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Evaluating Grip Strength and Hand Performance among School - Going Children Who Use Smartphones: A Cross-Sectional Study

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Abstract: ***This study investigated the interaction effects between high frequency smartphone use and its effect on handgrip, pinch strengths, and functional hand performance in children. [Participants and Methods] A total of 240 school going children aged between 9 and 15 were taken in this study based on inclusion and exclusion criteria. Minimum of 2-3 hours of smartphone use since 2 years daily was considered. A hand dynamometer and pinch gauge were used to measure handgrip and pinch strength respectively. Smartphone Addiction scale was used to identify smartphone addicts. Abilhand ABILHANDKIDS Questionnaire - English version was used to assess hand function [Results] The results indicated that a longer duration of average daily smartphone usage was related and contributed to a weaker hand-grip and pinch-grip strength. Motor functions were likely to be affected [Conclusion] Results indicated that high levels of smartphone use diminished hand and pinch-grip strengths as well as and hand function. The effects of smartphone use frequency on grip and hand-pinches strengths were not the same for the dominant and non-dominant hands; the non-dominant hand expressed low values for all four strength variables among high-frequency smartphone users. Majority of children were found to be addicted to smartphone.***

Keywords: Smartphone overuse, Hand function, Hand-grip strength, Smartphone Addiction scale (SAS-SV), Abilhandkids Questionnaire

1. Introduction

Recently, the pandemic made most of the schools and classes to switch to online mode to continue their curriculum and learning process. Due to this most of the children started using smartphones as online mode of learning and education [2]. Online schools and classes made children to use smartphone continuously for about 6-7 hours per day [2]. This led to long time exposure of smartphones by children on daily basis for more than 2 years. This has influenced children to spend a lot of their time on smartphones which is initially a habit but later on becomes an addiction. As per the recent survey in India in March 2022, 23.8% of children use their phone more in night time [3].

Use of Smartphone can cause various Musculoskeletal disorders in children [4]. Using smartphone for a prolong time results in poor posture causing pain in neck, shoulder, elbow and hands [5]. Reports have shown that prolong smartphone 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 and would reduce hand functionality over time [4].

Disturbance in hand function, weakness of hand muscles, dull aching pain and MSK disorders such as De Quervain's Tenosynovitis, Cumulative trauma disorders in thumbs and associated joints may develop, as excessive use of smartphone exposes thumbs and fingers to operational stresses beyond their planned function [4,6]. Supply of blood and nutrients to muscles of the hand may also decrease due to repetitive static motion of the hand leading to pain and muscle fatigue [4,6]. This may limit the movement as well as functions of hand and continuous use may cause weakness of muscles of hand [4].

Many studies have implied that grasping, repeated pushing movements, and repeated motions of the thumb are risk factors that could lead to upper limb dysfunction [6,7].

A study done on children revealed that high levels of smartphone use, diminished hand grip and pinch strength as well as hand function. Also hand and pinch grip strengths were reduced in dominant hands of high frequency smartphone users [4].

Few studies done also suggest that repetitive upper limb work not only cause minimal damage to the muscles, nerves, joints, and blood vessels, but also produce chronic pain and paresthesia in the neck, shoulders, arms, wrists, and fingers [7].

Any functional impairment to hand can disturb upper limb function [4]. This study is to assess the influence of high smartphone use on hand performance and strength while examining the possibility of an interaction effect between the level of smartphone use and hand dominance usage on the handgrip and pinch strength in children.

2. Materials and Methods

2.1 Materials used

- Pen & Pencil
- Demographic Data Form
- Consent Form
- Smartphone Addiction Scale-Short Version (SAS-SV) Scale
- ABILHANDKIDS Questionnaire – English version used to assess hand function.
- Equipment: Jamar Hand Dynamometer, Pinch Gauge

Interpretation: The smartphone addiction range is between 40-60. Total score is 60.

