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Effect of tendon gliding exercises versus upper limb strengthening exercises along with forearm stretching on handwriting speed for undergraduate students of Physiotherapy College: A comparative study

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Abstract
Background: Writing is an essential life skill required in daily life as a form of communication, expression of creativity and knowledge by students. It is a complex process which involves speed and grip strength.
Method: The present study was conducted at M.B. Gohil Institute of Medical Science and Research Center, Navsari, Gujarat. The study included 40 physiotherapy students, divided into two groups using convenience sampling. Participants were right-handed, aged between 19 and 21 years, with a tripod grip, and with no history of upper or lower limb injury in the past six months, nor any musculoskeletal or neurological conditions. One group (n = 20) performed Tendon Gliding Exercises, while the other group (n = 20) performed Upper Limb Strengthening Exercises for four weeks (five days per week). Handwriting speed and grip strength were measured pre- and post-intervention using the Handwriting Speed Test and a hand dynamometer.
Statistical analysis: An independent t-test was used to analyze the differences in grip strength and handwriting speed between the groups.
Result: Handwriting speed and grip strength increased in both groups. The Tendon Gliding Exercises group showed improvements of 22.99% in the 3-minute test and 18.20% in the 9-minute test. The Upper Limb Strengthening Exercises group showed improvements of 23.08% in the 3-minute test and 26.18% in the 9-minute test. Grip strength improved by 22.58% in the Tendon Gliding Exercises group and by 29.25% in the Upper Limb Strengthening Exercises group.
Conclusion: Both types of training are effective in improving handwriting speed and grip strength. However, upper limb strengthening exercises resulted in slightly better improvements than tendon gliding exercises.

Keywords: Handwriting speed, hand dynamometer, tendon gliding exercise, upper limb strengthening exercise

Introduction

Writing is an essential life skill for communication and expressing creativity and knowledge. It is a complex process involving speed and grip strength [1]. Writing is a key feature of human cultural development. The ability to communicate, store and retrieve information, and express oneself creatively and intellectually remains vital, especially for students today. Physically moving a pen or pencil over paper is the first step in developing writing skills [5].

A person's handwriting develops from childhood scribbling into more refined writing over time [2]. Handwriting depends on fine motor skills like dexterity, precision, and coordination, requiring cooperation among the skeletal, muscular, and neurological systems. It can be influenced by a person's health, mental acuity, skeletal structure, writing instrument, and writing surface. Most movements start in the forearm with shoulder strength, while the hand and wrist move minimally [5].

Producing written text involves three actions: moving the arm rightward, the wrist horizontally, and the fingers vertically [2]. Although pen use has declined with rising technology, handwriting remains vital in the educational system, as most assessments are still done on paper [2].

A writer's muscle strength, flexibility, hand position, and posture affect handwriting. The palmar pinch grip, holding the pen between the index and middle fingers with thumb support, is common. When choosing handwriting or typing, joint sensation matters most. Trained shoulder muscles perform better, while smaller muscles provide finer control. [5].

Adults (18–64) write at an average speed of 68 words per minute, ranging from 26 to 113. Girls reach peak writing speed earlier than boys, and women type faster than men (14.7 vs. 13.8 words per minute) [1].

Muscle strength, flexibility, coordination, processing delays, and writing style can slow performance. Strengthening exercises increase muscle size and power, with effort depending on finger and wrist position and intensity [2].

Endurance in handwriting is often overlooked in favor of speed gained through strengthening exercises. Strengthening hand and forearm muscles may improve writing speed, as increased intramuscular tension boosts muscle power, stamina, and strength [1].

Tendon gliding exercises improve finger mobility by affecting motion and strength. Tendon movement, or "tendon excursion," depends on hand position and movement intensity. Full range-of-motion hand exercises are as important as cardio, helping muscles work efficiently and allowing tendons to glide. The superficial muscles extend most in the first position, where the profundus tendon moves during the hook grip. The flexor pollicis longus is the only tendon involved in thumb flexion. Stretching shifts body parts into positions that lengthen muscles and connective tissues [2].

- **Benefits of stretching**

1. Improves flexibility [2]

2. Boosts power and reduce fatigue [2]
3. Enhances circulation [2]
4. Promotes relaxation [2]

Slower typing or handwriting hinders task completion and affects written communication. If students have limited writing time or frequent interruptions, they may not learn to write smoothly. Exams often test knowledge within time limits, and research shows that slow handwriting discourages writing, leading to low self-esteem, less school engagement, and higher risks of learning and behavioral issues [1].

Writing quality depends on muscle strength, flexibility, pen grip, and body posture, all influencing the final result [1].

