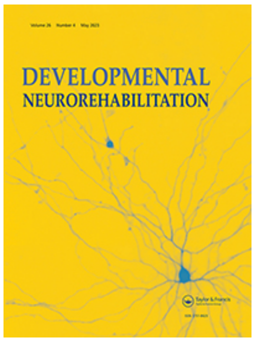

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An investigation of the effects of dual-task balance exercises on balance, functional status and dual-task performance in children with Down syndrome

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ABSTRACT

Purpose: To investigate the effects of dual task (DT) balance exercises on functional status, balance, and DT performance in children with Down Syndrome (DS).
Methods: Participants were divided into two groups: intervention group (IG; $n = 13$) and control group (CG;$n = 14$). WeeFIM was used to measure the functional independence level and balance was evaluated using the Pediatric Balance Scale. DT performance was assessed using Timed Up and Go, Single Leg Stance, Tandem-Stance and 30 s Sit to Stand tests without concomitant task, with motor task or cognitive task. The IG received 16 sessions of DT training twice a week for 8 weeks.
Results: Functional level, balance, and DT performance improved significantly in the IG, whereas only balance improved in the CG. Significantly better results were achieved in the IG, as demonstrated by greater pre/post-treatment changes.
Conclusion: DT balance exercises improved functional level, balance and DT performance of children with DS.

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balance; cognition; Down syndrome; dual task; motor skills

Introduction

Down syndrome (DS) is a common genetic disorder which is associated with neurodevelopmental problems.[1] Neuromuscular anomalies such as hypotonia and muscle weakness, as well as intellectual disability and sensory integration disorders cause balance problems in individuals with DS.[2] Slow postural responses leading to balance impairment and failure to maintain stability have been reported in children with DS. It was suggested that balance problems in children with DS result from defects in the central nervous system structures involved in postural mechanisms.[3] Functional balance should be considered in physical therapy of children with DS because balance may affect development of motor skills, especially those that are developed in childhood.[4] Therefore, the development of motor abilities should be aimed in order to improve postural control in individuals with DS.[5]

Dual tasks (DT) have been proposed as a valid approach to investigate the interaction between cognitive and motor domains in individuals with neuromotor disorders, such as DS and Developmental Coordination Disorder (DCD).[6,7] The cross-domain effects of impairments in executive functions (EF) play a decisive role in deficits in motor performance, particularly in locomotion. EFs include high-order cognitive abilities, such as cognitive flexibility, inhibitory control, and working memory.[8] Deficits in executive function cause impairment of cognitive, motor, and DT skills, resulting in difficulties in performing activities of daily living.[9] The inability of children with DS to perform multiple tasks simultaneously has been reported in several studies.[6,10,11]

There are studies that reported the effects of dual-task exercise programs on functional mobility and balance in a variety of disease states.[12,13] Those studies have mostly focused on geriatric individuals and patients with neurological conditions.[14,15] It has been argued that since gait and balance are trainable in individuals with DS, there is a need to develop appropriate exercise and motor skill interventions during childhood and adolescence to increase strength, stability, and achieve more robust motor performance. Performing under DT conditions requires the ability to focus and attend to simple and complex movements and needs to be taught, practiced, and reinforced.[16] Previously, it has been shown that motor training programs can improve overall motor performance[17] as well as gait and balance performances.[18] Individuals with cognitive deficiencies should be exposed to developmentally appropriate motor training programs that not only facilitate movement but also require increased attention during task performance. Children with DS can improve their temporal and spatial components of gait by focusing on attention and cognitive engagement.[16] It was underscored that this approach would provide improvement in motor performance, especially in gait and balance performance.[16]

Assuming that motor actions result from an interplay of perceptual, cognitive and neurological mechanisms, neuromotor dysfunction is expected to interfere with the central coordination processes required to perform DT, leading to limited

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performance in children with DS.[19] However, most of the studies involved training programs to improve physical function only, leaving the cognitive aspect aside, and aimed to reduce the risk of falls or improve balance and gait function.[20] Studies on motor-cognitive interference in children with neuromotor disorders were only recently published, and especially dual-task studies in children with intellectual disabilities, such as DS are rare. One study showed that children with DS have greater difficulties in the motor domain under DT conditions. The extent of interaction between cognitive profiles and motor control in children with DS is still largely unexplored.[19] Taking into account the existing knowledge gap and research avenues proposed in the literature, this study aimed to investigate the effects of dual-task balance exercises on functional status, balance, and DT performance in children with Down syndrome.

