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Combined sensory integration therapy plus neurodevelopmental therapy (NT) versus NT alone for motor and attention in children with Down syndrome: a randomized controlled trial

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In this study, we aimed to analyze the incremental effects of sensory integration therapy (SIT) plus neurodevelopmental therapy (NT) versus NT alone on the attention and motor skills in children with Down syndrome (DS). We randomly assigned into experimental (i.e. SIT + NT; $n = 21$) and control (i.e. NT alone; $n = 21$) groups. While NT was applied to both groups for six weeks, SIT was applied simultaneously to the experimental group for six weeks. Participants' motor functions (Bruininks-Oseretsky Test of Motor Proficiency-Short form (BOT-2 SF)) and attention skills (Stroop TBAG (Turkish Scientific and Technological Research Association) Form) were evaluated before and after treatment (6 weeks later). Stroop TBAG and BOT-2 SF scores of the groups were similar at the baseline ($p > 0.05$). Significant improvement from baseline was observed in both BOT-2 SF, and Stroop TBAG results in both groups ($p < 0.05$). In addition, the improvement in both BOT-2 SF and Stroop TBAG results was found to be greater in the experimental group compared to the control group ($p < 0.01$). There were clear advantages to adding SIT to NT alone when seeking to improve motor and attention skills in children with DS.

KEYWORDS: Down syndrome, sensory integration therapy, attention, motor function, neurodevelopmental therapy

Introduction

Down syndrome (DS) is a genetic disorder caused by trisomy of the 21st chromosome (Parker *et al.* 2010). DS prevalence has been reported as 12.7 for each 10,000 live births (Heinke *et al.* 2021). Children with DS face many challenges, including delays in areas of development such as motor skills and physical fitness (Schott and Holfelder 2015). Furthermore, DS is frequently accompanied by moderate to severe intellectual disability, delayed language development, and academic problems (Wester Oxelgren *et al.* 2019). In the case of DS, intellectual disability is a broad cognitive deficiency in brain development that has associated negative effects on attention and motor skills (Ekstein *et al.* 2011, Giagazoglou *et al.* 2012). Thus, children with DS have been described by both their parents and neurodevelopmental experts as showing problems with attention, motor activities, and sensory integration (Breckenridge *et al.* 2013, Malak *et al.* 2015, Uyanik *et al.* 2003).

Motor skill development types include fine and gross motor skills and bilateral coordination (Miller *et al.* 2007), and, as noted above, motor development delays are evident in children with moderate to severe intellectual disability. Both fine and gross motor skill development have been delayed in children with DS, compared to typically developing peers (Aslan and Baş Aslan 2016, Malak *et al.* 2015, Spanò *et al.* 1999). The lower ability of children with DS to respond to changes in the environment and the uncoordinated, slower, and erratic movements suggest that children with DS are deficient in motor skills (Schott and Holfelder 2015). Delays in motor skills negatively affect these children in activities such as balance, dexterity, and game-playing resulting, and it tends to limit their participation in daily activities (Gawali *et al.* 2017, Uyanik *et al.* 2003).

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Apart from delays in motor functions, children with DS also have lower functions in attention skills. As attention is the first step in information processing, it plays an important role in learning (Ekstein *et al.* 2011, Hung *et al.* 2016). Children with DS have frequently exhibited problems in such specific attention skills as continuous auditory attention and selective visual attention (Porter *et al.* 2007, Rowe *et al.* 2006). In addition, some have reported that the prevalence of attention deficit hyperactivity disorder (ADHD) is as high as 43.9% among individuals with DS (Ekstein *et al.* 2011), although the appearance of attention problems sufficiently severe to diagnose ADHD in children with DS depends on whether the cognitive demands placed on these children are appropriate to their lower than typical mental development (American Psychiatric Association 2013). It has been reported that disturbances in attention parameters cause sensory processing disorders, decreased responsiveness, difficulties in distinguishing stimuli, and complications in proprioception and motor planning (Will *et al.* 2019). Sensory integration has been defined as the organization and interpretation of sensory information received from the body and the environment to create a meaningful adaptive response (Bumin and Kayihan 2001, Uyanik *et al.* 2003). The well-known problems that children with DS have with attention parameters relate directly to associated challenges with sensory modulation and integration (Costanzo *et al.* 2013, Kogan *et al.* 2009, Lanfranchi *et al.* 2010, Lee *et al.* 2011, Porter *et al.* 2007, Rowe *et al.* 2006).

