International Journal of Health Sciences and Research
Vol.12; Issue: 3; March 2022
Website: www.ijhsr.org
ISSN: 2249-9571

Original Research Article

A Study to Evaluate Pencil Grip Type, Hand Functions - Dexterity & Grip Strength in Children Using Tech for 2 or More Hours a Day

Maulik Shah[1], Sweety Shah[2], Vaibhavi Ved[3]

[1]PhD Scholar, MPT (Musculoskeletal & Sports), HOD, Government Civil Hospital, Gondal, Gujarat, India.
[2]PhD Guide, Gujarat University, MPT (Cardiopulmonary), Senior Lecturer, SBB College of Physiotherapy, VS General hospital, Ahmedabad, Gujarat, India
[3]MPT (Musculoskeletal & Sports), Chief Consultant Physiotherapist, Arham Physiotherapy Center, Rajkot, Gujarat, India

Corresponding Author: Maulik Shah

DOI: https://doi.org/10.52403/ijhsr.20220339

ABSTRACT

Background: These days, modern innovative technology plays a crucial part in our life. Touch screens has become the primary interaction method for smart phones due to their ability to combine input and output in a single interface. On the one hand, it has made our lives easier by allowing us to browse the internet, have essential conversations, and have a source of pleasure. Frequent use of technical devices without taking regular rest periods may result in cumulative trauma disorders to the neck, shoulders, hands and wrists. These disorders may occur because Smartphone, iPod etc. use typically requires thumb and finger interactions with the screen. Reports have shown that extended technology use accompanied by awkward wrist posture can lead to collective trauma disorders of the wrist joints, particularly when the wrist, hands, and fingers are overused. Repetitive static motion of the hands may also decrease blood supply and prevent nutrients from being delivered to muscles, thus leading to pain and muscle fatigue may result into poor hand function including reduced grip strength & poor dexterity. Children are attracted to smart phones because these devices can be used anywhere and contain games that are specifically matched to their ages. Numbers of studies have been done on Smartphone usage, hand writing performance & grip strength individually. However, the link between Smartphone addiction and grip strength and upper limb disability has been left unnoticed.
Methodology: A cross sectional observational study was conducted to evaluate pencil grip type, hand dexterity & grip strength in children using technological devices for 2 or more hours a day dividing subjects into 2 groups. Group A: Children using technological devices for 2 or more hours a day. Group B: Children not using technological devices. Written consent was taken from the subjects and the subjects were made to understand the purpose of the study. Hand dexterity was evaluated using Functional Dexterity Test, Grip strength with hand held dynamometer & Pencil grip type was evaluated.
Results: Data analysis was done using Graph Pad Prism 6. In Group A, Dynamic Tripod grasp was present in 19 subjects (61.29%) Five finger grasp in 0 subjects (0 %,), Thumb Wrap grasp in 1 subject (3.22%), Upright tripod grasp in 11 subject (35.48%).In Group B, Dynamic Tripod grasp was present in 26 subjects (83.87%) Five finger grasp in 0 subjects (0 %,), Thumb Wrap grasp in 1 subject (3.22%), Upright tripod grasp in 4 subjects (12.90%).The result showed significant difference for the functional dexterity test between Group A and Group B ($t = 5.725$ and $p = 0.0001$) & grip strength between Group A and Group B ($t = 6.449$ and $p = 0.0001$).
Conclusion: Increased use of tech devices significantly affects Hand performance like Grip strength, Hand dexterity & Pencil grip pattern amongst children.

Key Words: Hand Dexterity, Grip Strength, Pencil Grip Type, Smart Phone Use, Functional Dexterity Test, Hand Writing Performance

INTRODUCTION

The modern era is undoubtedly characterised by an increase in availability and use of electronic devices, especially mobile devices such as cellular phones and tablet computers (Common Sense Media, 2013). The impact of mobile devices on child and adolescent development however remains mostly unknown. The increase in use of cellular phones and electronic media is of concern, moreover has an unknown impact on the development of children[1]. Children are increasingly being entertained by electronic devices and the media. (gjhs.ccsenet.org, Global Journal of Health Science Vol. 11, No. 4; 2019)

The human hand is the most developed organ for prehensile use among all living creatures[4] and among children between the ages of seven and eight years, this highly developed prehensile organ develops through fine motor activities such as handwriting. There is however a lack of empirical evidence on children who do not master this stage of handwriting development and who utilise electronic devices more frequently.

When mobile devices and gaming equipment enter into a household, it is frequently used by younger children. Children, have smaller hands which often do not fit to devices that are designed for an older population[5]

Straker et al. (2008) voiced concern over promoting the use of electronic devices such as tablet computers, which are being incorporated as a learning aid in some elementary school environments, without being aware of the physical impact on children[8].

