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The Effect of Sports Stacking Speed on Handwriting Speed in School Going Children: Randomized Control Trial

Dr. Harshmeet Kaur Narang[1], Dr. Gaurai Gharote[2]

[1]BPTh, Department Of Physiotherapy, Tilak's Indutai College Of Physiotherapy, Pune, India
[2]Professor, Department Of Physiotherapy, Tilak's Indutai College Of Physiotherapy, Pune, India

Abstract

Background: Multiple researches are done to improve hand function and handwriting skills in children. This study will help to provide planned exercises for effective handwriting speed and to have a better outcome in the field of academics.

Aim: Aim of the study is to evaluate the effect of sports stacking speed on handwriting speed in school - going children aged 8 to 12 years old.

Design and Method: This randomised control trial examines the effectiveness of increasing cup stacking speed intervention for improving handwriting speed in right handed school going children, the sample size of 50 students further distributed into experimental and control group which included 25 students each. Intervention included sports stacking for 30 mins everyday for 4 weeks. Handwriting speed outcomes were measured by WPM's and stacking speed was measured in seconds.

Result: This approach targeted fine motor coordination, neuromotor development, facilitating interhemispheric communication, enhancing neural efficiency, hand function, bilateral intergration and reaction control according to findings in correlation with previous researches.

Conclusion: The findings indicate improvement in handwriting speed with increase in stacking speed and suggests that sports stacking is simple, enjoyable and powerful tool for enhancing handwriting efficiency and fine motor skills among children in their formative school years.

Limitations: Although the study has methodological limitations such as small sample sizes, no comparison in left and right handed children and no evaluation of long term gains.

Future Scope: Hence further research should focus on long term results and intervention protocols to enhance legibility and qualitative handwriting aspects.

Keywords: Sports stacking, cup stacks, handwriting speed, fine motor skills, handwriting efficiency, physiotherapy, neuromotor development, hand function, stacking speed.