To address the broad neurodevelopmental needs of children with DS, various interventions have been applied, including play therapy, virtual reality applications, and neurodevelopmental therapy (NT), depending on the child's individual needs (Ruiz-González *et al.* 2019). NT is an approach that aims to improve gross motor function and improve independence in individuals with neurological problems. It is thought that by stimulating the affected side to achieve the desired muscle movement, abnormal movement patterns can be corrected, and normal movement suitable for daily activities can be achieved (Zanon *et al.* 2015). Sensory integration therapy (SIT) is one of the techniques used to rehabilitate sensory integration problems. This method uses proprioceptive, vestibular, and tactile sensory signals to foster improvements in motor skills and active motor engagement to facilitate neural plasticity in the central nervous system (Ashori *et al.* 2018, Section on Complementary and Integrative Medicine *et al.* 2012). Thus, it is aimed to develop more organized behaviors by increasing the ability to process and integrate sensory information (Case-Smith and Arbesman 2008). Previous research has reported that SIT positively affects motor skills, attention, behavior control, reading skills, and participation in-game activities in children with many sensory processing or neurodevelopmental disorders such as autism, cerebral palsy, and ADHD (Lang *et al.* 2012, May-Benson and Koomar 2010, Shamsoddini and Hollisaz 2009). However, studies examining the effectiveness of SIT on motor skills and attention in DS children are limited in the literature. While Uyanik *et al.* (2003) did not show superiority of SIT, vestibular stimulation, and NT in individuals with DS, Ashori *et al.* (2018) showed that SIT applied for 2 weeks improved the attention span and motor skills of children with DS. However, the small number of participants in previous studies and short treatment protocols may be a reason for insufficient numbers of validating studies for the efficacy of SIT. Our hypothesis in this study was that SIT, administered in addition to NT, would improve attention and motor performance compared to intervention with NT alone. This study aimed to examine the effects of SIT added to NT compared to NT alone on attention and motor skills in children with DS for a total of 6 weeks.

Method

Subjects

Between December 2018 and December 2020, 50 volunteer children who were diagnosed with DS at the Special Education and Rehabilitation Center and participated in rehabilitation programs that support development, such as basic academic education and physiotherapy, participated in this study. Subjects were recruited at the Special Education and Rehabilitation Center, where they continued their rehabilitation. Children with DS who volunteered to participate in the study were evaluated by the physiotherapist and those who met the study criteria were included. Participant inclusion criteria were: (a) a diagnosis of DS by a pediatric neurologist, (b) aged between 7 and 18 years, (c) able to recognize commands given to them, (d) having the ability to read, and (e) being able to recognize colors. We excluded participants (a) with another neurodevelopmental disorder (e.g. cerebral palsy, autism, etc.), (b) who had undergone any surgical operation in the lower or upper extremities, (c) who were receiving any medical treatment, (d) who had a hearing or visual impairment, (e) who were taking part in any kind of sportive activity, and (e) who were not able to follow verbal instructions. The study was approved by the ethics committee of the University (date: 03.12.2018, number: 60116787-020/90551) and performed in accordance with the Declaration of Helsinki. Written informed consent to participate in the study was obtained from the parents of all children.