Materials and Methods

Participants

A total of 27 children with Down syndrome (7–18 years of age) were enrolled in this randomized controlled study, which was conducted between January and July 2021. The subjects were randomly assigned to two groups using the coin toss method: intervention group ($n = 13$) and control group ($n = 14$). Power analysis and sample size calculations were performed using the G*Power, version 3.1.9.7 (Heinrich Heine Universität Düsseldorf, Düsseldorf, Germany). The power analysis showed that a minimum sample size of 13 subjects per group would be needed to detect a significant difference between the groups in terms of Timed Up and Go and WeeFIM outcomes at the end of the study ($\beta = 0.20$, $\alpha = 0.05$). The effect size was estimated by dividing the difference between the means of two groups by their standard deviation. The power of the study was estimated at 83% ($d = 1.2$) based on post hoc power analysis.

The researcher recruiting the participants in the study and the physiotherapist assessing the children were blinded to group allocation. The parents of the children were explained about the purpose, scope, and duration of the study, and written informed consent was obtained from the parents prior to initiation of the study.

Inclusion and Exclusion Criteria

Children (7–18 years of age) diagnosed with Down syndrome by a pediatric physician, who were cooperative, able to walk without assistance and comprehend instructions were included in the study. Since obesity could adversely affect balance performance, children with a body mass index (BMI) of ≥30 kg/m^2 (obese) were excluded. Also, children with orthopedic problems affecting gait, cognitive impairment that interferes with communication, any neurological problems and those actively participating in sports were excluded from the study.

Ethical Considerations

Approval for the study was obtained from the Institutional Review Board of Hasan Kalyoncu University, Faculty of Health Sciences (No. 2020/055).

Assessment Tools

Data on age, sex, body weight, height, BMI, comorbidities (cardiac, respiratory, nutritional problems, hearing/vision impairment, thyroid dysfunction, epilepsy, hip dysplasia, patellar subluxation and other problems, if any) were collected. In addition, the parents were questioned about sociodemographic characteristics and clinical manifestations. Intelligence level of the children was assessed by a psychologist using the IQ (Intelligence Quotient) test and IQ values were noted.

WeeFIM was used to assess functional ability of the children. Balance was evaluated using the Pediatric Balance Scale, functional mobility using the Timed Up and Go test, balance, and postural steadiness using the Single Leg Stance Test, static balance using the Tandem Stance test, and lower limb strength and dynamic balance using the 30 s Sit to Stand test.

All measurements were verbally explained to each child before conducting any test using visual aids. During measurements, verbal instructions were frequently provided, and the subjects were asked to perform the secondary task concurrently with the primary task. The primary task was simulated by the physiotherapist (assessor), matched with the pace of the subjects, to motivate them to complete the given task. Task performance was constantly monitored by the physiotherapist throughout the sessions. All measurements were obtained twice, and the second measurement was recorded. Initial and final assessments were conducted by the same physiotherapist.

Assessment of Functional Independence

The Functional Independence Measure for Children (WeeFIM) is an assessment tool used to evaluate a child's performance in basic daily living and functional skills in children from 6 months to 7 years of age and children with neurodevelopmental disabilities from 6 months to 21 years of age. The WeeFIM has been used in many pediatric conditions, such as spina bifida, cerebral palsy and genetic diseases.[21] The tool consists of 18 items in 3 main domains including self-care, mobility, and cognition. Each item is assigned a score between 1 and 7. Final summed score ranges from 18 (complete dependence) to 126 (complete independence).[22]

Balance Assessment

The Pediatric Balance Scale (PBS), a modified version of the Berg Balance Scale (BBS) developed by Franjoine et al.,[23] was used to evaluate functional balance in activities of daily living. The PBS consists of 14 items that are scored from 0 to 4 points, with a maximum possible score of 56 points. The PBS features a number of minor modifications to BBS, including reduced time for maintenance of static postures, clarification of directions and reordering of test items.[23]

Assessment of Dual Task Performance

In order to evaluate DT performance of the subjects, Timed Up and Go, Single Leg Stance, Tandem Stance and 30 s Sit to Stand tests were conducted in three different conditions:

Table 1. Assessment of Dual Task Performance.