COVID pandemic has made a lot of change in the education pattern with entry of online education almost as routine up to the extent which was never before. Handwriting remains the predominant task in the first three grades of the elementary school programme and amounts to more than fifty percent of time a day spent on handwriting and fine motor dexterity instruction in the classroom[6].

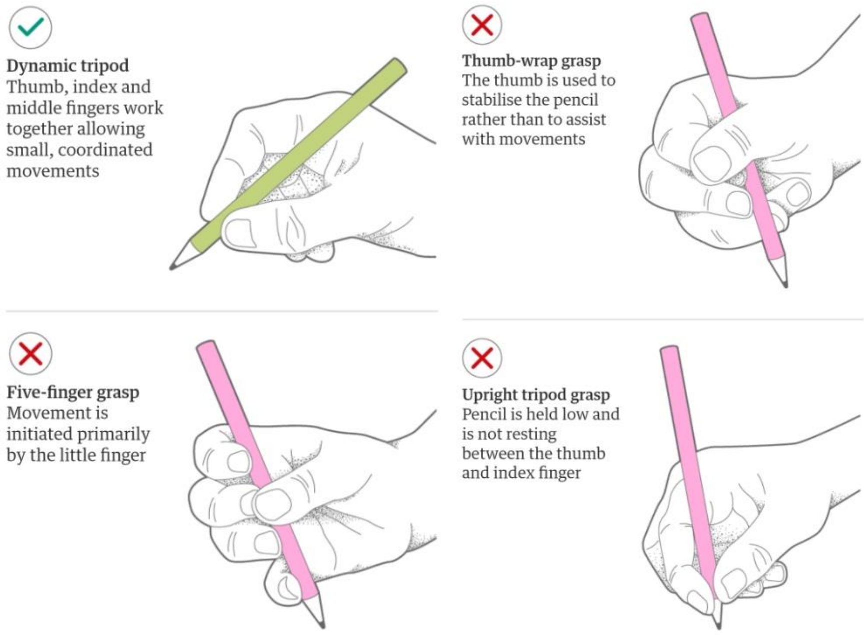
Handwriting determines the success, self-esteem and communication of children in their school career with adequate writing skills being imperative for children to be able to *"express their thoughts, feelings and ideas for both themselves and the intended audience"* (KwaZulu Natal Department of Education, 2006). Early success in handwriting is thus imperative for children's future academic success and experience[7] . The correct handwriting instruction with proper hand grip is only one external factor that influences handwriting at the foundation phase schooling level, with other factors including but not limited to; writing instruments, material used, sufficient time and the quality of handwriting practice undertaken.

The increase in the use of modern technology has led to the inquiry of the importance of handwriting instruction in the twenty first century (Hanover Research Report, 2012). Fine motor dexterity is an important performance component in fluent handwriting as well as improved handwriting performance[3]. Volman, Schendal & Jongmans' (2006) study on handwriting in second and third grade children, with and without handwriting problems concluded that one of the underlying factors that impact the quality of handwriting is fine motor coordination[9].

High-frequency use of electronic devices, such as smart phones, iPods, could lead to musculoskeletal problems as handheld electronics may require prolonged grips, repetitive motion on small buttons and awkward wrist movements[13]. These are referred to as overuse injuries or repetitive strain injuries (RSI) because of insufficient recovery time between demands and high-frequency use of smart phones. The cumulative effect of stress on the region causes the mechanical or chemical activation of pain and loss of grip strength, weakness or fatigue.[14]

Certain handwriting problems have its origin in the early foundation years of childhood development. For a child to display fluent age appropriate handwriting, a complex interaction of various internal and external factors needs to be considered in its instruction[2]. Adequate fine motor dexterity development is a crucial prerequisite for fluent handwriting performance at an appropriate speed[2, 3]. A further cause of concern is immature pencil grips. The inadequate isolation and grading of the fingers affects pencil grips and directly affects fine motor dexterity. There are various types of pencil grips.

Types of Pencil Grips:



(Source: https://brightautism.org/blogs/news/how-to-choose-the-right-pencil-grip)

The tripod pencil grasp among other grips is important childhood developmental milestone for stimulating the correct cognitive patterns.

A new review from the UK based Foundation reports that kids are coming into classrooms ill-prepared for writing and other activities that require finger muscle strength. Paediatricians blame on technology and the lack of traditional activities young children often do, such as stringing beads, colouring, cut with scissors and other pastimes. Handwriting development is not only crucial in the success of the child's school career, but aids in developing crucial cognitive abilities that impacts normal development on all levels. This study thus sought to determine an association between the electronic device use and grip strength, handwriting patterns like pencil grips and dexterity.

