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Effectiveness of the protocol for enhancing handwriting readiness skills of preschoolers aged 4-6 years

Phensri Singpun* **Sarinya Sriphetcharawut**

Occupational Therapy Department, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai Province, Thailand

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ABSTRACT

Background: Handwriting problem is an important issue for school-aged children and is believed to affect their ability to learn, self-confidence, and participation in school activities. In order to prevent handwriting problems, handwriting readiness training is essential to build crucial pre-writing skills in Thai students.

Objectives: The aim of this research was to examine the effectiveness of the protocol for enhancing handwriting readiness skills of preschoolers aged 4-6 years.

Materials and methods: The study was conducted with quasi-experimental design; pretest-posttest control group. In total, 40 students with low standard scores on the Beery™ VMI, 6th edition participated in this study. Participants of the experimental group (n=20) participated in a 20-session protocol, across four weeks with 4 sessions in a week, lasting 30 minutes per session, whereas the control group (n=20) students continued their normal school classes. Two students from the experimental group were withdrawn because they attended less than 16 sessions; therefore 38 participants completed the study successfully. The outcome measures included the Beery™ VMI, 6th edition full form and its supplemental Motor Coordination Test; and the BOT™-2. Data were analyzed using descriptive and inferential statistics.

Results: By using the Wilcoxon Signed-Rank Test, a comparison of VMI and motor coordination scores between before and after receiving a protocol in the experimental group showed the statistical difference of $p<0.05$, and no statically significant difference were found in fine motor skill scores ($p>0.05$) with 95% confidence. However, by using the Mann-Whitney U Test, motor coordination scores in the experimental group after post-protocol were higher than pre-protocol with a statistical significance of $p<0.05$.

Conclusion: This study indicated that the protocol for enhancing handwriting readiness skills of preschoolers aged 4-6 years could be beneficial for improving motor coordination.

Introduction

It was found that 12-33 per cent of primary students have handwriting problems.[1] The Office of Basic Education Commission reported that students in primary 1-3 have handwriting problems at 8.70, 11.20 and 7.61 per cent, respectively.[2] These problems affected their ability to learn, self-confidence, and participation in children's learning activities.[3] Early intervention on facilitating handwriting readiness skills for preschoolers is important in order to prevent failure in learning and participation of school activities. There are researches to support that children in preschool are at the appropriate age to develop handwriting readiness effectively,[4-6] through practicing skills related to handwriting.[5]

* **Corresponding author.**
Author's Address: *Occupational Therapy Department, Faculty of Associated Medical Sciences, Chiang Mai University, Chiang Mai Province, Thailand*
** **E-mail address:** : poosingpun@gmail.com
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Handwriting readiness is a development in which children are satisfactorily able to perform the skills necessary and related to handwriting.[7] In the early stage of learning to write, children learn to copy which requires the processes of perception and movement in the form of visual-motor integration and fine motor skills. These underlying skills are important and occupational therapists play a major role in developing handwriting readiness skills to decrease and prevent handwriting problems that children may have.[8] The role of the occupational therapist is evolving from that of the assessment and provision of intervention related to handwriting readiness and handwriting, which may focus on different skills related. There are many skills involved in handwriting, for example, hand and finger strength, visual perception, motor coordination, postural control, etc. However, it has been found that there are three major underlying skills, including motor coordination skill, fine motor skill,[9] and visual-motor integration skill.[10-13] Research highly confirmed their relationship to handwriting ability and that they are the most important predicting factors for handwriting in school-age children.

Motor coordination and fine motor skills are movement ability which requires the coordination of the hands and fingers. Children who have problems with these skills have decreased the ability to write; inconsistent letter size and inability to keep the letters on the lines.[14] Another important skill affecting handwriting readiness is visual-motor integration skill, which is the collaboration of visual perception and coordinated movement of the hand and fingers.[15] Children with problems in visual-motor integration skill have difficulties with copying letters with consistent size,[14] staying on the lines, and spacing between letters.[10,16-17] Numerous research studies have found that visual-motor integration skill is highly related to children's ability to write and is the most important predicting factor for legibility in handwriting for school-age children.[10,14,16-17] Moreover, the most common reason school-age children are referred for occupational therapy services is handwriting difficulty.[18] In order to prevent handwriting problems in Thai students, handwriting readiness training is essential to build the crucial pre-writing skills. Thus, we developed the protocol for enhancing handwriting readiness in preschoolers with the purpose to examine its effectiveness in preschoolers aged 4-6 years.