1) Without Concomitant Task	2) With Cognitive Task	3) With Motor Task
Timed Up and Go Test	Naming colors in the room	Carrying an empty box
Single Leg Stance Test	Saying names of relatives	Arms flexed to 90°
Tandem Stance Test	Saying names of fruits and vegetables	Arms flexed to 90°
30-Second Sit to Stand Test	Saying names of friends	Arms abducted to 90°

without concurrent task, with cognitive task and with motor task. Table 1 presents the details of DT performance assessment.

Timed Up and Go (TUG) Test

The Timed Up and Go (TUG) test assesses functional mobility. Although it is used as a dynamic balance test in adults, Williams et al. adapted the test for use in children and demonstrated its validity and reliability in healthy and disabled children.[24] For this test, the subject wearing their regular footwear is asked to stand up from a chair, walk the designated distance of 3 m at a comfortable and safe pace, turn, walk back to the chair and sit down again. The time in seconds is recorded using a stopwatch.[25]

Single Leg Stance Test

The Single Leg Stance (SLS) test is used to assess balance and postural steadiness in a static position in children.[26] For this test, the subject is asked to lift one leg while standing unassisted and try to stay in this position as long as possible. The time until the foot touches the ground is recorded in seconds using a stopwatch. The test is considered as completed in individuals standing on one leg for 30 s at a single trial.[27]

Tandem Stance Test

In the Tandem Stance test, the subject is asked to assume a standing posture, placing his feet in heel-to-toe position, with one foot directly in front of the other. Thereby, the base of support is narrowed and static balance is assessed. The test is terminated when the subject cannot maintain this position and timed in seconds using a stopwatch. The test is not repeated in individuals who are able to hold the tandem stance for 30 s.[28]

30-Second Sit to Stand Test

For this test, the child is asked to stand up from a chair (seat height 43 cm) with a straight back without arm rests, with arms crossed over the chest, then sit back down again and repeat it for 30 s. The number of times the child stands in 30 s is recorded. This test assesses lower limb strength and dynamic balance.[29]

Treatment Protocol

The control subjects who did not receive any exercise training were evaluated at 8-week intervals. The intervention group received a total of 16 sessions of DT balance training, 2 sessions per week for 8 weeks. Each session lasted 30 min on average. The session was stopped when the exertion level exceeded 60% of maximal heart rate.

The content of the DT training program is summarized below.

1) Walking 3 m on hard/soft ground

- Walking 3 m on hard/soft ground while performing a motor task (carrying an empty box) (21 × 27 × 18 cm)
- Walking 3 m on hard/soft ground combined with a cognitive task (saying the names of some fruits and vegetables),

2) Sitting on a Pilates ball with the feet touching the floor

- Sitting for 1 min with eyes open/closed while performing a motor task (arms flexed to 90 degrees),
- Sitting for 1 min with eyes open/closed combined with a cognitive task (saying the names of friends),

3) 2-feet forward jumps for 3 meters

- Jumping forward with both feet for 3 m while performing a motor task (carrying an empty box),
- Jumping forward with both feet for 3 m combined with a cognitive task (naming the colors in the room),

4) Standing on one leg

- Standing on right/left leg for 30 s while performing a motor task (arms abducted to 90 degrees),
- Standing on right/left leg for 30 s combined with a cognitive task (saying the names of relatives),

5) Sit-to-stand using a stool

- Sit-to-stand with 15 repetitions while executing a motor task (carrying an empty box)
- Sit-to-stand with 15 repetitions combined with a cognitive task (saying the names of some fruits and vegetables)

Since our study was conducted during the COVID-19 pandemic, the participants have not been involved in any exercise and physiotherapy program recently. Our study was initiated during gradual lifting of COVID-19 restrictions when patients started going to rehabilitation centers regularly. Care was taken to avoid possible transmission of COVID-19 among the participants by taking precautions such as physical distancing, wearing a face mask and implementation of hygiene measures. Due to restrictions imposed by the pandemic, the number of participants who received training in rehabilitation centers had to be kept at a certain level. While the children assigned to the study group started the training program, the children in the control group had to wait to receive treatment in accordance with the rules of social isolation limiting the number of people allowed in confined spaces. During this time, initial and final assessments of the control group were noted. The parents of the control children, who were in line to receive rehabilitation services, were informed that the same training will be provided to their children at the end of the study.

