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Original Article

Influence of Play-based Occupational Therapy Intervention on Preschool Children with Fine Motor Delay

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Occupational therapists often provide training activities for preschool children with fine motor delay to enhance their neurodevelopment and sensory integration. Although clinically occupational therapy is often employed to improve fine motor skills in preschool children, few studies have discussed the effects following occupational therapy.

The subjects of this study were 3- to 5-year-old preschool children diagnosed with delay in fine motor development. These children received occupational therapy. After 1 year of treatment or less than 1 year after treatment was stopped, they were assessed again for comparative analysis of the effects of occupational therapy intervention. Fifty-three preschool children with fine motor delay were followed up (37 boys and 16 girls). All subjects showed obvious progress after occupational therapy intervention ($p < 0.001$), and the effect size was large (Grasping = 1.24, VMI = 0.94).

A high proportion of children initially diagnosed with delayed development improved to normal level of development (Grasping, 51.1%; VMI, 40.5%), and 57.4% of children initially diagnosed with delay in development of overall fine motor skills improved to normal level of development after occupational therapy intervention. From the results of this study, occupational therapy can help children to improve or even reach normal level of fine motor development. The results of this study provide a reference for occupational therapists in clinical practice.

Keywords: occupational therapy, fine motor, developmental delay, preschool children

Introduction

A high proportion of motor skill developmental delay exists among preschool children [1, 2]. According to the World Health Organization's statistics, the incidence of developmental delay among preschool children is 6-8% [3] and is increasing year by year [4, 5]. Motor development can be divided into gross motor and fine motor skills. The development of fine motor skills enables preschool children to explore, play, and operate utensils or tools used in daily life [6]. It has been confirmed that preschool children's development of

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fine motor skills has a distinct effect on their writing skills [7-9]. If the writing skills of preschool children are poor, then their ability to read, express, understand, and converse will be affected [9, 10].

In Taiwan, scales are often used to assess children's motor skills development, such as the Movement Assessment Battery for Children-Second Edition (MABC-2) [11], the Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT-2) [12], and the Peabody Developmental Motor Scales-Second Edition (PDMS-2) [13]. PDMS-2 is the most common [14, 15], as it can be used to facilitate early intervention by occupational therapists, physical therapists, physicians, and professionals, as well as assess the performance of children compared to their peers, identify differences in the development of gross motor and fine motor skills, set individual treatment or educational goals, and monitor individual progress. It also serves as a research tool. Past studies have demonstrated that there are good content, construction, and criterion-related validities for the evaluation of children's motor development [13]. There is also high degree of intra- and inter-observer reliability [16]. Moreover, this scale can be used as a diagnostic tool to distinguish normal and abnormal motor development in infants and young children [14].

Occupational therapy intervention is important in the fine motor development of children [17, 18], and can help to improve neurodevelopment and sensory integration [18-20]. Such training highlights the central role of family and promotes children's functional performance and value interactions with the environment [21]. Occupational therapy can strengthen children's perception and movement, which further affect functional performance [18, 22-25] and fine motor skills [26-28]. Many studies have confirmed that occupational therapy intervention can improve writing skills [8, 29-30] and self-care ability [31]. Although occupational therapy has been used to improve fine motor skills of preschool children with developmental delay [32-34], few studies have discussed the influence of occupational therapy intervention.

The aim of this study is to compare the statuses of preschool children before and after occupational therapy intervention via a long-term follow-up and to record the duration of intervention to explore the effects of occupational therapy on preschool children with delay in development of fine motor skills.

Materials and Methods

Participants

This study was conducted among preschoolers aged 3 to 5, who were diagnosed with fine motor delay according to the assessment of functional development by physicians. This study was conducted on cases at hospitals and institutions in Taichung, Taiwan from January 2015 to June 2016. Children (1) with injury of upper limbs within 6 months, (2) with a history of musculoskeletal or neurological illness (eg, mental retardation, cerebral palsy, autism, or traumatic brain injury) that affects the structure or movement of the upper limbs, (3) with a history of having received occupational therapy, and (4) aged above 6 during the follow-up test were excluded. This study was approved by the Institutional Review Board of the Chung Shan Medical University Hospital and complied with the tenets of the Declaration of Helsinki.

