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Role of Scapular Muscle Strengthening on Grip Strength and Handwriting Speed among Physiotherapy Students

Niharika Jha[1], Sapna Dhiman[1]*, Sanya Kundra[1], Ananya Shrivastava[1] and Saurabh Kumar[2]

1. School of Physiotherapy, Delhi Pharmaceutical Sciences and Research University, New Delhi, India
2. Faculty of Physiotherapy, SGT University, Gurugram, India

*** Corresponding author**
Sapna Dhiman, PhD
School of Physiotherapy, Delhi Pharmaceutical Sciences and Research University, New Delhi, India
Tel: +91 8588055147
Email: sapnaphysio@dpsru.edu.in

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Abstract

Background: The study aimed to investigate the effectiveness of scapular muscle strengthening exercises on grip strength and handwriting speed among physiotherapy students.

Methods: A pre-post study was conducted with 40 participants both male and female aged 18-24 years, who were right-handed and were able to read and write in English. The participants were recruited through convenient sampling, and then, randomly allocated into two groups *i.e.*, Group A (Control) and Group B (Experimental). The experimental group B (20 participants) received scapular muscle strengthening exercises for three days per week for six weeks, whereas the control group A (20 participants) practiced one-page handwriting for the same frequency and duration. Then grip strength and handwriting speed were measured following intervention by hand dynamometer and handwriting speed test, respectively.

Results: The mean age of the participants was 21.72 and 21.67 in the group A and group B, respectively. The data was analysed using the paired t-test and independent t-test which revealed that Group B's handwriting speed and grip strength improved significantly when compared to Group A ($p<0.05$).

Conclusion: The scapular exercise receiving group significantly showed an increase in grip strength and handwriting speed (words per *min*), therefore to increase handwriting speed and grip strength, scapular strengthening exercises are effective.

Keywords: Hand strength, Handwriting, Muscles, Physical therapy modalities, Students

Introduction

The intricate task of handwriting requires coordination between the neurological and muscular systems. One of the most unique aspects of human cultural progress is writing, which involves fine, precise, and coordinated movements in the upper extremities (1,2). Since, speed is closely related to the capacity to accurately learn information about numerous fields, it is essential for academic performance. All age groups in society, including school-age children, college students, and office-age adults, require a legible handwriting (3).

There are numerous facets to the writing process. The hand's fine motor skills are responsible for the capacity to form letters of various sizes and shapes (4). The development of full arm and hand movements, pincher grasp with thumb, index finger, and middle finger, and coordination of pincer grip with these three fingers are the four steps that make up writing ability (5).

Additionally, handwriting is aided by motor muscles, which include the scapular muscles; legibility of handwriting is positively correlated with the scapular muscles. A solid foundation for handwriting skill development is established by the development of sturdy shoulders and upper arms (6). Maintaining good posture through the proximal group of muscles helps in the regulated movement of the distal muscles, which in turn aids with writing. A person's ability to accomplish distal tasks, such grip strength, may be limited if their scapular muscles are unable to provide proximal stabilization (7).

The synergistic coordination of the wrist and finger flexors and extensors is known as hand grip strength. A hand dynamometer is used to measure it (8). The hand's capacity to hold object between its fingers and thumb is known as its grip. It is widely accepted that tests of grip and pinch strength provide an unbiased assessment of the functional integrity of the upper extremities (9). The relationship between hand grip and shoulder stabilization has been the subject of various studies. It has been suggested that there are strong correlations between the power of hand grip and shoulder stabilizer muscles, and that shoulder muscle activities increase with increasing hand grip strength (10,11).

The majority of research on handwriting has previously been conducted on school-aged children, covering topics like proprioception, fine motor abilities, and initiatives like handwriting without tears (5). The primary goal of this study was to determine whether or not handwriting of college students improved as a result of the scapular muscles strengthening exercise.

Materials and Methods

Study design

The present study was a pre-post study design. Ethical clearance was obtained from Research Review Development Committee of the institution, before commencement of the study. The study's goal was described, and the participants gave their informed consent in the written before participating.

