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The Effects of Sensory Integration Training on Motor, Adaptability and Language Development in 3-5 Year-old Children with Developmental Delay

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Abstract

The purpose of this study is to examine the effects of sensory integration training on children with developmental delays. To achieve this goal, an educational experiment is conducted in five main areas: gross motor ability, fine motor ability, adaptive ability, language and social ability in children with developmental delay. The study subjects were children with developmental delays aged 3-6 years diagnosed at Beijing Institute of Pediatrics and Beijing Medical University and received sensory integration intervention and home-based training at the Golden Rain Forest Beijing Tongzhou Center from 2018 to 2021. According to the purpose of the analysis, the data collected are subjected to descriptive statistics using SPSS 21.0 statistical program, Two-way MANOVA analysis, and data analysis method of multivariate analysis is used to process the collected data. In addition, a total of 39 subjects were selected, including 19 children who received sensory integration training and 20 children who only received family training. The results show that the sensory integration training group outperformed the home training group in all aspects and developmental quotient, but the home training group also showed higher levels of significance for improvements in gross motor, fine motor and developmental quotient.

Keywords: *Developmental Delay, Sensory Integration Training, Gross Motor, Adaptability, Language*

1. INTRODUCTION

Children are the hope and future of families and society, and their healthy growth is always a topic of great concern, the rapid development of medical technology and health care in recent decades has reduced the incidence of certain diseases, but it has also brought negative results. The increase in the survival rate of newborns at risk has brought about a series of neonatal problems, and developmental delay is one of them, which is related to the quality of life of children throughout their lives.

Developmental Delay (DD) is an important problem for both society and families. It can be transient or persistent and is common in the child population, with a prevalence of 6-8% [1]. Childhood developmental delays are defined as individuals who do not meet the child's expectations in gross motor, fine motor, cognitive, neurological development, personal and social, and language for their corresponding age groups [2, 3]. Low family income, inadequate parental mental health and education, poor family relationships, and poor parenting

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practices may all increase the risk of childhood developmental delay [4], DD caused by lack of companionship, neglect and other social reasons has become a serious social phenomenon in the context of rapid economic development, while the lack of social and cognitive big data of children in developing countries also makes it difficult to identify DD related to this issue [5]. In addition, some parents are reluctant to acknowledge the symptoms associated with their children, and some children with DD are only identified and determined when parents are concerned about preschool issues or during primary care visits 6]. National and international organizations, such as the World Health Organization and UNICEF, have emphasized testing the growth of children under the age of 5 in developing countries, but many developmental issues have not received the attention they deserve. Children with developmental delays are among the most vulnerable members of society, and without professional intervention, DD can greatly limit the potential of children later in life [7]. Movement is an important part of a child's early development, and it can also reflect the development of the nervous and central systems motor underdevelopment may also be the first indication of other signs of DD. Motor qualities and behavioral patterns can also have a complex impact on the child's perceptual and emotional development [8, 9]. Sensory integration is "the neural process that organizes sensations from one's own body and environment and makes possible the effective use of the body in the environment" [10, 11]. Sensory integration is a process in which the human body's visual, auditory, olfactory, gustatory and tactile vestibular senses acquire information and transmit it to the brain, where the brain differentiates, selects, integrates, analyzes and processes it, and then makes adaptive responses.

The general concept of sensation refers to sight, hearing, taste and smell, but in fact the most basic and important senses needed for human survival are tactile sensation, vestibular and proprioception. Tactile sensation is the sensation of temperature, humidity, pain, pressure and vibration from the outside world received by nerve cells distributed throughout the body. Vestibular balance perception uses the three pairs of semicircular canals in the inner ear and otoliths (calcium carbonate crystals) to detect gravity and control the orientation of the head during movement and to maintain body balance. Proprioception is the sensation that comes from the muscles and joints inside our body, and it is the sense of understanding the position and movement of the limbs. Human sensory learning occurs throughout one's life and is simply a process of learning in which the brain and body coordinate with each other. Simply put, it is a learning process coordinated between brain and body. Without sensory integration, neither the brain nor the body can develop [12]. Sensory integration training is mainly based on interactive games, using a variety of specialized training equipment, toys, and so on. It can give children reasonable motor, language, personal and social, cognitive, psychological and other comprehensive guidance training, and through the movement of the nerve, brain stimulation to promote children's cognitive, motor and social skills to improve. The motor and social, language, and psychological aspects have many common features with sensory integration disorder symptoms and developmental delays, and the commonalities are particularly similar in terms of the need for intervention. Decades of research at home and abroad have demonstrated the effectiveness of early intervention in improving the prognosis of children with developmental delays. The primary interventions are through physical measures such as visual stimulation, auditory stimulation, tactile stimulation, vestibular motor stimulation, etc. The active cooperation and participation of parents can promote the best training effect [13, 14].