Materials and methods

Research design and participants

This research was designed as a quasi-experimental research, pretest-posttest control group, to study the effectiveness of a protocol for enhancing handwriting readiness in preschoolers. The samples were students who were studying in kindergarten 2 in 4 classrooms at the Dara Academy, Chiangmai province during 2017 academic year. The sample size was determined by G*power 3.1 program from Lust & Donica (2011).[19] The result was 18 samples for each group. With the 10 per cent dropout rate considered, the sample of 40 students were included. They were then divided into 2 groups of 20 through simple randomization. One group received the protocol and the other did not receive the protocol. The inclusion criteria were as followed 1) being able to communicate with fluent Thai, 2) having no cognitive or physical deficits, 3) having scores on the Beery™ VMI, 6th edition ranking in the lowest 40 out of all the samples, and 4) obtaining informed consent signed by parents before participating in the study. The data of participants who attended the protocol less than 80% were excluded from the study (less than 16 sessions).

Ethical approval for the study was obtained from the ethical review committee for research in humans, Faculty of Associated Medical Sciences, Chiang Mai University (Ref. no AMSEC-60EX-027)

Measures

Components of 3 instruments were used in data collection, the Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (Beery™ VMI, 6th edition) full form, its supplemental Motor Coordination Test, and the Fine Motor Precision and Fine Motor Integration subtests of the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT™-2).

Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition (Beery™ VMI, 6th edition) is an assessment tool used to find a standard score to measure visual-motor integration skill related to copying shapes.[15] In this study, Beery™ VMI, 6th edition which is a full battery, was used to assess visual-motor integration skill. Moreover, the supplementary Motor Coordination Test was administered to assess motor skills by tracing within a confined space. The Beery™ VMI, 6th edition has sound psychometric properties, with high interrater (r=0.93), test–retest reliability (r=0.87), internal consistency score of 0.96, as well as, content and concurrent validity.[15]

Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT™-2) is a commonly used standardized test designed to measure the gross and fine motor skills of people ages 4–21 yr. This test includes four composites of two subtests each. For this study, the Fine Manual Control Composite, including Fine Motor Precision (Subtest 1) and Fine Motor Integration (Subtest 2), was administered. Fine Motor Precision measures bilateral hand skills and accuracy with folding paper, cutting, and coloring. Fine Motor Integration addresses visual–motor skills determined by copying different types of shapes. Both subtests were used to evaluate participants' skills in integrating visual perception with hand and finger motor movements. Internal consistency reliability for Fine Manual Control has been established in 4-yr-olds (=0.87) and 5-yr-olds (r=0.86). BOT–2 has published test–retest reliability for Fine Manual Control with 4- to 7-yr-olds (r=0.81).[20]

Intervention

The protocol for enhancing handwriting readiness skills of preschoolers aged 4-6 Years was developed by the researchers. The protocol consisted of two main parts: (1) indirect intervention, in which we worked with homeroom teachers through 2 ways: the classroom observation with the purpose to understand the kindergarten curriculum and classroom contexts, and the therapist-teacher meeting with the purpose to explain and discuss about the protocol and its implementation; and (2) direct intervention, in

which four occupational therapy graduate students led twenty 30-min sessions, four times a week for 5 consecutive weeks for participants in the experimental group (1 adult, 5 students), whereas the control group students continued their normal school classes. Scheduled direct interventions for the experimental group were begun with a 5-min warm-up activity, and then followed by a 25-min group activity of visual-motor integration, motor coordination and fine motor skill activities. Everyone conducting direct intervention had the training of the protocol to ensure consistency before the study began.

Data collection schedule

Pre- and posttest data were collected within 1-day timeframe immediately before and immediately after the study, by two occupational therapy graduate students who were trained in the proper administration of the battery. These two graduate students were blinded to group assignment during the assessment. They recorded raw scores during the BOT-2 (Fine Motor Precision and Fine Motor Integration subtests) administration, and administered the Beery™ VMI, 6th edition full form and its supplemental Motor Coordination Test. These graduate students were neither involved in scoring nor providing the intervention protocol Interrater reliability testing was not implemented due to its potential effect on student's performance. For the indirect intervention, the first author worked closely with the homeroom teachers throughout the intervention process. Other four occupational therapy graduate students, including the first author, administering the direct intervention were formally trained. They met with the research team daily to plan the intervention session, and review progress. Finally, without respect to the person administering the test or grouping, we checked and reviewed all data scoring to verify the accuracy of reporting and scoring.

