children

## 1. INTRODUCTION

Postural balance may be considered as one of the most relevant parameters of kinetic performance and mobility (Horak, 2006; Kanekar & Aruin, 2014) It facilitates independent movement and contributes to overall physical well-being (Paillard, 2017). Adequate postural balance

reflects proper neuromuscular control and communication between the central nervous system and muscles (Kwon et al., 2014). Both static and dynamic postural control are important and necessary for the execution of movement (Woollacott & Shumway-Cook, 1990). Additionally, developing and maintaining postural control are prerequisites for the regular execution of movements. Simple or complex tasks of gross and fine motor skills enable the person to maintain their gravity center on the base of support (“Abstracts of Seventh International Symposium on Osteoporosis,” 2007). In addition to physiological factors, various non-physiological factors also affect children's balance including body weight and their physical activity levels. As a skill, balance can be developed and improved significantly, particularly in early childhood and the first years of school, thus emphasizing the critical role of physical activities in schools. Research also suggests that interventions in schools such as physical education, sports and other physical activities have improved children's weight, physical activity and postural behavior (Verjans-Janssen et al., 2018). Dynamic balance is necessary to move from one position to another or to move freely in the community, whereas static balance is the ability to maintain a position of the body without moving (Berg et al., 1992a).

Balance typically emerges in early childhood and improves throughout adolescence, but its development may be affected due to various factors, such as children with disabilities (Ohtsu et al., 2021). Children with disabilities are individuals with developmental, physical or intellectual differences (World Health Organization, n.d.). Children with Down syndrome (DS) present genetic characteristics that may affect the achievement of kinetic skills (Winter, 2009). Also in postural balance, they experience series of physical, kinetic and functional challenges throughout their lives (Beqaj et al., 2018). Balance and kinetic functions are interrelated, therefore both aspects of development should be considered together when providing physical therapy to children with Down syndrome (Malak et al., 2015).

Dynamic balance is more affected than the static balance (Nadeesha Kalyani & Wanigasinghe, 2021). Abilities such as standing, walking and other kinetic skills are significantly delayed in children with DS compared with children with typical development (Sado et al., 2019). Throughout their lives, these children receive physiotherapy as part of early intervention to improve their balance, although outcomes may differ between those who receive physiotherapy services and those who do not (Malak et al., 2013). Overall, findings indicate that children with DS require prolonged physiotherapy service.

In Kosovo, there is a lack of research on children with DS. One study shows that these children experience delays in kinetic development (Beqaj et al., 2018). These delays can have

profound implications for children with DS development and quality of life. Motor skills are foundational for independent living, social participation and cognitive development. Therefore, further research is crucial to accurately characterize the specific kinetic development challenges faced by children with DS in Kosovo and to identify early predictors of kinetic difficulties.

The purpose of this study is to evaluate balance skills, specifically the ability to perform kinetic activities requiring postural control in children with DS compared to their typically developing peers.

## **2. METHODS**

### **2.1. Participants**

The research was conducted on children with Down Syndrome (DS) who were evaluated at the Down Syndrome Kosova Association (DSK), including 30 children from Prishtina, Prizren and Ferizaj during January to May 2022. A control group of 30 children with typical development was evaluated at the elementary school “Daut Bogujevci” in Fushë Kosovë. This school was chosen due to its smaller class sizes and ethnically diverse student population,

The selection of children was done randomly, all students within the defined age range had an equal opportunity to be part of the study. Participants in the control group were drawn from grades 1 to 4, including three classes from the first grade and two classes from each of the second, third and fourth grades. To select participants, we randomly chose 2 children's ordinal number 1 and 15 from each of the 3 first-grade classes. From the second to fourth grades, we randomly selected 4 children ordinal number 1, 7, 15, 23, from each class. Inclusion criteria for the control group were children between 6 to 12 years old. Exclusion criteria were children with physical disabilities, mental disabilities and those with acute medical conditions.

