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Visual–Motor Integration and Handwriting Performance among Children with Down Syndrome Aged 6–12 Years: A Cross-Sectional Study

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ABSTRACT

Background: Handwriting is a fundamental school-related occupation that requires the integration of visual perception, motor coordination, motor planning, and cognitive processing. Children with Down syndrome commonly experience impairments in visual-motor integration (VMI) and handwriting performance due to neurodevelopmental deficits affecting sensory-motor processing. This study aimed to determine the relationship between visual-motor integration and handwriting skills among children with Down syndrome aged 6–12 years.

Methods: A quantitative correlational study with a cross-sectional design was conducted involving 47 children with Down syndrome aged 6–12 years. Participants were selected using purposive sampling. Visual-motor integration was assessed using the Beery-Buktenica Developmental Test of Visual-Motor Integration Sixth Edition (Beery VMI), while handwriting performance was measured using the Test of Handwriting Skills-Revised (THS-R). Descriptive statistics were used to summarize participant characteristics and study variables. Spearman rank correlation analysis was performed to examine the relationship between VMI and handwriting skills.

Results: The mean Beery VMI score was 49.89 ± 6.89, indicating very low visual-motor integration performance. The mean THS-R score was 56.32 ± 3.31. All participants demonstrated handwriting performance below age expectations. Spearman correlation analysis revealed a strong positive relationship between visual-motor integration and handwriting skills ($r = 0.717$, $p < 0.001$). Approximately 51.4% of the variance in handwriting performance could be explained by visual-motor integration ability.

Conclusion: Visual-motor integration is strongly associated with handwriting performance among children with Down syndrome. Occupational therapy interventions should therefore address underlying visual-motor integration processes in addition to handwriting-specific training to improve academic participation and occupational performance.

1. INTRODUCTION

Down syndrome (DS) is the most common chromosomal condition associated with intellectual disability and developmental delay. Children with Down syndrome frequently experience impairments across multiple developmental domains, including cognition, motor performance, sensory processing,

language, and adaptive behavior. These impairments may significantly influence participation in meaningful occupations, particularly school-related activities [1–6].

Among school-based occupations, handwriting remains one of the most important skills supporting academic participation. Despite advances in digital technology, handwriting continues to be required for classroom assignments, examinations, communication, and educational achievement. Handwriting is a highly complex occupation involving the integration of visual perception, eye–hand coordination, fine motor control, motor planning, postural stability, attention, and executive functioning [7–10].

Visual-motor integration (VMI) refers to the ability to coordinate visual perceptual information with motor output. According to the Beery-Buktenica framework, VMI represents the integration of visual processing and motor execution necessary for successful performance in activities such as copying, drawing, and handwriting. Previous research has consistently demonstrated that VMI contributes significantly to handwriting performance among typically developing children and children with developmental disabilities[10–12].

Children with Down syndrome present unique neurodevelopmental characteristics that may compromise visual-motor integration. Hypotonia, ligamentous laxity, delayed motor maturation, impaired motor planning, reduced processing speed, and deficits in executive functioning may interfere with the efficient coordination of visual and motor systems. Consequently, handwriting difficulties observed among children with Down syndrome may reflect broader impairments in visual-motor processing rather than isolated deficits in fine motor skills [13–16].

Although previous studies have documented handwriting difficulties among children with Down syndrome, evidence regarding the contribution of visual-motor integration to handwriting performance remains limited, particularly within the Indonesian context. Identifying the relationship between these variables may provide important implications for occupational therapy assessment and intervention planning. Therefore, this study aimed to investigate the relationship between visual-motor integration and handwriting skills among children with Down syndrome aged 6–12 years.

2. MATERIALS AND METHODS

2.1. Study Design and Participants

This study employed a quantitative correlational design using a cross-sectional approach. Participants consisted of 47 children diagnosed with Down syndrome aged 6–12 years who met the inclusion criteria. Participants were recruited through purposive sampling.

2.2. Instruments

2.2.1. Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery VMI)

The Beery VMI Sixth Edition was used to assess visual-motor integration. The instrument measures the ability to integrate visual perception and motor output through a series of geometric copying tasks with progressively increasing complexity.

2.2.2. Test of Handwriting Skills-Revised (THS-R)

Handwriting performance was assessed using the Test of Handwriting Skills-Revised. The instrument evaluates handwriting performance through tasks assessing letter formation, spacing, alignment, size consistency, and writing accuracy.

2.3. Data Analysis

Descriptive statistics were used to summarize demographic characteristics and outcome measures. Data normality was assessed before inferential analysis. Because the data were not normally distributed, Spearman rank correlation analysis was used to determine the relationship between visual-motor integration and handwriting skills. Statistical significance was established at $p < 0.05$.