Statistical analysis

Data were presented by descriptive statistics. Statistical comparison between pretest and posttest performance within a group was performed using the Wilcoxon Signed-Rank Test, and comparisons between the experimental and control groups were performed using the Mann-Whitney U Test. The level of significance for testing was set at 0.05. All statistical analyses were conducted using SPSS statistical package.

Results

Two students from the experimental group were withdrawn because they attended less than 16 sessions; therefore 38 participants completed the study successfully. For both groups, the samples were mostly females at the percentage of 60 and 55.56, respectively. The control group has an average age of 59.60 months, and the experimental group has an average age of 58.28 months. For both groups, the samples were mostly right-hand dominant at the percentage of 80 and 83.33, respectively. Results from the assessment via the Beery™ VMI, 6th edition 'before' receiving the protocol showed that most of the samples from both groups were ranked at 50 percent standard score, as shown in Table 1.

Table 1. Demographic data for the control group and experimental group.

	Control Group (n=20)	Experimental Group (n=18)
Gender *(n,%)*		
Male	8 (40)	8 (44.44)
Female	12 (60)	10 (55.56)
Age, months *(n,%)*		
48-59	11 (55)	11 (61.11)
60-71	9 (45)	7 (38.89)
Maximum	54	53
Minimum	66	64
Mean (SD)	59.60 (3.71)	58.28 (3.08)
Dominant hand *(n,%)*		
Right	16 (80)	15 (83.33)
Left	4 (20)	3 (16.67)
Level of VMI* performance *(n,%)*		
Below Average	1 (5.50)	1 (5)
Average	9 (50)	10 (50)
Above Average	7 (39)	4 (20)
High	1 (5.50)	5 (25)

**VMI: Visual -motor integration*

Comparison of scores on three handwriting readiness skills including visual-motor integration, motor coordination, and fine motor, 'before and after' receiving the protocol was done using the Wilcoxon Signed-Rank Test. It was found that the control group has a statistical significant difference (p<0.05) in visual-motor integration skill scores (p=0.029). No statistical significant difference (p<0.05) was found in motor coordination-skill scores (p=0.195) and fine motor scores (p=0.321). As for the experimental group, statistical significant differences (p<0.05) were found in visual-motor integration skill scores (p=0.016) and motor coordination skill scores (p=0.001). No statistical significant difference (<0.05) was found in fine motor scores (p=0.312), as shown in Table 2.

Table 2. Comparison of handwriting readiness skill scores in visual-motor integration, motor coordination, and fine motor, 'before and after' receiving the protocol between the control and experimental groups.

Handwriting readiness skills	Control Group (n=20)				Experimental Group (n=18)			
	Pretest *Mean (SD)*	Posttest *Mean (SD)*	*z*	*p*	Pretest *Mean (SD)*	Posttest *Mean (SD)*	*z*	*p*
VMI	110.15 (9.35)	114.60 (6.14)	-2.19	0.029*	107.22 (7.92)	112.44 (5.70)	-2.41	0.016*
MC	106.35 (12.80)	109.45 (10.47)	-1.30	0.195	109.28 (6.50)	117.78 (8.48)	-3.41	0.001*
FM	55.50 (7.33)	57.30 (6.71)	-0.99	0.321	54.22 (9.40)	55.89 (7.66)	-1.01	0.312

*VMI: Visual-motor integration, MC: Motor coordination, FM: Fine motor, *p<0.05*

Comparison of scores for three handwriting readiness skills including visual-motor integration, motor coordination, and fine motor, 'after' receiving the protocol between the 2 groups was analyzed using Mann-Whitney U Test. Statistical significant difference (p<0.05) was found in motor coordination skill scores (p=0.017). No statistical significant difference (p<0.05) was found in visual-motor integration skill scores (p=0.239) and fine motor scores (p=0.518), as shown in Table 3.

Table 3. Comparison of handwriting readiness skill scores in visual-motor integration, motor coordination, and fine motor, after' receiving the protocol between the control and experimental groups.