Data Analysis

SPSS (Statistical Package for the Social Sciences), version 20.0 (IBM Corp., Armonk, NY) was used for statistical analysis. The descriptive statistics were summarized as frequency and percentage (%) for categorical variables, and arithmetic mean and standard deviation (X±SD) for numerical variables. The normality of data distribution was checked using Kolmogorov–Smirnov test. Nonparametric tests were used due to non-homogeneous distribution of the study data. The study and control groups were compared using Mann–Whitney U test. Wilcoxon signed-rank test was used to compare pre- and post-treatment data between the groups. The significance level was set at $p < .05$ for all statistical analyses.

Results

Demographic and physical characteristics of the study population are shown in Table 2. The mean age, height, body weight, IQ score, BMI of the participants and maternal age at delivery were similar between the intervention and control groups ($p > .05$). The study sample consisted of 9 girls and 18 boys. Among the children, 14 had moderate intellectual disability, 12 had mild intellectual disability and 1 had severe intellectual disability. The comorbidities of the subjects included speech problems ($n = 18$), vision problems ($n = 8$), heart defects ($n = 5$) and other problems ($n = 6$). Five subjects had no comorbidities.

Pre- and post-treatment comparisons within the groups showed a difference in WeeFIMT (WeeFIM Total Score), WeeFIM1 (Self-care) and WeeFIM5 (Communication) scores in the intervention group only and in PBS scores in both groups ($p < .05$). On between-group comparisons, greater mean pre- and post-treatment changes in WeeFIMT, WeeFIM5 and PBS scores were found in the intervention group versus control group ($p < .05$) (Table 3).

Within-group comparisons revealed significant improvements in Timed Up and Go and Single Leg Stance measurements at three conditions tested (without concurrent task, with cognitive and motor tasks) only in the intervention group ($p < .05$). Between-group comparisons showed a reduction in

Table 2. Demographic and physical characteristics of the study population.

Demographic characteristics	Intervention Group ($n = 13$) X±SD (min-max)	Control Group ($n = 14$) X±SD (min-max)	z	p
Age (years)	12.08 ± 2.56(8–18) (8–18)	1.86 ± 4.09(7–17) (7–17)	−1.123	.262
Height (cm)	138.46 ± 11.77(117–162) (117–162)	129.93 ± 19.55(97–165) (97–165)	−1.239	.215
Body weight (kg)	43.23 ± 12.05(27.1–66) (27.1–66)	43.43 ± 18.69(18.5–80) (18.5–80)	−0.364	.716
Body mass index (kg/m 2	22.01 ± 3.12(15.8–26.6) (15.8–26.6)	24.41 ± 4.25(17.3–29.4) (17.3–29.4)	−1.383	.167
Maternal age at delivery (years)	3.85 ± 12.08(16–59) (16–59)	33.14 ± 9.54(17–49) (17–49)	−0.657	.511
IQ Score	5.23 ± 1.24(37–67) (37–67)	48.71 ± 11.27(32–68) (32–68)	−0,364	.720

*$p < .05$: statistically significant, IQ: Intelligence Quotient. Mann-Whitney U test, X±SD: Mean ± standard deviation.

Table 3. Within-Group and Between-Group Comparisons of WeeFIM, Pediatric Balance Scale, Timed Up and Go and Single-Leg Stance Measurements.