	Items	Strongly disagree	Disagree	Weakly disagree	Weakly agree	Agree	Strongly agree
1	Missing planned work due to smartphone use	1	2	3	4	5	6
2	Having a hard time concentrating in class, while doing assignments, or while working due to smartphone use	1	2	3	4	5	6
3	Feeling pain in the wrists or at the back of the neck while using a smartphone	1	2	3	4	5	6
4	Will not be able to stand not having a smartphone	1	2	3	4	5	6
5	Feeling impatient and fretful when I am not holding my smartphone	1	2	3	4	5	6
6	Having my smartphone in my mind even when I am not using it	1	2	3	4	5	6
7	I will never give up using my smartphone even when my daily life is already greatly affected by it	1	2	3	4	5	6
8	Constantly checking my smartphone so as not to miss conversations between other people on Twitter or Facebook	1	2	3	4	5	6
9	Using my smartphone longer than I had intended	1	2	3	4	5	6
10	The people around me tell me that I use my smartphone too much	1	2	3	4	5	6

Note. Adapted from "The smartphone addiction scale: Development and validation of a short version for adolescents," by M. Kwon, D-J. Kim, H. Cho and S. Yang, 2013, *PLoS ONE, 8(12)*, (https://doi.org/10.1371/journal.pone.0083558). Copyright 2013 by Kwon et al.

Figure 1: Smartphone Addiction Scale-short version (SAS-SV)

ABILHAND-Kids - Manual Ability Measure
English version

Patient _____ **Date** _____

	How **DIFFICULT** are the following activities?	Impossible	Difficult	Easy	?
1.	Putting on a backpack/schoolbag				
2.	Washing the upper-body				
3.	Putting on a hat				
4.	Taking a coin out of a pocket				
5.	Opening a bread box				
6.	Taking off a T-shirt				
7.	Buttoning up trousers				
8.	Opening a jar of jam				
9.	Filling a glass with water				
10.	Sharpening a pencil				
11.	Zipping-up trousers				
12.	Fastening the snap of a jacket				
13.	Unscrewing a bottle cap				
14.	Buttoning up a shirt/sweater				
15.	Unwrapping a chocolate bar				
16.	Zipping-up a jacket				
17.	Squeezing toothpaste onto a toothbrush				
18.	Switching on a bedside lamp				
19.	Opening the cap of a toothpaste tube				
20.	Rolling-up a sleeve of a sweater				
21.	Opening a bag of chips				

Impossible: the child is unable to perform the activity without using any other help;
Difficult: the child is able to perform the activity without any help but experiences some difficulty;
Easy: the child is able to perform the activity without any help and experiences no difficulty;
Question mark: the parents cannot estimate the difficulty of the activity for their child because he/she has never done the activity. However, if the activity was never attempted because it is impossible, then it must be scored as "Impossible" rather than "Question mark".

Figure 2: ABILHAND-Kids Questionnaire (English Version)

2.2 Methodology

Study design:

Type of study: Cross-sectional study (observational)
Duration of study: 18 months
Location of study: Metropolitan city

Sample design:
Sample size: 240 children.
Sample population: School going children between 9-15 years.
Sampling method: Convenient sampling

Inclusion criteria:
- School going Children
- Age group 9-15 years willing to participate in the study were included.
- Children who use phone for at least 2-3 hours daily since two years daily.
- Smartphone addiction based on SAS-SV scale (smartphone addiction scale-short version)

Exclusion criteria:
- Age more than 15 years
- Children who don't use mobile phones
- Congenital hand Deformity
- Fractures of hand
- Never injury - Radial nerve palsy, Erb's palsy, Klumpke's palsy

3. Statistics

The data was collected was collected on a data sheet and a master chart was prepared using Microsoft excel. The data was statistically analysed using SPSS version 28.0. Multivariate analysis of variance (MANOVA) test was used for analysis. Data was then plotted in form of charts. Total number of 240 school going children in the age group of 9-15 years underwent a screening program for onetime assessment. The data of the study was analysed in terms of outcome measures which were Jamar hand dynamometer, Pinch guage, ABILHAND-Kids Questionnaire and SAS-SV (Smartphone Addiction Scale) Scale.

4. Results

A total of 240 school going children were included in the study with age group between 9-15 years.

Their smartphone usage was minimum 2-3 hours daily since 2 years.

