

Impact of Digital Device Usage on the Frequency of Musculoskeletal Symptoms among Collegiate Students: A Cross-Sectional Study

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Abstract:- In today's world, information acquisition and communication has become easier utilizing various digital devices leading to huge rise in the usage of smartphones and computers among the younger population leading to postural abnormalities. However, little is known about musculoskeletal pain syndrome in Indian youth. The aim of this study was to find out the frequency of musculoskeletal symptoms associated with utilization of smartphones and other digital devices among college students in Mangaluru, Karnataka.

Methods and Materials: This was an observational analytical preliminary study conducted using a validated questionnaire among 379 college students aged between 18-25 years. Students from various colleges were contacted and the questionnaire was distributed.

Results: The usage of smartphones in college students in Mangaluru is 99%. Computer users were 77% and only 13% of individuals were using tablets. The study result shows that prolonged duration of smartphone usage is associated with increased frequency of neck, upper and lower back pain. Also, prolonged computer usage leads to upper back and shoulder pain whereas continuous tablet usage without changing position has been associated with arm pain.

Conclusion: This study provides information about the influence of different digital device usage and its impact on the occurrence of musculoskeletal symptoms like neck, shoulder, upper/ lower back and arm pain in college students. Hence, it is a global concern to spread awareness of proper ergonomics and good posture while using various digital devices to prevent musculoskeletal pain or discomfort in youth.

Keywords:- Musculoskeletal pain, digital device, smartphone, students.

I. INTRODUCTION

Evolution of communication technologies has improved communication within the community, amplifying the usage of these technologies causing a global concern to understand the health risks involved. [1,2,3]. Computer usage during free time quite often has been associated with pain symptoms in various body parts. A survey on adolescents found that intensive use of computers was associated with neck, shoulder and low back pain.[4] Also, computer usage at work was found contributing to varied musculoskeletal pain syndrome.[5] Evidence suggests an increase in swelling of median nerve following 30 to 60 minutes of typing which resolved with 30 minutes of rest period. The cross-sectional area of the carpal tunnel was found widened with peak ulnar deviation while typing on the computer.[6] Intensive keyboard or mouse usage was linked with an increased risk of acute or transient pain among computer users but casual usage and association of symptoms is still uncertain.[7] A few researchers considered that the constant or repeated movements in a particular posture while using smartphones may lead to non-neutral neck posture and often results in neck and back pain. Correspondingly, a survey carried out by Kim HJ et al [8] found that smartphone usage is one of the main causes of musculoskeletal pain and is closely related to the same.

In a preliminary Canadian study among 140 university students, 98% were using mobiles. Amidst them, 84% reported pain in thumb and in the dominant shoulder, justifying association between the duration of smartphone usage and pain. [9] Literature suggests unilateral texting causing more loading on the forearm muscles than bilateral texting. Furthermore, while texting on a smart phone, it was noticed that neck extensor and thumb muscles were overactivated whereas, upper /lower trapezius and wrist extensors were underactivated.[10] The head flexion angle associated with smartphone usage was large while texting and peaked in sitting rather than standing posture rendering it a contributing factor for neck pain among smartphone users.[11] Studies suggest that prolonged duration of smartphone usage or gaming could cause changes in cervical, lumbar spine posture, impaired proprioception in the cervical spine with impaired pain, threshold thumb

pain, poor pinch strength with impaired hand function, reduced pain perception and forward neck posture.[12,13,14,15]

A randomized trial on the prolonged use of touch screen tablets in office environments and its health effects depicted that abnormal postures in the upper body may lead to greater risks of developing musculoskeletal symptoms in users. [16] Few studies conducted on tablet usage have concluded that touch screen tablet users are exposed to more non-neutral wrist positions than other computing devices. Hence, there may be a greater risk of developing musculoskeletal symptoms among touch screen tablet users with more prevalence seen in females and adolescents. [17,18,19,20] An investment firm of Singapore, stated in their statistical study that by 2017 there will be an increase of 15.6% of smartphone users and the annual growth rate of smartphone users in India would be around 12.9% which is more than that of China (10.9%).[21]