Participants

The participants of the study were selected through convenient sampling. 40 participants both male and female aged 18-24, who were right-handed and were able to read and write in English, were recruited for the study. Participants with any history of upper limb injury in last 3 months, or any orthopaedic or neurological condition, or recent surgeries or any hearing or visual impairments were excluded from the study.

Procedure

After explaining the purpose and method of the study to the participants and receiving their written consent, they were divided into 2 groups *i.e.* group A (control group) and group B (experimental group) and then were assessed and baseline measures were recorded on the day of enrolment and the recording took about 60 *min* on an average. The exercise protocol was started from next day onwards. The group A participants wrote the same paragraph of 200 words every day in their notebooks. The paper was not provided by the researcher to avoid bias with group B participants. They performed handwriting practice for 40-45 *min*, 3 days a week for 6 weeks. The group B received exercises for scapular muscle strengthening which included strengthening of the following muscles- middle trapezius, lower trapezius and serratus anterior, which was supervised by the researcher (12,13). The training protocol is described in table 1. After completion of the study protocol, the participants were reassessed and outcome measures were recorded the next day.

Table 1. Scapular muscle strengthening protocol

Muscle	Exercise	Dosage	Progression
Lower trapezius	- An efficient way to activate and strengthen the lower trapezius is to raise the arm above the head while keeping the upper extremity in line with the lower trapezius muscle fibers. Normally, this exercise is performed in the prone position. - In the prone position, the shoulders are extended horizontally while rotating them externally	Frequency: 3 times per week Intensity: 3 sets of 10 repetitions Duration: 6 weeks Rest interval- 1 *min* between each set	- Increasing the total number of repetitions until the participant could complete three sets of ten repetitions. - Theraband was used for further advancement. Therabands were advanced based on color coding, which is deter*mine*d by the resistance they offer *i.e.*, from yellow to red to green
Middle trapezius	- Unilateral row - External rotation of the shoulder with the elbow supported on the table and the shoulder abducted 90 degrees and flexed 90 degrees in the prone position	-	-
Serratus anterior	- Shoulder abduction in the scapular plane over 120 in standing position - While seated, perform diagonal exercises that combine external rotation, shoulder flexion, and horizontal flexion	-	-

Outcome assessments

Grip strength and handwriting speed were recorded at baseline and at 6 weeks post intervention for both groups. Grip strength was evaluated using hand held dynamometer, and handwriting speed was assessed using the handwriting speed test (14,15). Handheld dynamometer was used to determine the handgrip strength of the dominant hand and expressed in *kg*. The participant was instructed to stand or sit with their elbow at a 90-degree angle. They were then told to squeeze the dynamometer as hard as they could, and the highest reading in kilos was noted. Three trials were recorded for each hand, with a 5-*min* rest between each trial. The average of the maximal hand grip strength of the dominant hands was calculated. For calculating the handwriting speed, a single English-language audio recording was given to the participants, who had two *min* to replicate it on an A4 sheet in a single lecture room with the same writing equipment and seating arrangements. Upon completion, the number of words was recorded and the writing speed was computed.

Statistical analysis

The sample size was calculated by using G*power with effect size 0.25, alpha (α) error probability 0.05 and power (1-β err prob) 0.95. The study was carried out in university premises. Forty participants were allocated into two groups: Group A (control group) and Group B (experimental group). Each group consisted of 20 participants.

The data was found to have a normal distribution by the Shapiro-Wilk normality test. For every variable, the descriptive statistics (mean and standard deviation) were calculated. The difference between the pre- and post-tests within each group was examined using the paired sample t-test and independent sample t-test was used to compare the mean difference of pre and post-tests between groups, with a significance level at $p<0.05$. IBM SPSS Statistical Version 24 was used to analyze the data.

Results

A total of 40 participants participated in this study out of which 20 participants were in control group and

Table 2. Demographic characteristics

		Group A (n=20)	Group B (n=20)	p-value
Age Mean (SD)		21.72(1.124)	21.67(0.84)	0.286
Gender N(%)	Male	9(45%)	12(60%)	0.342
	Female	11(55%)	8(40%)	
Number of students N(%)	1st year	8(40%)	7(35%)	0.936
	2nd year	7(35%)	8(40%)	
	3rd year	5(25%)	5(25 %)	
Height *(cm)* Mean (SD)		171.00(6.68)	-	167.15(7.39)	0.672
Weight *(kg)* Mean (SD)		67.71(7.61)	-	70.19(7.14)	0.892
BMI Mean (SD)		23.17(2.49)	-	25.28(3.57)	0.134

SD: Standard Deviation; %: Percentage; Body Mass Index (BMI).

