Research Article

The Effect of Sensory Diet on the Impulsivity of Children with Attention Deficit Hyperactivity Disorder

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ABSTRACT

Introduction: The present study was conducted to evaluate the effect of a family-centered sensory diet program on the impulsivity in children with attention deficit hyperactivity disorder (ADHD).

Materials and Methods: This is a quasi-experimental study with a pretest-posttest design with a control group. The study population included all children with ADHD aged 6-12 years in Tehran, Iran referred to the clinics of Hasti, Bahar, and Masir-e Sabz in 2020. Of these, 30 children were selected using a convenience sampling method and randomly divided into two groups of intervention and control. The intervention group underwent 12 sessions of a family-centered sensory diet program, 3 days a week, each for 45 minutes based on the Wilbarger protocol. The used tools were the Wechsler intelligence scale for children-Fourth Edition to test intellectual ability and the Conners' parent rating scale to diagnose ADHD in children. Independent t test and analysis of covariance (ANCOVA) were used in SPSS software v. 20 for data analysis.

Results: In this study, the mean age of participants was 9.56±4.38 years, including 11 girls (36.6%) and 19 boys (63.3%), and the mean age of mothers of these children was 34.23±6.9. The mean impulsivity scores of children in the intervention group decreased and the results of the ANCOVA showed a statistically significant difference in the mean posttest scores between the two groups (P=0.001).

Conclusion: The family-centered sensory diet program has a positive effect on the impulsivity of children with ADHD. It is recommended that therapists use the sensory diet program as a complementary therapy along with other therapeutic interventions.

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1. Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders in childhood, characterized by inattention, hyperactivity, and impulsivity [1]. The prevalence of this disorder in primary school children is 3%-6% [2]. Impulsivity means the manifestation of unpredictable behaviors without considering the consequences that occur due to the difficulty in inhibiting the response [1]. Children with ADHD are constantly affected by defects in sensory processing in general and defects in sensory modulation in particular. Various behavioral assessments have shown that these children are highly sensitive to the stimulation of senses, including tactile, visual, auditory, and taste senses and they have defects in vestibular and somatosensory functions, such as balance, post rotational nystagmus, differentiation, and tactile detection [3].

Sensory processing refers to how the peripheral and central nervous systems manage the received sensory information and includes receiving, modulating, integrating, and organizing sensory stimuli [3]. Children with ADHD have difficulty interacting effectively with the environment due to sensory processing disorders. Too much or too little sensory information causes poor motor coordination, incessant movements, impulsive behaviors, and inattention that impair a child's overall performance at school, family, life skills, and risky activities as well as her/his self-concept development. ADHD seems to have a profound effect on the quality of life in terms of functional tasks, regardless of cultural and national limitations [4].

Children who have difficulty in sensory registration and sensory seeking in balance and proprioception systems actively move around in the environment and appear restless, active, and excited in daily life. Children who need excessive proprioceptive stimulation usually seek muscle resistance, and joint pressure or stretching (e.g., Knocking feet instead of walking, intentionally falling or hitting other objects or people, or pushing large objects). They may also make violent behaviors, such as throwing objects. Some of these children do not understand the position of their organs except with severe proprioceptive stimulation. These behaviors may be interpreted as aggressive behaviors. Sensory seeking in the balance system includes behaviors, such as climbing, running, and restlessness. These behaviors interfere with sitting in school, playing with peers, and performing self-care activities, and increasing the rate of failures in the environment. Comparisons with normal peers and environmental blames ultimately reduce a child's feeling of self-worth and self-confidence [5]. Functional problems associated with sensory processing disorders include decreased social skills and participation in play, reduced frequency, duration, and complexity of adaptive responses leading to low self-esteem, and raw gross and fine movements [6]. These children only seek to absorb sensory stimuli. Hence, their behaviors will be interpreted as distasteful, law-breaking, or aggressive.

