

Effects of Combined Coordination Exercise and Strength Training for Increasing the Speed of Handwriting Among College Students

Dr. Harini. Palani¹, Dr. V. Balchandar², Dr. A. Srimathy³

^{1,3}Assistant Professor, Department of Physiotherapy, Jaya college of Physiotherapy.

²Principal, Department of Physiotherapy, Jaya college of Physiotherapy.

ABSTRACT

INTRODUCTION: Handwriting is the activity performed by every single individual with synchronization of the musculoskeletal and neurological system. While writing fine, precise and coordinated motions are involved. Speed is important to perform academically in healthier way.

OBJECTIVE Determine whether the combined activity of coordination exercise and strength training is effective to improve speed of handwriting.

METHODOLOGY: The combined coordination exercise and strength training to improve speed of handwriting on undergraduate students were allocated randomly to the experimental (n=15) and control group(n=15). In experimental groups both coordination exercise and strength training were to be given. In control group, handwriting practice was given for 4 days a week for 5 weeks. Outcome measures were to be assessed by using dynamometer for strength, word per minute test for speed and peg board for coordination test at 1 week and 5 weeks.

RESULT: This study showed the statistically significant pre-test and post-test of handwriting speed (≤ 0.05), grip strength (≤ 0.05) and peg board activity score for coordination (≤ 0.05).

CONCLUSION: Coordination exercise and strength training improves the speed of handwriting in undergraduate students.

KEYWORDS: Handwriting, Speed, Coordination exercise, Strength Training.

INTRODUCTION:

Handwriting – an essential and complicated activity requiring precise synchronization of the musculoskeletal and neurological systems. Fine, precise, and coordinated motions in the upper extremities occur during writing, and it is one of the most distinctive elements of human cultural evolution. Speed plays a vital role in academic performance. Handwriting is one of the modes of communication in the test (1). Skilled handwriting is an important activity for school-aged children, enabling them to write efficiently within a reasonable time while producing clear and readable work that effectively communicates their thoughts and ideas (2). Handwriting is often perceived as a reflection of an individual's intelligence and abilities. Several studies have shown that children with poor handwriting tend to receive lower marks, while those with neat and legible handwriting are awarded higher marks, even when the content of their work is similar. Gender is also an important factor in handwriting development. Studies suggest that girls generally produce more legible handwriting and write faster than

boys. Additionally, right-handed individuals tend to write faster than left-handed individuals.(2,15). Legible handwriting is an essential skill for children to develop during their elementary school years (2). Handwriting is a complex activity that requires fine motor skills involving precise and coordinated movements of the upper extremities. It depends on the integrated functioning of the muscular, skeletal, and neurological systems. During handwriting, most movements originate from the forearm, while the shoulder provides stability and power, with minimal movement occurring at the fingers and wrist. Factors such as muscle strength and flexibility, pen grip, and overall posture significantly influence handwriting performance. Joint position sense is considered one of the most important factors affecting handwriting ability. Research shows that girls generally achieve maximum writing speed earlier than boys. The average writing speed is approximately 14.7 words per minute (wpm) for girls and 13.8 wpm for boys, while a speed of 10–20 wpm is considered normal for 15-year-olds. Handwriting speed plays a vital role in academic success, as it directly affects a student's ability to express knowledge across different subjects. Handwriting is also regarded as one of the unique aspects of human cultural development. It remains an essential life skill used for communication, record-keeping, creative expression, and knowledge sharing. Researchers have reported that many students experience fatigue after writing for only a few minutes. Several factors influence handwriting performance, including the anatomy of the upper extremity, general health, mental alertness, writing instruments, and the writing surface. During handwriting, most movements originate from the forearm, while the shoulder provides stability and power, with only minimal movement occurring at the fingers and wrist (4). Strengthening the forearm and intrinsic hand muscles can help improve handwriting speed. During resistive training, muscles undergo isotonic contractions, which involve an increase in intramuscular tension along with a change in muscle length (4). Resistive training increases intramuscular tension, which gradually enhances muscle power and leads to muscle hypertrophy. As muscle tone improves through hypertrophy, both muscular strength and endurance are enhanced. Strength training is a form of physical exercise that uses resistance to produce muscular contractions, thereby improving strength, anaerobic endurance, and skeletal muscle size. The benefits of strengthening exercises include increased energy levels and reduced muscle fatigue. Activation of the proximal muscles is essential for effective functioning of the distal muscles. Fine motor skills become especially important when children begin learning handwriting. These skills involve the use of small muscles that enable precise movements and functions such as handwriting and grasping small objects. Fine motor abilities contribute to the development of an effective grip on writing instruments and can be improved through activities such as playing with building blocks, pegboards, dough, and motion boards (5). Proficient handwriting is widely regarded as an essential foundation for later academic success. Nevertheless, handwriting difficulties are commonly seen among primary school children, particularly boys. The reported prevalence ranges from 5% to 27%, depending on the grade level, assessment methods, and selection criteria used in different studies. Reduced handwriting speed is often linked to poor handwriting quality and underlying difficulties in handwriting performance (7). Handwriting is a complex motor skill that is closely connected to reading development. Measures of motor proficiency associated with handwriting in school-aged children have shown an indirect influence on handwriting through reading-related abilities, such as orthographic skills. This highlights reading as a mediating factor in the relationship between motor proficiency and handwriting performance (9). Research indicates that handwriting difficulties may be associated with impairments in motor coordination and/or visuo-motor skills (10). Handwriting involves controlling a writing instrument, such as a pen, on a two-dimensional surface like paper. The pen tip must be kept