Study design

This was a prospective, randomized, and controlled study. Children with DS were randomly assigned to either an experimental group receiving SIT added to

NT or a control group receiving NT training for six weeks. Eight children were excluded because they did not meet the inclusion criteria. The closed-envelope technique was used after baseline measurements for simple randomization of subjects. Another investigator (E.K.) who did not participate in the assessment and treatment prepared 42 sealed envelopes, each containing a card labeled as control or study. Each child was asked to choose a sealed envelope identifying whether he was assigned to the control or experimental group. The experimental design is shown in Figure 1 as a flowchart.

Outcome test measures

All children were tested by a physiotherapist. Demographic data of the subjects were recorded, and then their motor functions (Bruininks-Oseretsky Test of Motor Proficiency-Short form (BOT-2 SF)) and attention skills (Stroop TBAG (Turkish Scientific and Technological Research Association) Form) were evaluated. For the outcome measures, we tested all subjects before their receipt of six weeks of NT. Baseline measurements were taken at week 0 before the intervention and the end of the 6th week after treatment for both groups.

Demographic data

Before administering any test, demographic descriptive data of all children, including age, gender, height, body weight, and dominant hand, were obtained through a prepared questionnaire. Age, gender, and dominant hand were answered by the child's caregiver, height was measured in cm with a tape measure, and body weight in kg was recorded using a platform scale.

Stroop test

The Turkish form of the Stroop test (Stroop 1935) is a part of the Neuropsychological Test for Cognitive Potentials Battery (BILNOT), created by combining the original Stroop test and its Victorian Form (Stroop 1935). The new Turkish form of the test is named the Stroop TBAG Form (Karakaş *et al.* 1999). The Stroop test measures perceptual ability, shift attention under changing demands, and a 'disruptive influence'. In addition, it measures the function of shifting attention, such as the ability to suppress a habitual behavior and perform an unusual behavior (Karakaş *et al.* 1999). The Stroop test TBAG Form includes five subtests that involve four sequential cards, sized 14.0×21.5 cm. These examinees' responses are given in separate

