



Influence of fine motor dexterity and pinch grip strength on handwriting speed in primary school children- correlation study

Jyoti Yadav¹, Bhawna Sharma^{2*}, Nilofar Rasheed³, Gunjan Rathi⁴

^{1, 2, &3}Department of Physiotherapy, ITS Institute of Health and Allied Sciences, Ghaziabad, India

⁴Faculty of Allied Health Sciences, Amity University, Greater Noida, India

Email – ¹yadavaahana05@gmail.com, ²sbhawna.bs@gmail.com, ³rasheednilo@gmail.com.,

⁴dr.gunjanrathi@yahoo.com

Abstract: Objectives: To determine the correlation between Handwriting speed with Fine Motor Dexterity and Pinch Grip Strength in Primary school children of different age group.

Methods: 180 Primary school children were randomly selected and divided in two groups (A & B) respectively. Subject performed a copying test to assess Handwriting speed. Pinch Grip Strength was measured by Pinch Gauge and to measure Fine Motor Dexterity we used Groove Peg Board.

Result:

The mean handwriting speed in Group A (6-7 years) was 19.65 ± 8.086 wpm, mean dexterity was 26.21 ± 0.346 , mean palmar pinch grip was (1.56 ± 0.615) , mean key pinch grip was (0.58 ± 0.355) and mean lateral pinch grip was (1.99 ± 0.582) . Karl Pearson's correlation coefficient showed moderate positive correlation of hand writing speed with dexterity ($r=.465$), palmar pinch grip ($r=0.621$), key pinch grip ($r=.0.338$) and lateral pinch grip ($r=0.341$).

The mean handwriting speed in Group A (8-9 years) was 21.5 ± 13.6 wpm, mean dexterity was 44.9 ± 10.6 , mean palmar pinch grip was (2.42 ± 0.97) , mean key pinch grip was (2.22 ± 0.82) and mean lateral pinch grip was (2.67 ± 1.04) . Karl Pearson's correlation coefficient showed moderate positive correlation of hand writing speed with dexterity ($r=.601$), palmar pinch grip ($r=.421$), key pinch grip ($r=.658$) and lateral pinch grip ($r=.661$).

There is Moderate significant correlation between Handwriting speed, Pinch Grip Strength, and Fine Motor Dexterity.

Discussion and Conclusion: In my study, I have concluded that by improving Fine Motor Dexterity or Pinch Grip Strength can improve the Handwriting skills and Handwriting speed in early age & also can prevent the Behavioral Disorder and Learning Disorder in children.

Key Words: Fine motor dexterity, palmar pinch grip strength, behaviour disorders, learning disorders.

1. INTRODUCTION:

Handwriting is a complex, fine motor skill, where fine, precise, coordinated movements occur in the extremity¹. It involves muscular action and the individual's reflexes.

Competent handwriting depends on the maturation and integration of cognitive, visual perceptual, and fine motor skills². Fine motor skills are essential because accurately formed letters can only be produced by the proper timing and force control of coordinated arm, hand and finger movements². Fine motor difficulties greatly affect children's performance in the classroom. Several studies have found that children with handwriting problem show a deficit in fine motor control



whereas others shows that visual motor integration contributes significantly to poor quality or slow speed of handwriting³..

The ergonomics such as pencil grip and pressure and perceptual motor factors, the writing instrument, the skillfulness of the writer and surely the pencil grips have an impact on handwriting⁴.

Slow Handwriting may be due to delays in information processing, difficulties with spelling, improper motor coordination and adopting labor intensive writing styles¹. Inadequate handwriting can impair academic performance, an important occupation of childhood, adolescence and adulthood. Elementary school children typically spend up to 50% of the school day engaged in paper-and-pencil tasks. Writing speed of teenagers improve rapidly parallel to their physical maturity⁵.

Students who have difficulty with handwriting must concentrate on correctly forming letter and may attend less to the subject matter or to the instructor. The student may turn indulge in shortened written responses because the motor effort is fatiguing.