Studies conducted in the Indian population on computer usage in the IT and computer professionals who use a variety of digital devices in an uninterrupted work environment revealed behaviour leading to early pain and musculoskeletal symptoms with increased academic/ work absenteeism and substandard performance. [22] There is limited literature on Indian college students and usage of other digital devices like tablets and smartphones. There has been an increased usage of digital devices over the years, with an increased risk of development of musculoskeletal issues in the future population. It is a global emergency to learn the association of digital device usage and frequency of musculoskeletal pain syndrome across different geographical areas and to explore the impact of newer technologies on the health of youth. Therefore, this study aims to find out the frequency of musculoskeletal symptoms associated with smartphone and other digital devices (computer, laptop and tablet), through a survey among college students in Mangaluru, India.

II. MATERIALS AND METHODS

This was a preliminary observational analytical study using a survey method. Ethical clearance was obtained from the Institute, Mangaluru India (Annexure-A). The sample size of 500 students was estimated utilizing the study conducted by Kim HJ, Kim JS [8] and Korpinen L, Paakkonen R [1] where they reported the overall prevalence of musculoskeletal symptoms as 55.8% { $p=55.8\%$, $p=0.558$ }. Five hundred students were recruited using a convenient sampling technique. Among them, only 379 students completed the questionnaire for the study from six different colleges based on inclusion criteria of age group between 18-25 years, both males and females, people using smartphones, computers and/or tablets for at least 6 months. Exclusion criteria included, an incomplete questionnaire and students with pre-existing musculoskeletal disorders due to causes other than digital product usage or previous trauma. The survey was conducted from February 2016 to February 2017 in and around Mangaluru.

A questionnaire was formulated comprising 30 close-ended questions in English which were utilized to explore the digital devices usage and musculoskeletal symptoms. The questionnaire (Annexure-C) was constructed based on the available literature.[1,8,9] The questionnaire was sent for content and face validation to the experts in the field of musculoskeletal physiotherapy and research. The experts had a minimum of 5 years of experience in the field of musculoskeletal physiotherapy. Experts provided suggestions and changes in the questions and the multiple choice responses implemented. Prior to the data collection, permission from the college authorities was obtained from six randomly selected colleges. The study and questionnaire were explained to the respondents and informed consent (Annexure-B) was obtained before answering the questionnaire. The self-reported questionnaire was distributed and data was collected.

III. RESULTS

Results were analyzed from the collected data using SPSS version 23 statistical software. All probability (p) values in this study were calculated within a confidence interval of 95%. The significance was set as $p \leq 0.05$. Frequencies were implemented to find out the prevalence of musculoskeletal symptoms due to the usage of digital devices. A Chi-square test was used to find out the correlation of musculoskeletal symptoms with digital device usage. From a total of 379 participants, 309 (82%) were females and 70 (18%) were males. This population had 375 (99%) smartphone users, 290 (77%) computer users, 51 (13%) tablet users. However, 4 (1%) did not use smartphones, 89 (23%) did not use computers & 328 (87%) did not use tablets. Out of 375 smartphone users, 107 (28.5%) used smartphones in standing position, 277 (73.9%) used while sitting, 74 (19.8%) used while lying on the stomach, 178 (47.5%) used while lying on the back and 82 (21.9%) used the phone in the side-lying position. Among the 375 smartphone users, 249 (66.4%) used the phone mostly for internet browsing, 102 (27.2%) used for gaming, 267 (71.2%) used for messaging, 196 (52.3%) used mostly for calling and 131 (34.9%) used the phone mostly for watching movies. Out of 51 tablet users, 28 (54.9%) used it for internet browsing, 24 (47.1%) used it for gaming, 6 (11.8%) used it for messaging and 22 (43.1%) used it for watching movies. Among the 51 tablet users, 7 (13.7%) used the tablet mostly in standing posture, 35 (68.6%) used it mostly in sitting posture, 12 (23.5%) used it while lying on the stomach, 19 (37.3%) used it while lying on the back and 6 (11.8%) used it in side-lying position. Among 290 computer users, 184 (63.4%) were using back support while 106 (36.6%) were not. Out of 290 computer users, 150 (51.9%) were viewing their computer while the head is above the midpoint of screen and 139 (48.1%) were viewing their computer while the head is in line with the midpoint of screen. Out of 379 participants, majority of the smartphone users and computer users have been using these devices for four years or more, while majority tablet users since less than one year.