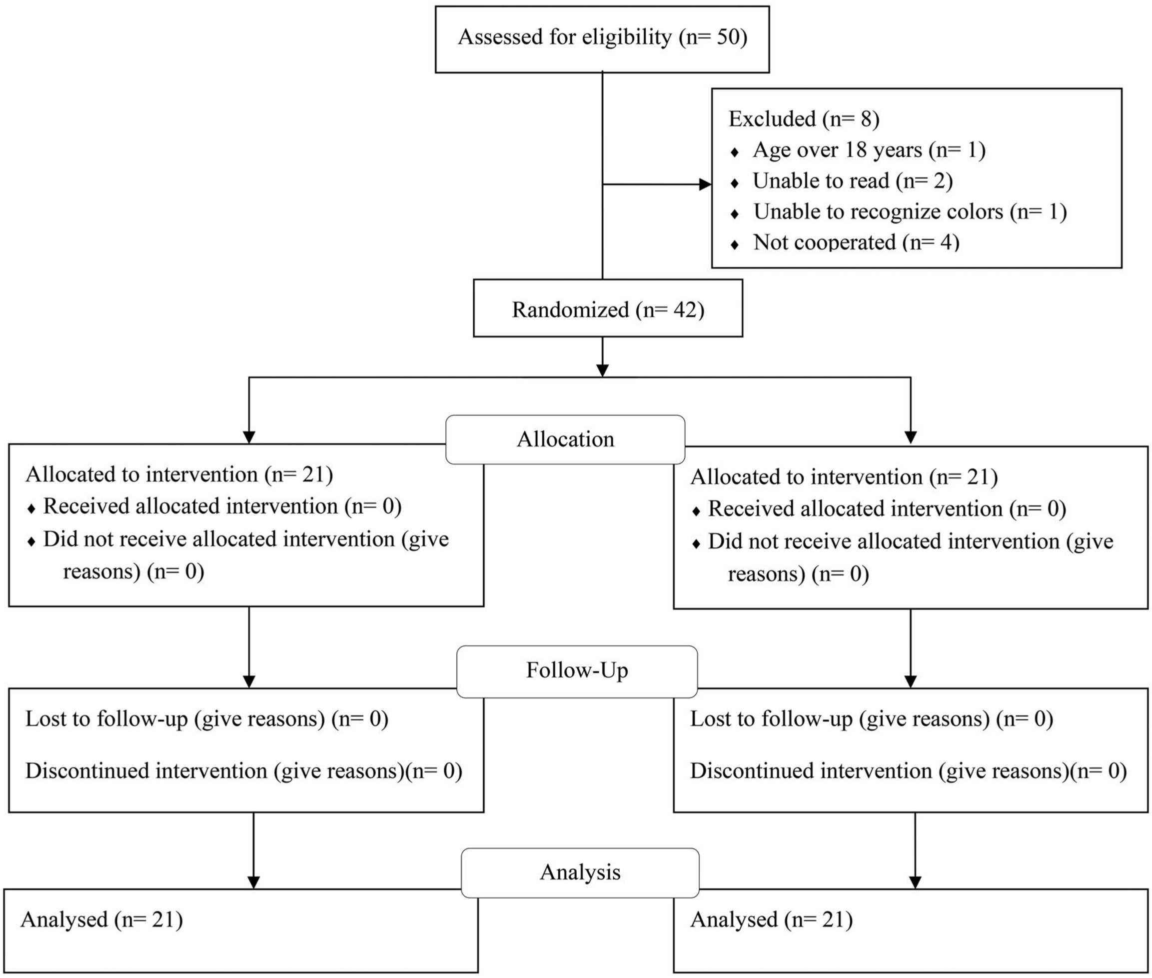

Figure 1. Flow chart of experimental design.

phases by first reading the names of four colors written in black ink (STP-TBAG-1), then reading the colors of the ink in which the color words are written (STP-TBAG-2), then naming the actual colors of the colored circles (STP-TBAG-3), then naming the colors of the color-neutral words (STP-TBAG-4), and finally by naming the colors of colored words for which the color and meaning are mismatched (e.g. the word 'yellow' printed in red) (STP-TBAG-5). For each section, the subjects' time to complete the section, the number of errors, and the total number of corrections were recorded, and the total score was calculated for each subtest (Karakaş *et al.* 1999, Kılıç *et al.* 2002). It has been reported that the test–retest reliability coefficients for the subtests of the Stroop TBAG form vary between 0.26 and 0.80 and can be used (Karakaş *et al.* 1999).

Bruininks-Oseretsky Motor Proficiency Test-Short Form

The BOT-2 SF was used to assess the subjects' motor skill proficiency. The BOT-2 SF is used to assess motor functions of children 4–21 years and is completed within 15–20 min (Deitz *et al.* 2007). The BOT-2 SF consists of eight subtests, total of 14 items, measuring fine and gross motor skills. These subtests consist of two subscales to measure fine motor control (fine motor integration and fine motor precision), two subscales to measure manual coordination (manual dexterity and upper limb coordination), two subscales to measure body coordination (bilateral coordination and balance), and two subscales to measure strength and agility (Strength, running speed and agility) (Deitz *et al.* 2007, Nocera *et al.* 2021). The total score is obtained by summing the raw scores obtained from each subtest. The maximum score obtained from BOT-2 SF is 88, and as the score increases, it is determined that there is an increase in motor skills (Bruininks and Bruininks 2005, Nocera *et al.* 2021). Inter-rater reliability was found to be >0.90 in BOT-2 SF in individuals aged 4–21 years (Bruininks and Bruininks 2005). Test–retest validity of BOT-2 SF with individuals with DS has been reported as ≥ 0.75 (ICC $= 0.86$, $p < 0.001$) (Nocera *et al.* 2021).