INTRODUCTION

Handwriting is one of the most vital fine motor skill that support academic achievement in school-aged children. Writing allows young children to write or express their thoughts, record information efficiently, and participate meaningfully in classroom activities and assessments. Efficient handwriting depends on the integration of visual-motor coordination, perceptual abilities, attention, and muscular control of the upper extremities. The students with learning disabilities often have poor handwriting legibility. Slow writing and weak visual motor coordination reduces letter formation and spatial accuracy while negative attitudes lower motivation and effort if the students are motivated these legibility with improve, hence in this study these the correlation between all these aspects was found. Working on one will surely improve other.(1) Within the domain of physiotherapy, handwriting is often considered an important outcome for assessing fine motor coordination, neuromotor development, and hand function. The handwriting speed test (HST), as standardized by Wallen and Bonney, serves as a reliable tool for quantifying changes in handwriting speed.(2) Similarly, the DASH test is widely recognized for its psychometric validity and sensitivity to detect change in writing fluency. Reliable and standardized tests such as the Detailed Assessment of Speed of Handwriting (DASH) and the Handwriting Speed Test (HST) have been widely adopted to objectively measure handwriting proficiency. (3) Both instruments rely on standard sentences or pangrams such as “the quick brown fox jumps over the lazy dog,” ensuring that writing assessments are consistent and comparable over repeated trials. The test is frequently used in both clinical and educational research to measure intervention effects, including those targeting fine motor and perceptual-motor domains.(2) One such intervention that has recently attracted considerable attention is sport stacking, also known as cup stacking. Sport stacking involves the rapid manipulation of specially designed plastic cups into predetermined sequences such as 3–3–3, 3–6–3, and the cycle pattern.(4) A fourteen weeks sports stacking intervention in second grade students showed improvement in handwritring speed, hand eye coordination and reaction time. The repetitive, structured nature of sport stacking helps to develop these motor skills.(5) For people who had a stroke, upper-limb function recovery is a barrier to their independence. The study shows the effects of combined action observation and motor imagery therapy for upper-limb recovery in chronic stroke survivors that was assessed. Mean of movement execution time was significantly reduced overall compared to baseline. Hence the results shows that when physical practice is not suitable, combined action observation and motor imagery therapy offers an effective intervention for neurorehabilitation in these survivors.(6) Activities like sport stacking can serve as accessible, low-cost interventions that bridge physical and cognitive development. With minimal equipment and adaptable difficulty levels, stacking offers a scalable approach for large classroom or community settings, a critical advantage in the Indian educational system, where resource availability and student-to-teacher ratios pose significant challenges.(7) Exercise prescription can improve handwriting speed in healthy children by combining upper limb resisted and coordination exercises. children aged 10-12 who performed exercises like resisted shoulder activities, hand and forearm activities, and coordination exercises showed significantly greater improvement in handwriting speed compared to those who only did handwriting practice. Combine exercises that build strength with those that focus on fine motor control and coordination. A structured program combining different types of exercises can be more effective than simple practice alone.(8) Kwon and Kim reported improvements in upper extremity function and leisure satisfaction in children with brain lesions following sport stacking sessions, scoring its relevance in paediatric rehab. These findings align closely with physiotherapy’s goal of promoting functional independence and optimizing hand function through engaging, skill-based interventions. The neurophysiological basis of both handwriting and sport stacking involves activation of overlapping cortical and subcortical structures such as the cerebellum, motor cortex, and basal ganglia. These regions are responsible for motor sequencing, temporal coordination, and adaptation through repetitive practice.(9) Yekeler et al. documented that handwriting speed tends to increase progressively from grades 4 to 8, with developmental plateaus influenced by motor maturity and practice exposure. This increases the need for intervention that not only accelerate motor proficiency but also maintain engagement across this developmental phase.(10) Combination of action observation and motor imagery improves learning of daily living activities in children with developmental coordination disorder and has demonstrated the both action observation and motor imagery techniques engaging the mirror neuron system can enhance motor learning and coordination by activating neural pathways similar to those used during activities. Evidence indicates that combining action observation with motor imagery training produces greater improvements in motor performance, movement accuracy and task timing than using either one of them.(11) As Moodley extended these findings beyond children, showing that short-term stacking interventions enhanced perceptual-motor and cognitive functioning in geriatric participants. Such results highlight that the neural and motor benefits of stacking are not confined to a specific age group but can generalize across the lifespan.(12) The study which is effects of sport stacking on neurobiological, psychological, and functioning of brain performances in patients with mild Alzheimer's disease and mild cognitive impairment investigates effect of sports stacking in Alzheimer's and mild cognitive impairment after 12 weeks of intervention. The findings of this research were effective for patients of mild cognitive impairment and mild Alzheimer's possible through increasing the expression of neuroprotective growth factors and enhancing neural plasticity to improve neurocognitive performance.(13) During these formative years, children consolidate academic skills like handwriting while engaging in a variety of physical activities that improve their sensorimotor integration. The period also coincides with significant neuromuscular maturation, where bilateral coordination and fine motor control reach measurable proficiency levels, making this age group particularly responsive to interventions targeting fine motor skills and speed tasks. The functional overlap is particularly relevant for physiotherapy interventions aimed at improving bimanual coordination, sensorimotor feedback, task-oriented training and skill learning.(14) Zareian and Delavarian found that sport stacking significantly improved fine motor proficiency among children with Down syndrome. Their results highlighted the adaptability of stacking as a therapeutic intervention, showing benefits even among children with developmental challenges.(15) Distributed practice, as demonstrated by Gibbons et al. enhances skill retention by allowing consolidation periods between repetitions. Task specificity ensures that the practiced task closely mirrors the target activity in terms of motor and sensory demands. Sport stacking meets both these criteria, as it requires rapid, coordinated hand movements, under visual control, much like handwriting.(17) Delamere further underscored the therapeutic implications of structured, repetitive manual tasks in neurorehabilitation, emphasizing that engagement, motivation, and task complexity are crucial determinants of successful outcomes (18) Hart et al. reported that participation in cup stacking units led to marked improvements in hand-eye coordination and movement timing among elementary school children.(19) Murray et al. further demonstrated that stacking activities have moderate energy expenditure, are non-fatiguing, and can be safely used as an intervention in educational environments. These features align perfectly with physiotherapy principles of graded motor training and activity-based therapy, which emphasize functional movement practice through purposeful engagement.(20) Udermann et al. demonstrated significant gains in reaction time and bilateral coordination following stacking activities. These findings underscore the capacity of stacking exercises to promote dynamic coordination and speed of movement—skills that overlap considerably with those required for handwriting.(21) From a physiotherapy perspective, interventions that leverage enjoyable, goal-oriented, and self-paced activities often result in superior compliance and outcomes compared to conventional repetitive drills. Sport stacking embodies these characteristics by offering a playful yet challenging format that maintains children's interest while promoting key therapeutic goals such as improved timing, rhythm, dexterity, and bilateral coordination.