Readings was taken using Jamar dynamometer and Pinch guage for hand grip and pinch grip strengths respectively. Hand Function was assessed using Abilhand kids questionnaire

Smartphone Addiction Scale - Short version (SAS-SV) was used for evaluation of smartphone addiction.

Table 1: Smartphone Addiction Scale (SAS-SV) Interpretation (Total Children – 240)

	Percentage	Number of Children
Addicted	48.33	116
Not Addicted	51.66	124

Interpretation: The difference between addicted and non-addicted children is very less. Almost half of the population is found to be addicted which is 48.33%.

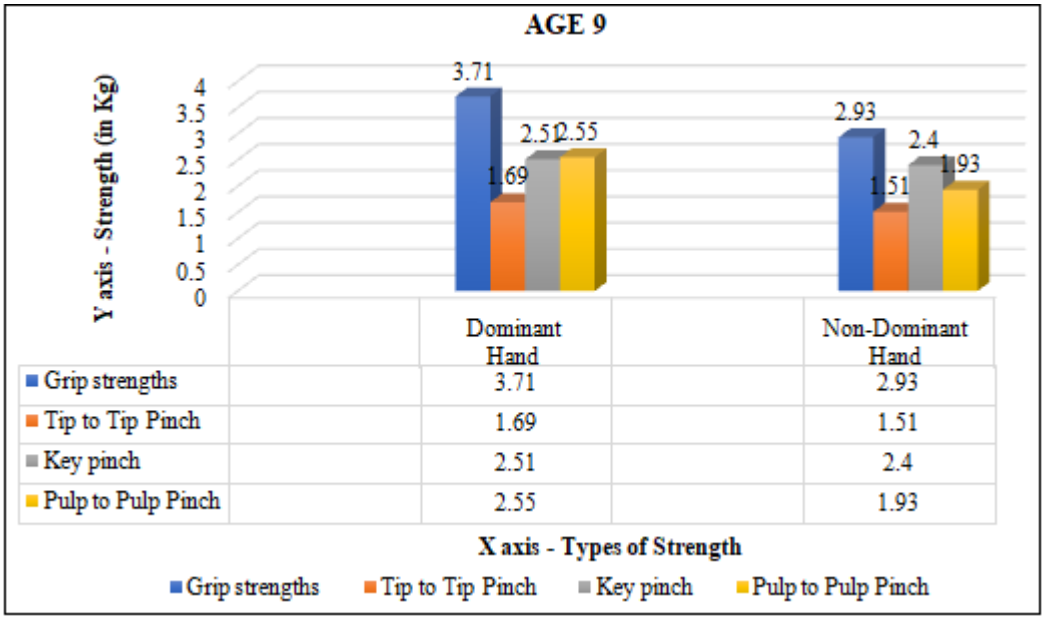

Figure 3: Chart showing Average Value of strength (Age 9)

For age group 9, the values of all grip and pinch strength for dominant as well as non-dominant hand was less when compared with normal base strength values of that age.