Children are attracted to smart phones because they devices can be used anywhere and contain games that are specifically matched to their ages.[24.25] Despite such widespread smart phones use especially among children, the possible effects on hand function have not been defined. In the earliest stages of development, this setback can be detrimental to kids throughout their childhood if it's not addressed by teachers, parents, and professionals. Very few studies have investigated the effects of extensive Smartphone use on hand function among children. This study therefore was planned to assess the influence of high smart phone use on hand performance, type of hand (Pencil) grip and grip strength.

AIMS & OBJECTIVES

- To evaluate pencil grip type, hand dexterity & grip strength in children using technological devices for 2 or more hours a day
- To evaluate pencil grip type, hand dexterity & grip strength in children not using technological devices.
- To compare pencil grip type, hand dexterity & grip strength between two groups.

HYPOTHESIS & NULL HYPOTHESIS

- **Hypothesis:**
  There is significant difference in pencil grip type, hand functions - dexterity & grip strength in children between two groups.
- **Null Hypothesis:**
  There is no significant difference in pencil grip type, hand functions - dexterity & grip strength in children between two groups.

MATERIALS & METHODOLOGY

MATERIALS:

- Hand held dynamometer
- 16 hole pegboard
- Stop watch
- Pencil
- Note pad & Pen

METHODOLOGY

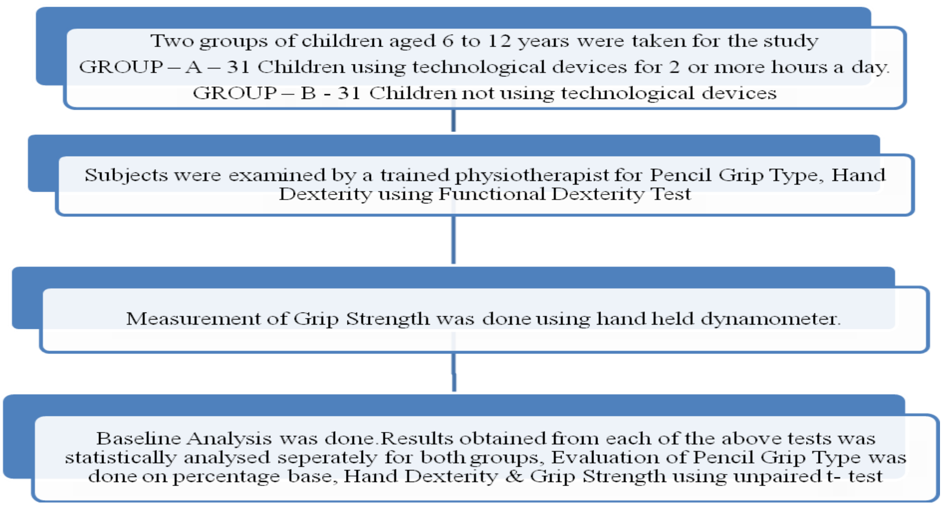
INCLUSION CRITERIA

- Two groups of 31 children each aged 6 to 12 years was taken for the study
- GROUP – A – Children using technological devices for 2 or more hours a day.
- GROUP – B - Children not using technological devices
- Each of the groups was assessed for pencil grip type, hand dexterity using Functional Dexterity Test & Grip Strength using hand held dynamometer.
- Both Genders

EXCLUSION CRITERIA

- Children with any pre-existing diagnosis (attention deficit/hyperactivity disorder (ADD/ADHD), developmental co-ordination disorder (DCD)
- Preterm children; children with major physical disabilities, genetic disorders.
- Children with a history of head trauma and Infections If they were obese (body mass index > 40)
- Children with Psychiatric conditions such as autism and depression.
- Children with Neuromuscular Diseases who had or were receiving occupational therapy intervention or remediation for handwriting or fine dexterity problems.

PROCEDURE



- **Functional Dexterity Test (FDT)**

Instructions for Use

The examiner places the pegboard 3.9” (10 cm) from the edge of a height-adjusted table where the child is sitting. The examiner instructs the child to turn over and replace each peg, beginning with the peg farthest from the hand being tested, and proceeding in a zigzag manner. If the left hand is being tested, the child starts with the peg at the top row, right corner; turns over each peg in the top row from right to left, moves to the next row down (closer to the child) and completes it left to right. They would continue in this zigzag manner until they reach the bottom left peg. The direction is reversed for testing the right hand. The examiner provides the following verbal instructions to the child: “Make all the pegs change colour with only one hand. Don’t touch the pegs to the board or to your body, try not to turn your hand palm-up, and don’t help with your other hand. Do it as quickly as you can without dropping a peg. Do it in this pattern….” The examiner points to the starting peg and turns over two rows in the proper sequence to demonstrate. The child is asked to complete a full practice trial with their most functional hand. Verbal cuing and correction by the examiner is permitted during the practice trial. The test is then performed with the dominant hand. The examiner times with a stopwatch the time it takes to turn over all of the pegs and records it in seconds. If a child drops a peg, time is stopped, and the peg returned to its starting position. The child is instructed to resume the test with the replaced peg. The stopwatch is restarted when the child makes contact with that peg.