METHEDOLOGY

- Study Design:- Randomized Control Trail
- Study Type:- Pretest - Posttest Experimental study
- Target population:- School going children age 8 – 12 years
- Sample Size:- 50 students (25- experimental group, 25- control group)

INCLUSION CRITERIA

- Age: - 8 to 12 years old
- Right hand dominance
- Good general health
- Zero Previous Experience with Sports Stacking:
- Willingness to Participate, Parental/Guardian Consent

EXCLUSION CRITERIA

- Pre-existing Injuries or disabilities
- MSK or Neurological disorders
- Learning Disabilities or Cognitive Impairments
- Participated in other grip-strengthening activities
- Psychological Conditions
- Left Hand Dominance

OUTCOME MEASURES:

- **Handwriting Speed Test:** This test will be used to assess the handwriting speed of the children by measuring the words per minute using the Fox – Dog Pangram. The results will be recorded in WPM to provide a quantifiable measure of writing speed, both pre intervention and post intervention.
- **Sports Stacking Equipment:** A standard set of 12 plastic cups will be utilized for the sports stacking activity, adhering to established guidelines. The task will involve stacking and unstacking these cups in a specific sequence, testing the children's hand coordination and speed.
- **Timer/Stopwatch:** A digital stopwatch used to measure the time that each students took to complete the sports stacking task. The results, recorded in seconds, will offer insights into stacking speed both pre- test and post-test.

Handwriting Speed (WPM) and Stacking speed (seconds) will be assessed before and after the sports stacking tasks to evaluate the impact of the activity on these physical attributes.

PROCEDURE

Permission will be taken from the institutional ethical committee. Students selected will undergo the handwriting speed test and stacking speed test and then randomly distributed into two groups: experimental and control. Procedure will be explained to these students.

Experimental Group Intervention (Sports Stacking):
This group will participate in a sports stacking program for 4 weeks, with five sessions per week, each about 25 to 30 minutes. The sessions will involve a variety of stacking exercises, focusing on speed and accuracy of the stacking process with warm-up and cool down exercises and stretches.
Control Group Intervention (Sports Stacking):
This group will participate in sports stacking research but without sports stacking session. These students will be doing their normal school activity and studies regularly.

MEASUREMENTS

Pre-Test Measurements: Handwriting Speed: Each child will undergo an initial speed test of their handwriting using a Handwriting Speed Test. The child will be asked to copy and write the Fox-Dog Pangram repeatedly for 2 minutes and further WPM value of each student will be calculated and noted to assess baseline writing speed. Stacking Speed: The child will perform the sports stacking task (stacking and un-stacking the 3-6-3 sequence cups in the fastest possible time) to assess baseline stacking speed.
Post-Test Measurements: After the 4 weeks intervention period, the experimental and control group will undergo the same tests as the pre-test to measure changes in handwriting speed and stacking speed. Handwriting Speed Test: Re-measure the writing speed using test and note in WPM. Stacking Speed Test: Re-assess stacking speed through the same sports stacking task to measure improvement in performance.
Follow-Up: A follow-up assessment will be conducted one month after the completion of the program to examine whether any improvements in writing speed and stacking speed are maintained over time.

