Research Paper: The Effect of Sensory Integration on the Attention and Motor Skills of Students With Down Syndrome

Mohammad Ashori[1*], Elham Zarghami[2], Mohsen Ghaforian[3], Seyyedeh Somayyeh Jalil-Abkenar[4]

1. Department of Psychology and Education of Students with Special Needs, Faculty of Education and Psychology, University of Isfahan, Isfahan, Iran.
2. Department of Psychology, Varamin-Pishva Branch, Islamic Azad University, Varamin, Iran.
3. Department of Psychology and Education of Students with Special Needs, University of Farhangian, Tehran, Iran.
4. Department of Psychology & Education of Exceptional Children, Faculty of Psychology and Education, University of Tehran, Tehran, Iran.

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ABSTRACT

Objectives: Sensory integration training plays a crucial role on the attention span and motor skills of students with Down syndrome. The present research aimed to investigate the effect of sensory integration training on the attention span and motor skills of students with Down syndrome.

Methods: This was a quasi-experimental research with a pretest, posttest design and control group. Participants were 28 male students with Down syndrome from two exceptional schools in Tehran. The samples were selected by convenience sampling method. Students were randomly divided into the control and experimental groups and each group consisted of 14 students. A 10-session sensory integration training was provided to the experimental group, while the control group did not receive this training. The Stroop color-word test and Bruininks Oseretsky Test of Motor Proficiency were used for measuring the attention span and motor skills of the students. The obtained data were analyzed using MANCOVA.

Results: MANCOVA indicated a significant difference between the attention span and motor skills in the experimental group after the training sessions (P<0.0001).

Discussion: Sensory integration training led to the improvement of attention span and motor skills of students with Down syndrome. Therefore, Sensory integration training could have positive impacts on the attention span and motor skills of students with Down syndrome.

*** Corresponding Author:**
Mohammad Ashori, PhD
Address: *Department of Psychology and Education of Students with Special Needs, Faculty of Education and Psychology, University of Isfahan, Isfahan, Iran.*
Tel: *+98 (313) 7932548*
E-mail: *m.ashori@edu.ui.ac.ir*

Highlights

- Sensory integration had positive effect on attention and motor skills of students with Down Syndrome.
- There are significant differences between control and experimental (Down Syndrome with training) group in the scores of attention and motor skills.
- These changes of score are due to the effect of sensory integration training in experimental group.

Plain Language Summary

Down Syndrome composes the largest group in intellectual and developmental disabilities. It occurs in 1 per 700 to 1000 live births. Limitation in attention and motor skills is a common characteristic in children with intellectual disability. Intellectual disability is a condition of deficiency in brain development, which affects the attention as well as the motor skills. Children with Down syndrome have problems in attention and motor skills. Attention is the first stage in information processing. It refers to collection of information from the environment for later processing. Delays in motor development is well observed in people with moderate and especially severe and profound intellectual disability. These groups usually show delay or deficit in motor skills. Children with Down syndrome frequently have problems in attention, motor skills, and sensory integration. The sensory integration is defined as the interpretation and organization of sensory information from the body and environment to make meaningful responses. When children with Down syndrome participate in sensory integration program, they show improvement in attention, motor skills, daily activities and quality of life. The present research was a quasi-experimental study using pretest and posttest and control group design. Participants were 28 male students with Down syndrome from two exceptional schools in Tehran City, Iran. The samples were chosen by convenience sampling method. Students were randomly assigned to experimental and control groups and each group consisted of 14 students. To evaluate the participants' motor skills, short form of Bruininks-Oseretsky test of Motor Proficiency was used. Experimental group participated in 10 intervention sessions and were trained by sensory integration program, while control group did not. Sensory integration training led to the improvement of attention rate and motor skills of students with Down syndrome.

1. Introduction

Intellectual and developmental disability comorbid with considerable problems both in intellectual functions and adaptive behaviors that originate before the age of 18 [1, 2]. People with Down Syndrome (DS) are the largest group with intellectual and developmental disabilities. Down syndrome is a genetic disorder, determined with physical features, moderate to severe intellectual disability, and deficits in academic achievement and language. The prevalence of this syndrome is about 1 per 1000 births [3].