Instructions for Scoring

Unlike the adult FDT, no penalties are assessed when testing children less than 18 years of age. The FDT is sensitive enough to detect functional inefficiencies in in-hand manipulation without additional penalties.

Two scores are obtained: (1) the time, in seconds, to complete the test and (2) the speed of test completion (speed = number of pegs completed / second).

For example, if all 16 pegs are turned over in 32 seconds, the speed is 16 divided by 32, or 0.5 pegs per second.

To use the growth chart, find the child’s age along the x-axis, and then plot their speed vertically on the y-axis. Comparison can be made with normative speeds for each age according to hand dominance. Alternatively, expected normative speed can be calculated from the following formula: Dexterity = 0.215 + 0.037(Age in years) + (0.088 if Dominant hand) .The predicted speed is compared to the actual speed to assess a child’s function.

- **Proper Grip strength testing procedure with the hand held dynamometer:**

In order to capture the most accurate data for a hand grip strength test there are several key procedures must be considered.

- First off, make sure the patient is in a comfortable sitting position with their shoulder abducted and neutrally rotated. Angle of the elbow should be kept as close to 90 degrees as possible.
- The forearm should also be in a neutral position with the wrist between 0 and 30 degrees dorsiflexion while also between 0 and 15 degrees ulnar deviation.
- Instruct the patient to grip the hand dynamometer with their fingers around the second handle with the readout dial pointing away from their body. The administrator of the test should lightly grip the readout dial in order to prevent and accidental dropping of the device.
- Once the patient is comfortable instruct them to grip the device as hard as they can for 4-5 seconds and relax. It is best to perform this part of the test 3 times or more to generate an average grip strength reading.

STATISTICAL ANALYSIS

Mean and standard deviation were computed as measure of central tendency and measure of dispersion respectively. Unpaired t test was done for between groups to check the level of significance. Data Analysis was done using Graph pad Prism.

1. ARITHMETIC MEAN

$$\overline{X} = \frac{\sum X}{N}$$

Where, $\overline{X}$ = Arithmetic

$\sum x$ = Sum of the variable

N = the total number of variables.

2 .STANDARD DEVIATION (S.D)

$$S.D = \sqrt{\frac{\sum (x - x)^2}{N}}$$

where x = the individual score.

$\overline{X}$ = the mean score.

N = the total number of scores.

UNPAIRED t-TEST

$$t = \frac{\bar{X}_1 - \bar{X}_2}{S_{X_1X_2} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where

$$S_{X_1X_2} = \sqrt{\frac{(n_1 - 1)S_{X_1}^2 + (n_2 - 1)S_{X_2}^2}{n_1 + n_2 - 2}}.$$

Where $S_{X_1X_2}$ - common standard deviation (SD) of the two samples

Table 1.1 MEANS OF AGE (years) FOR BOTH THE GROUPS

	AGE MEAN (years)	SD
GROUP A	9.21	1.94
GROUP B	9.11	1.75

Interpretation:

The above table shows classification of individuals in group A with mean and SD of age in terms of (years) i.e. 9.21 ± 1.94, & group B with mean and SD of age in terms of (years) i.e. 9.11 ± 1.75.

Table: 1.2 GRIP TYPES OF ALL PARTICIPANTS

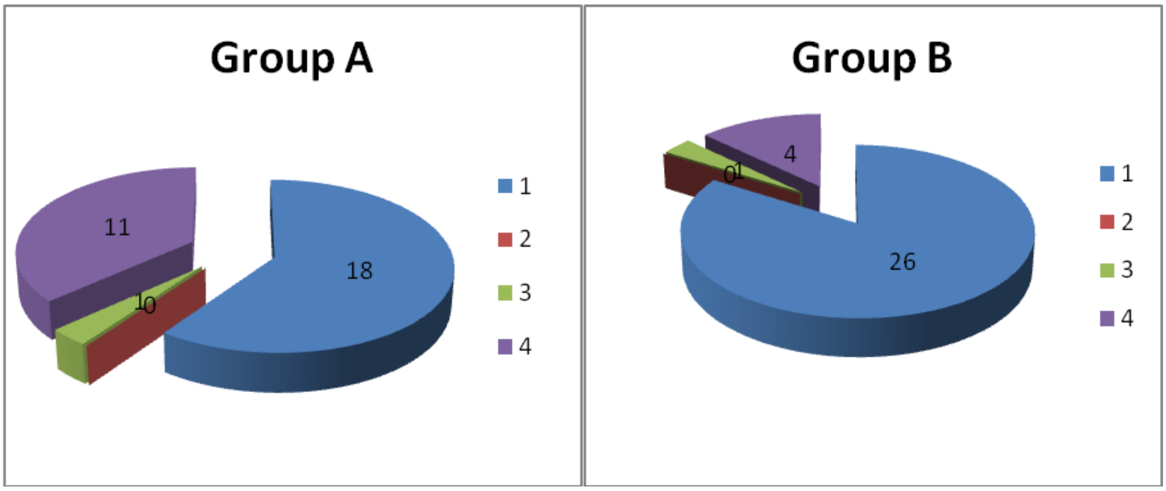
GRIP TYPES	GROUP A	GROUP B
Dynamic Tripod Grasp	19	26
Five finger grasp	00	00
Thumb Wrap grasp	01	01
Upright tripod grasp	11	04