COMPONENTS OF THE INTERVENTION FOR EXPERIMENTAL GROUP

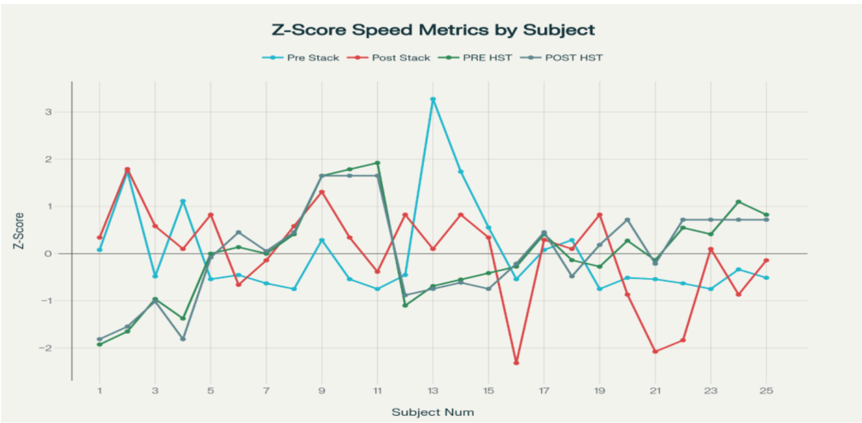
The study's intervention for experimental group will involve the following key components:
Warm-Up (5 minutes):
The session starts with a 5 minute warm-up to prepare the all the students for the activity. This will include: Gentle stretching exercises for the hands, wrists, fingers, forearms, and shoulders, basic hand movements (e.g wrist rotations), activities such as jogging in place or marching with shaking hands.
Skill Development Drill (15 minutes):
Basic Stacking Patterns: The children will start by learning the basic stacking patterns used in sports stacking, beginning with the 3-3-3 (3 stacks of 3 cups) and the 3-6-3 (3 cups in two stacks and 6 cups in a second stack) pattern. These patterns will require children to stack and un-stack the cups quickly.
Week 1-2: Introduction to basic stacking patterns. Emphasis on mastering the 3-3-3 and 3-6-3 patterns with slow and controlled movements.
Week 2-3: Increasing speed in completing the stacking patterns. Children will be encouraged to reduce the time it takes to complete each stacking sequence maintain the accuracy
Week 3-4: Introduction of more complex stacking patterns (e.g., 10-cup stack or pyramid stack) and refining speed and accuracy. The focus will be on challenging the participants to stack and unstack the cups in the fastest time with proper form and technique.
Speed Drills (5 minutes):
As the intervention progresses, speed and accuracy will be emphasized. Students will perform timed stacking drills, where they will aim to complete specific stacking pattern as fast as possible with correct

form.
Week 1-2: Focus on performing each stacking pattern in a specified time limit, starting with a 30-second goal for completing the 3-3-3 pattern.
Week 2-3: Reducing time limits for each task. For example, the time for the 3-3-3 pattern may decrease from 20 seconds to 15 seconds.
Week 3-4: Children will work on reducing their time for both the 3-6-3 and 10-cup patterns without compromising the accuracy. They will also compete with their previous personal best time.
Cool-Down (5 minutes):
Each session will end with a cool-down period to promote recovery of the muscle and prevent any injury. This will include: Gentle stretching exercises for the wrists, hands, forearms, and shoulders, deep breathing exercises which helps the students relax after the drills.
Adjustments: If any child shows difficulty with the tasks or demonstrates frustration
Parental Involvement: Parents will be reminded about the importance of regular attendance, and they will be asked to encourage their children to participate in the intervention.

RESULT

Experimental Group: The line graph demonstrates the multidimensional response of subjects to the intervention. For most subjects, the post-intervention stacking speed (red line) seen below the pre-intervention line (blue), indicates improvement in the stacking performance (as lower time is better). Conversely, the post-intervention handwriting score (green line) seen above the pre-intervention (orange), indicates increase in writing speed (as higher words per minute is better).

The use of z-scores in the plot:
Allows group and individual performance to be compared on a common scale, regardless of original measurement units. Clearly shows that while most subjects exhibit positive change in both domains, the degree and direction of individual change can vary, highlighting diverse responses to the intervention. Clustered patterns above zero for post HST and below zero for post stacking speed indicate overall group success. This approach offers a unified, transparent overview of intervention effectiveness across subjects and skill metrics, supporting robust evaluation beyond simple averages or raw scores. All trends are more accurately interpreted within this standardized framework.