3. RESULTS

3.1. Participant Characteristics

A total of 47 children participated in the study. All participants were school-aged children diagnosed with Down syndrome and receiving educational or rehabilitation services. Participant characteristics are presented in Table 1.

Table 1. Participant Characteristics

Variable	Value
Total participants	47
Age range	6–12 years
Diagnosis	Down syndrome

3.2. Visual-Motor Integration Performance

Visual-motor integration was assessed using the Beery VMI. The mean VMI score fell within the very low range according to Beery VMI normative classification, indicating substantial impairment in visual-motor integration abilities among participants.

Table 2. Descriptive Statistics of Visual-Motor Integration

Variable	Mean ± SD
Beery VMI Score	49.89 ± 6.89

3.3. Handwriting Skills Performance

Handwriting performance was assessed using the THS-R. As shown in Tables 3 and 4, all participants demonstrated handwriting performance below normative expectations for their age.

Table 3. Descriptive Statistics of Handwriting Skills

Variable	Mean ± SD
THS-R Score	56.32 ± 3.31

Table 4. Handwriting Performance Category

Category	n (%)
Below Average	47 (100)

3.4. Relationship between Visual-Motor Integration and Handwriting Skills

Spearman rank correlation analysis revealed a statistically significant positive relationship between visual-motor integration and handwriting skills ($r = 0.717$, $p < 0.001$). The strength of the correlation indicates a strong association between the two variables. Children who demonstrated higher visual-motor integration abilities consistently showed better handwriting performance. The coefficient of determination ($r^2 = 0.514$) suggests that approximately 51.4% of the variance in handwriting performance may be explained by visual-motor integration ability.

Table 5. Correlation between Visual-Motor Integration and Handwriting Skills

Variables	r	p-value
Beery VMI and THS-R	0.717	<0.001

4. DISCUSSION

The present study demonstrated a strong positive relationship between visual-motor integration and handwriting skills among children with Down syndrome. The findings support the hypothesis that visual-motor integration is associated with handwriting performance.

The magnitude of the observed correlation suggests that handwriting should not be conceptualized merely as a fine motor activity. Rather, handwriting represents a complex occupational performance requiring continuous interaction between visual perception and motor execution. Children must accurately perceive letter forms, process spatial information, plan movement sequences, execute coordinated motor responses, and continuously monitor performance through visual feedback [13,15,17–23].

From a neurodevelopmental perspective, deficits in visual-motor integration may create cascading effects across multiple stages of handwriting production. Difficulties in integrating visual input with motor output may impair letter formation, spacing, alignment, size consistency, and overall writing quality [16,18,19,24–26].

These findings are particularly relevant for children with Down syndrome because the syndrome is characterized by hypotonia, delayed motor maturation, ligamentous laxity, impaired motor planning, reduced processing speed, and executive dysfunction. Such characteristics may interfere with the efficient integration of visual and motor systems, thereby contributing to poor handwriting performance.

The coefficient of determination indicates that visual-motor integration accounts for approximately half of the variance in handwriting performance. This finding highlights VMI as one of the most influential factors associated with handwriting skills within this population [10–12,15,16,27].

From an occupational therapy perspective, handwriting is a meaningful occupation that supports participation in educational activities, communication, self-expression, and academic achievement. Therefore, intervention approaches focusing exclusively on handwriting practice may be insufficient if underlying visual-motor deficits remain unaddressed [14,20,22,27,28].

The findings support the incorporation of visual-motor integration training into occupational therapy programs. Activities targeting eye–hand coordination, visual discrimination, motor planning, copying skills and sensorimotor integration may facilitate improvements in handwriting performance and broader occupational participation.

Although this study successfully demonstrated a significant relationship between visual–motor integration and handwriting performance in children with Down syndrome, several limitations should be acknowledged. First, the cross-sectional design precludes causal inference. Second, potentially influential factors such as cognitive functioning, executive functioning, educational exposure, and therapy intensity were not controlled. Third, participants were recruited from a limited geographical area, potentially affecting generalizability. Future studies should employ longitudinal and multivariate designs to investigate causal pathways linking visual-motor integration and handwriting performance.

5. CONCLUSIONS

A strong positive relationship was identified between visual–motor integration and handwriting skills among children with Down syndrome aged 6–12 years. Children with better visual–motor integration abilities demonstrated superior handwriting performance. These findings suggest that visual–motor integration is closely associated with handwriting performance and may play an important role in the development of handwriting skills. However, the findings demonstrate an association rather than establish visual–motor integration as the primary determinant of handwriting performance. Given the multifactorial nature of handwriting, future studies should incorporate additional variables, including cognitive abilities, language skills, executive functions, and the severity of intellectual disability, to provide a more comprehensive understanding of the factors influencing handwriting performance in children with Down syndrome.

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