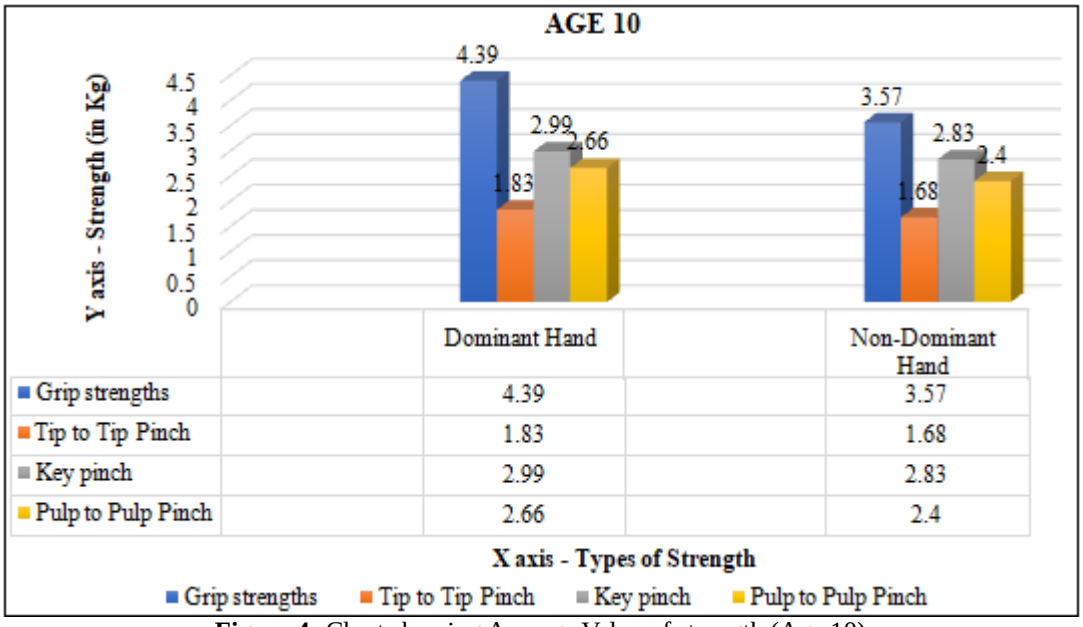

Figure 4: Chart showing Average Value of strength (Age 10)

For age group 10, the values of all grip and pinch strength for dominant as well as non-dominant hand was less when compared with normal base strength values of that age.

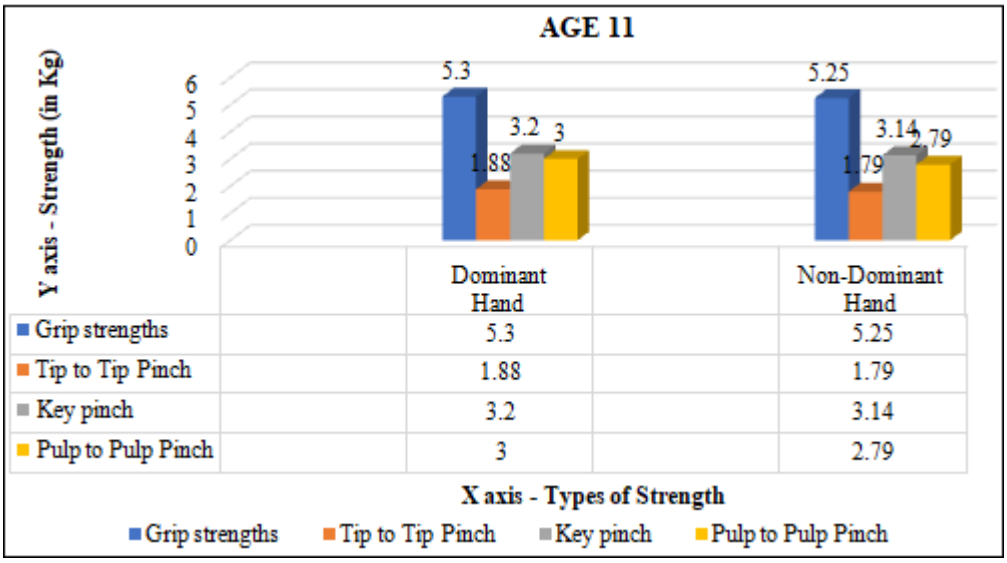

Figure 5: Chart showing Average Value of strength (Age 11)

For age group 11, the values of all grip and pinch strength for dominant as well as non-dominant hand was less when compared with normal base strength values of that age.

