Use of PNF Techniques and S.I. Principles for Improving Handwriting for Children of First Standard Children in A Single Sitting

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Abstract

Background: The COVID-19 pandemic disrupted in-person education, causing children to miss essential kindergarten learning and early motor skill development. This gap has led to difficulties in handwriting, including poor letter formation, spacing, and size regulation.
Objective: To improve letter formation and alphabet sizing in first-standard children using principles of *Proprioceptive Neuromuscular Facilitation (PNF)* and *Sensory Integration (SI).*
Methods: An intervention program was collaboratively designed by occupational therapists, teachers, and school counsellors. The program combined PNF techniques to enhance motor coordination with SI strategies to improve perceptual and sensory-motor processing. Structured handwriting exercises targeted letter formation, alignment, and size consistency.
Results: Initial findings demonstrated significant improvement in handwriting fluency, legibility, and uniformity of letter size. Children showed better motor planning, coordination, and sensory feedback during writing tasks, indicating the effectiveness of the combined PNF–SI approach.
Conclusion: Handwriting is a critical skill for academic success and cognitive development. This study highlights the potential of integrating PNF and SI principles as an innovative intervention to address handwriting difficulties in children whose foundational learning was impacted by the COVID-19 pandemic.
Keywords: Proprioceptive Neuromuscular Facilitation (PNF), Sensory Integration (SI), Handwriting, Fine Motor Skills.

I. Introduction

Handwriting, also referred to as **graphomotor integration**, is a critical functional skill for school-aged children. It serves as the primary means through which children express their thoughts, ideas, and knowledge (Feder & Majnemer, 2007). Handwriting is often described as the vehicle that conveys information—when it is illegible, the intended message is lost. Beyond its functional role, handwriting reflects the integration of cognitive and motor skills, and difficulties in this area can significantly affect academic performance and self-confidence. Fluent handwriting not only supports effective communication but also facilitates better access to one's own ideas and information (Kuhl, 1994).

Despite the growing emphasis on digital literacy, handwriting remains a foundational skill in early education and cognitive development. Its fine motor and perceptual demands provide valuable insights into developmental, cognitive, and neurological differences among children. Importantly, handwriting proficiency influences educational achievement, self-esteem, and participation in classroom activities (Feder & Majnemer, 2007; Graham & Harris, 2000).

Handwriting is a complex process that requires the integration of cognition, visual perception, and fine motor coordination (Cornhill & Case-Smith, 1996; Smits-Engelsman & Van Galen, 1997). While typically developing children acquire basic handwriting skills between the ages of six and seven through traditional

instruction, research highlights that difficulties are common. Levine et al. (1981) reported that 72% of children with low academic achievement demonstrated deficits in fine motor tasks, including pencil use and object manipulation, as identified by parents and teachers. These findings underscore the strong association between motor function and academic success.

Children over the age of five spend a significant portion of their school day engaged in writing. Evidence indicates that students with proficient handwriting tend to perform better academically, producing longer and more complex written assignments than peers with handwriting difficulties. Moreover, improvement in handwriting has been linked with enhanced quality and complexity of written work (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997).

The COVID-19 pandemic further exacerbated handwriting challenges. Children entering school during this period missed essential kindergarten experiences due to online learning, where responsibility for foundational skill development largely shifted to parents. As a result, many children presented with difficulties in letter formation, alignment on lines, spacing between letters and words, casing, and writing speed. Recognizing these challenges, a collaborative effort was undertaken by the school's occupational therapy department, counsellor, class teachers, and principal to design and pilot an innovative handwriting improvement program. This initiative aimed to address handwriting deficits and, if effective, integrate the program into the school curriculum.

II. Objectives of the Study

1. To improve the letter formation and alphabet size in first standard children through the application of Proprioceptive Neuromuscular Facilitation (PNF) and Sensory Integration (SI) principles.
2. To evaluate the effectiveness of PNF and SI techniques in enhancing handwriting legibility and consistency.

III. Methodology

3.1 Study Design

This study adopted a **pre–post experimental design** to examine the effect of proprioceptive neuromuscular facilitation (PNF) and sensory integration (SI) techniques on handwriting performance in children.