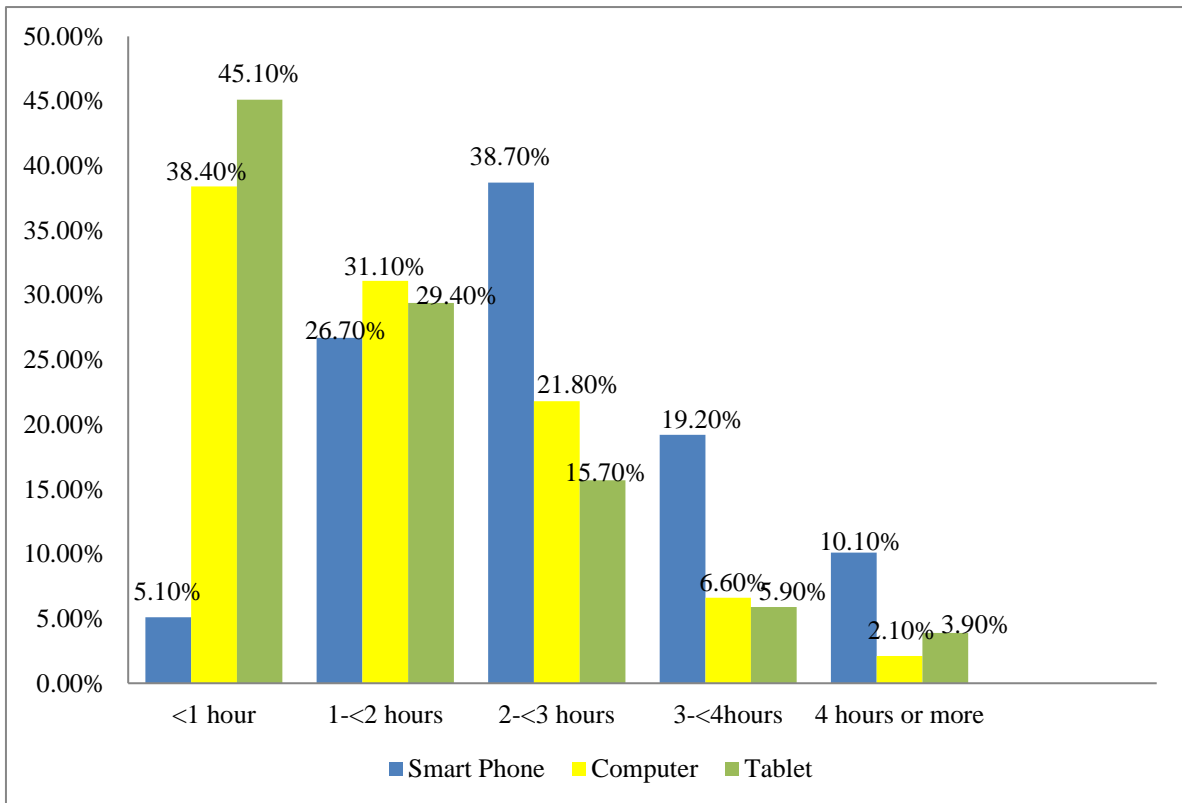


Fig. 1: Daily usage duration of digital devices

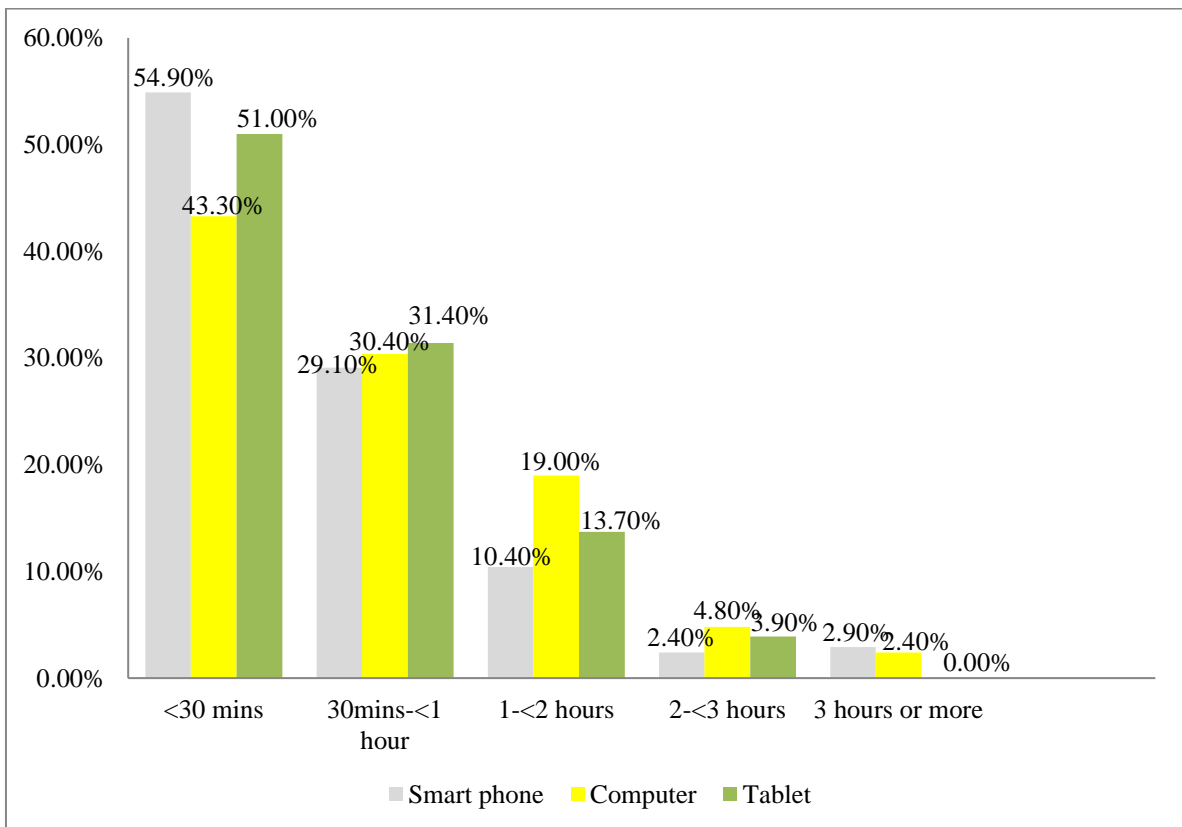