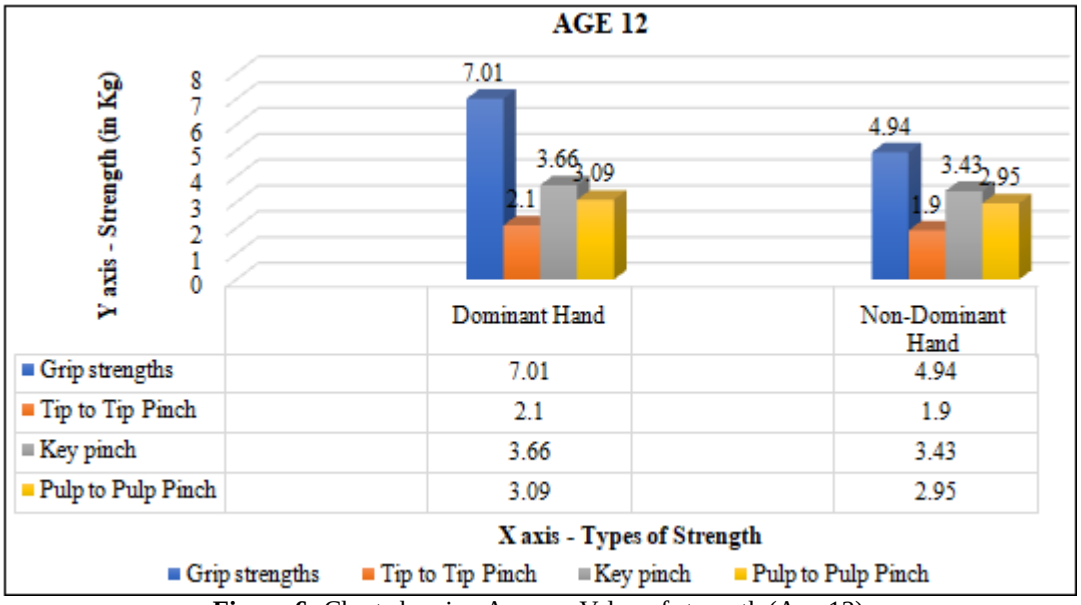

Figure 6: Chart showing Average Value of strength (Age 12)

For age group 12, the value of grip strength for dominant hand was more and grip strength for non-dominant hand was less when compared with normal base strength values of that age. Values of pinch strength for dominant as well as non-dominant hand were also less.

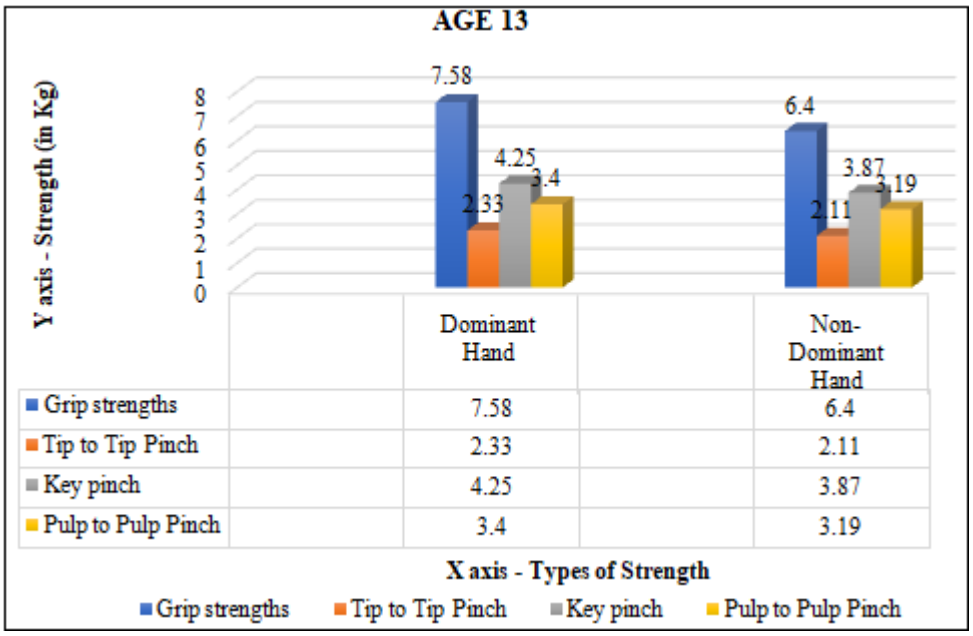

Figure 7: Chart showing Average Value of strength (Age 13)

For age group 13, the values of all grip and pinch strength for dominant as well as non-dominant hand was less when compared with normal base strength values of that age.