About 95% of Down syndrome cases, also called trisomy 21, are due to the presence of an extra copy of 21st chromosome. In this type, a baby is born with three #21 chromosomes, rather than the usual pair. These cases of Down syndrome are not inherited and is caused by nondisjunction. In other words, it is a fraction of chromosome 21 in moment meiosis stage. Mother transfers 2 chromosomes instead of 1 in many cases of trisomy 21. Also, some cases of paternal nondisjunction have been reported [4]. Limitation in attention and motor skills are usual features in students with intellectual disabilities like Down syndrome. Intellectual disability is a condition of increased deficiency in brain cells, which negatively affect attention and motor skills [5, 6].

Attention is the first stage in information processing. It collects part of the environmental information for later processing. In fact, attention is an important component in learning and education. Children with Down syndrome have attention problems [7]. Motor skill development includes gross and fine motor skills and bilateral coordination [8]. Delay in motor development is common in children with moderate to profound intellectual disabilities. These children usually have deficit or delay in motor skills that can lead to compelled immobility. This delay occurs in locomotion, balance, dexterity and practical skills such as working, playing games, and doing daily living activities [9]. Furthermore, Down syndrome children have frequent problems in attention,

motor activities, and sensory integration [10], constantly reported by parents and professionals [11, 12].

The sensory integration theory describes the relation between deficit in the interpretation of environmental sensory stimulus and body sensations and problems with motor skills learning [13]. The principles of this theory were derived from contemporary neuroscience, occupational therapy, and developmental psychology. Sensory integration is defined as the interpretation and organization of sensation information from the body and environment to make meaningful responses [14]. Sensory therapy is used in the management of students with intellectual and developmental disabilities. This therapy engages skills which are thought to manage the sensory system with providing proprioceptive, auditory, tactile, and vestibular inputs [8].

Studies showed that the motor activities of students with intellectual disability are either poor or considerably delayed [4]. A research regarding the effect of Spark motor program on the improvement of gross motor skills in children with intellectual disability reported that Spark motor program improves gross motor skills in this group [15]. Another research investigated the effectiveness of teaching basic motor skills to 6-year-old boys and girls. The results stated that motor therapy led to the improvement of fine and gross motor activities of intellectually disabled children [16]. A study examined the effectiveness of sensory motor intervention on attention span of students with learning disabilities. Results indicate that sensory motor intervention increases the attention span of these students [17].

Another study investigated the effectiveness of creative movements on attention span of students with autism spectrum disorders. Their results present significant improvement in the attention span in the experimental group [18]. Another research investigated the effectiveness of gross motor activities on attention process of students with Down syndrome. Their results indicate that gross motor activities increases the attention process of these students [19]. Amel and Amira investigated the effect of sensory integration plan on motor skills of children with autism spectrum disorders and reported a significant difference in gross and fine motor skills at post treatment [8]. Also, Sadati Firoozabadi et al. reported that sensory-motor integration had a positive and significant effect on motor skills in students with learning disabilities [20].

According to prior research, students with Down syndrome showed attention problems and delay in motor skills development [6, 21-23]. Studies revealed which levels of cognitive functioning and motor skills are related in students with intellectual disability [6, 23]. Children with Down syndrome have problems in attention span and motor skills which negatively affect gross and fine motor skills. Also, research studies show that Down syndrome children have weak levels of attention span and motor skills in comparison with the normal children. Sensory integration training seems necessary for them. Children with Down syndrome participated in sensory integration program, which improved their attention span, motor skills, daily activities, and quality of life. Also, although children with Down syndrome process similar steps of motor development in the same order as normal students, stages may be obtained delayed and some activities and skills may not be developed the same as normal student, and may rather be achieved later or may not develop. Therefore, this study aimed to investigate sensory integration training on attention span and motor skills of children with Down syndrome.

2. Methods

This was a quasi-experimental research with pretest and posttest and a control group design. Participants were male students with Down syndrome from two exceptional schools in Tehran, Iran. The samples were selected by convenience sampling method. Students were randomly divided into the control and experimental groups; each consisting of 14 students by the following formula:

$$n=\frac{\sigma^2(z_{1-a/2})^2}{d^2}=\frac{(20.62)^2\times(1.96)^2}{(11)^2}=13.49$$

The inclusion criteria consisted of the having diagnosed with intellectual disability caused by Down syndrome, living with parents, being 10-12 years old and being student of fourth to sixth grade. Exclusion criteria consisted of the symptoms of neurodevelopmental disorders or significant health problems, and receiving any concurrent similar training programs. The importance of this study was explained to the mothers of the subjects and the school counselors. The mothers of the subjects provided an informed consent. We randomly assigned the subjects into the control and experimental groups. The experimental group received 10 sensory integration training and the control group participated in the routine program of school.