Fig. 2: Duration of continuous digital device usage

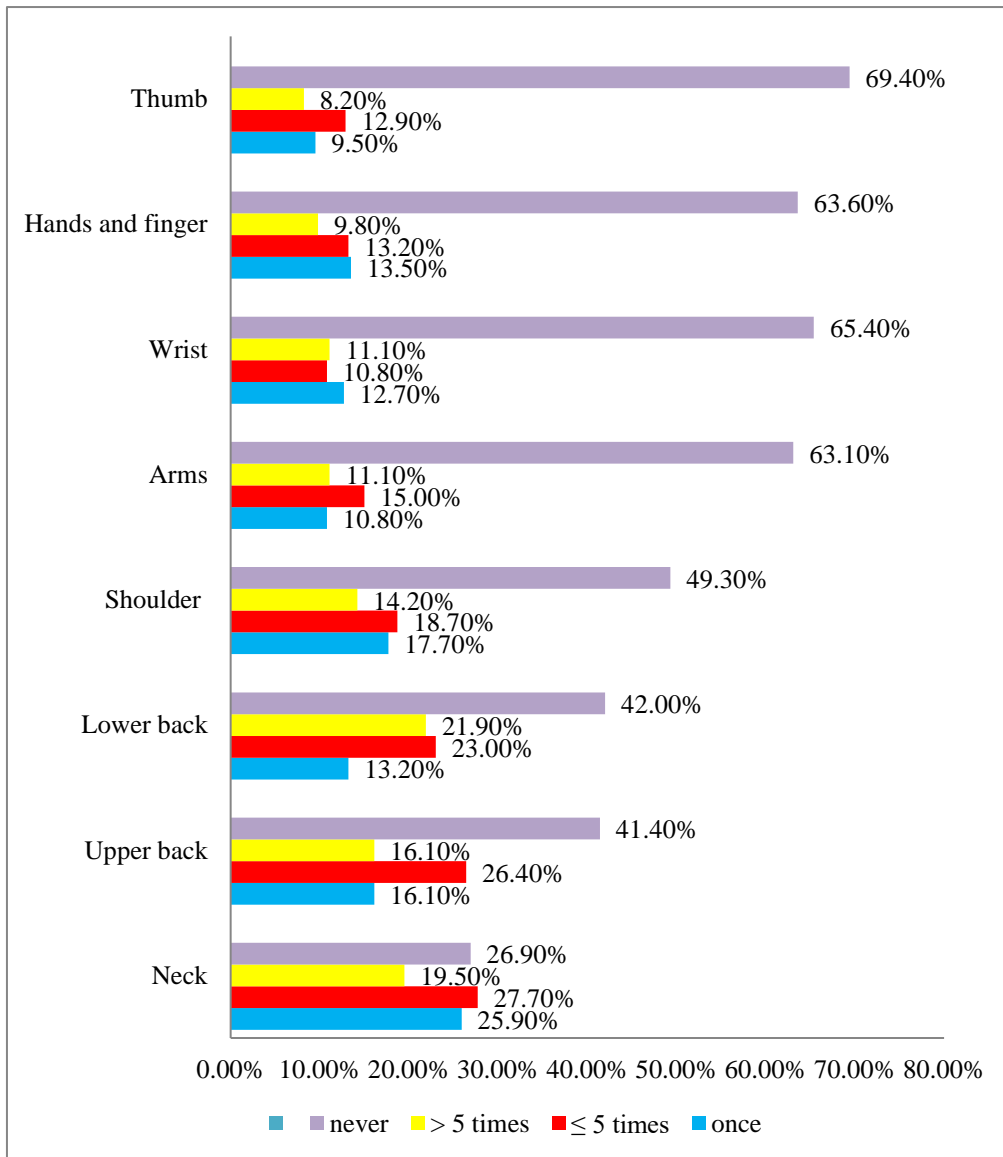


Fig. 3: Subjective association of musculoskeletal symptoms due to digital device usage based on the last 6 months duration