However, the current literature on non-pharmacological interventions for developmental delays is scarce, so it is important to use sensory integration training to provide early interventions for children with developmental delays and to give benign stimulation to sensory organs in multiple directions, so as to further develop their visual, auditory, motor, and social interaction abilities and improve their intelligence and motor levels.

2. ANALYSIS METHOD AND SURVEY TOOL

2.1 Study Subjects

In this study, 19 children with predominantly motor, cognitive, and social developmental delays, 13 boys and 6 girls, diagnosed at Beijing Institute of Pediatrics and Beijing Medical University from 2018 to 2021, who received rehabilitation training at our institution from 3 to 6, and named them as group A. Twenty children aged 3-6 years who received only family intervention, 12 males and,8 females, named the group as Group B, were used as study subjects. The information of gender and age between the two groups of children are shown in <Table 1>. Exclude special children with hearing impairment and other neuro developmental disorders, and special children with developmental coordination disorders, autism, Down syndrome, and vestibular dysfunction.

Table 1. Study Subjects

Team	Age	Grander	N	Percentage
A	50.958±6.498	Male	6	15.4%
		Female	13	33.3%
B	52.105±5.585	Male	8	20.5%
		Female	12	30.8%

2.2 Survey Tools

Comprehensive, reliable and valid assessment methods are a prerequisite for effective intervention planning and implementation [15]. The Developmental Behavior Assessment Table for Children aged 0-6 in China is compiled by The Capital Institute of Pediatrics in Beijing, based on the theory of cognitive development, and developed after 30 years of continuous improvement [16], which can comprehensively evaluate the development level of children and identify early developmental abnormalities. The scale contains five main areas, ① Gross motor ability (GM) : test children's basic motor ability; ② Fine movement ability (FM) : test the child's ability of fine movements of both hands; (3) Adaptability (AD) : test children's ability to see, pick and draw daily activities; ④ Language ability (L) : test children's listening, understanding and language expression ability; ⑤ Personal social interaction (PS) : test children's reaction and response ability to people around them [17].

To verify the validity of the questionnaire used in this study, a panel of experts conducted a face validity analysis.

Figure 1. Gross Motor Ability Test

Figure 2. Ability Testing Courses

Figure 3. Family Questionnaire Assessment

2.3 Investigation Procedures

To examine the changes in motor, cognitive, language, and social skills of children with motor delays before and after the integrated sensory intervention, a pedagogical experimental study was conducted from March 2018 to March 2021 on children with developmental delays who received sensory training at our center.

At 1 week before and after the intervention, 6 months after the intervention (±1 week), and 12 months after the intervention (±1 week), the scale Developmental Behavior Assessment Table for Children aged 0-6 in China was adopted for the children's Gross motor (GM), Fine Movement (FM), Adaptability (AD), Language (L), Personal social (PS) indicators, the special evaluator to evaluate the child's development quotient (DQ). Intervention guidance for children in a cycle of "assessment - training - re-assessment - re-training".

2.4 Statistical Analysis

The investigation procedure is to collect data before the first time, during the second time and after the third time of test content. The data collected were subjected to descriptive statistics using SPSS 21.0 statistical program, Two-way MANOVA analysis, and data analysis method of multivariate analysis was used to process the collected data according to the purpose of analysis.

3. RESEARCH RESULTS

3.1 Two-way MANOVA Analysis Results before, during and After the Experiment

As shown in <Table 2>, there was no significant difference in the scores of GM, FM, AD, L, PS, and DQ between groups A and B before the intervention. The results of the second test scores showed that there was a significant difference between the scores of groups A and B in GM, FM, AD, L, PS, and DQ, and the scores of group A were higher than those of group B. It can be seen from the results of the third test scores that the difference in scores of GM, FM, AD, L, PS, and DQ between groups A and B is statistically significant, and the scores of group A are significantly higher than those of group B.