Control Group:
The line graph displays z-score normalized pre and post results for stacking speed and handwriting

speed of each control group subject, allowing for direct comparison on a same single scale. As seen, both pre and post lines for most subjects cluster near the mean (z=0), indicating very little change during the study. No systematic trend or significant improvement is present, confirming the stability of performance when no intervention is given. This baseline allows any marked effects observed in the intervention group to be confidently attributed to the actual intervention. Using z-score normalization clearly shows that the control group remained stable, ensuring reliable comparison and strengthening study conclusions.

DISCUSSION

The aim of this study is to examine the effect of a four-week sports stacking intervention on handwriting speed and stacking speed among school-going children aged 8–12 years. The results shows a significant improvement in both variables within the experimental group, whereas the control group exhibited minimal or no change across the same duration. Specifically, the mean difference in handwriting speed was –5.79 WPM (SD = 1.72, effect size = –3.336), indicating a substantial increase in handwriting efficiency post-intervention. Similarly, the stacking speed improved by a mean of 4.21 seconds (SD = 1.85, effect size = 2.28), confirming strong within group performance enhancement following the sports stacking sessions. The large effect size observed in handwriting speed (Cohen's *d* = –3.336) suggests not merely statistical significance but also practical clinical relevance. In paediatric physiotherapy, effect sizes greater than 0.8 are typically considered large; hence, a value exceeding 3 indicates a substantial behavioural impact. The observed improvement supports the hypothesis that task-specific but transferable fine motor training can generalize to functionally related skills, consistent with the transfer of learning theory. The reason behind the results are mentioned in relation to previous researches done on sports stacking, stacking speed and handwriting speed which are the main factors of this research helps prove main points like:- Motor demands overlapping: Stacking and writing share fine motor, timing, and visuomotor components, allowing positive transfer, High training dosage: The regimen provided sufficient repetition and intensity to induce learning and neural adaptation. Neuroplastic responsiveness: The age group (8–12) is developmentally responsive to motor interventions, enabling effective cortical remodelling, Bilateral coordination emphasis: Repetitive bilateral tasks may accelerate interhemispheric communication, simplifying motor control, Feedback-rich environment: Immediate visual and proprioceptive feedback in stacking consolidates correct motor patterns, Motivational structure: Game-like structure, novelty, competition, and engagement promoted high attentional investment and consistency, Supportive structure: Warm-up and cool-down minimized fatigue and maintained performance quality across sessions, Cognitive-motor interaction: The cognitive demands of stacking (sequence recall, planning, error correction) may affect motor learning of writing. Functional task orientation: Though not identical, stacking is functionally analogous to writing in motor demands, making transfer plausible.

CONCLUSION

The study concludes that a 4 week sports stacking intervention has proven to significantly improve the stacking speed and handwriting speed in school going children of age 8 to 12 years old who are registered in the regular schooling. The result strongly supports that with increasing stacking speed the handwriting speed also increases in these children which indicates successful improvement of fine motor skills and enhanced motor coordination. The integration of rhythmic and visually guided movement practice neuroplastic adaptation, motor efficiency and functional performance gains. Hence the research suggests that sports stacking is valuable clinical and educational intervention which is simple, enjoyable and powerful tool for enhancing handwriting efficiency and fine motor skills among children during their formative school years.

Declaration of the parent's consent: The consent form for research purpose was filled by the parents of selected students. Names or any personal data will not be disclosed and confidentiality was maintained throughout the study.

LIMITATIONS

The small sample size of 50 students is a limitation because only 25 are in the experimental group and other rest in control group limiting results validity. Only Right-hand dominance students were selected for the study leading to limited sample size and no comparison between left- and right-handed children. The assessment for handwriting legibility or endurance were not assessed which are critical aspects of functional handwriting. Additionally, long-term retention of gains was not evaluated, so it remains unclear whether improvements persist beyond the intervention period.

FUTURE SCOPE

Further studies can be done using more specific and advance devices like: Use of Stacking mat, Advance stacker cups and DASH test. Larger multicentre trials with longer follow ups. Including other aspects like legibility and qualitative handwriting assessments. Study for comparison between the genders handwriting speed or stacking speed. Expanding this intervention to populations with developmental coordination disorder, dysgraphia, or neurodevelopmental conditions could demonstrate broader therapeutic applications. Stacking vs traditional fine motor training vs digital tablet-based writing tasks, to determine relative efficacy and understand which is better for all aspects.

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