### **2.2. Tests and Procedure**

Two groups were evaluated on 14 skills related to balance, assessed using the Pediatric Balance Scale (PBS) test (Berg et al., 1992b). It assesses 14 specific balance skills, including: sitting to standing, standing to sitting, transfers, standing unsupported, sitting unsupported, standing with eyes closed, standing with feet together, standing with one foot in front, standing on one foot, turning 360 degrees, turning to look behind, retrieving object from floor, placing alternate foot on stool, reaching forward with outstretched arm.

Each test is scored from 0 points (lowest function) to 4 points (highest function). The evaluation was done by first author A.I, in two groups. Participants were categorized by gender (male and female) and by age, grouped into four categories: 5-6, 7-8, 9-10, 11-12 years old. Permission was obtained from both the relevant institution and the parents to include the children in the research.

Evaluation was conducted in a physical therapy department for children with Down syndrome and in a classroom for children with typical development. During the evaluation, seats of different heights, support chairs, a stopwatch and a blindfold were used.

Informed consent was obtained from all parents of children included in this study. Ethical approval with number 200/2024 was approved by the law and regulation DS organization. It was also approved by school management. All procedures in this study were conducted in accordance with the principles of the Declaration of Helsinki.

### 2.3. Statistical Analyses

The data were analyzed using the SPSS (Statistical Package of Social Sciences, version 21). Results were presented in tables, including relevant statistical correlations. T-test was used to observe the variations between groups, allowing for a detailed comparison of the means. Descriptive statistics were calculated to present characteristics of the data. Significance was set at  $p < 0.01$ .

## 3. RESULTS

Table 1 presents the descriptive analysis of the participants ages. The total sample included 60 children, divided into 4 age groups, 12 children or 20% were 5-6 years old, 15 children or 25% were 7-8 years old, 19 children or 31.7% were 9-10 years old and 14 children or 23.3% were 11-12 years old.

**Table 1.** Descriptive analysis of the distribution of respondents by age groups (5-12 years)

Years (group)	Frequency	Percent	Valid Percent	Cumulative percent
5-6	12	20.0	20.0	20.0
7-8	15	25.0	25.0	45.0
9-10	19	31.7	31.7	76.7
11-12	14	23.3	23.3	100.0
<b>Total</b>	<b>60</b>	<b>100.0</b>	<b>100.0</b>	

Table 2 provides the results of the independent samples t-test for overall balance performance between children with DS and those with typical development.

**Table 2.** Independent sample t-test and Levene’s test for equality of variance on balance score

Balance	Levene’s Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	Df	p	Mean Difference	Std. Error Difererence	95% Confidence Interval of the Difference	
								Lower	Upper
<b>Equal Variance assumed</b>	36.948	.000	-5.950	58	.000	-11.7667	1.97747	-15.7250	-7.80833
			-5.950	29.933	.000	-11.7667	1.97747	-15.8056	-7.72776
<b>Equal variances not assumed</b>									

The t-test results indicated statistically significant differences ( $p < 0.01$ ). Overall, the analysis showed significant variations between children with Down syndrome and those with typical development in the performance of the 14 activities included in the balance test. In the following, Table 3 presents the analysis of relevant variations of PBS tasks between two groups, children with DS and those with typical development.

**Table 3.** Independent samples t-test and Levene’s test for equality of variance on items of PBS scale

	Levene's Test for Equality of Variances		Df	p	t-test for Equality of Means							
					Mean Difference	Std. Error Difference	95% Confidence Intervals					
							Lower	Upper				
<b>Sitting to standing</b>	Equal variances assumed	9.6	.003		.155							
						-1.43	58					
						-1.43	29.0					
<b>Standing to sitting</b>	Equal variances assumed	27.1										
						-2.44	58	.018	-433	.177	-788	-078
						-2.44	29.0	.021	-433	-177	-796	-070
<b>Transfers</b>	Equal variances assumed	31.2	.000									
						-2.64		.011	-433	-163	-761	-.105
						-2.64		.013	.433	.163	.768	.098
	Equal variances											