The computerized Stroop color-word test was used to assess subject's attention span. This test was developed

Table 1. The content of sensory integration training program

Sessions		Context of Session
1 & 2	Gross motor skills	This activity or skill included big activities of body, like jumping, walking, catching and throwing, coordination among hands and feet, and going down and up the stairs.
3 & 4	Tactile	This activity refers to information processing about body position, temperature and pain by the body skin. Essential sense material included finger painting and touchable materials.
5 & 6	Proprioceptive	This system processes information about the pressure of body and movements by receptors in ligaments, tendons, joints, tissues, muscles. Hand weight during walks, modeling clay, weighted blanket and stress ball are appropriate practices for this activity.
7 & 8	Vestibular	This system processes data about mobility and balance through sensory receptors in the neck, eyes, inner ear and other receptors. Practices included spinet, tumbled, bouncing and rocking. Balancing board, swing, trampoline and therapy exercise ball are appropriate material for this activity.
9 & 10	Heavy work activities	These activities included total body reactions such as moving, pulling, pushing, playing and lifting; using hands for pinching, squeezing and catching different materials, carrying objects like book and chair, twisting body, the use of balance board, bouncing and jumping, running and walking on soft or hard objects like sand, seesaw swing, sitting on a spinning chair and spinning toward right and left on low and high speed, playing with a heavy blanket at bedtime, ball play, rolling a ball on the floor at home.

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by Reedley Stroop. The Persian version of the computerized Stroop color-word test (Ravan Sina Inc, Iran) includes two stages. The first stage is the training phase, and the participant should choose the color of circle shown on the monitor screen in 4 possible colors of red, blue, green and yellow, then press the key that is covered by each colorful label on keyboard. The score of this stage has no influence on the final result. The main part of the test consists of 96 colorful words, 48 colorful congruent words (the meaning of the word complies with the ink color, the word is written with) and 48 colorful incongruent words (the meaning of the word does not comply with the ink color the word is written with) which were displayed in a pseudorandom sequence in the middle of the monitor screen for 2000 ms with 800 ms inter stimulus interval. Subjects answered to 'identify words color' regardless of their meanings.

The correct responses, incorrect responses, no responses, reaction time of congruent words and reaction time of incongruent words in the Stroop test were calculated by computer. The Persian version of the Stroop test has an acceptable validity and reliability [24]. The reliability of this test, (based on retest) falls in the range of 0.80 to 0.91 [25].

To evaluate the participants' motor skills, Bruininks Oseretsky Test of Motor Proficiency-short form (BOT-2) was used. This test is a famous instruments for assessing motor proficiency and was designed to obtain useful information about the motor skills of children aged 4.5 to 14.5 years. BOT-2 includes 14 items and 8 subscales [26]. Three subscales of BOT-2 were used to evaluate fine motor skills in this study: fine motor integration subscale, fine motor precision subscale, and manual dexterity subscale. Four subscales were used to assess gross motor skills: balance, speed and agility, upper limb coordination, and strength. Also, bilateral coordination subscale was used to evaluate both gross motor skills and fine motor skills. Retest coefficient and reliability of BOT-2 was reported as 0.86 [27].

The experimental group participated in 10 intervention sessions (twice a week, each lasting for 40 minutes) and were trained by the sensory integration program, while the control group did not receive these interventions (for an overview of session content, see Table 1). The Stroop color-word test and Bruininks Oseretsky Test of Motor Proficiency were used for measuring the attention span and motor skills in students as the pretest. Then, the experimental group participated in 10 intervention sessions. In the final stage of the research, each group was assessed by the Stroop color-word test and Bruininks Oseretsky Test of Motor Proficiency as the posttest. The obtained data were analyzed with Multivariate Analysis of Covariance (MANCOVA).

3. Results

The mean age of the experimental and control groups were 11.09 and 11.14 years, and the mean score of IQ were 63.04 and 61.97, respectively. The descriptive indices of attention span and motor skills for the experimental and control groups in the pretest and posttest are reported in Table 2.