Various pharmacological, cognitive, behavioral, combined, and complementary therapies are used to treat children with ADHD. Effective treatment involves teamwork, a multidisciplinary approach, and a combination of different techniques determined based on individual needs [7]. One of the methods is sensory integration therapy, which includes controlled sensory stimulation in the form of self-directed and meaningful activities, in a way that leads to an adaptive response and improves some behavioral, motor, educational, and language functions and skills via the integration of sensory inputs [8]. Sensory integration therapy combines sensory inputs with planned motor outputs so that the child can experience success [9]. The integration of different sensory information increases the efficiency of children in sensory-motor and perceptual-motor function and consequently empowers the child. Sensory integration helps these children regulate themselves. As a result, the nervous system becomes able to change and maintain the level of arousal that is necessary for the development of abilities, such as attention to task, impulse control, increased frustration tolerance, and balance in emotions [10].

One of the interventions used in modifying the effects of sensory processing is sensory diet therapy [11]. A sensory diet is several activities, specifically included in a child's daily planning to help his/her attention, arousal, and adaptive responses. The activities are selected according to the child's needs and based on the theory of sensory integration. The sensory diet uses a variety of proprioceptive, motor, tactile, auditory, auditory, vestibular, taste, and oral stimuli at different times of the day to help the brain regulate attention and the right level of arousal. These stimuli release neurochemicals that can last up to two hours depending on the type and intensity of the stimulus. To maintain the flow of these neurochemicals in the brain, it is essential to plan a sensory diet throughout the day [12]. According to Tabasi et al. [3], some behavioral symptoms in children with ADHD may be due to sensory processing disorder.

Motahari Muid et al. [4] in a study on primary school students with ADHD showed that sensory integration has a significant effect on hyperactivity, attention deficit, and impulsivity in the experimental group. Ebrahimi et al. [13] proved the effectiveness of sensorimotor integration activities in improving the symptoms of ADHD. Patterson et al. [14] in a study showed that a sensory diet has positive effects on reducing abnormal behaviors and increasing attention level and mental retention in children with ADHD. Chang et al. [15] indicated that sensory integration results in superior brain function, and as a result, sensory integration intervention can improve impulsivity.

Due to the high prevalence of ADHD in school-age children and the consequent problems of these children in various areas of individual and social life and the importance of early intervention, and considering the available evidence on the effectiveness of sensory integration therapy and sensory diet in improving various behavioral, motor, educational and linguistic functions in patients with other childhood disorders and the existence of scant research on the effect of sensory diet therapy on the symptoms of ADHD, this study aims to investigate whether providing a family-centered sensory diet program can be effective on the impulsivity of primary school students with ADHD.

2. Materials and Methods

This is a quasi-experimental study with a pretest-posttest design with a control group. The study population included all children with ADHD aged 6-12 years in Tehran City, Iran referred to the clinics of Hasti, Bahar, and Masir-e Sabz in 2020. Of these, 30 children were selected using a convenience sampling method and based on the scores of the Wechsler intelligence scale for children 4th edition (WISC-IV) used to test intellectual ability and Conners' parent rating scale (CPRS) to diagnose ADHD in children. The inclusion criteria included the diagnosis of ADHD by a child psychiatrist, having normal intelligence question based on WISC-IV score, not having vision and hearing problems, and not having epilepsy and seizures. Exclusion criteria included lack of cooperation and unwillingness to participate in the program. Children were randomly divided into intervention (n=15) and control (n=15) groups. The intervention group underwent 12 sessions of a family-centered sensory diet program, 3 sessions per week and each session for 45 minutes by the researcher (Multiple Sclerosis (MS) in occupational therapy), in addition to routine occupational therapy, received 2 sessions per week. The control group received only two sessions of routine occupational therapy. In the first session of the sensory diet program, after getting acquainted with the family and the child, the child's sensory condition was examined and instructions were given about correcting environmental stimuli, plans were made, and the sensory diet was scheduled. To modulate sensory inputs and increase self-regulation in children, parents were directed to activities that use appropriate and controlled vestibular, proprioceptive, visual, and auditory stimulations to organize and integrate the child's senses. It should be noted that in each treatment session, 5-6 activities were taught to the families, and according to the progress of each child, other exercises were used in the next sessions, or their difficulty increased. In the seventh session, the performance and process of the presented sensory diet were evaluated. In the last session, after training and continuing the process of a sensory diet, the CPRS was completed for both groups as the posttest assessment. Independent t-test and analysis of covariance (ANCOVA) were used in SPSS software, v. 20 for data analysis. The t-test was used to examine the mean differences of the study statistical population.