20 were in experimental group. 20 were females and 20 were male participants in the age range of 18-24 years with mean age of the participants 21.72 and 21.67 in the control and exercise group, respectively, as presented in table 2. Total number of the male participants in Group A were 9 (45%) and female were 11 (55%) out of which maximum number of students were from first year *i.e.*, 8 (40%) whereas total number of the male participants in Group B were 12 (60%) and female were 8 (40%) out of which maximum number of students were from second year *i.e.*, 8 (40%). There were no statistically significant differences in age, height, weight and Body Mass Index (BMI) ($p>0.05$) analysed by independent t test. Frequency and percentage were used for gender and number of students analysed by chi-square test which showed no statistically significant difference.

Table 3 illustrates a statistically significant improvement in the mean values of grip strength and handwriting speed. The difference was more evident in the group B than in the group A. Within-group analysis using paired t-test revealed statistically significant improvement in group B in comparison to Group A ($p=0.001$). Mean difference of Grip strength ($p=0.001$) and handwriting speed test ($p<0.001$) after six weeks of intervention were greater in Group B in comparison to Group A, which was statistically significant, too.

Discussion

The purpose of the present study was to find the effectiveness of scapular muscle strengthening exercises on the grip strength and handwriting speed among physiotherapy students. The results demonstrated that during the six-week intervention, grip strength and handwriting speed improved significantly in the experimental group. Additionally, both measures were more effective in the experimental group than the control group.

Scapular strengthening and grip strength

The most effective recruitment of hand muscles in the distal region is considered to rely on proximal scapular stability. The distal functional motions and proximal stability are responsible for the upper extremities' functions. The muscles that surround the scapula stabilize the upper extremity proximally and serve as a fixed point when the distal portion moves. When the scapula is stable, the upper extremities, which are crucial for the functional performance of daily tasks, will function more effectively. Since the proximal portion of the upper extremity influences the hand's functional movements, impairment to this area can cause dysfunction without affecting the distal portion of the upper extremity. This is why there is a substantial correlation between grip strength and the strength of scapular muscles (16).

Table 3. Within- and between-group comparison of grip strength and handwriting speed test among group A and group B

Variables	Group A Mean (SD)	Group B Mean (SD)	MD	t-value	p-value
Grip strength					
Pre	22.77(6.606)	22.35(6.239)	0.420	0.207	0.837
Post	22.54(6.577)	30.78(7.907)	-8.240	-3.583	0.001*
MD	0.23	-8.43	-	-	-
% of change	1.02%	31.73%	-	-	-
t-value	1.682	-5.112	-	-	-
p-value	0.109	<0.001	-	-	-
Handwriting speed test					
Pre	30.52(4.801)	30.92(3.658)	-0.402	-0.297	0.768
Post	31.09(5.428)	45.12(4.686)	-14.034	-8.753	<0.001*
MD	-0.57	-14.2	-	-	-
% of change	1.85%	37.35%	-	-	-
t-value	-0.868	-12.683	-	-	-
p-value	0.396	<0.001	-	-	-

SD: Standard Deviation; MD: Mean Difference; p-value: probability value (p<0.05)*

Research has verified that the amplitude of shoulder muscle activation-the proximal component-is linked to grip strength, which is a distal function. Glenohumeral stability depends on the rotator cuff muscle connection, which is supported by the scapula. Scapular instability can result from weakness in the rhomboids, trapezius, serratus anterior, and pectoralis minor, which can alter the rotator cuff's length–tension relationship. This could lead to ineffective contractions and possibly weaker hand grip strength (17). The findings of current study are supported by a study that was conducted to investigate the effects of scapular exercise and Kinesio-taping of upper trapezius muscle on grip strength. The results revealed that the grip strength of scapular exercise group showed a significant difference (p<0.05) (18). Similarly, one of the researches was conducted to examine the activity and fatigue of shoulder muscles on 16 healthy subjects. In a controlled hand grip, they used electromyography of scapulothoracic muscles during grip task which indicated that grip increases the activity of both muscles (19). The results of the present study are consistent with a study looking into how grip strength is affected by scapular muscle strengthening in individuals with lateral epicondylalgia. It demonstrated that individuals with chronic lateral epicondylalgia exhibited significantly improved grip strength after performing scapular strengthening activities (12).