Although a lot of research work has been done on studying handwriting difficulties in adults and factors affecting them, no study has been done on primary school children to find the correlation of handwriting speed with various factors. This study aims at establishing the correlation of handwriting speed with dexterity and pinch grip in primary school children. The study may also the help physiotherapists in catering with the problems of handwriting speed at an early age for best possible results in future.

2. METHODOLOGY:

Sample size: 180

Source of subject: E.D.M.C. Primary school Sunder Nagri F-1 1st and E.D.M.C. Primary school Sunder Nagri F-2nd

Sampling Technique: Convenience

Design of study: Correlational

Duration of study: One year

Inclusion criteria

- Both male and female
- Age: 6-7 yrs, ,& 8-9 yrs
- Able to follow command
- Able to read and understand English

Exclusion Criteria

- Any acquired or congenital anatomical defect of upper limb.
- Significant visual and auditory impairments.
- Any condition limiting cognition.
- Any neurological and musculoskeletal diagnosis.
- Recent history of (3 months) of any medication.
- Fracture of dominant hand

Instruments/Equipments/Tool

1. Pinch Gauge



2. Groove Peg Board



Materials Required

- Pencils that were of same type
- Paper typically used in class
- Stopwatch
- Chair without arms
- Table

Variables

Dependent variables- Handwriting Speed

Independent Variable-Dexterity and Pinch grip strength

Protocol

A sample of 180 students of two age groups i.e. (6-7 years, & 8-9 years) i.e. 90 students in each groups was recruited on the basis of inclusion and exclusion criteria. A brief description was given to all the subjects about the protocol and the procedure which was to be followed. An informed consent was obtained from the teacher of the subjects as they are minor. Their demographic measurements were taken prior to the test. Handwriting speed, pinch grip and dexterity were measured in all the students. The readings were noted for all the students in the data collection form.

Handwriting Speed Test

Handwriting speed was assessed for all the subjects by copying test. The participant was made to sit on a standard school chair and in front of a school desk which was appropriate to his or her height. The tasks were written on normal writing paper with printed literature. Each participant was instructed in the same fashion about what he or she would be required to do. Handwriting sample was obtained via copying test. The student was asked to copy a short paragraph which was printed at the top of the paper as quickly as possible without making mistake. The student is asked to stop copying at the end of 1.5 min. The student copied the text on the same paper in the writing lines below.

A measure of handwriting speed was obtained by counting the numbers of letters copied correctly in the copying test. The number of copied letters was then divided by 1.5 min to obtain an index of number of letters copied per minute. Once the student completed the copying task the values for pinch grip strength were taken.

The normal handwriting speed for Grade 1 students is 15-32 letters per minute and for grade 2 students is 20-35 letters per minute.



Figure 3.3 Handwriting Speed Assessment

Pinch Grip Strength

Subjects were asked to sit on the chair with straight back, without armrest with their shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in neutral position, and wrist between 0° and 30° dorsiflexion and between 0° and 15° of ulnar deviation and the feet flat on the floor. The pinch gauge (0-60 lb), which measures tip, key, and palmar pinch, was held by the examiner at the distal end to prevent it from being dropped. For palmar pinch grip, the student to hold the pinch gauge with thumb and middle and index finger. For key pinch ask to hold it with tip of thumb and index finger. For lateral pinch ask the subject to hold it with pad of thumb to the lateral side of proximal index fingers. Subject was instructed to take 2-3 seconds to reach maximum effort and then verbal encouragement was given consistently throughout all measurements. Scores were read on the needle side of the red readout marker. Three readings



were taken and a rest of at least one minute was given between each reading to minimize the fatigue. Average of three readings was taken to calculate the final result.



Figure 3.4 Pinch Grip Strength Test

Measurement of Fine motor Dexterity

Dexterity was measured by Groove Peg Board. Instructions need to be read aloud to the participants to explain the shape of the pegs and how they will be put in to the pegboard. Each hand is tested separately and is timed each trial. The dominant hand is tested first.