	Intervention Group ($n = 13$)				Control Group ($n = 14$)				Between-Group Difference
	Pre-T X ± SD	Post-T X ± SD	Within-group change (Δ)	Pa	Pre-T X ± SD	Post-T X ± SD	Within-group change (Δ)	Pa	Pb
WeeFIMT	111.85 ± 7.90	114.54 ± 6.91	+2.69 ± 2.13	.003*	109.14 ± 14.73	11.07 ± 13.86	+.93 ± 1.97	.066	.007*
WeeFIM1	34.69 ± 5.28	35.69 ± 4.62	+1 ± 1.35	.038*	35.28 ± 6.69	35.69 ± 4.62	.41 ± 1.28	.181	.243
WeeFIM2	12.69 ± 1.65	13.07 ± 1.32	.38±.65	.059	12.21 ± 3.59	12.35 ± 3.64	.14±.36	.157	.283
WeeFIM3	21.0±.00	21.0±.00	0±.00	1.000	21.0±.00	21.0±.00	0±.00	1.000	1.000
WeeFIM4	14.0±.00	14.0±.00	0±.00	1.000	13.42 ± 1.5	13.42 ± 1.51	0±.00	1.000	1.000
WeeFIM5	1.84 ± 2.44	11.61 ± 1.98	.76±.92	.014*	9.85 ± 2.5	1.0 ± 2.38	.15±.53	.311	.011*
WeeFIM6	18.61 ± 2.81	19.15 ± 2.44	.53 ± 1.19	.109	17.35 ± 4.41	17.5 ± 4.46	.15±.53	.311	.255
PBS	5.00 ± 2.00	53.38 ± 1.50	+3.38 ± 1.38	.001*	49.50 ± 4.99	5.64 ± 4.31	+1.14 ± 1.83	.027*	.001*
TUG1	12.02 ± 3.07	8.84 ± 3.34	−3.18 ± 1.59	.001*	1.65 ± 4.71	1.00 ± 4.31	−.65 ± 1.60	.108	.001*
TUG2	19.47 ± 5.87	12.78 ± 4.24	−6.69 ± 3.17	.001*	14.31 ± 7.99	13.71 ± 6.91	−.60 ± 1.60	.196	.001*
TUG3	14.05 ± 3.92	9.73 ± 4.12	−4.32 ± 1.95	.001*	12.46 ± 5.98	11.81 ± 5.30	−.65 ± 2.24	.814	.001*
SLS1	3.88 ± 1.90	9.98 ± 9.27	+6.1 ± 8.47	.001*	8.73 ± 1.38	8.58 ± 9.53	−.15 ± 1.36	.552	.001*
SLS2	2.99 ± 1.86	6.72 ± 5.21	+3.73 ± 4.99	.001*	8.28 ± 1.46	8.75 ± 11.18	+.47 ± 1.64	.382	.009*
SLS3	3.47 ± 3.33	8.84 ± 1.05	+5.37 ± 7.09	.001*	7.48 ± 9.50	7.88 ± 9.55	+.40 ± 1.45	.328	.001*

$p < .05$: statistically significant, X±SD: mean ± standard deviation, Pre-T: pre-treatment, Post-T: post-treatment, WeeFIMT: Functional Independence Measure for Children Total Score, WeeFIM1: Self-care, WeeFIM2: Sphincter Control, WeeFIM3: Transfers, WeeFIM4: Locomotion, WeeFIM5: Communication, WeeFIM6: Social Cognition, PBS: Pediatric Balance Scale, TUG1: Timed Up and Go test without concomitant task, TUG2: Timed Up and Go test with cognitive task, TUG3: Timed Up and Go test with motor task, SLS1: Single Leg Stance Test without concomitant task, SLS2: Single Leg Stance Test with cognitive task, SLS3: Single Leg Stance Test with motor task, $P_{a:}$ Wilcoxon Signed-Rank Test,$P_{b:}$ Mann-Whitney U test.

Table 4. Within-Group and Between-Group Comparisons of Tandem Stance and 30 s Sit to Stand Test Results.

	Intervention Group (*n* = 13)				Control Group (*n* = 14)				Between-Group Difference
	Pre-T X ± SD	Post-T X ± SD	Within-group change (Δ)	P_a	Pre-T X ± SD	Post-T X ± SD	Within-group change (Δ)	P_a	P_b
TST1	4.66 ± 4.79	16.57 ± 13.93	+11.91 ± 14.20	0.002*	14.35 ± 15.53	15.27 ± 14.79	+0.92 ± 3.17	0.683	.001*
TST2	2.67 ± 3.47	10.00 ± 7.10	+7.33 ± 6.95	0.002*	13.27 ± 14.93	13.59 ± 14.18	+0.32 ± 1.35	0.386	.001*
TST3	3.26 ± 4.81	11.59 ± 9.90	+8.33 ± 9.16	0.002*	12.79 ± 13.44	13.72 ± 13.16	+0.93 ± 2.19	0.110	.002*
30STS1	9.00 ± 2.68	13.23 ± 3.77	+4.23 ± 3.03	0.003*	9.57 ± 3.78	9.64 ± 3.52	+0.07 ± 1.43	0.852	.001*
30STS2	4.54 ± 2.07	8.00 ± 1.87	+3.46 ± 1.85	0.001*	8.14 ± 5.25	8.29 ± 5.00	+0.15 ± 1.29	0.713	.001*
30STS3	8.77 ± 2.77	13.46 ± 4.31	+4.69 ± 3.11	0.002*	8.43 ± 3.84	8.86 ± 3.68	+0.43 ± 1.50	0.277	.001*