3.2 The Scores of the First, Middle and Last Three Tests Compared in Pairs' Results

The comparison of the results of the three test scores of groups A and B is shown in Table 3, in terms of GM group A three test scores two by two comparison and before and after comparison $P < 0.001$; group B 1-2, 2-3 score difference $P < 0.01$; before and after overall comparison results A and B Group P value are < 0.001, there are significant differences between the scores. In terms of FM in group A, $P < 0.01$ for 2-3, $P < 0.001$ for 1-2 and 1-3 score comparisons; in group B, only $P < 0.001$ for 1-3 score difference comparisons; however, the overall FM values in both groups were statistically significant with $P < 0.001$ for pre- and post-intervention comparisons. In terms of AD, only group A had a P value < 0.05 on the 1-3 comparisons between the two comparisons, but the results of the pre- and post-intervention comparisons has a $P < 0.001$. In terms of L, the score two-by-two comparison was only $P < 0.001$ for group A on the 1-3 comparisons and $P < 0.001$ for the results of the pre- and post-intervention comparison in group A. In terms of PS, $P < 0.01$ for the comparison of two scores on 1-3 comparisons, and $P < 0.01$ for the results of the pre- and post-intervention comparison in group A. It indicates that only group A's reflected significant differences in AD, L, and PS before and after the intervention. Finally, in terms of DQ scores, there was a significant difference in the score results before and after the intervention between groups A and B, but $P < 0.001$ in group A and $P < 0.01$ in group B; moreover, before, during, and after group A, the P value of the three score two comparisons was $P< 0.001$, while group B only had a significant difference $P < 0.01$ in 1-3 comparisons; obviously the intervention effect of group A was significantly higher than that of group B.

Table 2. Pairwise Comparison Results between Groups

Constructs	Time	M±SD (A)	M±SD (B)	(I) G	(J) G	Mean difference I-J	S.E.	F	Eta
GM	1	67.416±5.747	66.955±9.091	Team A	Team B	0.461	2.629	0.031	0.000
	2	83.405±4.949	74.255±10.707			9.150	2.629	12.110***	0.098
	3	95.995±6.962	82.065±9.792			13.930	2.629	28.064***	0.202
FM	1	71.020±8.857	70.970±5.542			0.051	2.124	0.001	0.000
	2	80.570±7.775	76.050±5.173			4.518	2.124	4.527**	0.039
	3	87.690±6.640	80.000±5.088			7.694	2.124	13.128***	0.106
AD	1	84.411±12.354	84.015±11.265			0.396	3.140	0.016	0.000
	2	92.137±9.997	85.525±7.273			6.612	3.140	4.43**	0.038
	3	97.400±9.448	87.310±7.584			10.090	3.140	10.327***	0.085
L	1	91.426±15.554	92.225±13.538			-0.799	4.102	0.038	0.000
	2	101.384±14.134	92.815±11.490			8.569	4.102	4.364**	0.038
	3	106.911±11.857	96.110±9.538			10.801	4.102	6.932**	0.059
PS	1	87.889±10.114	83.510±11.860			4.379	3.157	1.924	0.017
	2	94.100±10.097	85.635±9.506			8.465	3.157	7.188***	0.061
	3	97.700±8.483	88.655±8.646			9.045	3.157	8.207***	0.069
DQ	1	80.433±7.423	79.535±7.741			0.898	2.155	0.173	0.002
	2	90.319±6.337	82.856±6.421			7.463	2.155	11.99***	0.097
	3	97.139±6.411	86.827±5.838			10.312	2.155	22.894***	0.171

*P＜0.05, **p<0.01, ***P＜0.001

Table 3. The Results of the Two Groups were Compared Three Times before, during and After the Test