	not assumed										
<b>Standing unsupported</b>	Equal variances assumed	4.2	.043								
	Equal variances not assumed			-1.0	58			-.033	.033	-1.100	.033
				-1.0	29.0			-.033	.033	-.101	.034
											.326
<b>Sitting with band unsupported</b>	Equal variances assumed	16.9	.000								
	Equal variances not assumed			-1.96	58	.054		-.300	.152	-.605	.005
				-1.96	29.0	.059		-.300	.152	-.612	.012
<b>Standing unsupported with eyes closed</b>	Equal variances assumed	48.5	.000								
	Equal variances not assumed			-3.99	58	.000		-.966	.242	-1.45	
				-3.99	29.0	.000		-.966	.242	-1.461	
											-.471
<b>Standing unsupported with feet together</b>	Equal variances assumed	69.7	-0.000								-.719
	Equal variances not assumed			-4.80	58			-1.233	-.256	-1.747	
				-4.80	29.0			-1.233	.256	-1.758	
											.000
<b>Standing unsupported one foot in front</b>	Equal variances assumed			-6.4		.000		-2.000	.309	-2.619	-1.38
	Equal variances not assumed			-6.4		.000		-2.000	.309	-2.625	-1.37
					39.0						
<b>Standing on one</b>	Equal variances assumed	8.9	.004								
	Equal variances not assumed			-6.27	58	.000		-1.600	.254	-2.110	-1.08
				-6.27	39.1	.000		-1.600	.254	-2.115	-1.08
<b>Turn 360 degrees</b>	Equal variances assumed	92.8	.000								.001
	Equal variances not assumed			-3.52	58			-.500	.141	-.783	-.216
				-3.52	29.0			-.500	.141	-.790	-.209
<b>Turning to look behind left &amp; right shoulders while standing still</b>	Equal variances assumed	61.4									
	Equal variances not assumed			-3.06	58	.003		-.500	.163	-	-.172
				-3.06	34.0	.004		-.500	.163	.8271	-.167
										-.832	

<b>Pick up Object from the floor from a standing position</b>	Equal variances assumed			-3.35	58	.001	-166	-228	-1.22	-309
	Equal variances not assumed			-3.35	29.0	.002	-766	-228	-1.23	-299
<b>Placing alternate foot on step stool while standing unsupported</b>	Equal variances assumed	35.0								
	Equal variances not assumed			-4.53	58	.000	1.366	.301	-1.969	.763
<b>Reaching forward with outstretched arm while standing</b>	Equal variances assumed	76.1	.000							
	Equal variances not assumed			-4.95	58	.000	-1.366	.275	-1.918	-.814
				-4.95	29.8	.000	-1.366	.275	-1.929	-.803

The results in the table above show the significant variations between the two groups of children. These variations are evident in all activities excluding the fourth activity standing unsupported, which has no significant variations between the children with DS and those with typical development ( $p>0.05$ ).

There are also variations in the first activity which is sitting to standing, that shows that there are children with DS over the age of 5 who can't go from sitting to standing without additional help. Moreover, there are greater variations in the activities such as standing unsupported with closed eyes, with legs together, climbing on a chair or stretching with arms forward. Children with DS had more difficulty performing these tasks or were unable to do them compare to their peers with typical development.

T-test analysis presents significant differences in all activities ( $p<0.05$ ) except for standing unsupported ( $p=0.43$ ), whereas there are greater variations in other activities between the two groups. Some of the activities with greater variations are standing to sitting ( $p<0.00$ ), standing unsupported with eyes closed ( $p<0.00$ ), standing unsupported one foot in front ( $p<0.00$ ) and placing alternate foot on a step stool while standing unsupported ( $p<0.00$ ). Overall, the t-test confirmed statistically significant differences in balance abilities across 13 of 14 PBS items.