Data collection

Tests and treatments were carried out by three occupational therapists. Their average length of clinical experience was 13 years (7 to 17 years). Informed consent was obtained after the study process was explained to the parent or legal guardian of each child and before the child was enrolled in the study. Basic information of the subjects, including age, gender, height, weight, and body mass index, was recorded.

The Fine Motor Quotient (FMQ) test of PDMS-2 was adopted as the measurement tool. The FMQ test is divided into two items: Grasping and Visual-Motor Integration (VMI). The Grasping item contains 26 tests, mainly for evaluating the ability of a child to use his or her hands. As for VMI, this item contains 72 tests, mainly for assessing the ability of a child to perform complex tasks of eye-hand coordination with visual perception, including reaching, taking, tower making, and reproducing a painting, etc. The testers gave scores of 0, 1 or 2 according to the performance of the child. Two points represent that the actions are accurate and correct; 1 point represents that the child can perform the actions, but the accuracy is low; 0 points represent that the child cannot or does

not try to perform the action, or has tried, but the technique or ability has not yet been mastered.

The raw scores were obtained by combining the scores of all the tests in the two major items of Grasping and VMI. The raw scores were then compared with the age norm table of PDMS and converted into a standard score. The full standard score of each item was 20 points; 8 points to 12 points was the average score for normal development. The sum of the standard scores of Grasping and VMI was the standard score of FMQ. The final standard score was compared with the age norm table to convert to development age percentile. If the child failed to reach the 25th percentile, he/she was diagnosed with delay in fine motor development [13].

If a subject's standard score was less than 8 points for either Grasping or VMI, delay in fine motor development was defined and treatment was advised for the subject. Occupational therapy is based on the subject's lack of ability according to development age. Each subject received a 30-minute session for the item for which delay was diagnosed once a week [35, 36] If developmental delay was diagnosed for both items, the subject received treatments twice a week. When 8 points were recorded for the two 2 items, respectively, the sum of the two items failed to reach 25% of development age of FMQ, and developmental delay was defined for both items. It was then suggested that the subject receive intervention for both items. After receiving therapy for 1 year or less than 1 year after treatment was finished, another test was given, and the duration of therapy was recorded for comparative analysis before and after intervention (Fig. 1).

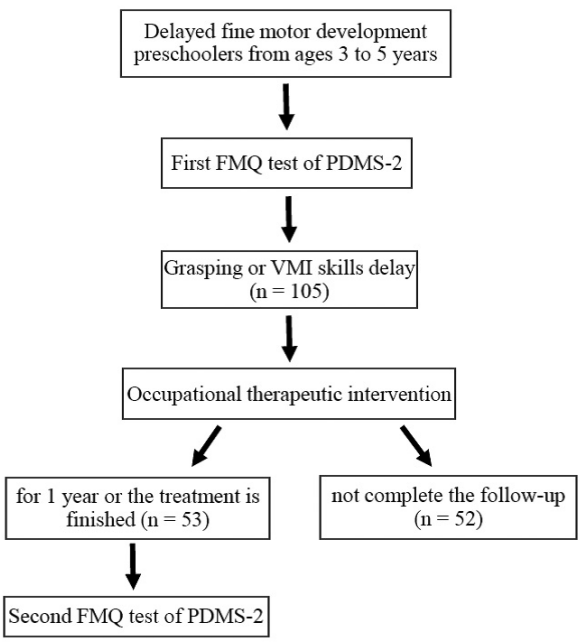

Figure.1. Flow chart of enrollment

Statistical Analysis

The subjects' basic information and test results are presented as means +/- standard deviation. Paired-samples T Test was used to compare the differences between the subjects with complete follow-up and subjects with incomplete follow-up.

Due to the variation in the duration of treatment, partial correlations analysis was used to rule out the influence exerted by this variance. The test results before and after occupational therapy were then compared to calculate their relevance, and effect size was used to analyze the therapeutic effect of the intervention. Cohen [35] defined a small effect size as 0.2, medium effect size as 0.5, and large effect size as 0.8 and above.