Clarity of Directions: In the user’s manual, the instructions are simple and to the point of how to administer this test. It has scripts for you to say so you do not have to worry about administering it incorrectly. Some directions need to be thoroughly read over to understand scoring and interpretation.

Scoring Procedures : The first part of scoring is simply the time it took the participant to complete the task. Start the clock once the participant starts and stop it once the task has been completed. If after five minutes the participant has not completed the pegboard, stop the participant. In your results, document what was difficult for the participant and mark the results with an “A” flag, which symbolizes an incomplete test. Another score of how many drops the participant had during the test is also noted. A drop is if the peg is picked up and then it falls to the table again unintentionally. If the participant sets it back down do not mark this as a drop. If the participant also picks up a bunch of pegs and lets go of some, it is not considered a drop as long as there is still one peg in the hand. If the hand that is not being tested turns one of the pegs over it is noted but if it happens again the participant receives a “D” flag for a non standard assessment. The third score is to count how many pegs were put in correctly. To find the final score you add up all three scores (time for completion in seconds, number of drops, and how many were correctly put in). When you have this number, locate the table of page seven of the Grooved Pegboard Manual to compare the score of the participant to the scores listed on the table. This table will help you compare you participant’s results in the same age group.

This pegboard has more visual-motor coordination than other pegboard assessments.



Fig 3.5 Measurement of fine motor dexterity

3. RESULT :

Demographic data

A total of 180 subjects were participated in the study with their Mean Age is (7.5± 0.960). Height of subjects was (126.1±149.1)inches and their mean weight was (20.07±3.132)kgs.

Parameters	Mean±SD
Age(Yrs)	7.5± 0.960
Height(inches)	126.1±149.1
Weight(kgs)	20.07±3.132

Table- 5.1 Demographic data



GROUP-A

CORRELATION BETWEEN THE HANDWRITING SPEED AND DEXTERITY WITH IN A GROUP (6-7) YEARS

The mean handwriting speed was 19.65 ± 8.086 wpm and mean dexterity was 26.21 ± 0.346 . Karl Pearson's correlation coefficient showed moderate positive correlation between hand writing speed and dexterity ($r = .465$). The result showed significant correlation between hand writing speed and dexterity.

Handwriting speed(wpm) Mean \pm SD	Dexterity Mean \pm SD	r value	p value
19.65 ± 8.086	26.21 ± 0.346	0.465	$P < 0.05$

Table 5.2 correlation between Handwriting speed and dexterity

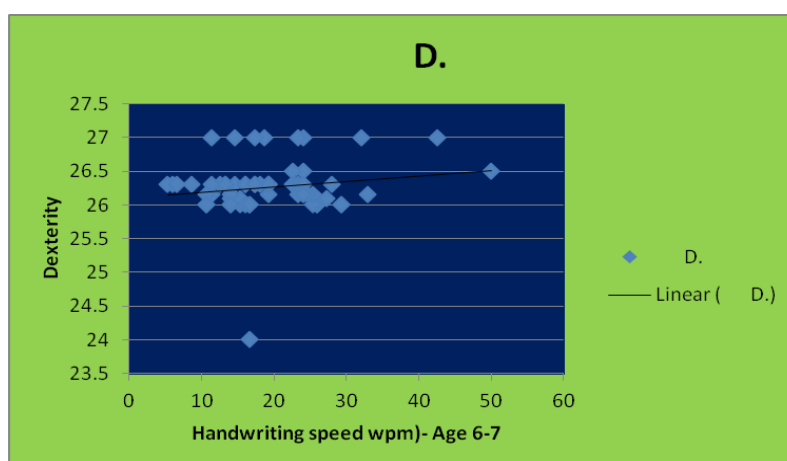


Fig 5.1 Correlation between handwriting speed and dexterity

CORRELATION BETWEEN THE HANDWRITING SPEED AND PALMAR PINCH GRIP STRENGTH WITH IN AGE GROUP (6-7) YEARS

The mean handwriting speed was 19.65 ± 8.086 wpm and mean palmar pinch grip was (1.56 ± 0.615) . Karl Pearson's correlation coefficient showed moderate positive correlation between hand writing speed and palmar pinch grip ($r = 0.621$). The result showed significant correlation between hand writing speed and palmar pinch grip.