Family-centered sensory diet program

This program was adapted from the Wilbarger protocol, which is a comprehensive approach to treating sensory problems. It is also called the Wilbarger deep pressure and proprioceptive technique and oral tactile technique. It is used to help organize the mind, brain, and body, increase attention, participate in daily activities, reduce tactile defense, and increase body self-regulation. This protocol consists of three steps, including brushing, joint compression, and a sensory diet. A sensory diet involves a set of sensory activities and inputs to the body and nervous system to maintain optimal levels of arousal. These activities are included in the child's daily planning according to the child's needs and it reduces tactile defense, increases body awareness about itself, the environment, and others, increases participation in social activities and interaction with peers, and increases efficiency [16]. Table 1 presents the protocol of the family-centered sensory diet program.

Outcome measurement

The fourth edition of WISC (2003) was used in this study. It provides a full-scale intelligence quotient (FSIQ) and four index scores, including (a) verbal comprehension index (VCI) with subtests of similarities, vocabulary, comprehension, general information, and word reasoning; (b) perceptual reasoning index (PRI) consist-

Table 1. Protocol of family-centered sensory diet program

Sessions	Objectives and Contents
1	Getting acquainted with families, assessing the sensory status of children, introducing the program and the conditions of the child's training area, scheduling the program
2	Vestibular and proprioceptive stimulations, deep massage before school, walking on a slippery surface, sitting with a heavy vest and hat, and sitting in a rocking chair in the classroom
3	Visual and vestibular stimulations, jumping in place before homework, sitting on a yoga ball and talking, spinning in in a circular room, or playing in the sand
4	Visual and vestibular stimulations, jumping in place before homework, sitting on a yoga ball and talking, spinning in in a circular room, or playing in the sand
5	Proprioceptive stimulation and increase of tolerance, leaning and sitting behind a desk longer, squeezing a jelly ball in the classroom, sleeping in a sleeping bag, and playing with a cloud mattress
6	Proprioceptive stimulation, doing heavy physical activity, playing skateboarding, and moving objects
7	Measuring progress, Re-assessing performance and sensory diet
8	Proprioceptive stimulation, dancing, drawing growing circles, squeezing a sponge in the water, and jumping on a mattress
9	Vestibular stimulation and interaction between brain nuclei, crawling, climbing up a ladder, repeating memorization, listening to lessons with headphones, and walking in a straight line
10	Visual and vestibular stimulations, playing wall ball, Swedish swimming, structural puzzle activity, swing game, and review of lessons
11	Proprioceptive and balance stimulation, balance on unstable surfaces, cutting thin strips of paper, rope game, and biking
12	Reassessment and summarization

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ed of subtests of block design, picture concepts, matrix reasoning, and image completion; (c) working memory index (WMI) with subtests of digit span, letter-number sequencing, and arithmetic; and (d) Processing Speed Index (PSI) with subtests of coding, symbol search, and cancellation. The validity and reliability of the Persian version of WISC-IV were evaluated by Sadeghi et al. [17]. The validity results showed a significant correlation between this scale and Raven's progressive matrices. The reliability results showed split-half reliability of 0.83-0.91 and test-retest reliability of 0.80-0.88.

The CPRS used to diagnose ADHD is a popular tool to measure childhood behavior problems. It was first developed by Conners (1973) with 93 items. Then the short form of this scale with 48 items was prepared by Goethe et al. in 1978. The CPRS was first developed to evaluate the effect of stimulant drugs on children with ADHD and to distinguish these children from normal children. Today, a revised form of CPRS with 26 items is used to diagnose ADHD in children. The test-retest reliability coefficient for the overall scale is 0.58 with a Cronbach's alpha coefficient of 0.73 and its validity is 0.84, which measures the three factors of impulsivity, hyperactivity, and attention deficit. The items are rated on a 4-point scale as 1=never, 2=sometimes, 3=often, and 4=always [18]. In this study, we used the oppositional subscale of CPRS, indicating impulsivity. This subscale has a positive correlation with reaction time in cognitive-motor function test (r=0.82, r=0.92, respectively) [19].