3.2 Participants

A total of **171 children enrolled in the First Standard** were recruited for the study. All participants were asked to perform handwriting tasks under different intervention conditions. Children with significant visual, motor, or neurological impairments that could influence handwriting ability were excluded.

3.3 Procedure

At baseline, each child was instructed to **write their name in their exercise book** to record their initial handwriting performance. Following this, the intervention was implemented in three sequential stages:

1. **Gross Motor Exercise and Tactile Input** – Participants engaged in whole-body gross motor activities combined with tactile stimulation. They were then asked to write their names again.
2. **PNF-Based Sensory Input** – Children performed handwriting tasks after receiving proprioceptive neuromuscular facilitation inputs.
3. **Proprioceptive Input** – Additional proprioceptive-based activities were administered, after which participants wrote their names for the final time.

This sequence enabled the observation of changes in **letter formation, alphabet size, legibility, and writing speed** across stages.

3.4 Outcome Measures

Handwriting performance was analysed using four key metrics:

- **Within Lines:** Accuracy of maintaining written characters within designated boundaries.
- **Alphabet Size:** Consistency and proportionality of letter size during writing.
- **Legibility:** Clarity and recognizability of characters.
- **Speed of Writing:** Number of characters produced within a given time frame.

Each metric was assessed at **two points**:

- **Baseline (Pre-intervention):** Initial handwriting sample without sensory input.
- **Final (Post-intervention):** Handwriting sample after completion of all interventions.

IV. Results:

Table 1.0 Paired Samples Correlations:

Stats		N	Correlation	Significance One-Sided p	Significance Two-Sided p
Pair 1	A SIZE Pre & A SIZE Post	175	.711	<.001	<.001
Pair 2	a size3 Pre & a size3 Post	175	.468	<.001	<.001
Pair 3	DICTATION ALPHABETS PER MINUTES Pre & DICTATION ALPHABETS PER MINUTES Post	175	.729	<.001	<.001
Pair 4	FPC FOR 3 MINTUES Pre & FPC FOR 3 MINTUES Post	175	.428	<.001	<.001
Pair 5	NPC FOR 2 MINUTES Pre & NPC FOR 2 MINUTES Post	175	.216	.002	.004
Pair 6	COMPOSITION FOR 5 MINUTES Pre & COMPOSITION FOR 5 MINUTES Post	175	.409	<.001	<.001
Pair 7	SP A Pre & SP A Post	175	.621	<.001	<.001
Pair 8	SP W Pre & SP W Post	175	.830	<.001	<.001

The results indicate that PNF and SI techniques significantly improved children's handwriting. Alphabet size and formation showed marked gains, while dictation speed, composition, and fine motor endurance also improved. Strong correlations in spacing and alignment further confirm enhanced legibility and consistency, meeting the study objectives.

Table 2.0 Paired Samples Effect Sizes

Stats		Standardizer	Point Estimate	95% Confidence Interval Lower	Upper
Pair 1 Sum of A SIZE Pre - Sum of A SIZE Post	Cohen's d	.0779	1.225	1.028	1.420
	Hedges' correction	.0783	1.219	1.023	1.414
Pair 2 Sum of a size3 Pre - Sum of a size3 Post	Cohen's d	.0737	1.194	.999	1.387
	Hedges' correction	.0740	1.189	.995	1.381
Pair 3 Sum of DICTATION ALPHABETS PER MINUTES Pre - Sum of DICTATION ALPHABETS PER MINUTES Post	Cohen's d	1.394	-3.444	-3.834	-3.052
	Hedges' correction	1.400	-3.429	-3.817	-3.039
Pair 4 Sum of FPC FOR 3 MINTUES Pre - Sum of FPC FOR 3 MINTUES Post	Cohen's d	6.324	-2.037	-2.296	-1.776
	Hedges' correction	6.351	-2.028	-2.286	-1.768
Pair 5 Sum of NPC FOR 2 MINUTES Pre - Sum of NPC FOR 2 MINUTES Post	Cohen's d	6.979	-1.127	-1.316	-.937
	Hedges' correction	7.010	-1.123	-1.310	-.933
Pair 6 Sum of COMPOSITION FOR 5 MINUTES Pre - Sum of COMPOSITION FOR 5 MINUTES Post	Cohen's d	9.534	-2.580	-2.888	-2.271
	Hedges' correction	9.575	-2.569	-2.876	-2.261
Pair 7 Sum of SP A Pre - Sum of SP A Post	Cohen's d	.0657	.670	.505	.833
	Hedges' correction	.0660	.667	.503	.829
Pair 8 Sum of SP W Pre - Sum of SP W Post	Cohen's d	.1765	.440	.284	.595
	Hedges' correction	.1773	.438	.283	.592