Interpretation:

The above table shows classification of grip type in all participants in both Group A & Group B.

In Group A, Dynamic Tripod grasp is present in 19 subjects (61.29%) Five finger grasp in 0 subjects (0 %,), Thumb Wrap grasp in 1 subject (3.22%), Upright tripod grasp in 11 subject (35.48%).

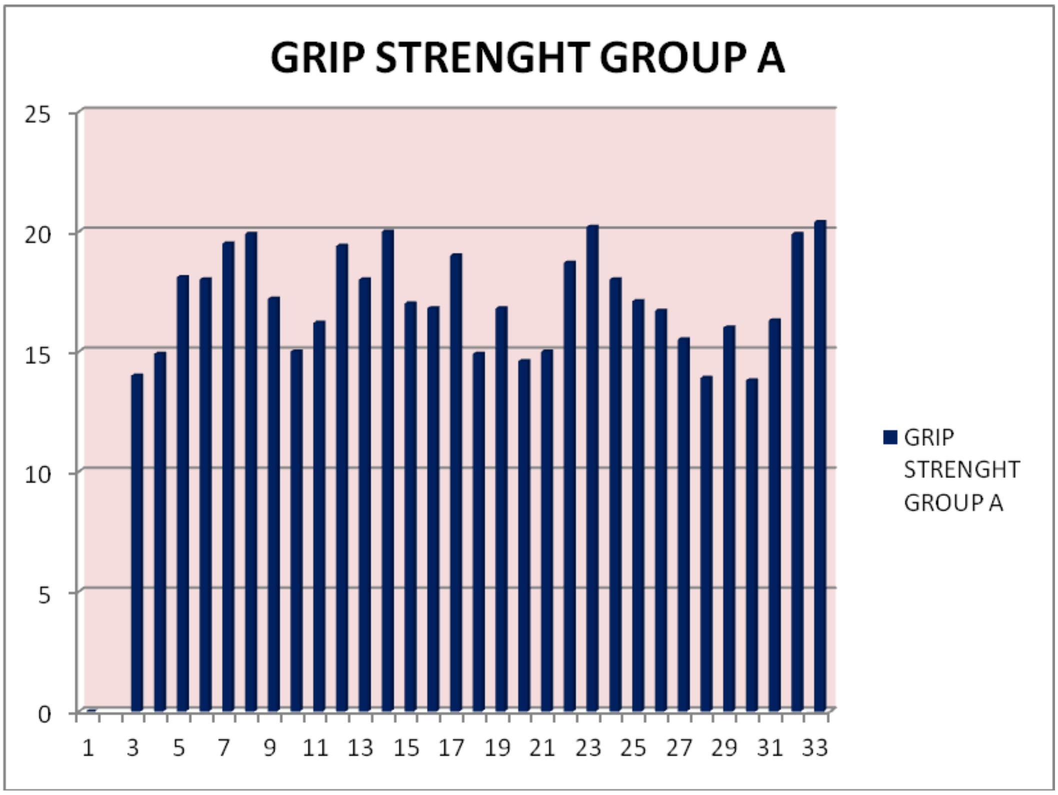
In Group B, Dynamic Tripod grasp is present in 26 subjects (83.87%) Five finger grasp in 0 subjects (0 %,), Thumb Wrap grasp in 1 subject (3.22%), Upright tripod grasp in 04 subject (12.90%).