p < .05, statistically significant, X±SD: mean ± standard deviation, Pre-T: pre-treatment, Post-T: post-treatment, TST1: Tandem Stance Test without concomitant task, TST2: Tandem Stance Test with cognitive task, TST3: Tandem Stance Test with motor task, 30STS1: 30-Second Sit to Stand Test with motor task, 30STS2: 30-Second Sit to Stand Test with cognitive task, 30STS3: 30-Second Sit to Stand Test with motor task, P_a: Wilcoxon signed-rank test, P_b: Mann-Whitney U test.

mean changes in time to complete Timed Up and Go test at all three conditions in the intervention group versus control group (*p* < .05). However, an increase was found in the intervention group in the mean pre- and post-treatment changes in Single Leg Stance Test times measured at all 3 conditions compared to control group (*p* < .05) (Table 3).

Within-group comparisons showed improvements in measurements from Tandem Stance and 30-Second Sit to Stand tests at all three conditions only in the intervention group (*p* < .05). On between-group comparisons, an increase in mean changes was observed in Tandem Stance test measurements at all three conditions in the intervention group compared to control group (*p* < .05). Greater mean pre- and post-treatment changes were found in 30 s Sit to Stand test scores at all three conditions in the intervention group versus control group (*p* < .05) (Table 4).

Discussion

In this study, we investigated the effects of DT balance exercises on balance and functional status in children with Down syndrome, improvements were observed in functional level, balance and DT performance.

By modulating the interaction between cognitive and functional domains, DT activities may improve balance, functional ability and DT performance.[6] Effectiveness of DT training has been investigated in people with a variety of health conditions. There are studies examining the effects of DT functional exercises on balance in adolescents with intellectual disabilities. These studies have reported favorable effects of DT exercises on balance and performance in functional tasks of daily life.[11,30] Lee at al. reported that the DT exercise training provided improvements in balance and gross motor functions in children with spastic diplegia.[31] In a study on geriatric individuals with chronic stroke, improvements were reported in functional independence level with the use of walking with DT training combined with conventional stroke rehabilitation.[32]

It is known that DT paradigms improve not only the functional ability but also balance performance. Plummer et al. suggested that DT training might be a promising approach for improving gait and balance.[33] DT exercise training proved to be effective in improving motor skills and balance performance, with beneficial effects maintained after the intervention in children with cognitive disability.[34] Pellecchia et al. evaluated balancing skills in healthy young to middle-aged adults assigned to single task, DT or no training groups. At the end of the training, only the dual-task training group was able to decrease their dual-task body sway to single-task levels.[35] In our study, improvement was observed in balance in both intervention and control groups. We consider that the improvement in the control group was related to the learning effect, by which the subjects become familiar with the task and practice the exercises in daily life. Therefore, at the time of the second assessment, individuals may perform better by focusing more on the activities. While individuals generate ideas to figure out how to act in the face of or adapt to new conditions (i.e., tasks) during the first trial, they perform better in subsequent trials due to working memory.[36] A similar situation may have occurred in our study. The analyses on the between-group differences showed better balance performance in the intervention group. Thus, DT training can provide improvements in balance, adaptation to daily life and functional independence in individuals with DS. We believe that DT training may be beneficial in pediatric syndromes associated with balance problems.

Although dual tasking has become a popular training to improve functional ability in recent years, few studies examining the relationship between functional independence and DT training are available in the literature.[32] However, it has been shown that motor and cognitive dual-task exercises increase the gait speed, stride length, cadence, gait performance and functional independence.[37] Sahu et al. reported that dual-task exercise training increased the level of functional independence by reducing the number of falls in patients with Parkinson's disease.[38] In the current study, the functional independence level including self-care and communication skills improved in the intervention group but not in the control group. The analysis of the difference between the groups showed improvement in total functional independence level and communication skills in the intervention group.