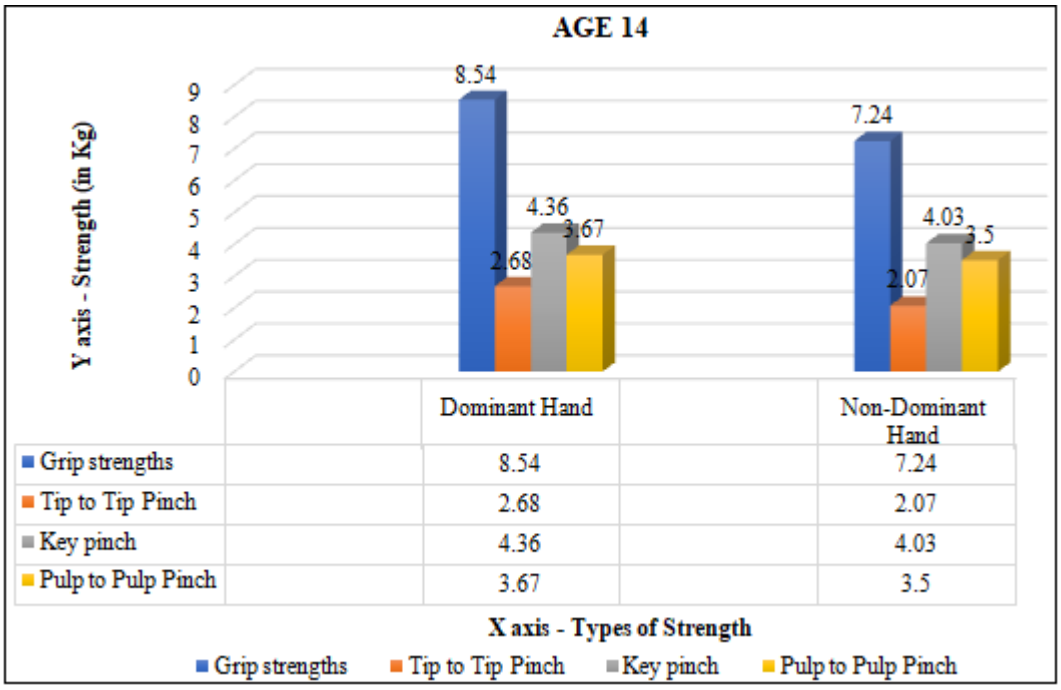

Figure 8: Chart showing Average Value of strength (Age 14)

For age group 14, the values of all grip and pinch strength for dominant as well as non-dominant hand was less when compared with normal base strength values of that age