either stable or in controlled motion above the surface to form specific sequences, such as legible letters. In adults, the wrist and fingers (distal joints) are primarily responsible for producing the written output, while the shoulder and elbow (proximal joints) help maintain the writing arm on a horizontal plane. The degree of movement at the proximal joints is generally related to the size of the letters or drawings being produced. Typically, handwriting consists of two main types of movement. In the first, the index finger and thumb oppose each other and move toward and away from the palm through flexion and extension of the finger joints, creating back-and-forth pen movements. In the second, the entire hand rotates around the wrist through palmar flexion/extension and ulnar deviation, along with thumb movements such as radial abduction and dorsal flexion. The main muscles involved in these actions include the thenar muscles (thumb), wrist flexors and extensors, and the trapezius muscle at the shoulder. These two movement patterns form the primary axes of handwriting and have been widely studied in relation to writing performance and output. Writer's cramp is a condition characterized by excessive and inappropriate co-activation of flexor and extensor muscles in the arm during writing. It may also present as painful muscle cramps in the thumb and adjacent fingers, often resulting from excessive pressure on the pen. This condition can cause individuals to grip the pen more tightly and adopt abnormal hand or arm postures due to discomfort (11). Children spend approximately 31% to 60% of their school day engaged in handwriting and other fine motor activities. Difficulties with fine motor tasks are a common concern among school-aged children in the general population. It is estimated that handwriting difficulties affect about 11–12% of female students and 21–32% of male students, with an overall global prevalence ranging from 10% to 34% among school-aged children (12). Writing is a complex language process that involves multiple brain mechanisms, beginning with eye–hand coordination, visual–motor integration, and proprioceptive–kinesthetic feedback, which provides awareness of movement and finger position in space. It also depends on motor memory, or motor engrams, which work alongside visual–motor coordination to produce symbols with efficiency, speed, and accuracy (13). In addition to difficulties with legibility and writing speed, clinical observations show that children with dysgraphia tend to erase their work more frequently, report greater fatigue and hand pain, and often show reluctance to write or complete homework (14). Slow handwriting or typing not only extends the time needed to complete assignments but also alters the overall writing experience (15).

METHODS:

A comparative study was conducted among 30 college students selected through a convenient sampling method. The study included pre- and post-examinations over a duration of 6 months, with an intervention period of 5 weeks. Participants were undergraduate students aged between 18–22 years, including both males and females, who exhibited slow handwriting speed and dysgraphia. Only right-handed students who consented to participate in the study were included. Participants were excluded if they had a history of upper limb surgery or any upper limb fractures, upper limb amputation, musculoskeletal or neurological conditions affecting the upper limb, developmental delay, recent upper limb surgery, hearing or visual impairment, or if they were not interested in participating. The outcome measures assessed in the study included speed, coordination, and strength. These were evaluated using the following outcome measurement tools: Word Per Minute Test, Peg Board Activity, Dynamometer.

STUDY PROCEDURE

After obtaining informed consent, 30 participants were selected through convenience sampling and then

assigned to two groups. Group A (experimental group) and Group B (control group). Pre-test and post-test assessments were conducted using the Words Per Minute (WPM) test for handwriting speed, the Purdue Pegboard Test for coordination, and a hand dynamometer for grip strength.