3. Results

In this study, 30 children with a combined type of ADHD (Mean±SD age: 9.56±4.38 years), including 11 girls (36.6%) and 19 boys (63.3%), and mothers of these children (mean age=34.23 years) participated. Table 2 presents the demographic and clinical characteristics of the participants. As can be seen, 9 children were in the age group of 6-8 years, 11 aged 8.1-10 years, and 10 aged 10.1-12 years. Moreover, 9 mothers had a diploma, 14 had a bachelor's degree, and 7 had a master's degree or above. In terms of occupation, 16 mothers were employed and 14 were housewives. The mean intelligence score of boys was 103.84 and for girls, it was 104.01. No significant difference was observed in intelligence scores between girls and boys (P>0.05).

Table 2. Demographic and clinical characteristics of participants

Characteristics		Mean±SD/No. (%)
Gender	Female	11(36.6)
	Male	19(36.3)
Children's age	6-8	9(30)
	8.1-10	11(37.7)
	10.1-12	10(33.3)
Mean intelligence score	Female	104.01
	Male	103.84
Mother's education	Associate degree or lower	9(30)
	Bachelor's degree	14(47.7)
	Master's degree or higher	7(23.3)
Mother's occupation	Employed	16(53.3)
	Housewife	14(47.7)
Type of ADHD	Combined (both inattention and hyperactivity/impulsivity are present)	

ADHD: Attention Deficit Hyperactivity Disorder.

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As presented in Table 3, the mean and standard deviation of pretest impulsivity were 30.93 and 3.81 in the intervention group and 30.67 and 2.89 in the control group, respectively. Moreover, their posttest impulsivity was 24 and 3.047 in the intervention group and 30.47 and 2.85 in the control group, respectively.

According to Table 4, the assumption of the equality of variances of the two groups was rejected (P>0.05). In comparing the pretest and posttest means between the two groups, the t statistic was equal to 3.550 and the P value was less than 0.05 (P=0.001). Therefore, the impulsivity was significantly different in participants who received the sensory diet program plus occupational therapy and those who received only occupational therapy. According to the results in Table 5, family-based sensory diet program sessions were effective in reducing impulsivity in children with ADHD; $F_{(1,27)}$=207.937, P=0.001<0.05.

4. Discussion

This study aimed to evaluate the effectiveness of a family-centered sensory diet program on impulsivity in children with ADHD. The results showed that the program could reduce their impulsivity. This is consistent with the results of Petterson et al. [14] who showed that a sensory diet has positive effects on reducing abnormal behaviors, increasing attention span, and mental retention in children with ADHD. Sahoo et al. [10] investigated the effect of sensory diet for 2 months on functional behaviors of 28 children with

Table 3. Descriptive statistics of impulsivity variable in children (n=15)

Stages	Groups	Mean±SD	Min	Max
Pre-test	Intervention	30.93±3.81	24	36
	Control	30.67±2.89	25	36
Post-test	Intervention	24.00±3.047	20	28
	Control	30.47±2.85	24	35

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Table 4. Independent t-test of variances between the two groups

Assumptions	F	Sig.	df	Sig.	t
Equality of variance	2.674	0.107	58	0.001	3.550
Inequality of variance			54.076	0.001	3.550

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ADHD aged 6-12 years, and improved functional behaviors at home, school, and community as well as the ability to self-control were observed. In explaining these findings, it can be said that linking the motor, perceptual and limbic areas of the brain is one of the special functions of the prefrontal cortex. Extensive projectiles reach the prefrontal cortex from most of the parietal, temporal, and posterior regions. Subcortical structures, including the basal ganglia, cerebellum, and various nuclei of the brainstem, also have some indirect frequency connectors to the prefrontal cortex. The prefrontal cortex also interacts with most parts of the brain. Given these broad connections, the brain also plays a coordinating and executive role [20]. Due to the interaction between the subcortical and cortical parts, especially the prefrontal area, it can be expected that the sensory diet intervention will improve the function of the prefrontal cortex in addition to affecting the thalamus and cerebral cortex.