Handwriting speed(wpm) Mean \pm SD	Palmar pinch grip Mean \pm SD	r value	p value
19.65 ± 8.086	1.56 ± 0.615	0.621	$P < 0.05$

Table 5.3 correlation between hand writing speed and palmar pinch grip

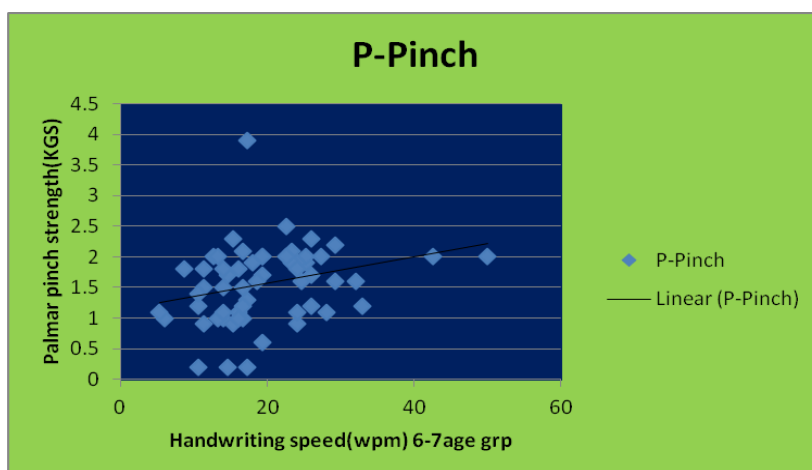


Fig 5.2 correlation between hand writing speed and palmar pinch grip.

CORRELATION BETWEEN THE HANDWRITING SPEED AND KEY PINCH GRIP STRENGTH

The mean handwriting speed was 19.65 ± 8.086 wpm and mean key pinch grip was (0.58 ± 0.355) . Karl Pearson's correlation coefficient showed moderate positive correlation between handwriting speed and key pinch grip ($r = 0.338$). The result showed significant correlation between hand writing speed and key pinch grip.

Handwriting speed(wpm) Mean±SD	key pinch grip Mean±SD	r value	p value
19.65 ± 8.086	0.58 ± 0.355	0.338	0.008

Table 5.4 correlation between hand writing speed and key pinch grip

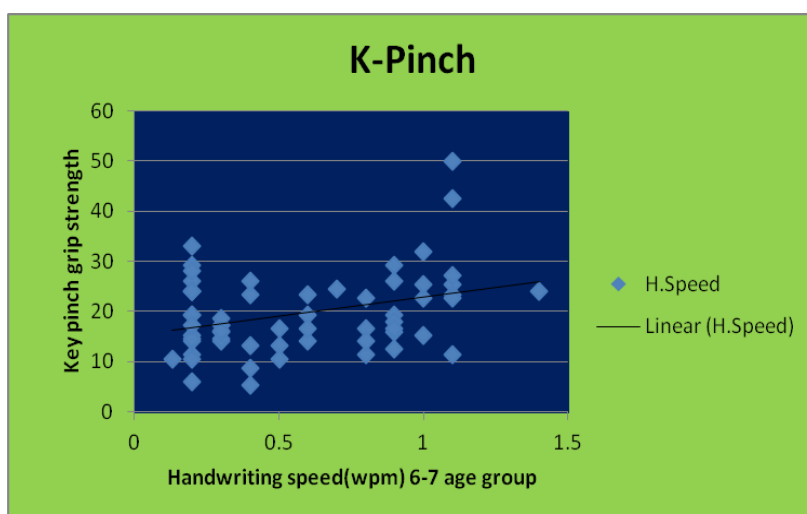


Fig 5.3 correlation between hand writing speed and key pinch grip

CORRELATION BETWEEN THE HANDWRITING SPEED AND LATERAL PINCH GRIP STRENGTH

The mean handwriting speed was 19.65 ± 8.086 wpm and mean lateral pinch grip was (1.99 ± 0.582) . Karl Pearson's score between hand writing speed and lateral pinch grip ($r = 0.341$). The result showed significant correlation between hand writing speed and lateral pinch grip