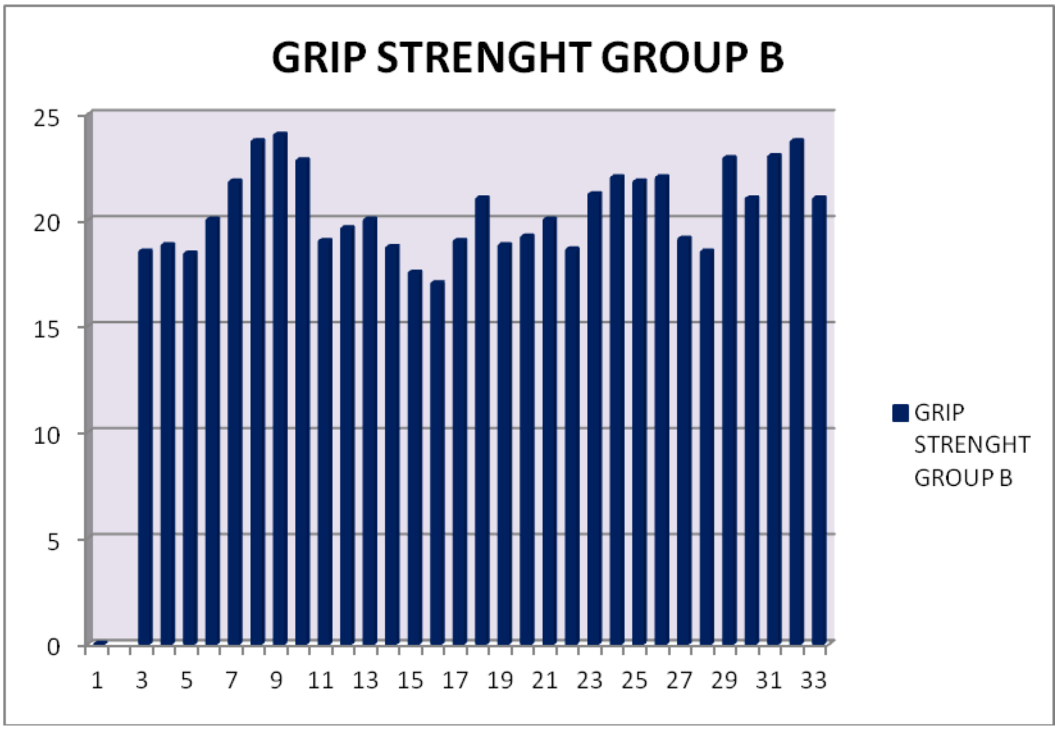
GRAPH 1.1: GRIP TYPE OF SAMPLE POPULATION
1. Dynamic Tripod Grasp **2. Five finger grasp**
3. Thumb Wrap grasp **4. Upright tripod grasp**

Table 1.3 MEANS OF GRIP STRENGTH (kgs) & FUNCTIONAL DEXTERITY TEST SCORES (seconds) FOR BOTH THE GROUPS

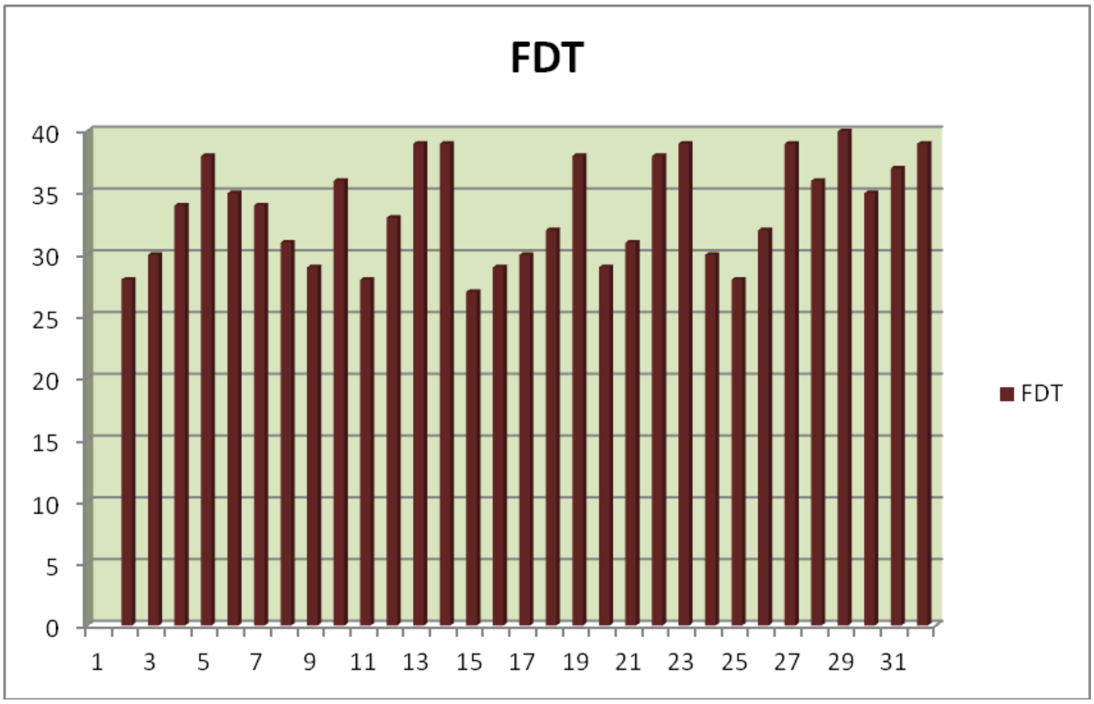
	GRIP STRENGTH (kgs)	FDT (secs)
GROUP A	17.12	33.6
GROUP B	20.40	28.6