Group A – Experimental Group

Fifteen subjects participated in a structured exercise program conducted four sessions per week for five weeks. Handwriting speed was assessed by asking participants to write on an A4 sheet for one minute, and the number of words written was recorded. Grip strength was assessed using a hand dynamometer while participants were seated upright with the shoulder in a neutral position, the elbow flexed at 90°, and the wrist maintained in a neutral alignment. Coordination was evaluated using the Purdue Pegboard Test, in which participants placed pegs on the board for 30 seconds over three trials, with the median score recorded for analysis. The exercise program focused on muscles involved in handwriting, including the forearm, wrist, biceps, brachioradialis, and thenar muscles. Exercises included thumb flexion-extension, thumb extension using a rubber band, ball squeezing, pinch strengthening, thumb-to-finger touches, dumbbell curls, hammer curls, reverse curls, wrist extension exercises, towel grip exercises, and coordination exercises such as finger-to-nose, finger-to-finger, rapid alternating movements, and rebound phenomenon exercises.

Group B – Control Group

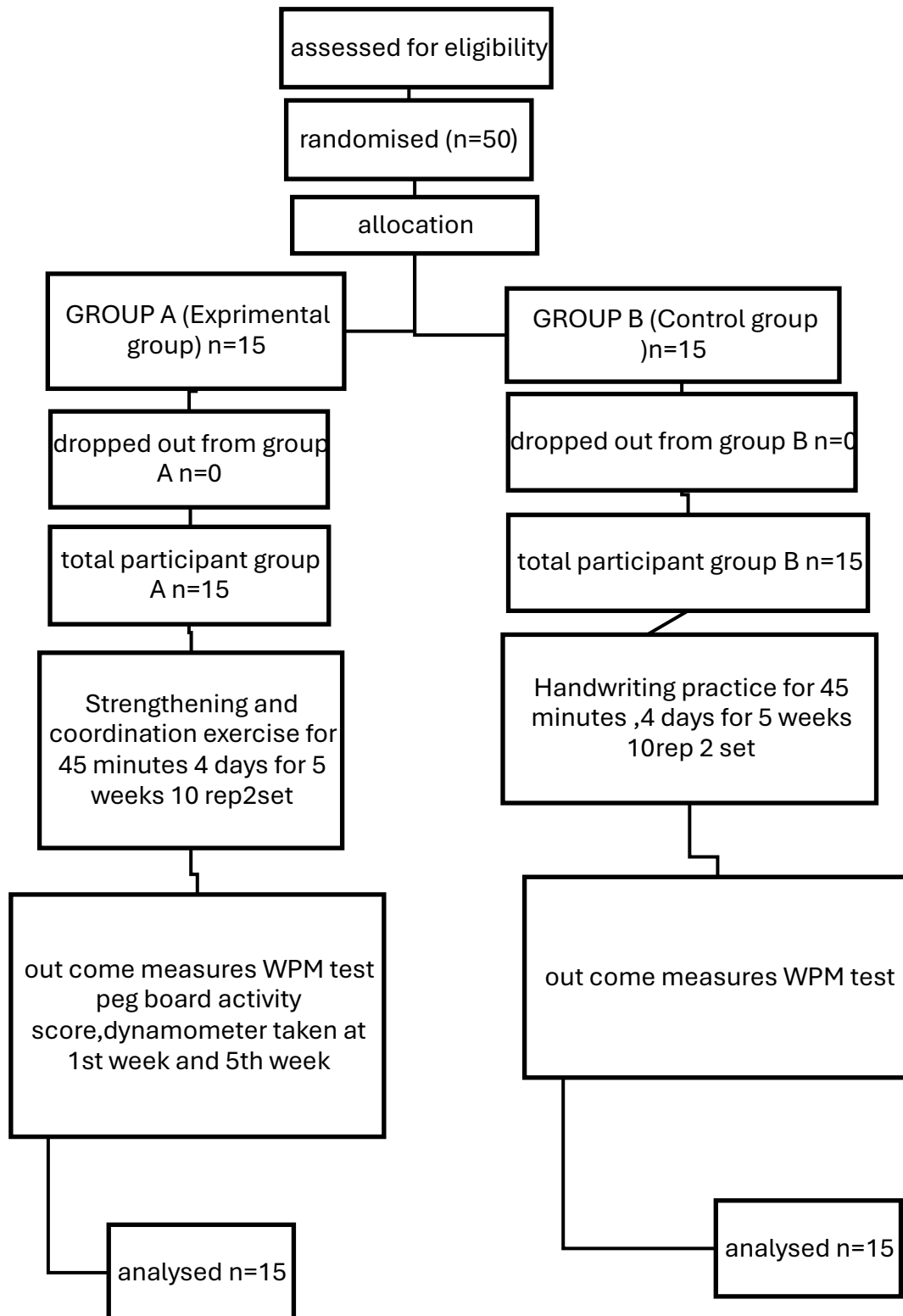
Fifteen subjects in the control group performed handwriting practice four sessions per week for five weeks. Pre-test and post-test assessments for handwriting speed, grip strength, and coordination were conducted similarly to the experimental group.