Handwriting speed(wpm) Mean±SD	lateral pinch grip Mean±SD	R value	P value
19.65 ± 8.086	1.99 ± 0.582	0.341	0.008

Table 5.5 correlation between hand writing speed and lateral pinch grip

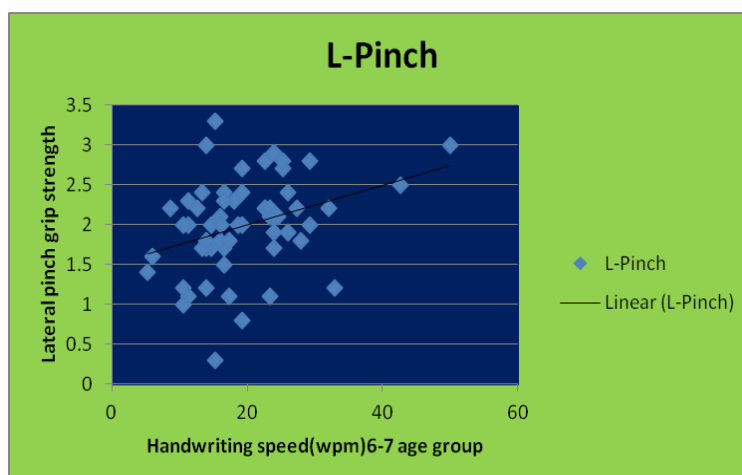


Fig 5.4 correlation between hand writing speed and lateral pinch grip

GROUP-B

CORRELATION BETWEEN THE HANDWRITING SPEED AND DEXTERITY IN B GROUP (8-9) YEARS

The mean handwriting speed was 21.5 ± 13.6 wpm and mean dexterity was 44.9 ± 10.6 . Karl Pearson's correlation coefficient showed moderate positive correlation between hand writing speed and dexterity ($r = .601$). The result showed significant correlation between hand writing speed and Dexterity. .

Handwriting speed(wpm) Mean \pm SD	Dexterity Mean \pm SD	r value	p value
21.5 ± 13.6	44.9 ± 10.6	0.601	.0001

Table 5.6 Correlation between handwriting speed and dexterity

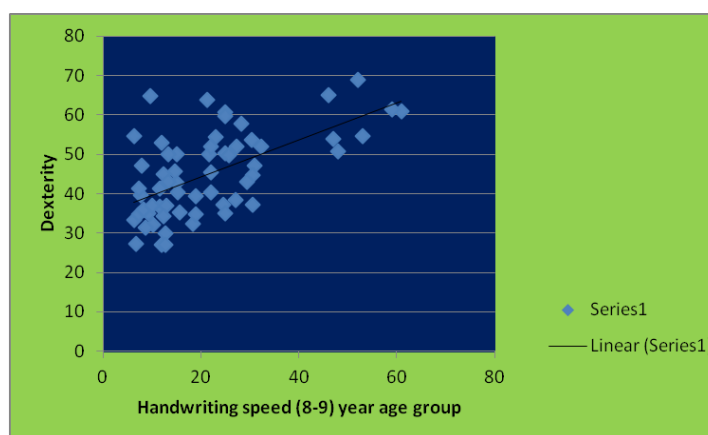


Fig 5.5 Correlation between handwriting speed and dexterity

CORRELATION BETWEEN THE HANDWRITING SPEED AND PALMAR PINCH GRIP STRENGTH IN GROUP (8-9) YEARS

The mean handwriting speed was 21.5 ± 13.6 wpm and mean palmar pinch grip was (2.42 ± 0.97) . Karl Pearson's correlation coefficient showed moderate positive correlation between hand writing speed and palmar pinch grip ($r = .421$). The result showed significant correlation between hand writing speed and palmar pinch grip.