Intervention protocols

NT and SIT were administered by the same physiotherapist who was trained in these areas and who also evaluated the subjects before and after treatment. The 42 children included in the study were randomly assigned to two groups (control and experimental), 21 children in each group (Figure 1). The children included in the study in both groups did not participate in any other treatment program during this study. The children registered in both groups were given NT for six weeks consisting of a total of 12, 45-min sessions repeated twice/week. In addition to NT, the experimental group received SIT, consisting of 12 sessions of 45 min repeated twice a week, simultaneously with NT.

The content of the NT program was determined according to the needs of the individual, using exercises that facilitated postural control, trunk extension and rotation, weight transfer in different positions (sitting, crawling, etc.), and static and dynamic balance in front of the mirror, balance training on the balance board, bosu ball on a trampoline, and on a Swiss ball. There were also protective reaction exercises, single-leg stance training, walking exercises on different surfaces (tandem, double feet, etc.), climbing and descending steps, and training on daily life activities that require the use of the upper extremities such as buttoning, dressing, and using spoons and forks.

The SIT is a clinical-based intervention that uses play activities and sensory-enhanced interactions to elicit the child's adaptive responses. The SIT is often administered using specialized equipment (swings, therapy balls, inner tubes, trampolines, climbing walls, etc.) that can provide tactile, proprioceptive, and vestibular challenges embedded in targeted, purposeful, and enjoyable activities (Case-Smith and Arbesman 2008). A SIT program including games and goal-oriented activities was designed for each child according to their sensory needs by the researchers of this study. This program was applied in the same way throughout the treatment period. The SIT program included: Approximation to all joints, swinging linearly with a swing, jumping on a trampoline, pulling and pushing objects, incline climbing and rolling back down hill, playing games in obstacle courses, crawling or walking on a soft path made of pillows in balance, finding objects in boxes full of substances with different surfaces and in different sizes.

Statistical analysis

We used the Statistical Package for the Social Sciences (SPSS, Version 22.0; IBM Corp. Armonk, NY: IBM Corp.) for the statistical analysis of the data. Based on the results of the previous study (Ashori *et al.* 2018), the sample size was calculated that 21 subjects in each group would have a power of 80% to detect the increase in motor skills for an α value of 0.05 according to ANOVA repeated measures. We evaluated the conformity of the data to the normal distribution with the Shapiro–Wilk test. Descriptive analyses were presented using tables of means and standard deviations (SD) for normally distributed variables of interest, and in terms of frequency, medians, and range of quartiles (IQR 25/75) for variables that were not normally distributed or represented ordinal variables. We used independent *t*-tests and Mann–Whitney *U* tests for independent group comparisons. On the other hand, we made group comparisons on some dependent measures through the Wilcoxon paired-sample test and analyzed differences between some qualitative variables using chi-square analysis. We set $p < 0.05$ as the statistical significance level.

Results

A total of 50 children with DS were screened, and eight children with DS dropped out of the study, the reasons for which were noted (Figure 1). A total of 42 individuals with DS, 22 (52.4%) boys, and 20 (47.6%) girls, were included in the study. The demographic characteristics of the children participating in the study were shown in Table 1. Age, BMI, gender, and dominant side did not differ much between the groups at the beginning of the study ($p > 0.05$). In addition, no difference was observed between the Stroop TBAG test and BOT-2 SF results of the groups at the beginning of the study ($p > 0.05$).

The comparison of the results of the groups at the beginning and after the treatment was shown in Table 2. In all of the Stroop TBAG test total scores, a significant decrease was found after the 6 weeks treatment ($p < 0.01$). While no significant change was observed in the control group's total score after 6 weeks treatment ($p > 0.05$), total duration and total numbers of errors decreased significantly ($p < 0.01$). There was a significant increase in BOT-2 SF results when the beginning and after 6 weeks of treatment were compared within both groups ($p < 0.01$).