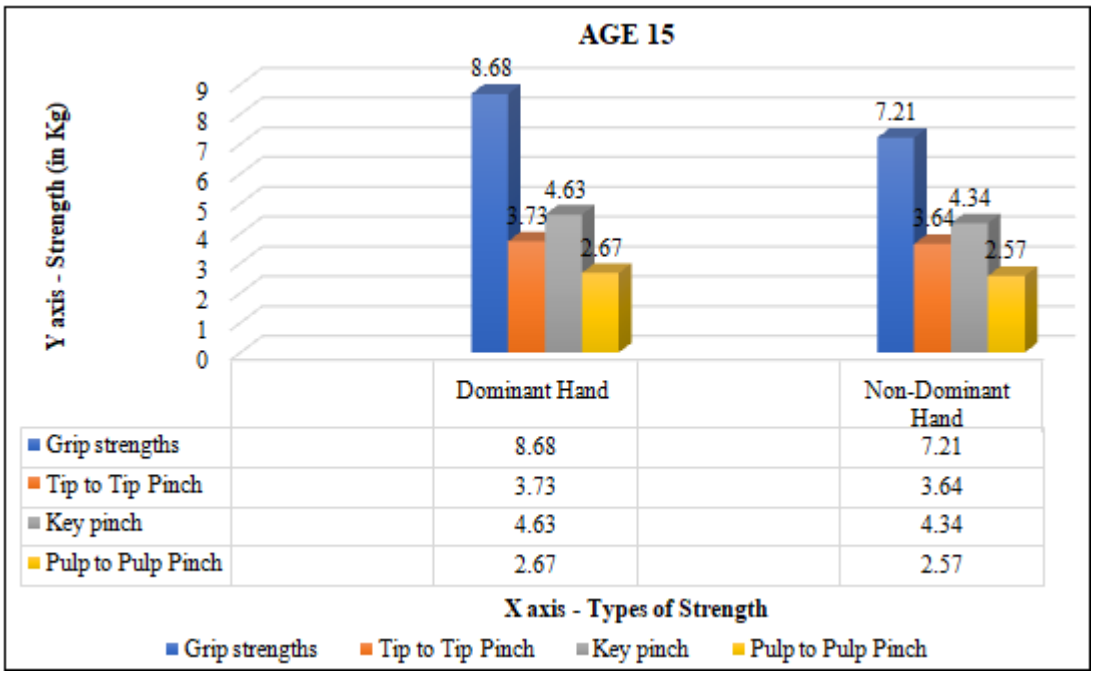

Figure 9: Chart showing Average Value of strength (Age 15)

For age group 15, the values of all grip and pinch strength for dominant as well as non-dominant hand was less when compared with normal base strength values of that age.

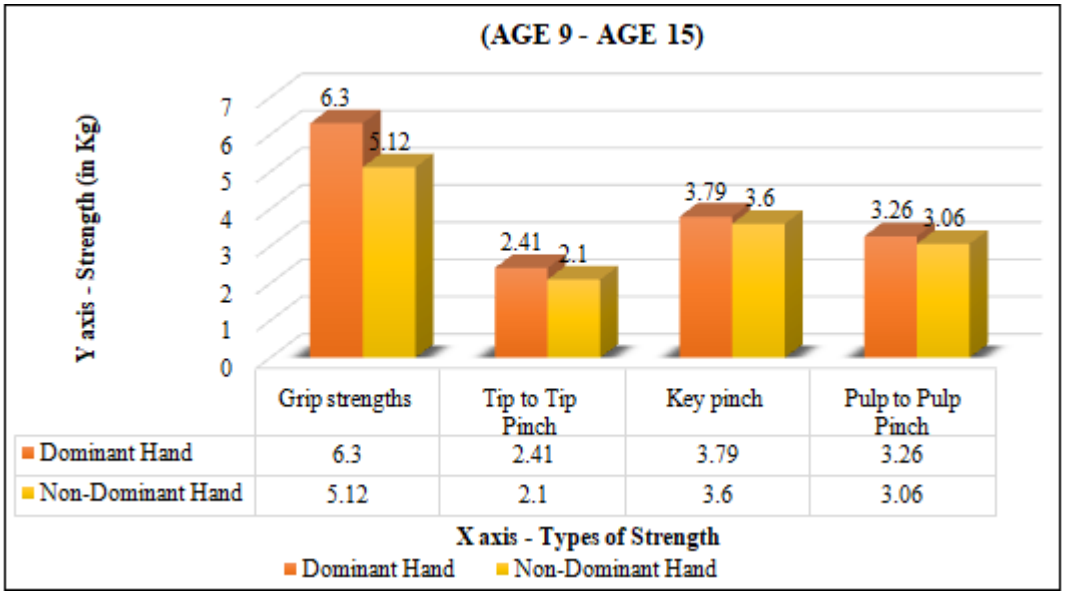

Figure 10: Chart showing Average Value of strength (Age 9 –Age 15)

By using this data, we found the result of impact of high frequency usage of smartphone on grip strength and hand functions. We used Two way MANOVA revealing a significant impact for the level of smartphone use across grip strength,tip to tip pinch, key pinch, and palmar pinch strength measurements. The level of significance for this test was $p<0.05$.There was a seperate interaction between level of smartphone use and hand dominance on combined depended variables. The effects of smartphone use frequency on grip and hand-pinches strengths were not the same for the dominant and non-dominant hands; the non-dominant hand expressed low values for all four strength variables among high-frequency smartphone users.

Interpretation of ABILHAND-Kids Questionnaire:

The ABILHAND-Kids Questionnaire consists of 21 questions rated on the basis of easy, difficult, impossible. The scores for the same are 2, 1, 0 respectively. Majority of the children experienced easiness while performing activities of daily living. Few children faced difficulty while performing some of the given activities. Such activities are

1) Opening the jar of jam
2) Unscrewing a bottle cap
3) Buttoning up shirt

There was no such activities which was impossible for any children.