The test results of each item can be used to judge whether a subject is under the influence of fine motor developmental delay. To understand the changes in test results before and after treatment, subjects were divided into four groups. Group A consisted of subjects originally diagnosed with fine motor delay, but after therapy test results indicated normal development. Group B subjects were originally diagnosed with fine motor delay. After therapy, test results indicated the same status. Group C was comprised of subjects who were originally diagnosed with normal development, and received no therapy. Follow-up test results indicated the same status. Group D subjects were originally diagnosed with normal development and received no therapy.. Follow-up test results indicated developmental delay. The changes in test results are presented as number of persons and percentages to understand the influence of occupational therapy on fine motor development changes.

Statistical significance in the study was represented by p value <0.05, and data was

Table 1. Characteristics of participants

	All subjects (n = 105)	Subjects that completed the follow-up (n = 53)
Gender (Male/Female)	75 / 30	37 / 16
Age (in months)	45.9 ± 6.81	45.3 ± 7.04
Height (cm)	101.1 ± 6.82	101.0 ± 7.46
Weight (kg)	15.8 ± 2.69	16.2 ± 3.05
Body mass index	15.4 ± 1.49	15.8 ± 1.43
Grasping Raw score	43.8 ± 2.79	43.6 ± 2.84
Grasping Standard score	6.1 ± 1.99	6.1 ± 1.99
Grasping Percentile (%)	14.1 ± 14.45	14.0 ± 13.53
VMI Raw score	112.7 ± 12.90	111.2 ± 13.53
VMI Standard score	7.1 ± 1.88	7.0 ± 1.90
VMI Percentile (%)	20.3 ± 17.28)	19.6 ± 17.40
FMQ Standard score	13.2 ± 2.97	13.1 ± 2.92
FMQ Quotient	79.5 ± 9.40	78.9 ± 9.70
FMQ Percentile (%)	11.98 (10.01)	11.5 ± 9.31

The values are given as mean ± standard deviation

analyzed with SPSS version 14.0 (SPSS Inc., Chicago, IL).

Results

In the beginning of this study, 105 children were tested and diagnosed with delay in fine motor development. However, 52 children failed to complete the follow-up and were excluded, as they refused treatment, stopped treatment, refused to participate in the follow-up, or moved. During the study period, 53 (37 males, 16 females) children aged 3 to 5 with fine motor delay were included, for a total follow-up rate of 50.5%. There was no statistical difference between excluded and included children in terms of basic information, except for BMI, or their values on the individual tests that comprise the two items of FMQ (Table 1).

As shown in Table 2, a total of 45 children completed follow-up for the Grasping item with improvements after treatment (P<0.001). The raw scores increased from 42.9 points to 46.5 points, and the effect size was defined as large (ES=1.24). The development age percentile increased from 9.6% to 24.0%. A total of 37 children completed the follow-up for the VMI item, with improvements after treatment (P<0.001). The raw scores rose from 108.1 points to 121.3 points, and the effect size was defined as large (ES=0.94). The development age percentile increased from 11.1% to 21.7%.

The average duration of occupational therapy for the Grasping item was 48.2 hours (range: 16-173 hours). There was no significant association between the in duration variance and changes in test results before and after treatment. After ruling out the possible influence of duration, there were significant correlations in the raw scores of the Grasping item, the standard scores of FMQ, and the development age percentile, with strongly positive correlation for the standard scores of FMQ and the development age percentile (FMQ raw score r = 0.68, FMQ percentile r = 0.69).

The average duration of occupational therapy received by the subjects who were followed-up for the VMI item was 58.7 hours (range: 16-

Table 2. Comparisons of fine motor assessment results before and after occupational therapy intervention

Grade	Initial	Follow up	difference	*p* value	*r*	*Effect size*
Grasping (n=45)						
Raw score	42.9 (42.2-43.6)	46.5 (45.5-47.6)	3.6 (2.8-4.4)	<0.001*	0.56	1.24
Percentile (%)	9.6 (7.4-11.9)	24.0 (17.5-30.6)	14.4 (8.2-20.6)	0.09	0.26	
FMQ Standard score	12.7 (11.8-13.6)	14.8 (13.2-16.3)	2.1 (1.0-3.1)	<0.001*	0.68	
FMQ Percentile (%)	10.2 (7.5-12.9)	23.6 (16.3-30.8)	13.3 (7.7-18.9)	<0.001*	0.69	
VMI (n = 37)						
Raw score	108.1 (103.7-112.6)	121.3 (116.4-126.2)	13.1 (10.6-15.7)	<0.001*	0.87	0.94
Percentile (%)	11.1 (8.7-13.4)	21.7 (15.0-28.5)	10.4 (4.5-16.4)	0.001*	0.54	
FMQ Standard score	12.2 (11.2-13.3)	13.9 (12.3-15.6)	1.7 (0.5-2.9)	<0.001*	0.69	
FMQ Percentile (%)	9.1 (5.9-12.2)	20.0 (12.9-27.0)	10.8 (5.6-16.0)	<0.001*	0.72	