According to the Stroop TBAG test and BOT-2 SF results, a significant difference was observed between the groups after 6 weeks of treatment ($p < 0.05$). The change in the experimental group was found to be higher than the control group (p<.05) (Table 3). The study power and effect size according to BOT-2 SF value was $(1-\beta)$=99.9% and $d = 2.22$, respectively. In addition, effect sizes for comparisons between control/experimental performance are given in Table 3.

Table 1. Demographic characteristics of the subjects ($n = 42$).

Groups	Experimental (21)	Control (21)	*p* value
Age (years), mean (SD)	12.4 ± 3.5	12.6 ± 2.9	0.849
BMI (kg/m^2), mean (SD)	26.0 ± 3.3	27.5 ± 2.3	0.113
Sex (*n*. %)			
Female	10 (47.6%)	12 (57.1%)	0.757
Male	11 (52.4%)	9 (42.9%)	
Dominant side			
Right	19 (90.5%)	18 (85.7%)	0.634
Left	2 (9.5%)	3 (14.3%)	

BMI: body mass index, SD: standard deviation, independent *t*-test, chi-square analysis.

Discussion

In this study, NT was found to be effective to improve the motor functions of children with DS. It was also shown that SIT combined with NT was more effective compared to NT alone in improving motor functions, perceptual ability, and attention in children with DS.

Lower attention functions cause difficulties in learning cognitive skills (Hung *et al.* 2016). Studies show that cognitive functions such as attention and memory are frequently affected in children with DS (Liogier d'Ardhuy *et al.* 2015, Wester Oxelgren *et al.* 2019). Moreover, it is indicated that attention spans are shortened even more due to sensory modulation problems in children with DS, and challenges in various attention parameters, such as continuous auditory and visual selective attention, are often seen (Costanzo *et al.* 2013, Kogan *et al.* 2009, Lanfranchi *et al.* 2010, Lee *et al.* 2011, Porter *et al.* 2007, Rowe *et al.* 2006). The relationship between attention deficit and sensory integration has been previously described in the literature. Sensory integration therapy develops attention skills, increasing the attention span, hand–eye coordination, body awareness, orientation, and selective attention (Cermak 1988). Kashoo and Ahmad (2019) stated that after SIT was added to conventional treatment for ten sessions, more improvement could be achieved in the attention parameters of the Stroop test in their study with patients with left hemiplegia between the ages 12 and 15 years (Kashoo and Ahmad 2019). That is why it is thought that SIT will contribute to developing attention parameters in children with cognitive disorders, including attention. Sensory integration theory is

Table 2. The comparison of the values at the baseline and after the treatment ($n = 42$).

	Experimental (21)		*p* value	Control (21)		*p* value
Test	Baseline	6th week		Baseline	6th week	
Stroop TBAG						
Total duration (s)	264.0 (200.5/354.0)	198.0 (154.0/319.5)	<0.001*	289.0 (206.0/385.5)	259.0 (185.5/355.5)	<0.001*
Total numbers of errors	7.0 (4.0/11.5)	2.0 (0.0/4.0)	<0.001*	6.0 (4.5/9.5)	5.0 (2.5/8.0)	0.001*
Total number of corrections	5.0 (3.0/10.5)	3.0 (1.0/4.5)	0.001*	7.0 (4.0/11.5)	6.0 (4.5/9.0)	0.115
BOT-2 SF						
Fine manual control	10.0 (5.5/11.0)	17.0 (14.0/19.0)	<0.001*	9.0 (7.5/10.5)	13.0 (11.0/15.5)	<0.001*
Manual coordination	7.0 (4.0/10.0)	13.0 (10.0/14.0)	<0.001*	7.0 (4.0/10.0)	10.0 (8.0/12.0)	<0.001*
Body coordination	5.0 (3.5/9.0)	11.0 (10.0/14.0)	<0.001*	7.0 (3.5/8.5)	10.0 (8.0/11.0)	<0.001*
Strength and agility	9.0 (6.0/10.5)	12.0 (9.0/14.0)	<0.001*	9.0 (7.0/10.0)	11.0 (9.0/12.0)	<0.001*
Total score	31.0 (20.0/37.5)	53.0 (43.5/61.0)	<0.001*	31.0 (25.5/35.5)	44.0 (39.0/46.5)	<0.001*