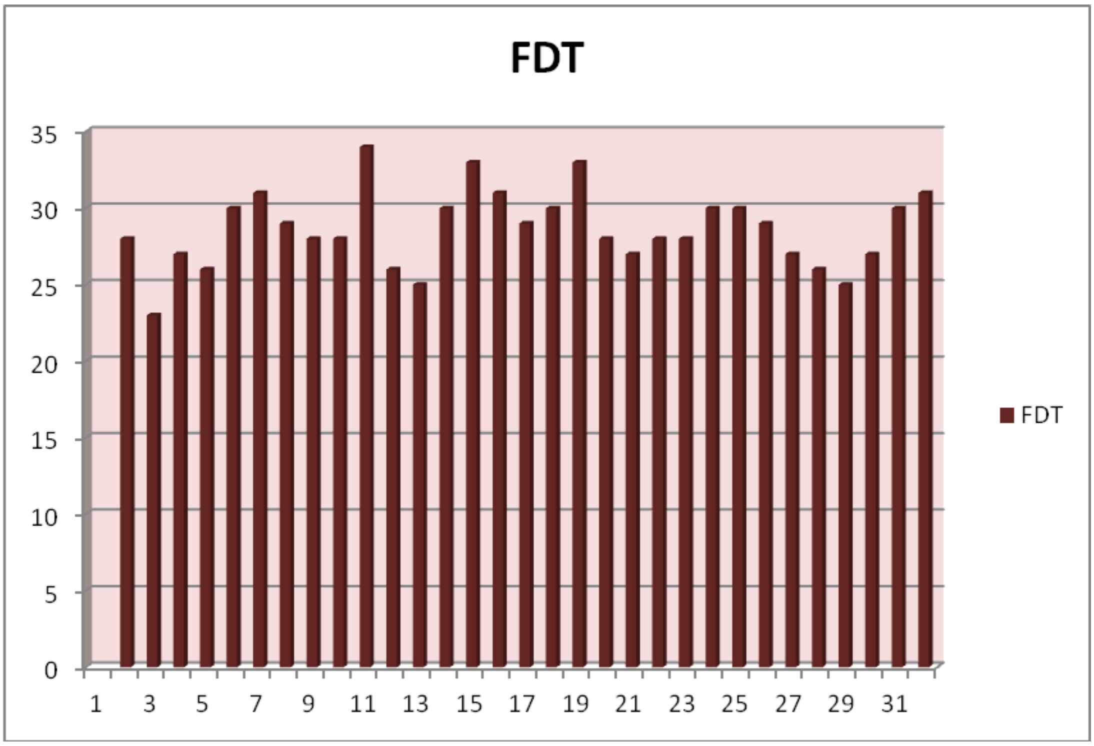
GRAPH 1.2 – GRIP STRENTH OF GROUP – A



GRAPH 1.3 – GRIP STRENTH OF GROUP – B



GRAPH 1.4 – FUNCTIONAL DEXTRITY TEST MEASURE OF GROUP – A



GRAPH 1.5– FUNCTIONAL DEXTRITY TEST MEASURE OF GROUP – B

TABLE 1.4 INTER GROUP ANALYSIS OF GRIP STRENGTH

VARIANT	MEAN		SD		T VALUE	P VALUE	RESULT
GRIP STRENGTH	G – A (kg)	G – B (kg)	G – A (kg)	G – B (kg)			
DOMINANT HAND	17.12	20.41	0.3685	0.3515	6.449	<0.0001	S

NS: not significant, S: significant, HS: highly significant, VHS: very highly significant

Interpretation:

The above table shows the mean of grip strength of Group A i.e. 17.12 ±0.3685 & the mean of grip strength Group B i.e. 20.41 ±0.3515

The result showed significant difference for the grip strength between Group A and Group B (t = 6.449 and p = 0.0001) for both groups.