Handwriting speed(wpm) Mean \pm SD	Palmar pinch grip Mean \pm SD	r value	p value
21.5 ± 13.6	2.42 ± 0.97	0.421	.0001

Table-5.7 correlation between hand writing speed and palmar pinch grip

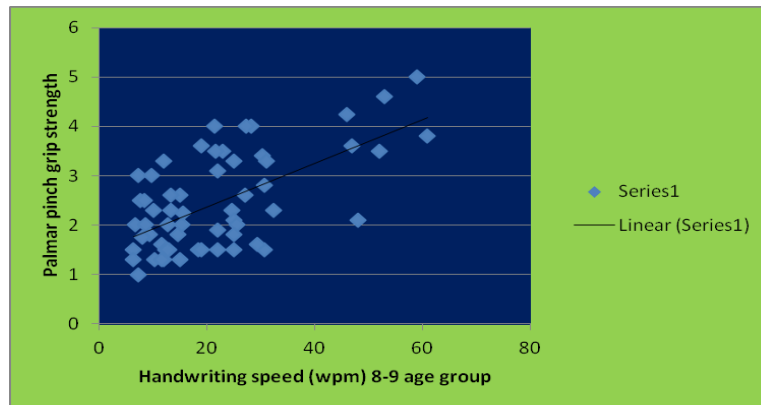


Fig 5.6 correlation between hand writing speed and palmar pinch grip

CORRELATION BETWEEN THE HANDWRITING SPEED AND KEY PINCH GRIP STRENGTH IN GROUP(8-9) YEARS

The mean handwriting speed was 21.5 ± 13.6 wpm and mean key pinch grip was (2.22 ± 0.82) . Karl Pearson’s correlation coefficient showed moderate positive correlation between hand writing speed and key pinch grip ($r = .658$). the result showed significant correlation between hand writing speed and key pinch grip.

Handwriting speed(wpm) Mean±SD	key pinch grip Mean±SD	r value	p value
21.5±13.6	2.22±0.82	0.658	0.0001

Table 5.8 correlation between hand writing speed and key pinch grip

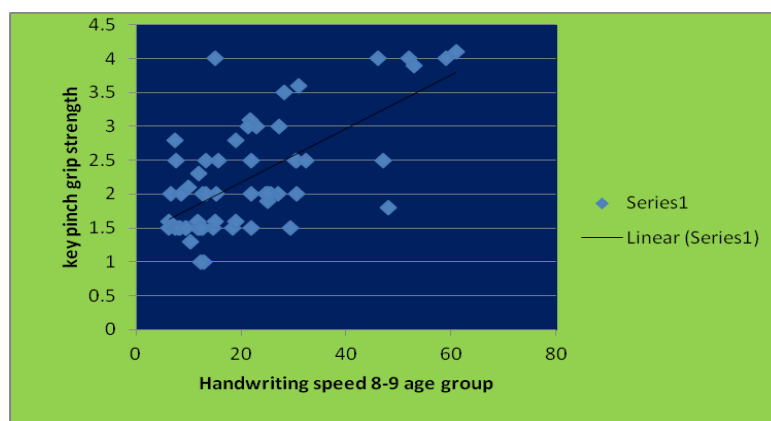


Fig 5.7 correlation between hand writing speed and key pinch grip.

CORRELATION BETWEEN THE HANDWRITING SPEED AND LATERAL PINCH GRIP STRENGTH IN 3 GROUP(8-9) YEARS

The mean handwriting speed was 21.5 ± 13.6 wpm and mean lateral pinch grip was (2.67 ± 1.04) . Karl Pearson’s correlation coefficient showed moderate positive correlation between hand writing speed and key pinch grip ($r = .661$). the result showed significant correlation between hand writing speed and lateral pinch grip.