Methodology

- **Study Setting:** M.B. Gohil Institute of Medical Science and Research Center (College of Physiotherapy), OPD, Navsari, Gujarat, India.
- **Study Population:** Undergraduate students of M.B. Gohil College of Physiotherapy
- **Study Design:** A comparative study
- **Study Duration:** 6 months
- **Sampling Method:** Convenient sampling
- **Sample Size:** 40 students

1. Materials Used

- Piece of cloth
- Dumbbell
- Rubber band
- Pencil (2B)
- Stopwatch
- Hydraulic hand dynamometer
- A4-size paper

2. Selection Criteria

2.1 Inclusion Criteria

1. Healthy young undergraduate physiotherapy students
2. Both males and females
3. Age between 19 and 21 years
4. Right-handed individuals
5. Having a tripod grip
6. Those who are willing to participate

2.2 Exclusion Criteria

1. Any history of illness, musculoskeletal, or neurological conditions
2. Those who are not willing to participate

3. Outcome Measures

- **Handwriting Speed Test**

Students were informed about the study and given a 2B pencil. They wrote the sentence "The quick brown fox jumps over the lazy dog" as neatly and quickly as possible for 3 minutes, took a 30-second break, skipped two lines, and continued writing for 9 minutes. Results from the 3-minute session were compared to the 9-minute session. The test showed excellent reliability (ICC = 1.00, $P < 0.0001$).

- **Hand Dynamometer**

Following ASHT (2015) guidelines, participants held the dynamometer in a palmar grasp with the elbow at ~90°, shoulder slightly abducted, and forearm in neutral rotation. Using their dominant (writing) hand, they squeezed maximally after a 3-second countdown. Grip strength was tested three times. The hydraulic dynamometer is highly reliable (ICC = 0.98) and valid (ICC [2, K] = 0.99) for clinical use.

4. Procedure

- Written informed consent was obtained from all participants to ensure privacy and confidentiality. Subjects were selected based on inclusion and exclusion criteria. Upper limb strength was assessed using a hand dynamometer, and handwriting speed was measured.
- Handwriting speed testing was initially performed on 45 individuals, with 40 included in the study through convenience sampling.

- **Participants were divided into two groups**

1. **Group A (n=20):** Performed tendon gliding exercises with forearm stretching (5-second holds, 10 repetitions, twice daily; forearm stretches for wrist flexors and extensors, 5 repetitions, 30-second holds).

2. **Group B (n=20):** Performed upper limb strengthening exercises (six exercises, 3 sets of 10 reps each) with the same forearm stretching protocol as Group A.

- After the training program, grip strength and handwriting speed were reassessed using the hand dynamometer and handwriting speed test.

5. Intervention

- **Group A: Tendon Gliding Exercise**

Participants performed exercises 5 days/week, twice daily for 4 weeks. One cycle of tendon gliding exercises included:

1. **Straight hand:** 10 reps, 5-sec hold
2. **Hook fist:** 10 reps, 5-sec hold
3. **Full fist:** 10 reps, 5-sec hold
4. **Table top:** 10 reps, 5-sec hold
5. **Straight fist:** 10 reps, 5-sec hold

Followed by stretching

1. **Wrist flexors:** 5 reps, 30-sec hold
2. **Wrist extensors:** 5 reps, 30-sec hold

- **Group B: Upper Limb Strengthening Exercise**

Participants performed exercises 5 days/week for 4 weeks. One cycle of upper limb strengthening included:

1. Biceps strengthening: 10 reps × 3 sets
2. Brachioradialis strengthening: 10 reps × 3 sets
3. Wrist extensor strengthening: 10 reps × 3 sets
4. Thenar eminence strengthening: 10 reps × 3 sets
5. Hand and forearm strengthening: 10 reps × 3 sets
6. Hand strengthening: 10 reps × 3 sets

Followed by stretching:

1. **Wrist flexors:** 5 reps, 30-sec hold
2. **Wrist extensors:** 5 reps, 30-sec hold

Statistical Analysis

- The study compared grip strength and handwriting speed between groups using independent t-tests, and within-group pre- and post-intervention differences using paired t-tests. Significance was set at $p < 0.05$. Analysis was performed using Microsoft Excel (2019).

Result

The study included 40 students: 20 performed tendon gliding exercises, and 20 performed upper limb strengthening exercises with forearm stretching. Handwriting speed and grip strength were measured pre- and post-training.

Handwriting speed improved by 22.99% (3-min HST) and 18.20% (9-min HST) in the tendon gliding group, and by 23.08% (3-min HST) and 26.18% (9-min HST) in the strengthening group. Grip strength increased by 22.58% in the tendon gliding group and 29.25% in the strengthening group.