TABLE 1.5 INTER GROUP ANALYSIS OF FUNCTIONAL DEXTRITY TEST

VARIANT	MEAN		SD		T VALUE	P VALUE	RESULT
FUNCTIONAL DEXTERITY TEST	G – A (Sec)	G – B (Sec)	G – A (Sec)	G – B (Sec)			
DOMINANT HAND	33.65	28.61	0.7557	0.4488	5.725	<0.0001	S

NS: not significant, S: significant, HS: highly significant, VHS: very highly significant

Interpretation:

The above table shows the mean of functional dexterity test of Group A i.e. 33.65 ±0.7557 & the mean of grip strength Group B i.e. 28.61 ±0.4488.

The result showed significant difference for the functional dexterity test & between Group A and Group B (t = 5.725 and p = 0.0001) for both groups.

DISCUSSION

Modern technology plays a key role in daily human life. This involves keeping pace with rapid changes in the field of communication technology. In this context, smart phones have become an essential part of life, not only in matters related to communication, but also as essential social accessories[10-12]. As a result of this social involvement in communication technology, young children have become avid smart phones users[11].

It is now common for children to spend many hours each day playing Smartphone games and thus assuming awkward postures. As such, these children may incur musculoskeletal complications.

One of the most common consequences related to the increased use of smart phones is hand and wrist weakness[27]. This weakness is caused by repeated flexion and extension of the finger, thumb, and wrist which leads to greater musculoskeletal disorders. The association between smart phone usage duration (as measured by the phone's capacity to track screen time) and hand-grip are incompletely defined. As a result, a link between smart phone usage duration as well as hand-grip strength in young adults was investigated in which the long-term smart phone use was linked to a weaker grip grasp and the length of time spent on a smart phone, as well as age which may play a role in the strength of the hand muscles.[28]

It is generally believed that grip strength gives an objective index for the functional integrity of the upper extremity as well a reliable and valid assessment of hand strength which is necessary for regulating the efficacy of treatment measures [29].

The study examined the effects of Smartphone overuse on functional hand performance in children and assessed the interaction effects between the level of Smartphone use and hand dominance on handgrip strength, hand dexterity, and overall hand function. Results indicated that the level of Smartphone use alone significantly decreased hand grip strength; affect normal Grip as well hand dexterity is significantly affected on the dominant side in the high-frequency Smartphone-user group. This may be the result of modern Smartphone designs, which require repeated finger motions such as clicking, scrolling, swiping, tapping, and pressing buttons. These requirements may affect fingertip forces, tendon excursion, and muscular effort[15]. Furthermore, many studies have shown that longer durations of Smartphone use may decrease blood flow; prevent oxygen and nutrients from being supplied to muscles, and lead to small amounts of pain and fatigue[16-19].

The human hand has unique features; functional impairment can affect quality of life[20]. Studies on hand pain resulting from repetitive tasks have found that hand function and pinch strength were reduced through frequent Smartphone use. Frequent smart phone use without taking regular rest periods may result in cumulative trauma disorders to the neck, shoulders, hands and wrists. These disorders may occur because smart phone use typically requires thumb and finger interactions with the screen.[26]This study's results specifically supported research by both Kalra[21], Kim et al.[22], who found that frequent Smartphone use resulted in decreased grip strength and hand function. Both reported that these conditions may have been due to physical factors, including a reduced number of contracting muscle fibres, decreased motor-unit firing rates, and changes in muscle fibre type. Moreover, Samaan et al.[23] reported that repetitive tasks (e.g., using smart phones) may be associated with repetitive micro trauma to the musculoskeletal structures. This condition is caused by an alteration of the length-tension relationship in the muscles. Aly et al.[24] also reported that repetitive strain injuries may be caused by repeated finger motions that are performed for long periods of time at high velocity. Smartphone users typically adapt their hand postures to the constraints of Smartphone design layouts[21]. In this context, faulty postures such as prolonged wrist flexion and repeated thumb use may affect median nerve[20.]

CONCLUSION

This study provides initial data and may be valuable towards understanding the impact of these electronic devices on scholastic performance.

Further research is therefore encouraged as there is need to work over impact of electronic devices on non dominant hand also regarding to grip strength, dexterity & Pencil grip type. This study can even be more specific even regarding to type of device like laptop, smart phone, desktop or videogames etc. This will help us in determining which device is more hazardous in developing fine motor milestones in children. More research work considering a gender specific study also should be done.

Funding

This study did not receive any specific grants from funding agencies in the public, commercial, or non-profit sectors.

Acknowledgement: None

Conflict of Interest: None

Ethical Approval: Approved

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How to cite this article: Shah M, Shah S, Ved V. A study to evaluate pencil grip type, hand functions - dexterity & grip strength in children using tech for 2 or more hours a day. *Int J Health Sci Res.* 2022; 12(3): 274-284. DOI: *https://doi.org/10.52403/ijhsr.20220339*

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