The values are given as mean (95% confidence interval)
*p<0.05 was considered statistically significant

173 hours). There was no significant association between the variance in duration and the change in test results before and after treatment. After ruling out the possibile influence of duration, moderate to highly positive correlation occurred for the raw scores of the VMI item and the development age percentile, as well as the standard scores of FMQ, and the development age percentile. The strongest correlation was for the raw scores of the VMI item (r = 0.86), showing that occupational therapy significantly influences the test results.

To compare and understand the changes in the test results before and after occupational therapy, children were divided into four groups according to four scenarios. It was found that 23 of 45 children who had been diagnosed with developmental delay for Grasping item received occupational therapy and were followed up . They were diagnosed as normal on the second test, accounting for 51.1% of the total number of this group. In addition, 1 of 8 (12.5%) children who had been diagnosed as normal on the Grasping item was diagnosed with developmental delay on the second test. Fifteen of 37 children who had been diagnosed with developmental delay for VMI item received occupational therapy and were followed-up. They were diagnosed as normal on the second test, accounting for 40.5% of the total number of

Table 3. Results of follow-up after occupational therapy intervention

Baseline → Follow up	Grasping	VMI	FMQ
D.D. → follow-up, normal[a], n (%)	23 (51.1%)	15 (40.5%)	27 (57.4%)
D.D. → follow-up, D.D.[b], n (%)	22 (48.9%)	22 (59.5%)	20 (42.6%)
Normal → follow-up, normal[c], n (%)	7 (87.5%)	14 (87.5%)	6 (100.0%)
Normal → follow-up, D.D.[d], n (%)	1 (12.5%)	2 (12.5%)	0 (0%)

a: Initial D.D. and follow-up as normal after therapy intervention
b: Initial D.D. and follow-up as D.D. after therapy intervention
c: Initially normal and follow-up as normal, no therapy intervention
d: Initially normal and follow-up as D.D., no therapy intervention

this group; and 2 of 16 (12.5%) children who had been diagnosed as normal on the VMI item were diagnosed with developmental delay on the second test. A total of 47 children were diagnosed with developmental delay on FMQ. After receiving treatment and follow-up, a total of 27 showed improvement and were diagnosed as normal on second test, accounting for 57.4% of the total number. Six children initially diagnosed as normal on FMQ were again normal on the second test (Table 3).

Discussion

This study is one of the few to explore the influence of occupational therapy on preschoolers with delay in fine motor development based on motor scales. A total of 53 children with delay in fine motor development completed follow-up. Compared with the test results before treatment, those 1 year after the intervention showed improvements in Grasping and VMI ($P<0.001$). The development age percentile of Grasping rose from an average of 9.6% to 24%, while that of VMI rose from an average of 11.1% to 21.7%. Results showed that the fine motor skills of preschoolers diagnosed with developmental delay significantly improved after occupational therapy.

Although occupational therapy has been a significant supporting factor in the improvement of preschoolers with fine motor delay [11,12], studies on the long-term effects of intervention on preschoolers with this deficiency are very limited. From a study conducted by Dankert et al. [36], after receiving a 30-minute individual occupational therapy session and a 30-minute group occupational therapy session every week for 1 year, 12 preschoolers with fine motor delay displayed significant improvements. Significant progress was made in VMI with a large effect size (ES=1.15). In comparison, 16 children with similar deficiency who only accepted 30-minute group occupational therapy session every week and 15 normal children who did not receive any therapies displayed only a small effect size for VMI (ES=0.09 and 0.16, respectively).