5. Discussion

The findings of this observational study will contribute to the understanding of the potential impact of smartphone usage on grip strength and hand function in children age 9-15. By assessing hand performance and strength, we aim to identify any associations with high rates of smartphone usage.

This study was conducted to assess Grip Strength & Hand performance in prolong smartphone users in school going children. The study was conducted on 240 participants in the age group of 9-15 years which were selected on basis of inclusion and exclusion criteria. The results of study revealed a significant impact across grip strength, tip pinch, key pinch and pulp to pulp pinch measurements on use of smartphone for prolong time. The most affected age group was found to be from 13-15 years, also their average daily usage of smartphone was found to be 4-5 hours. The results of this study also interpreted that using smart phone for long duration not only affected their hand grip strength but also resulted in addiction of smartphone in children.

The results indicated that a longer duration of average daily smartphone usage was related and contributed to a weaker hand-grip and pinch-grip strength. This may be the result of modern smartphone designs, which require repeated finger motions such as clicking, scrolling, swiping, tapping, and pressing buttons[4]. These requirements may affect fingertip forces, tendon excursion, and muscular effort[4].Holding a smartphone for extended periods may result in reduced grip strength over time. Constantly grasping the device with the same hand position can lead to weakened hand muscles and diminished overall grip strength. 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[15].

An observational study conducted by Radwan et al in 2020 also found that the level of smartphone use alone significantly decreased grip, hand-pinch strength, and qDASH scores also grip and hand-pinch strengths were weaker on the dominant side than the non-dominant side in the high-frequency smartphone-user group[4].Our study found thatimpact of high frequency usage significantly decreased grip, hand-pinch strengths were weaker on the non -dominant hand than the dominant hand.

A similar study on Relationship of Smartphone Addiction with Hand Grip Strength and Upper Limb Disability by Din et al found that increasing smart phone addiction decreases hand grip strength and increases upper limb disability [17].In our study, out of 240 participants 48.33% were addicted to smartphones which affected their hand grip and pinch strength.

An observational study on 'The relationship between smartphone usage duration (using smartphone's ability to monitor screen time) with hand-grip and pinch-grip strength among young people' by Osailan et al also concluded that prolonged use of smartphones was related to weaker hand-grip and pinch-grip[6].In our study the relationship between smartphone usage duration with hand grip and pinch grip strength between age group 9-15 states, higher the usage of smartphone lower the hand and pinch grip strength.

Studies on hand pain resulting from repetitive tasks have also found that hand function and pinch strength were reduced through frequent smartphone use whose results supported by both Kalra[18], Kim et al[19], 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. These results are similar to our results that showed higher duration of smartphone use leads to weakness and muscle fatigue which decreased grip strength and motor functions hand.

Continuous and excessive use of smartphones can lead to reduced hand function overall. This may manifest as difficulty in performing fine motor tasks that require dexterity and precision, such as writing, grasping small objects, or manipulating tools. Supporting a smartphone while tapping its touch-screen with the same hand may be more difficult than operations using a two-handed grip. For instance, if the thumb is involved in maintaining device stability while being used to tap the screen, then these two functions may conflict. Thus, performance is decreased[4].

Essential issues to reduce the risks of using smartphones in children should be mentioned. Two-handed use and decreasing the time of chatting, gaming and searching less than 4 hours per day are considered as important factors to reduce the mechanical loads on hand and shoulder girdle.

Based on this study's results, it can be concluded that high levels of smartphone use decrease hand and pinch-grip strengths. Hand Function are likely to be affected as motor functions are affected. This study showed positive relation between smartphone usage duration and their effect on hand grip and pinch strength. Students were found to be likely addicted to smartphones due to high frequency use.

6. Conclusion

The impact of smartphone usage on grip strength and hand performance in school-going children is a multifaceted issue. While there are potential benefits to hand performances, there are also concerns about reduced grip strength and the risk of repetitive strain injuries. It is essential to address these concerns by promoting physical activity, setting usage limits, and fostering a healthy balance between smartphone use and other activities. By adopting a proactive approach, parents and educators can help children maximize the benefits of technology while safeguarding their physical well-being. Further research in this area is warranted to better understand the long-term effects of smartphone usage on children's hand performance.

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