In general, the term dual-task refers to the ability to perform two tasks simultaneously.[13] In our daily lives, we simultaneously perform multiple tasks involving self-care skills, such as eating, washing hands and faces, bathing, dressing, and toileting.[39] Thus, performing dual tasks together with exercises in our study may have improved the self-care skills of the individuals in the intervention group. In addition, to perform motor-cognitive dual tasks, the individuals need to understand and verbalize the desired task while executing the motor task. Since the communication skills include comprehension and verbal skills,[22] we believe that repeated execution of these tasks included in our dual-task training program may have improved communication skills of the participants.

In study by Lanfranchi et al. assessing DT performance in children with DS versus typically developing children, lower performance as well as impairment in all DT conditions were observed in children with DS.[40] In another study investigating the effects of DT conditions on movement in young adults with or without DS, a difference was observed in time-distance parameters of walking in individuals with DS compared to those without DS.[16] It is known that double-task training instead of single-task training improves motor mobility performance.[41] Therefore, DT exercise training can be used to achieve improvements in a variety of time-based performance tests in individuals with DS. When post-treatment DT performance of the intervention group was evaluated, improvements were observed in DT performance without concomitant task as well as with cognitive and motor tasks. However, there was no improvement in the DT performance in the control group. When the study groups were compared, the intervention group showed better results on each test versus control group. Our findings are in line with previous reports.

We think that physical activities as well as DT training contributed to the improvements seen in the intervention group in our study. Activities such as sitting, standing and standing on one leg were used both for assessment and therapeutic purposes. Muscle activations during these activities may have contributed to favorable effects on functional independence level and balance by improving motor control. Furthermore, it is well known that physical activity affects brain function by increasing the levels of various neurotransmitters, such as dopamine and serotonin in the central nervous system.[11] This may explain improved balance performance and independence level in DS, which is associated with neuromotor impairment.

We consider that, understanding the role of exercise training focused on dual-task performance for individuals with DS may be useful for developing practical strategies and guidelines on specific interventions for populations with intellectual disabilities. There is a need for further studies on DT training programs in individuals with DS. Such studies may provide more insightful data through assessment of gains with DT training by assigning DT training to the intervention group and an exercise training program without a simultaneous task to the control group or allocation of one group to motor–motor DT training and another group to motor-cognitive DT training. Inclusion of gait analysis may also provide a different perspective.

In our study, five children with heart disease had septal defects in infancy. The children included in our study had no active cardiac pathology. The study subjects underwent cardiac examinations on a regular basis by a cardiologist, and none showed or developed heart problems during the study. Children enrolled in our study had varying degrees of intellectual disability. It has been reported that children with mild intellectual disability can develop the adaptive skills required to perform activities of daily living because intellectually they are very close to normal. On the other hand, children with moderate intellectual disability can acquire social adaptation, communication, self-care and daily living skills. Also, it was reported that children with severe mental disability can develop basic self-care and communication skills through special education.[42] The children included in our study did not experience any problems in understanding basic commands to perform the dual tasks.

Limitations

One of the limitations of this study was that changes in body weight of the study subjects could not be kept under control. Accordingly, the possible effects of body weight changes on balance cannot be ruled out. Another limitation was that balance was evaluated using tests that are commonly used in the clinical setting, but technological devices might have been used for this purpose. Long-term effects of DT training were not evaluated in our study. Studies involving follow-up over an extended period of time can provide useful data on long-term effects and/or maintenance of benefits of DT training. In addition, the use of DT training in combination with various exercise approaches (e.g., aerobic, resistance) may be considered for individuals with DS, which can provide valuable data on relevant outcomes. Although none of the study subjects exhibited behavioral problems at the time of screening or after enrollment in the study, 41% of the children were excluded from the study due to behavioral problems. However, this may be explained by different kinds of behavioral problems typically observed in individuals with DS, such as compulsions. This dropout rate can be taken into account by the researchers in future studies.

Conclusion

Dual-task balance exercises used in this study resulted in improvements in the functional independence level including self-care and communication skills as well as balance and DT performance in children with DS. DT exercise training can be used as a functionally effective intervention method in children with DS. It may be useful to include DT exercise training with cognitive and motor tasks in conservative physiotherapy programs in individuals with DS. We believe that DT-based exercise training can be used as an adjunctive or alternative treatment method for rehabilitation of children and adolescents with DS.

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