Constructs	Group	Time	M±SD	(I) T	(J) T	Mean difference I-J	S.E.	F	Eta
GM	A	1	67.416±5.747	1	2	-15.989***	2.663	57.859***	0.510
		2	83.405±4.949	2	3	-12.589***	2.663		
		3	95.995±6.962	1	3	-28.579***	2.663		
	B	1	66.955±9.091	1	2	-7.300**	2.596	16.951***	0.234
		2	74.255±10.707	2	3	-7.810**	2.596		
		3	82.065±9.792	1	3	-15.110***	2.596		
FM	A	1	71.020±8.857	1	2	-9.547***	2.151	30.245***	0.353
		2	80.570±7.775	2	3	-7.121**	2.151		
		3	87.690±6.640	1	3	-16.668***	2.151		
	B	1	70.970±5.542	1	2	-5.080	2.096	9.317***	0.144
		2	76.050±5.173	2	3	-3.945	2.096		
		3	80.000±5.088	1	3	-9.025***	2.096		
AD	A	1	84.411±12.354	1	2	-7.726	3.180	8.444***	0.132
		2	92.137±9.997	2	3	-5.2	3.180		
		3	97.400±9.448	1	3	-12.989*	3.180		
	B	1	84.015±11.265	1	2	-1.510	3.099	0.566	0.010
		2	85.525±7.273	2	3	-1.785	3.099		
		3	87.310±7.584	1	3	-3.295	3.099		
L	A	1	91.426±15.554	1	2	-9.958	4.154	7.136***	0.114
		2	101.384±14.134	2	3	-5.526	4.154		
		3	106.911±11.857	1	3	-15.484***	4.154		
	B	1	92.225±13.538	1	2	-.590	4.049	0.535	0.010
		2	92.815±11.490	2	3	-3.295	4.049		
		3	96.110±9.538	1	3	-3.885	4.049		

PS	A	1	87.889±10.114	1	2	-6.211	3.198	4.818**	0.080
		2	94.100±10.097	2	3	-3.600	3.198		
		3	97.700±8.483	1	3	-9.811**	3.198		
	B	1	83.510±11.860	1	2	-2.125	3.117	1.376	0.024
		2	85.635±9.506	2	3	-3.020	3.117		
		3	88.655±8.646	1	3	-5.145	3.117		
DQ	A	1	80.433±7.423	1	2	-9.886***	2.183	29.622***	0.348
		2	90.319±6.337	2	3	-6.820***	2.183		
		3	97.139±6.411	1	3	-16.706***	2.183		
	B	1	79.535±7.741	1	2	-3.321	2.127	5.890**	0.096
		2	82.856±6.421	2	3	-3.971	2.127		
		3	86.827±5.838	1	3	-7.292**	2.127		

*P＜0.05, **p<0.01, ***P＜0.001

4. DISCUSSION

The present study and a pilot study to improve the developmental quotient of children with developmental delays were based on a sensory integration training intervention. The results of the intervention in the intervention group and the control group were studied by setting up an intervention program for each child's developmental level and discussing the results of the treatment according to the intervention approach.

From the prior studies on the effects of sensory integration training on gross motor (GM), fine movement (FM), adaptability (AD), language (L), and personal social (PS), the case results are as follows.

Sensory integration training had a significant effect on the improvement of motor ability in both groups of children. This one result is consistent with the previous findings that sensory integration training has a significant effect on the development of motor abilities in children [18], ASI (sensory integration) intervention has a significant effect on motor development and sensory processing in children with developmental delays [19], the interaction through serious games can strengthen the child's sense of movement, balance, space, attention, and have a positive effect on the development of motor ability [20]. Our approach to sensory training is mostly based on serious games combined with training content and fun teaching aids, which can stimulate children's interest in practicing and help counteract children's resistance to boring training, and at the same time praise every progress of children during the class, which psychologically gives children a lot of support and encouragement. The children continue to improve themselves through happy sports and games, and this has a positive impact on their willingness to participate in daily life sports.

Sensory integration training had a significant enhancement effect on fine motor development in both groups of children. It has been shown that training through sensory integration games confirmed to improve the accuracy and efficiency of hand task completion [21], after the intensive exercise intervention, subjects showed significant improvements in fine hand movements and solo performance of daily living tasks [22], sensory integration training is effective in enhancing non-dominant hand and hand fine motor performance and improving functional performance in subjects [23]. The improvement of fine motor requires not only the support of specialized equipment and training methods, but also the improvement of muscle strength and the control of visual attention. The comprehensive nature of sensory training effectively solves these fundamental problems and thus can have a positive effect on the development of fine motor.

There was a statistically significant effect of sensory integration training on the development of adaptive ability of children in the instructional intervention group. Sensory integration training among young children can provide a good foundation for their adaptive ability and physical and mental development [24]. The PGEE early intervention program had a significant intervention effect on children's adaptive capacity enhancement, with significant differences between the experimental and control group [25]. Adaptive ability is an important

component of cognitive development, which directly reflects the child's basic general knowledge comprehension. During the training process, teachers will constantly instill general knowledge and test what the child has mastered, while in the home group, parents may not understand their children accurately enough, or some parents really do not have much time to train their children due to work, thus leading to the difference between the teaching intervention group and the home training group.