Handwriting speed(wpm) Mean±SD	lateral pinch grip Mean±SD	R value	P value
21.5±13.6	2.67±1.04	0.661	.0000

Table 5.9 correlation between handwriting speed and lateral pinch grip

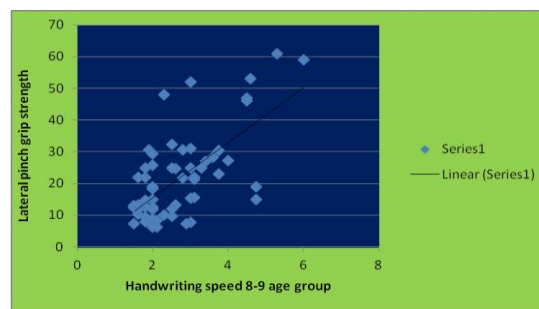


Fig 5.8 correlation between handwriting speed and lateral pinch grip

4. DATA ANALYSIS:

The data was analysed using Microsoft SPSS 15.0 version software and Microsoft Excel 2007.

Karl Pearson's coefficient of correlation test was used to find out the correlation between handwriting speed and dexterity, between handwriting speed and palmar pinch grip strength, handwriting speed and key pinch grip strength, and handwriting speed and lateral pinch grip strength.

Level of significance was set as $p < 0.05$.

5. DISCUSSION:

According to Thuraya Ahmed Al Shiudhani (2012) the detection of handwriting problem in early childhood is important because in later childhood stage socialization is important and school work demands are greater⁶. The difficulties with handwriting in early years may predict general learning difficulties later on and the stem from the difficulties in handwriting may become more complicated and difficult to resolve. Thus it is most importance to screen handwriting difficulties in the first years of school⁷. In my study the moderate correlation of handwriting speed with dexterity and pinch grip strength is noticed.

In the precision grip the object, e.g. the pencil, is pinched between the flexor aspects of the finger and the opposition of the thumb. In a precision grip the fingers grasp the writing tool in a pad-to-pad position, which facilitates precise writing movements, stability, and sensory feedback. The dynamic tripod is classified as a precision grip. The tripod grasp involves the thumb, index and middle finger in apposition, functioning as a tripod and allowing small, very coordinated movements. The fourth and fifth finger are fixed into the palm at the metacarpophalangeal (MCP) joint, providing stability. In the dynamic tripod grasp, the movements of the pencil originate from the interphalangeal (IP) joints of the hand and intrinsic muscle of the hand, compare to the static tripod grip where the movement of the pencil originate from the extrinsic muscle of the shoulder, elbow, and wrist. In other word when a person holds a pencil to write, this involves manipulation of the pencil through flexion and extension of the digits with in the hand via the intrinsic muscles of the hand, while the extrinsic muscles provide stability for the movement. Therefore, it has the biomechanical abilities for fine manipulation. It is for these reasons that the dynamic tripod grasp is suggested to have an advantage over other pencil grasps including the quadruped, the lateral tripod, and the lateral quadruped pencil grasp.

The biomechanics of lateral grasp are also like that of the dynamic tripod grasp. In particular, the lateral grasps still allow for the movement of the pencil to originate from the interphalangeal joints of the hand, though they differ from the dynamic grasp in terms of thumb position. The thumb is in a position of opposition in the dynamic grasps, but with the lateral grasps, it is in one of adduction. As such the pencil movement comes from the index, middle and ring fingers (if a quadruped grasp). The thumbs adducted position closes the webspace and contacts the pencil at the interphalangeal carpal bone, not the thumb pad. Though biomechanical positioning is different across the four grasps, there has been no literature to indicate that the grasp produces less legible or slower writing, infect, the opposite has been found with the children using the dynamic quadruped pencil grasp scoring the highest on speed and legibility. The dynamic tripod grasp is suggested to balance the forces involved in holding the pencil so as to limit the required amount of force used to manipulate the pencil to make letters.⁷⁹

Handwriting studies of typically developing children in grades one to five (ages 6-11 y typically), have found the quality of handwriting develops quickly during grade one (ages 6-7 y typically) and reaches a plateau by grade two (age 7-8y typically). Further development is seen by grade three (age 8-9y typically), in that handwriting becomes automatic, organized and is available as a tool to facilitate the development of ideas. Speed of writing develops in a somewhat linear fashion throughout primary school, and overall development of handwriting continues during the middle school years



Pencil grasps and correct penmanship plays a significant role in hand writing speed and for a mature pencil grip, action of various intrinsic muscle of hand is required. It is a known fact that intrinsic muscles play a role in making various types of grips. Thus, it can be attributed that increase in pinch grip strength may results in increase in hand writing speed in primary school children.