Table 2. Descriptive statistics for attention span and motor skills in groups (pretest & posttest)

Variables		Situation	Groups			
			Experimental		Control	
			Mean	SD	Mean	SD
Attention span	Correct responses	Pretest	30.52	1.89	30.65	1.80
		Posttest	34.67	1.26	31.08	1.77
	Incorrect responses	Pretest	41.73	1.93	40.34	2.82
		Posttest	37.55	1.47	40.81	2.39
	No responses	Pretest	24.15	1.96	24.11	1.42
		Posttest	18.60	2.07	23.14	1.25
	Reaction time of congruent words	Pretest	1311.64	6.08	1311.34	7.782
		Posttest	1193.52	10.74	1193.51	11.20
	Reaction time of incongruent words	Pretest	1437.12	6.88	1437.12	5.90
		Posttest	1280.71	4.83	1280.71	4.38
Motor skills		Pretest	70.38	6.27	71.90	7.03
		Posttest	64.61	6.83	72.84	6.53

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MANCOVA was used due to the presence of one independent variable and several dependent variables (subscales of attention span and motor skills) as well as the moderate of pretest effect. After checking and approving the normality of research variables, Box's test approved equality of variance-covariance matrices (P>0.05). Also, the assumption of variance equality was approved using Leven's test (P>0.05). Therefore, MANCOVA test could have been applied. The overall Wilk's lambda was significant ($F_{6, 15}$=5.34, P=0.0001), indicating a significant difference between the experimental and control groups, at least in one variable. In order to determine differences among the scores of attention subscales and motor skills between the control and experimental groups, MANCOVA test was used, and the findings are presented in Table 3.

To analyze the data, pretest variable was moderated because of correlation with posttest. According to Table 3, the type of the group has a significant effect on post-

Table 3. MANCOVA summary

Source of Change		Depended Variables	SS	df	MS	F	Sig	η^2
Group	Attention span	Correct responses	121.80	1	121.80	29.41	0.0001	0.52
		Incorrect responses	24.06	1	24.06	31.18	0.0001	0.57
		No responses	19.67	1	19.67	33.52	0.0001	0.60
		Reaction time of congruent words	1068.85	1	1068.85	28.03	0.0001	0.56
		Reaction time of incongruent words	1796.23	1	1796.23	29.04	0.0001	0.58
		Motor skills	158.11	1	158.11	34.86	0.0001	0.63

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test scores and there is a significant difference in the scores of attention subscales and motor skills between the control and experimental groups (P<0.0001). As per Table 3, the results of MANCOVA showed that the sensory integration program had a positive and significant effect on correct responses (F=29.41, P<0.0001), incorrect responses (F=31.18, P<0.0001), no responses (F=33.52, P<0.0001), reaction time of congruent words (F=28.03, P<0.0001), reaction time of incongruent words (F=34.86, P<0.0001) and motor skills (F=29.12, P<0.0001). According to Eta-squared (η^2), 52%, 57%, 60%, 56%, 58%, and 63% of the variation in variables of correct responses, incorrect responses, no responses, reaction time of congruent words, reaction time of incongruent words and motor skills, could be explained respectively due to the effect of sensory integration training in the experimental group.

4. Discussion

The present research was conducted to investigate the effect of sensory integration training on attention span of students with Down syndrome. Also, this research evaluated the effect of sensory integration training on motor skills in 2 groups (experimental and control) before and after the intervention.

Findings showed that the sensory integration training program increased the attention span components (correct responses, incorrect responses, no responses, reaction time of congruent words or reaction time of incongruent words in the Stroop test) among students with Down syndrome in the experimental group. These findings are in line with the results of many studies [17-19].

Children with Down syndrome have problem in attention span. The attention problems in children with Down syndrome are reflected in their low academic achievement [3]. Attention deficits are often linked to impairment in their cognitive ability for learning. Moreover, attention is the first stage in information processing that is based on formed concentration, awareness and perception. It initiates learning in children [7]. The sensory integration training program included reinforcement in attention skills; increase in attention span; eye and hand coordination; reinforcement of tactile sensory, body awareness, orientation and selective attention. Therefore, the sensory integration training program could promote attention in children with Down syndrome.