Scapular strengthening and handwriting speed

The findings of this study indicated a significant improvement in handwriting speed following scapular strengthening exercises. Hand grip strength and endurance have a positive moderate effect on writing speed (18). Exercises that increase hand strength and endurance can increase the writing speed and ultimately academic performance of students (20).

In simple terms, scapular muscles serve as a foundation for writing. The findings of the scapular muscular endurance test and the handwriting legibility score showed a correlation that was statistically significant (6). Regarding the impact of scapular muscles on hand function, Naider-Steinhart and Katz-Leurer discovered that in healthy adults, the speed of handwriting tasks was influenced by control of the upper trapezius muscle (21,22). They came to the

conclusion that when writing by hand, the proximal muscle serves as a stabilizer. This is supported by the proximal distal muscle principle it states that "proximal muscle stability is a pre-requisite for manipulative hand use (23).

A previous study on undergraduate students was conducted to test the effect of upper limb strengthening on handwriting speed. The exercise group showed better results than the handwriting practice group, according to the results. It occurs because when the larger muscles of the shoulder girdle operate effectively together, they provide stability for the smaller muscles of the hand and arm to do their job properly (14). The above studies are congruent with the finding which showed that the scapular strengthening exercises improve grip strength and handwriting speed.

The observed increase in handwriting speed after a scapular muscle strengthening program is a novel finding from this study; this relationship has not been well explored.

Although proximal stability's function in motor control has been studied before, this study is the first to illustrate how it directly affects handwriting, a fine motor skill. According to this research, improved scapular stability may have wider effects on functional activities involving the upper limbs than just traditional gross motor results.

These results provide credibility to the concept of a kinetic chain, in which distal mobility and function are based on proximal stability. For students or those who execute high-demand upper limb jobs on a regular basis, scapular strengthening could be an effective strategy to enhance functional capacity and task performance.

Limitations and future scope of the study

Since the study's subjects were college students and it was limited to small sample size, there may be some challenges interpreting the findings to individuals of all ages. The duration of intervention was short to observe the sustained improvements in grip strength and handwriting speed. Additionally, this study solely used hand grip strength as an indicator of upper extremity function; pincer strength and other strength indices were not taken into account.

Future research is required to explain how grip strength and handwriting speed are affected by both scapular strengthening and upper limb strength training.

Additionally, a comparison of grip strength and handwriting speed between male and female subjects may be possible. Also, a bigger sample size is needed for this purpose. Research can be conducted with students from many fields and subjects who need particular postures and fine motor skills: like engineering, architecture, and technical drawing. It can also include assessments of writing endurance and shoulder mobility.

Conclusion

The results of this study indicate that physiotherapy students' grip strength and handwriting speed can be considerably improved by targeted scapular muscle strengthening exercises. Scapular stability and fine motor performance are interdependent, and strengthening the upper limb's proximal stabilizers may help with distal motor control and functional efficiency. Fundamentally, development of sturdy shoulders and upper arms is the basis of the skill development of handwriting. These findings provide relevance to the inclusion of scapular-focused therapies in training regimens designed to maximize upper limb function, especially for tasks like handwriting that rely on dexterity and accuracy.

Ethical approval

Ethical approval was obtained from Research Review Development Committee of School of Physiotherapy, Delhi Pharmaceutical Sciences and Research University prior to commencement of the study (10/2044/SOP/DPSRU/2021/1033) dated 9th February, 2022.

Consent to participate

Informed consent was obtained from all individual participants included in the study.

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Conflict of Interest

There was no conflict of interest in this manuscript.

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