According to a study carried out by Case-Smith [31] on 44 preschoolers with delay in fine motor development, a comparison between results before and after 9 months of therapy led to the conclusion that in-hand manipulation, motor accuracy, fine motor skills and VMI significantly improve, with a large effect size (ES=1.83-2.13). Other studies concerning preschoolers with fine motor delay have demonstrated positive correlations between the intervention of occupational therapy and improvements of such developmental deficiencies [36-38]. The present study concerning one-year occupational therapy intervention and the improvement made by preschoolers with fine motor delay revealed similar results. Regardless of Grasping or VMI, there was large effect size (Grasping ES=1.24, VMI ES=0.94). This confirms that occupational therapy can improve the performance of preschoolers with delay in fine motor skill development.

Past studies have explored the relation between the intensity of occupational therapy intervention and fine motor skills [39-41], but with no definitive conclusions. Law et al. [40] suggested that the intensity of occupational therapy intervention does not affect functional performance, but that study targeted children with cerebral palsy. Case-Smith [31] demonstrated that more exposure to occupational therapy only increases visual, motor, and social functions, not fine motor skills. In this study, the duration of treatments accepted by the subjects and the differences in the second assessment after treatment and follow-up were compared with no significant correlation, which confirms that the duration of intervention does not influence fine motor performance. To further understand the effect of occupational therapy intervention, the factor of duration was excluded, and the test scores before and after occupational therapy showed a moderate to high positive correlation. For those children who completed a follow-up study on Grasping, strong correlations were found for raw scores of fine motor skills items and development age percentiles. For those children who completed a follow-up study on VMI, there were strong correlations for raw scores, raw scores of fine motor skills items, and development age percentiles. This shows that children's motor skills before

intervention are strongly associated with those after intervention, which means that children with better proficiency before treatment enjoy greater improvement after treatment. This is something not mentioned in past studies, but can serve as a reference for clinical practice.

Occupational therapists can promote children's functional performance in accordance with their areas of weakness and help them to adapt to environments and daily changes [42]. Fine motor skills and visual-motor skills have been confirmed to be positively correlated with the ability to write [9, 29]. Past studies have demonstrated that occupational therapy can improve the fine motor skills of preschoolers [31, 43], but all have failed to provide long-term follow-up data. In those studies, games were the main method of treatment. Pierce [44] mentioned that games can attract the attention of children and motivate them to exert more effort in the required fine motor activities. Play-based occupational therapy helps to develop skills and abilities required for performing daily life activities [45]. Case-Smith [31] also pointed out that game therapy can affect children's emotions and cognition of other motor elements and allow them to integrate these into their daily lives. In the present study, a high proportion of children previously diagnosed with developmental delay in the two major items were diagnosed as normal (Grasping, 51.1%; VMI, 40.5%) after occupational therapy intervention, and as many as 57.4% of children previously diagnosed with delay in overall fine motor skill development were diagnosed as normal on the second test. Only a small number of children encountered the reverse situation in which they were diagnosed as normal initially, but then diagnosed as developmentally delayed on second test (Grasping, 1/8, 12.5%; the VMI, 2/16, 12.5%). In conclusion, occupational therapy can indeed help children diagnosed with delay in fine motor development to improve their status or even regain normal status in terms of their fine motor skills, which is enormously beneficial for the development of their writing skills.

Conclusion

In this study, a one-year follow-up investigation was conducted to discuss the effects of occupational therapy on preschool children with delay in fine motor development. The results of this study confirmed the importance of occupational therapy. Test data showed distinct progress, with large effect sizes. Many children with deficiency initially were diagnosed as normal on second assessment. Although there are many other factors that influence the development of motor skills, early diagnosis and intervention greatly influence the improvement of preschoolers' fine motor skills. This study provides a reference for occupational therapists in clinical practice.

Limitation

One limitation of the study is the unexpected low follow-up rate caused by subjects refusing treatment, stopping treatment, refusing follow-up visits and tracking, or moving. Due to limited personnel in clinical work, only the duration of occupational therapy was recorded, while other factors including the treatment methods and tools were not. Moreover, , information on family background of the subjects, their living environment, and other factors that might have influenced the results are not available. These limitations should be addressed in future studies.

Conflict of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.

Ethics approval

The Institutional Review Board for Human Subject Research of Chung Shan Medical University Hospital approved this study (CSMUH No: CS14145). For each participant, parent or legal guardian gave written informed consent before data collection began.

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