BOT-2 SF: Bruininks-Oseretsky Motor Proficiency Test-Short Form; Stroop TBAG Form: Stroop Turkish Scientific and Technological Research Association Form.
*$p < 0.05$.
*Wilcoxon paired-sample test.
Data are presented as median and IQR (25/75).

Table 3. The comparison of the difference between groups before and after treatment (*n* = 42).

	Experimental (21)	Control (21)	Cohen's d	*p* value
Test				
Stroop TBAG				
Total duration (s)	−48.8 ± 32.9[a]	−27.8 ± 22.2[a]	0.74	0.021*
Total number of errors	−5.5 ± 4.1[a]	−2.1 ± 2.4[a]	1.01	0.002*
Total number of corrections	−3.7 ± 4.1[a]	−0.8 ± 2.4[a]	0.86	0.008*
BOT-2 SF				
Fine manual control	8.0 (5.5/9.0)[b]	3.0 (3.0/5.0)[b]	1.73	<0.001*
Manual coordination	6.0 (4.0/7.0)[b]	3.0 (2.0/4.0)[b]	1.53	<0.001*
Body coordination	6.0 (4.0/7.0)[b]	3.0 (2.0/4.0)[b]	1.21	<0.001*
Strength and agility	4.0 (2.5/4.0)[b]	2.0 (1.0/3.0)[b]	1.23	<0.001*
Total score	22.0 (18.0/25.0)[b]	13.0 (10.0/15.0)[b]	2.22	<0.001*

BOT-2 SF: Bruininks-Oseretsky Motor Proficiency-Short Form; Stroop TBAG Form: Stroop Turkish Scientific and Technological Research Association Form.
*$p < 0.05$.
[a]Data are presented as mean and SD.
[a]Independent *t*-test.
[b]Data are presented as median and IQR (25/75).
[b]Mann–Whitney *U* test.

defined as the relationship between the lack of interpretation of sensory stimuli from the environment and problems in learning body perception and motor skills (Critz *et al.* 2015). In a study, Uyanik *et al.* (2003) compare the effects of SIT alone, vestibular stimulation in addition to SIT and NT on children with DS. They reported that each treatment was effective but not superior to the other in DS (Uyanik *et al.* 2003). However, Ashori *et al.* (2018) showed in their study conducted on the effects of ten SIT sessions of on the attention parameter in 28 children with DS that there was an improvement in the attention span measured by the Stroop test (Ashori *et al.* 2018). Consistent with the previous findings, in the present study, it was observed that there was a significant improvement in the attention span in the Stroop TBAG test results in the experimental group and a positive effect on motor functions. Therefore, SIT, which has an impact on attention functions, should be included in the treatment process to increase the necessary coordination to ensure the development of cognitive and motor skills of developmental disabilities in children with DS.