a. The denominator used in estimating the effect sizes.

Cohen's d uses the sample standard deviation of the mean difference.

Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

The **effect sizes** for the intervention outcomes, which indicate the magnitude of improvement in handwriting following PNF and SI techniques. Large and statistically significant effect sizes are evident across most variables, confirming strong practical significance in addition to statistical significance.

For **alphabet size** (Pair 1 and Pair 2), Cohen's d values around **1.2** show a large effect, meaning substantial improvement in both capital and small letter formation. In **dictation speed** (Pair 3), the very large negative effect ($d \approx -3.4$) reflects a marked reduction in time per alphabet, i.e., much faster and more fluent writing post-intervention. Measures of **fine motor endurance** (Pair 4: FPC, $d \approx -2.0$; Pair 5: NPC, $d \approx -1.1$) also showed strong effects, confirming better sustained motor performance. Similarly, **composition writing** (Pair 6, $d \approx -2.6$) demonstrated a very large improvement in continuous writing ability.

For **spatial alignment and word spacing** (Pair 7 and Pair 8), effect sizes were moderate to large ($d = 0.67$ and $d = 0.44$), indicating clearer alignment and more consistent spacing, both critical for legibility.

Importantly, the Hedges' correction values are nearly identical to Cohen's d, suggesting the results are stable even after correcting for sample size bias.

In summary, the effect size analysis shows that PNF and SI interventions had a **large and meaningful impact** on alphabet formation, writing fluency, endurance, and legibility, strongly supporting the effectiveness of these techniques in improving handwriting among first standard children.

V. Discussion

The present study demonstrated that the combined application of Proprioceptive Neuromuscular Facilitation (PNF) and Sensory Integration (SI) techniques significantly improved handwriting performance among first standard children. Improvements were observed across multiple dimensions of handwriting, including alphabet size, formation, dictation speed, composition, and fine motor endurance. The results further indicated enhanced spatial alignment and word spacing, both of which are essential for legibility and consistency in written expression. These outcomes collectively confirm that the study objectives were effectively met. Effect size analysis provided additional evidence of the intervention's impact, highlighting not only statistical significance but also strong practical significance. The large effect sizes for alphabet size (Cohen's d ≈ 1.2 for both capital and small letters) suggest substantial gains in handwriting clarity and precision. Dictation speed showed an exceptionally large effect (d ≈ -3.4), reflecting a faster and more fluent writing ability, which may be attributed to improved motor coordination and reduced cognitive load during writing tasks. Similarly, fine motor endurance, as assessed through FPC and NPC measures, revealed strong improvements (d ≈ -2.0 and -1.1, respectively), indicating the children's enhanced capacity to sustain motor performance over time. Composition writing also benefited considerably from the intervention (d ≈ -2.6), suggesting that children developed better integration of motor planning, sequencing, and sustained writing ability. This finding is particularly relevant, as composition tasks require not only motor control but also higher-order cognitive and language integration. Spatial measures such as alignment and word spacing improved with moderate to large effect sizes (d = 0.67 and 0.44), reflecting more organized, legible, and visually consistent handwriting.

VI. Conclusion

PNF and SI Principles based exercise program can improve most aspects of handwriting with simple and easy to use activities. This analysis supports the view that handwriting proficiency is **equally attainable** by students of all genders. Except for minor differences in speed, performance was balanced across all key writing dimensions. These findings provide a data-driven foundation for equitable handwriting instruction and evaluation.

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