DATA ANALYSIS

The collected data were organized and analyzed using both descriptive and inferential statistical methods. All variables were processed using the Statistical Package for the Social Sciences (SPSS) version 24, with a significance level set at $p < 0.05$ and a 95% confidence interval applied for all analyses. The Shapiro–Wilk test was used to assess data normality, which indicated that the dependent variables were normally distributed ($p > 0.05$). Based on this result, parametric tests were applied. A paired t-test was used to evaluate differences within groups, while an independent t-test (Student's t-test) was used to compare differences between the groups.

RESULT

On comparing the Mean Values of Group A & Group B on Hand Writing Speedscores, both groups showed a significant improvement in post-test values. However, Group A demonstrated a higher mean score (42.13 ± 4.24) compared to Group B (34.00 ± 3.56), indicating greater effectiveness at $P \leq 0.05$. Therefore, the null hypothesis was rejected. Similarly, for hand grip strength scores, both groups exhibited a significant increase in post-test mean values. Group A recorded a higher mean value (44.27 ± 5.70) than Group B (35.82 ± 2.98), which was statistically significant at $P \leq 0.05$, leading to rejection of the null hypothesis. For pegboard activity scores, both groups showed a significant improvement in post-test outcomes; however, Group A again demonstrated a higher mean score (32.26 ± 5.63) compared to Group B (25.06 ± 2.81), indicating superior effectiveness at $P \leq 0.05$. Hence, the null hypothesis was rejected. In addition, within-group comparisons of pre-test and post-test results for handwriting speed, hand grip strength, and pegboard activity revealed statistically significant differences in both Group A and Group B at $P \leq 0.05$.



FLOW DIAGRAM

DISCUSSION

The results of the group comparison showed that the experimental group demonstrated greater improvement than the control group in words per minute, coordination test performance, and strength. This suggests that handwriting speed improved more effectively due to the combined effects of

coordination and strength training compared to handwriting practice alone. Hence, based on this, clinically it proves that, with combined coordination exercise and strength training, children can write their examination and homework without any difficulty with good handwriting, compared to those participants without exercising. Muscle strength is the most essential for a child to accomplish their gross and fine motor abilities, which is the basis of excellent legible handwriting. Previous research on handwriting stated that upper limb strengthening training showed the effect on handwriting speed in undergraduate students. The exercise intervention in the experimental group produced favorable results, as the larger muscles of the shoulder girdle worked efficiently together to provide stability, allowing the smaller muscles of the hand and arm to function more effectively (31). Another study reported that strengthening exercises for the brachioradialis, wrist extensors, and biceps, along with coordination and endurance training for the hand and forearm muscles, significantly improved pinch grip strength, handwriting speed, and upper limb coordination (2). In one of the previous studies, researchers performed research on handwriting speed in which exercise intervention was carried out with 3 components that is strength, coordination, and endurance. The result of the study showed that exercise program to forearm, hand and wrist improved handwriting speed. The proposed mechanism suggests that shoulder stability plays a crucial role in handwriting performance. When the shoulder is strong, it provides a stable base, making wrist stability essential for fine finger control. With a stable shoulder, precise finger movements and improved handwriting depend largely on effective wrist stability (36). In the present study, age group and sample size were limited. Children studying only in English medium were included. Further study can be done by taking a greater number of students and also finding the difference between boys and girls, righthanded and lefthanded dominant handwriting speed. Handwriting speed can be checked by different pen grips also. A study examining the effects of upper limb strengthening exercises on handwriting speed in healthy school-aged children reported that both resistive and coordination exercises produced a significant improvement in words-per-minute performance and handwriting proficiency screening scores. The findings indicated enhanced handwriting speed and hand grip strength among physiotherapy students (38). A study on the effects of resisted exercises on hand grip strength among tennis players reported a significant improvement in grip strength following upper limb strengthening exercises. These findings suggest improvements in hand grip strength among both male and female physiotherapy students (39). A previous study reported that handwriting skills can be improved through upper limb strengthening, as the large muscles of the shoulder girdle work effectively together to provide a stable base for the smaller muscles of the hand and arm to function efficiently. Gross and fine motor skills of the hand are strongly influenced by upper limb strength (15).

RECOMMENDATIONS OF THE STUDY:

Larger samples can be used. More number of exercise can be prescribed.

LIMITATIONS OF THE STUDY:

Small sample size. Gender difference as not considered. Exercise was more in numbers and its difficult for patient to remember and follow.

CONCLUSION

The findings of this study concluded that a combination of coordination exercises and strength training

is effective in improving handwriting speed among undergraduate students.

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