Pingal [21] in a review study examined the effectiveness of a sensory diet and achieved satisfactory results in this area and recommended the use of a sensory diet in the control of sensory processing disorders. Pingal et al. [22] examined the effectiveness of a sensory diet on three children with autism and observed a significant improvement in their sensory processing problems, social behaviors, and behavior control in the classroom. Hare [23] evaluated the effectiveness of sensory processing therapies in reducing impulsivity and anxiety in people aged 18-26 years with ADHD and found a significant effect in controlling impulses and anxiety in these individuals. Sheikh Taheri et al. [11] developed a mobile phone-based sensory diet program to educate parents of children with ADHD. The program was presented to parents for two weeks. Their results showed that sensory dieting programs help improve the symptoms of children with ADHD. A sensory diet can improve the symptoms of these children, perhaps by improving the function of the central nervous system in information processing, which can be greatly reduced by early diagnosis and the selection of better intervention methods [24]. Also, the sensory diet based on the theory of sensory integration, by transcending the environmental senses and increasing the level of arousal, causes the child more organized during the day on his/her responses to sensory stimuli and to interact more with his/her environment [14].

Hemant and Zarrin [25] examined sensory integration therapy for children aged 5-12 years with ADHD. The results of the study showed that sensory integration therapy was effective in the sensory processing problems of these children. Ghanizadeh [26] in a review study showed that sensory problems and hyperactivity interact with each other, and sensory processing programs have a positive effect on reducing anxiety and symptoms of oppositional defiant disorder. Rathod et al. [27] showed that sensory integration therapy alone and in combination with cognitive-behavioral therapy had a significant effect on reducing the symptoms of ADHD using the CPRS ($P<0.05$). Rahmani et al. [28] evaluated the effectiveness of sensory integration therapy in reducing the symptoms of ADHD. Their results showed that children who received sensory integration therapy reported a significant improvement in the ear-

Table 5. ANCOVA for the effect of the intervention on impulsivity of children with ADHD

Source	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Impulsivity	200.389	1	200.825	124.825	0.001	0.822
Group	333.872	1	333.872	207.973	0.001	0.885
Error	22807	27	1.605			
Total	557.367	30				

Abbreviations: ANCOVA, Analysis of Covariance; ADHD, Attention Deficit Hyperactivity Disorder

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ly symptoms of ADHD compared to the control group. Motahari Muid et al. [4] also showed the effectiveness of group-based sensory integration on the attention, hyperactivity, and impulsivity of elementary students with ADHD. Dehghan et al. [29] (Investigated the effect of using perceptual-motor exercises on behavioral disorders in children aged 7-10 years with ADHD and concluded that such exercises, in addition to improving the perceptual motor skills of these children, improve their behavioral problems, such as anxiety, attention deficits, aggression, and social problems.

A study by Batara et al., also showed that sensory stimulation had a significant effect on the three main symptoms of ADHD [30]. The results of Ebrahimi's [13] study also showed the effect of sensory integration therapy on attention deficit, hyperactivity, and impulsivity in children with ADHD. The difference between the present study and previous studies is in the treatment method. In the present study, children received a sensory diet program from their parents and performed it with their help. According to George et al. [31], families have limited information about sensory diet. Hadi et al. [32] showed that one of the most effective therapeutic interventions to reduce the symptoms of ADHD in children is parent education and family-centered therapies. Many parents tend to use strategies to help their children. Parents are known as the primary source of assistance in response to daily needs. This important source is used due to the children's dependence on them as well as being the most accessible source. The parent-centered approach seems to have been beneficial with positive effects by manipulating the psychological characteristics of children, such as a sense of belonging and solidarity, motivation, and higher confidence.

5. Conclusion

Sensory diet intervention is a new and effective method for children with ADHD. It improves their performance in various social situations and can be used in Iran as a novel, practical, and freely accessible method. It is recommended to use this intervention in combination with other therapeutic interventions in rehabilitation centers, schools, etc. There were some limitations in this study, including limitations in recruiting samples and holding sessions due to the COVID-19 pandemic, and the lack of a long-term follow-up phase. Therefore, it is recommended that future studies be conducted using larger sample sizes, more sessions, and a variety of sensory processing disorders.

Ethical Considerations

Compliance with ethical guidelines

The Ethics Committee of Science and Research Branch, Islamic Azad University approval the study (Code: IR.IAU.SRB.REC.1400.155). Also, a written and verbal consent was obtained from the participants and they were assured of the confidentiality of their information.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The author declared no conflict of interest.

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