Both interventions were effective for improving handwriting speed and grip strength, with slightly greater improvements observed in the upper limb strengthening and forearm stretching group.

Table 1: Percentage Difference between Pre- and Post- Data for Both the Groups

	HST		GRIP STRENGTH
	3-MIN.	9-MIN.	
TGE	22.99%	18.20%	22.58%
ULSE	23.08%	26.18%	29.25%

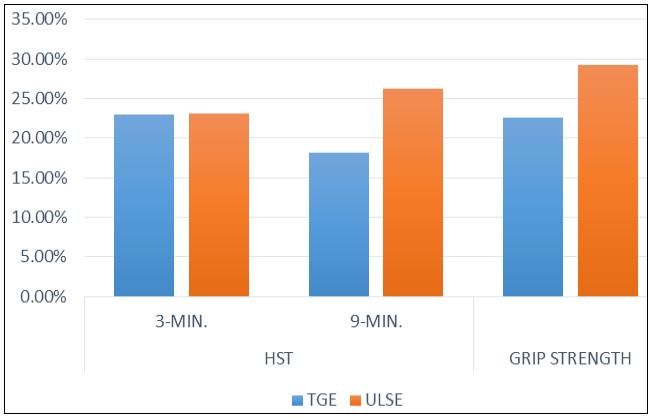

Fig 1: Percentage Difference between Pre- and Post- Data for Both the Groups

Discussion

Writing is a vital skill used daily for communication, creativity, and academic expression. It involves coordination between the musculoskeletal and nervous systems. Factors such as muscle strength, flexibility, hand positioning, and posture affect writing performance. Writing difficulties can hinder academic success and self-esteem.

This study, titled "Effect of Tendon Gliding Exercises versus Upper Limb Strengthening Exercise along with Forearm Stretching on Handwriting Speed in Undergraduate Physiotherapy Students," aimed to evaluate how these exercises impact handwriting speed and grip strength.

Forty students were divided into two groups of 20: Group A (Tendon Gliding Exercises) and Group B (Upper Limb Strengthening with Forearm Stretching). After obtaining consent, both groups followed a 4-week protocol, 5 days per week. Outcomes were assessed using the Handwriting Speed Test and Hand Dynamometer.

The results of this study showed significant improvements in both grip strength and handwriting speed after 4 weeks of intervention in Groups A and B among undergraduate physiotherapy students.

Paired t-tests demonstrated significant improvements in handwriting speed (ICC = 1.00, P < 0.0001) and grip strength (ICC (3,1) = 0.98; validity ICC [2, K] = 0.99).

Margarat Wallen *et al*. (1998) concluded that the 3-minute Handwriting Speed Test (HST) is a standardized tool for assessing writing speed improvements through exercise. Paul O'Mahony *et al*. (2008) [7] found that adding a 9-minute writing period enhances HST accuracy.

Studies by Gokulakrishnan J. and John Franklin on upper limb strengthening, and by Pratibha Pradip Pandekar and Poonam H. Patil on tendon gliding and forearm stretching, showed significant improvements in writing speed, highlighting the link between hand strength and writing performance.

These studies highlight that upper limb strengthening, tendon gliding, and forearm stretching exercises can improve hand strength and writing speed, benefiting students and professionals who need to write quickly.

Nilushika *et al*. (2012) found significant improvements in handwriting speed with upper limb exercises. In contrast, Mellisa M. Prunty *et al*. (2020) [8] reported that grip strength and pen pressure did not significantly affect handwriting difficulties in children with developmental coordination disorder (DCD), suggesting that improving these factors may not always enhance handwriting performance.

In this study, statistical analysis showed mean differences of -1.6 for grip strength, 0.15 for the 3-minute HST, and -1.6 for the 9-minute HST, indicating that upper limb strengthening exercises significantly improve handwriting speed and grip strength.

Conclusion

This study concludes that upper limb strengthening exercises improve handwriting speed and grip strength in undergraduate physiotherapy students. Therefore, such training can be incorporated to enhance these skills.

Limitations

- Short training duration; longer duration may yield better results.
- Small sample size limited to physiotherapy students; a larger, more diverse population is needed.
- Outcomes measured only with a hand dynamometer and handwriting speed test; additional measures should be included.
- Limited generalizability due to small sample size.
- No blinding of assessor or therapist.
- Only writing speed was assessed; factors like handwriting legibility and muscle fatigue were not evaluated.

Further Recommendations

- Extend training duration for more accurate results.
- Use additional parameters to assess handwriting speed and grip strength.
- Explore other interventions to improve these outcomes.
- Conduct studies with larger sample sizes.

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