#### **4. DISCUSSION**

The primary finding of the present study is that children with DS develop balance skills more slowly compared to children with typical development. Standing position and the ability to walk as a part of motor development, are the most common balance abilities that are affected and delayed at children with DS (Malak et al., 2015) .

Similar findings were reported in other studies, where motor development of children with DS is significantly delayed due to structural brain differences (Malak et al., 2013). These children have inefficient compensatory strategies such as increased step width, increased frequency of the mediolateral center of pressure displacement, decreased anteroposterior displacement, increased trunk stiffness, and increased posterior trunk displacement to maintain balance (Jain et al., 2022). As DS is characterized by interindividual variations; therefore, a thorough assessment is required before implementing a structured intervention to improve kinetic and balance function (Jain et al., 2022).

In our study, the participants were divided into four groups, with the largest group (31%) being 9 to 10 years old. In contrary Abd El-Hady et al. (2018) divided their participants in three groups. The age range of our sample was 5 to 12 years, which is similar to the range of 5 to 11 years participants in the study by Marianna Alesi et al. (2022).

The theoretical framework provides many details regarding the issue of what may be the cause of poor balance in children with DS (Gutiérrez-Vilahué & Guerra-Balic, 2021). In addition to basic research to see if there are variations in the development of balance in children with DS, there are also studies that explain the correlation between kinetic delays and physiological functioning (Jung et al., 2017). One study explains that children with DS have weak trunk muscles and poor balance (Granacher et al., 2012) Also, trunk muscle strength, mainly trunk extensors, affects the functional balance during sitting, standing, and transfers (Jain et al., 2022). Preyal et al. (2022) in their systematic review, and Hee-Kyoung Jung et al. (2017) found that children with DS have lower performance compared to their peers with typical development in terms of balance activities, consistent with our results. Balance skills of children with DS were significantly below age norms, particularly in dynamic balance and did not match their peers with typical development. The dynamic aspects of the balance were more affected than the static (Nadeesha Kalyani & Wanigasinghe, 2021).

Our t-test analysis shows that in general there are significant differences with  $p < 0.01$  between children with DS and those with typical development for the performance of the 14 activities that include the balance test, evaluated by PBS. Similar data were found by Nadeesha Kalyani &

Wanigasinghe (2021). Both studies investigated motor development in children with DS, focusing on specific motor skills, which likely contributed to the observed similarities in findings. For instance, sitting to standing revealed that some children with DS over age 5 were unable to perform the task without additional help, as noted also by Jain et al. (2022).

Our results emphasize the importance of comprehensive assessment of balance skills in children with DS, beyond general observations. Particularly difficult tasks included standing unsupported with closed eyes, with legs together, climbing on a chair or reaching with arms forward. Children with DS had more difficulty to perform these tasks or were unable to do them compared to typically developing peers. Hee Kyoung et al. (2017) also reported similar limitation, reinforcing that dynamic tasks pose more challenges than static ones (Jung et al., 2017).

In summary, our results, reveals statistically significant differences ( $p < 0.01$ ) between children with DS and those with typical development in 13 of 14 items on Pediatric Balance Scale. These findings have important clinical implications, as they emphasize the need for early identification and targeted interventions to improve balance and prevent secondary complications. By documenting the specific kinetic challenges of children with DS in Kosovo, this study raises awareness among healthcare professionals, educator and families. It supports advocacy for improved healthcare, educational and social support services for children with DS.

## 5. CONCLUSIONS

Children with Down syndrome have significant impairments in balance skills compared to their typically development peers. Activities such as standing unsupported with eyes closed, standing with feet together, climbing on a chair, and reaching forward showed significant difference between children with DS and their peer with typical development. No gender related differences were detected across any task. The ability to stand unsupported, or standing in a vertical position without support, does not show specific variations between the two groups, therefore static balance is less affected compared to dynamic balance.

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