Sensory integration training had a significant effect on the development of language skills of the children in the instructional intervention group. Children's brains have a high plasticity capacity, and giving appropriate experiential intervention and stimulation is an important prerequisite for the normal development of higher brain functions such as motor function, language and sensory [26]. Sensory integration training based on language processes had a positive impact on the subjects' language improvement, with qualitative improvements in word repetition and pronunciation standardization and simple communication [27]. Detecting the progress of language children's development requires communicative discourse training in terms of traits, contextual relevance [28]. In addition to specifically guiding children to initiate vocalization during our lessons, we often communicate with them by using short language that they can easily understand and simple questions and answers, and we also repeat short vocabulary and sentences for children with poor language skills, thus correcting pronunciation and basic reinforcement more frequently.

Sensory integration training had a significant effect on the development of social ability in children in the instructional intervention group. Sensory integration therapy positively influenced peer interaction in children with developmental delays [29]. Children in the sensory group showed a significant increase in social interaction after sensory intervention [30]. Sensory integration interventions focus on the improvement of the child's basic abilities, especially for children with developmental delays, as they are already below their biological age and most of them will show a lack of confidence and reluctance to actively interact with others in their peer group, as we gradually helped to complement their basic skills, most of the children showed an enthusiasm to participate actively in group activities and a desire to initiate communication with others.

Sensory integration training was statistically significant in improving the developmental quotient levels of children in both groups. Non-pathological developmental delays in children are mostly directly related to the lack of family companionship, and parental involvement in the intervention can promote the improvement of the developmental quotient indicators in children with developmental delays [31]. Supporting and strengthening parents' awareness of synergy can enable parents to better understand their children's current developmental characteristics, so that they can find the right educational approach for their children, which is of great significance to the overall development and strengthening of their children's developmental quotient [32]. While specialized training in specialized institutions is important, children ages 3-6 spend most of their time with their families, and often display a different attitude toward learning when training at school than they do at home, the ultimate goal of sensory training for children is to enable them to better adapt to society and school, which cannot be done without the company of parents, so the importance of family training can be imagined.

5. CONCLUSION

To examine the effects of sensory-motor integration training on the gross motor ability, fine movement, adaptability, language, Personal social and developmental quotient of children with developmental delays, an experimental study was conducted on 19 children who received sensory-motor teaching intervention and 20 children who underwent home sensory integration training.

After a year of targeted instruction or home training, for the instructional intervention group we provide a sensory training program through 3 sessions per week, one hour per session; for the home training group we

provide 3 sessions per week. Three scale evaluations were conducted before, during, and afterwards by specialized teachers and a combination of teacher and parent findings for a comprehensive score evaluation. The results of this study are as follows.

First, sensory integration training significantly improved the motor abilities of children in both the instructional intervention group and the home training group.

Second, sensory integration training significantly improved the fine motor ability of children in both the instructional intervention group and the home training group.

Third, sensory integration training has a significant effect on the adaptive abilities of children in both instructional intervention groups.

Fourth, sensory integration training has a significant effect on the language development level of all children in the instructional intervention group.

Fifth, sensory integration training significantly enhanced the personal social development of children in both instructional intervention groups.

Sixth, sensory integration training significantly enhanced the developmental quotient levels of children in both the instructional intervention group and the home training group.

Overall, all aspects and overall effects of the instructional intervention group were better than those of the home training group, but children in the home training group also demonstrated better levels of significance for motor, fine motor, and developmental quotient gains.

The limitations of this study are as follows:

Firstly, due to resource constraints and specific differences in the study population, the number of examples we selected for the study was small and there is a need to study a larger number of subjects for the intervention in future studies.

Secondly, the areas selected for this study are Tongzhou and Yanjiao districts in Beijing. Because of regional and economic and cultural differences, its representation may not apply to less developed districts, so the range of areas selected for the study will be expanded in the future.

Thirdly, a specific analysis will be carried out later on with regard to the background factors of the family in which the child lives, such as, family income, parental cultural background, time spent with the guardian.

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