Through the study it has been seen by the result for both Group A and B there is a moderate correlation between Handwriting speed and dexterity with Karl Pearson coefficients 0.465 and 0.601 respectively. For Group A and group B there is a moderate correlation between the handwriting speed and palmar pinch with karl pearson coefficients 0.621 and 0.421 respectively. For Group A and B there is a moderate correlation between handwriting speed and key pinch with karl pearson coefficients 0.338 and 0.658 respectively. For Group A and B there is a moderate correlation between handwriting speed and lateral pinch with karl pearson coefficients 0.341 and 0.661 respectively. Through the results it can be deduced that in 6-7 year of age Handwriting speed is more strongly dependent on the dexterity, palmar pinch than the lateral and key pinch while in 8-9 year of age Handwriting speed is more strongly depends on the dexterity, palmar, lateral and key pinch.

These result can supported by the previous studies which concluded that the development of a pencil grasp in children typically follows a predictable progression. Grasp pattern generally develop from least mature (i.e radial palmar grasp) to most mature (i.e. lateral or dynamic tripod grasp) and changes in grasp can continue until the child is approximately 10.5 year of age. However, the result of many researches indicates that children with poor handwriting use significantly less mature pencil grasp patterns than children with good handwriting.⁴

The mean handwriting speed for Group A (6-7 years of age) was 19.65 ± 8.086 and for Group B(8-9 years of age) was 21.5 ± 13.6 .

The study shows that the mean handwriting speed of Group A is greater than that of Group B, hence, there is increase in hand writing speed with the advancing age. The increase in hand writing speed has been correlated with the increased pinch strength in the former studies. Lumbricals has been quoted as the chief muscle responsible for efficient pinch. The strength of the lumbrical muscles increases with the increasing age, so, the dynamic tripod activity also increases, therefore, this can be attributed to the greater handwriting speed in the Group A as compared to Group B.

6. CONCLUSION:

Therefore, with this study I have concluded that, improvement in Fine Motor Dexterity or Pinch Grip Strength can improve the Handwriting skills and speed in early age & also can prevent the Behavioral Disorder and Learning Disorder in children.

REFERENCES:

1. Rosa Senatore, Angelo Marcelli, a neural for procedural motor learning of handwriting international conference on frontiers in handwriting recognition,2012,655-660.
2. Katya Feder, Annette Majnermer, Handwriting development, competency, and intervention, Development medicine and child neurology, 2007,49:312-317.
3. McGlashan, H. L., Blanchard, C. C., Sycamore, N. J., Lee, R., French, B., & Holmes, N. P. (2017). Improvement in children's fine motor skills following a computerized typing intervention. *Human movement science*, 56, 29-36.
4. Mei Hui Tseng, Sharon Cemak, the influence of ergonomic factors and perceptual motor abilities on handwriting performance, The American journal of Occupational therapy, October 1993, Vol.47, No.10.
5. Kathleen Mchale, Sharus A. Cemak, fine motor activities in Elementary school preliminary findings and provisional implication for Children with fine motor problems, the American journal of occupational therapy, October 1992, Vol.46, No.10.
6. Thuraya Ahmed Al Shidhani, Vinita Arora, understanding dyslexia in children through human development theories, Sultan Qaboob university med J, August 2012, Vol.12, Iss 3, 286-294.
7. Volman, M. J. M., Brecht M. van Schendel, and Marian J. Jongmans. "Handwriting difficulties in primary school children: A search for underlying mechanisms." *The American Journal of Occupational Therapy* 60, no. 4 (2