In DS, delays and impairments in gross and fine motor skills occur as a result of the proper sensory experience deficiency, sensory integration impairment, hypotonia, hypermobility in joints, delayed postural control, and lower balance (Russel et al. 1988). In this context, BOT-2 SF is used along with Gross Motor Function Scale to assess motor skills (Malak *et al.* 2015). Previous studies in the literature indicated that children with DS show lower motor skills than their peers with typical development (Aslan and Baş Aslan 2016, Connolly and Michael 1986, Malak *et al.* 2015). In this regard, the commonly used BOT-2 SF test was utilized in our study, too. The importance of the interventions to facilitate motor skills improvement drew attention in studies reporting that children with DS showed lower gross and fine motor skills than their healthy peers (Aslan and Baş Aslan 2016, Connolly *et al.* 1984). Since motor skills play an important role in children's ability to move independently, take care of themselves and adapt to the environment, rehabilitation programs should be planned accordingly. With this object in mind, besides vestibular rehabilitation, play therapy, NT, and SIT should be programmed according to the needs of children with motor problems (Ruiz-González *et al.* 2019). In a study conducted with children with DS aged 5–7 years, Souratji *et al.* (2008) showed that SIT is effective in developing gross and fine motor skills. In another study, it was shown that SIT applied in addition to physiotherapy practices improved gross motor coordination and grip control abilities in children with DS (Azzam 2019). Neurodevelopmental therapy is frequently used, and it forms positive results on postural responses in the rehabilitation process of children with DS (Bumin and Kayihan 2001, LaForme Fiss *et al.* 2009). Similar to the previous studies in the literature, significant improvements were observed in both motor skills and attendance performances of children with DS who received only NT compared to baseline. However, the number of studies examining the effectiveness of SIT on motor skills in children with DS is limited. Uyanik *et al.* (2003) stated in their studies with DS individuals on the efficiency of SIT, NT, and vestibular rehabilitation that there was a different degree of improvement in each group, and therefore, these treatments should be applied in combination (Uyanik *et al.* 2003).

Children with DS may lack sensory experiences because of the problems and delays in their motor skills. For this reason, it is thought that improvements in motor skills and performances can occur through correct and sufficient sensory input education. Sadati and Abasi (2017) applied ten sessions of SIT to 24 children with learning disabilities and reported statistically significant improvements in their motor skills that they used the Lincoln-Oseretsky motor development scale to measure before and after the treatment (Sadati and

Abasi 2017). Likewise, Parhoon *et al.* (2014) applied 16 sessions of SIT to 24 children with DS aged between 5 and 7 years and recorded that there were statistically significant improvements in their gross motor skills that were measured by implementing the Lincoln-Oseretsky motor scale (Parhoon *et al.* 2014). Also, in another study, which Ashori *et al.* (2018) conducted with 28 children with DS, applied SIT to the experimental group, and it was determined that the motor skills measured by the Bruininks-Oseretsky Motor Competence test improved more in the group that took SIT after the treatment compared to the control group. It was also reported that the effect of SIT could explain 63% of this significant improvement in motor skills (Ashori *et al.* 2018). Similar to the studies in the literature, SIT was shown to be effective on motor skills by improving the total scores in all BOT-2 SF test parameters in children with DS. Sensory integration therapy makes plastic changes in the brain by developing sensory experience and improves motor-sensual-perceptual fields. According to the findings in our study, NT applied with a combination of SIT was shown to improve the fine and gross motor skills of children with DS in accordance with the literature.

Taking the limitations of the study into consideration, first, the cognitive levels of the individuals participating in the study were not evaluated and classified with an objective method. In addition, individuals with reading skills and able to recognize colors were included in the study. This was necessary so that attention could be assessed with the Stroop test. Therefore, since the effect of SIT on attention cannot be evaluated for all DS individuals, it may not be generalizable. Another limitation of our study is the wide age range of the participants. This may be effective on the development of motor and attention parameters. Therefore, there is a lack of covariate analyses to control for constraints. Finally, it is thought that the duration of the study is sufficient, but it is thought that long-term studies should be carried out for the development to become permanent. As a result, we think that there is a need in the literature for studies that do not have these limitations, with longer treatment periods, and long-term follow-ups and evaluations.

Conclusion

Sensory integration therapy applied for a longer period in DS children increases the sensory experience and improves motor-sensory-perceptual areas. In this way, SIT develops DS children's motor and attention skills. For that purpose, combining NT processes with SIT has an importance in the rehabilitation of children with DS. Future studies are needed to include children in a specific age range and with the same level of mental abilities. In addition, it is thought that there is a need for follow-up studies examining the long-term effects of development.

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