The results support the effectiveness of sensory integration training on attention span and motor skills in students with Down syndrome. The result was similar to the findings of Sadati Firoozabadi et al. [20] regarding the effect of sensory integration training program on the motor skills in students with learning disorders. This study was consistent with the results of Amel and Amira [8] who investigated the effect of sensory integration training program on motor skills among students with autism spectrum disorders and reported a statistically significant difference between the control and experimental groups after the intervention, on gross and fine motor skills. Our results were in line with the study by Shahbazi et al. representing the effectiveness of sensory motor integration program on reaction time and balance in students with developmental coordination disorder [28].

Results of the current research were consistent with the study of Top who investigated the effects of swimming exercise program on the motor development levels in teenagers with intellectual disability and reported a statistically significant difference between the control and experimental groups in fine motor integration, fine motor precision, and bilateral coordination parameters [6]. Also, Top concluded that there are no difference in the experimental and control groups in gross motor skills and total motor skills at pretest and posttest [6]. This result was not in line with the present study. Moreover, the present research was consistent with the study of Parhoon et al. who investigated the effect of sensory motor program on gross motor skills of 5-7 years old students with Down syndrome, and reported a statistically significant difference between the control and experimental groups in gross motor skills, after the intervention [29].

The findings of this research was similar to the study of Westendorp, et al. who founded that, the scores of the gross motor skills of the experimental group in sports were significantly higher than the scores of the control group in individuals with mild intellectual disability [30]. Furthermore, the present study was consistent with the results of Vuijk et al. that concluded motor performance in students with borderline intellectual functioning and mild intellectual disability increased after receiving the intervention [23]. Our result was in line with the study of Surtchi et al. reported the effectiveness of sensory integration program on fine and gross motor skills, for 5-7 years old children with Down syndrome [31]. Moreover, this result was similar to the study of Bouffard that reported a significant difference in motor skills of individuals with educable intellectual disability after intervention [26].

In fact, the attention and movements depend on input from sensory channel, at birth. When child grows up and his/her interaction improves with the environment,

the visual and auditory system become very important and are accompanied by other sensory systems. Hands and eyes coordination are required to process sensory inputs and direct movements towards the intended targets. When baby's hand makes contact with the intended object, he/she integrates tactile information regarding the object's texture via visual proprioceptive about the size, color and shape.

More object handwork assembles information feedback from the hand movement of baby in response to the object, which may help explain data regarding the shape and size of the object [14]. Also, appropriate operative tasks are used for students with sensory processing problems to help them decrease defensiveness, change of arousal, and attention improvement. Improved fine and gross motor skills in students allows them perform considerable operative activities [8]. In addition, sensory integration training plays a crucial role in attention and motor skills of students with Down syndrome.

The present study investigated the effects of sensory integration training on attention and motor skills of children with Down syndrome. Although a few children with Down syndrome obtain appropriate motor activities with observing and imitating their classmates and other children in the community, engagement of parents and teachers of these children is also important in direct and indirect acquisition of attention and motor skills. According to the results, sensory integration training can have significant and positive effects [4]. Sensory integration training increase the neuroplasticity of nervous system in children, leading to improvements in desirable skills and behaviors and enhanced attention and motor skills [8].

Several limitations of this study should be noted. The rate of learning differs in the students with Down syndrome. It is difficult to ascertain these students' achievements in attention and motor skills. Moreover, the socioeconomic status of the students' parents were disregarded. Therefore, caution should be used when applying statistical generalization of our results to other populations. Also, the sample size in both experimental and control groups were small. It is difficult to relate these findings to other children with special needs, because each group only consisted of 14 children. Moreover, there was no opportunity for a follow-up assessment due to the time limitation [32].

5. Conclusion

It is expected that sensory integration training improves attention and motor skills of students with Down syndrome. Thus, paying attention to the sensory integration training plays a crucial role in enhancing attention and motor skills of children with Down syndrome. Ultimately, the present research demonstrated a significant improvement in the attention and motor skills of children with Down syndrome after receiving sensory integration training.

Ethical Considerations

Compliance with ethical guidelines

This research was approved by the Human Ethics Research Committee of Isfahan University and the Exceptional Education Organization of Iran.

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Conflict of interest

The authors certify that they have no affiliation with or involvement in any organization or entity with any financial, or non-financial interest in the subject matter or materials dismissed in this manuscript.

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