Handwriting readiness skills	Control Group (n=20)	Experimental Group (n=18)		
	Mean (SD)	*Mean (SD)*	*z*	*p*
VMI	114.60 (6.14)	112.44 (5.70)	-1.18	0.239
MC	109.45 (10.47)	117.78 (8.48)	-2.39	0.17*
FM	57.30 (6.71)	55.89 (7.66)	-0.65	0.518

*VMI: Visual-motor integration, MC: Motor coordination, FM: Fine motor, *p<0.05*

Discussion

Results from this study indicate that the protocol for enhancing handwriting readiness has potential as a promising intervention for preschoolers who were at risk of handwriting readiness, especially in motor coordination skill. Motor coordination is considered as an important skill toward handwriting readiness and is a predicting factor for the ability to write.[10,14,16] The reason for increased scores on motor coordination after receiving the protocol was the type of activities which was designed to provide repetitive practice to develop fine motor coordination skills, for example, making paper butterflies, making paper crown and tiara, paper tearing art, pegboard patterns game, making necklaces from plastic chains, using both hands to scoop and transfer pompom with ice-cream sticks, etc. These fine motor coordination activities are perfect for developing a variety of specific fine motor skills in a coordinated manner. Moreover, through the principles of sequencing and adapting tasks,[21] students in the experimental group had the intensive opportunity to repeatedly practice skills of their hands that were needed to perform delicate manipulation as well as to attain and manipulate objects. Fine motor coordination activities were designed and graded so that students successfully increased the coordination in their hands in performing more precision and delicate tasks. Such movement training is effective in enhancing children's motor learning[22] and consistent with the study by Hoy, Eagan, and Feder[23] which found that the more opportunities to practice and repeat in programs to enhance handwriting components, the more effective the intervention will be.

Increase in visual-motor integration skill scores of both groups can be explained by the rapid rate of visual-motor integration skill development of children aged 4-5 years. Learning to write in early stage through copying[24] highly relies on visual-motor integration skill.[15,25] Development of visual-motor integration skill in children this age is dynamic

and rapid. It was found that children at the age of 4 years old develop this skill very quickly and will develop fastest in the age of 5 years old.[26] Moreover, the context and learning activities in 'outdoor activity period' hosted by the school provided the opportunity for the control group students who did not receive the protocol to experience and practice visual-motor integration skills during the outdoor activity period. However, when comparing the average score of change between the two sample groups, it was found that the group who received the protocol have higher scores in visual-motor integration skill. This may be due to the direct intervention received from participating in the protocol, which specifically reinforced appropriate participation from the children.[27] All intervention sessions were also implemented in a small group format (one occupational therapy graduate student to every five students) that provided a comfortable and playful context to practice. The "just-right" challenges were provided so that children could succeed and master the tasks. Children were motivated to participate in the selected activities and consequently, expected performance outcomes were enhanced.[28]

In this study, no difference was found in fine motor skill scores both before and after receiving the protocol and between the two sample groups. It may be due to the fine motor activities were designed based on training multiple sub-skills, for example, muscle strength of the hands and fingers, in-hand manipulation (e.g., finger-to-palm translation and palm-to-finger translation), and hand dexterity. Therefore, the number of practice and repetition of each sub-skill was lessened and insufficient to induce the change in fine motor skill scores, especially translation and dexterity, which have the least proportion. These two sub-skills are predicting factors for children's handwriting ability.[29]

Our findings have some implications for occupational therapy practitioners. Occupational therapy practitioners play a key role in contributing to effective intervention that support the needs of students who are at risk of developing proper handwriting readiness skills in the classroom environment. Short-term interventions can have a significant effect on the fine motor coordination skills required for handwriting readiness in preschoolers.

Limitations and future research

There were some limitations of this study. Because this was a pilot study, the sample was small. The use of one geographic location also limits the generalizability of this study. An important future research must increase the collaboration process with classroom teachers in the intervention protocol. Furthermore, it is needed to examine whether students who receive the protocol perform better during midyear pre-handwriting tasks than a control group.

Conclusion

On the basis of the current findings, the study results proved that the protocol for enhancing handwriting readiness skills designed especially for preschoolers aged 4-6 years is effective in developing motor coordination skills of children at risk of handwriting readiness problems.

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