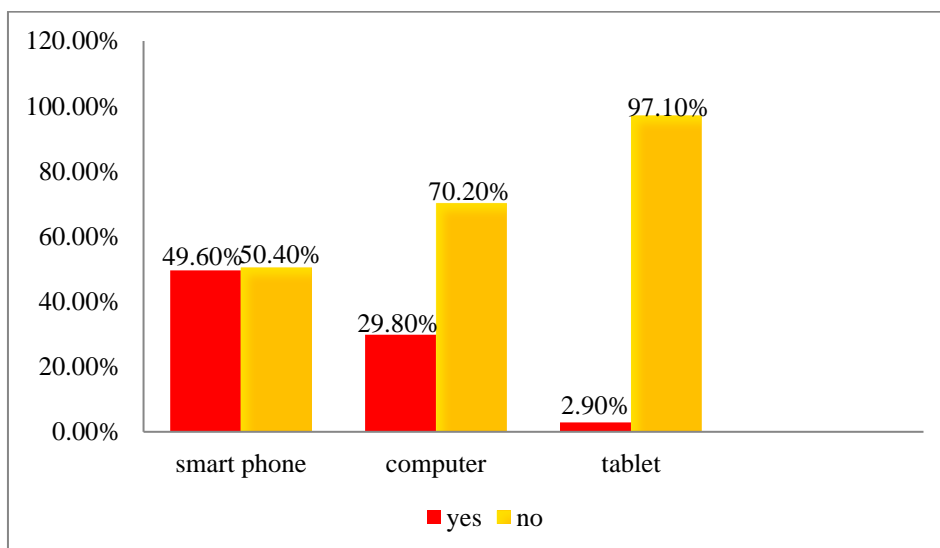


Fig. 4: Rate of perception about device usage & symptoms association

A. Duration of devices usage and its association with musculoskeletal symptoms

Table 1: Duration of smartphone usage and its association with neck pain

Symptoms	Duration of smartphone usage				
Neck pain	6 months <-1 year	1-<2 year	2-<3 year	3-<4 year	≥4 year
Once	20.8%	21.2%	28.4%	30.3%	24.6%
≤5 times	4.2%	21.2%	21.0%	36.8%	33.8%
≥ 5 times	33.3%	15.4%	16.0%	13.2%	23.9%
Never	41.7%	42.3%	34.6%	19.7%	17.6%
Chi-square test	p= 0.001				

Table 2: Duration of smartphone usage and its association with upper back pain

Symptoms	Duration of smartphone usage				
Upper back pain	6 months <-1 year	1-<2 year	2-<3 year	3-<4 year	≥4 year
Once	0%	13.5%	21.0%	18.4%	16.2%
≤5 times	20.8%	21.2%	24.7%	32.9%	26.1%
≥ 5 times	16.7%	7.7%	13.6%	13.2%	22.5%
Never	62.5%	57.7%	40.7%	35.5%	35.2%
Chi-square test	p= 0.036				

Table 3: Average time spent on a smartphone per day and its association with lower back pain

Symptoms	Duration of smartphone usage				
Lower back pain	6 months<-1 year	1-<2 year	2-<3 year	3-<4 year	≥4 year
Once	4.2%	15.4%	8.6%	18.4%	14.1%
5 times	12.5%	21.2%	18.5%	19.7%	28.9%
≥ 5 times	29.2%	11.5%	18.5%	21.1%	27.5%
Never	54.2%	51.9%	54.3%	40.8%	29.6%
Chi-square test.	p=0.016				

Table 4: Average time spent on a smart phone per day and its association with neck pain

Symptoms	Average time spent on a smartphone per day				
Lower back pain	<1 hour	1-<2 hour	2-<4 hours	4-<6 hours	6 hours or more
Once	21.1%	13.0%	12.4%	16.7%	7.9%
≤5 times	26.3%	16.0%	23.4%	29.2%	23.7%
≥ 5 times	10.5%	16.0%	20.7%	25.0%	42.1%
Never	42.1%	55.0%	43.4%	29.2%	26.3%
Chi-square test	p=0.018				

Table 5: Average time spent on a smart phone per day and its association with lower back pain

Symptoms	Average time spent on a smartphone per day				
Neck pain	<1 hour	1-<2 hour	2-<4 hours	4-<6 hours	6 hours or more
Once	42.1%	22.0%	31.7%	22.2%	10.5%
≤5 times	31.6%	17.0%	29.0%	34.7%	39.5%
≥ 5 times	5.3%	22.0%	15.9%	22.2%	28.9%
Never	21.1%	39.0%	23.4%	20.8%	21.1%
Chi-square test	p=0.007				

Table 6: Association of lower back pain and duration of smartphone usage continuously without changing position

Symptoms	Duration of smartphone usage continuously without changing position				
Lower back pain	<30minute	30min to <1 hour	1-<2 hours	2-<3 hours	3 hours or more
Once	15.5%	12.8%	5.1%	22.2%	0.0%
≤5 times	24.3%	19.3%	28.2%	22.2%	9.1%
≥ 5 times	16.0%	31.2%	20.5%	44.4%	27.3%
Never	44.2%	36.7%	46.2%	11.1%	63.6%
Chi-square test	p= 0.056				

Table 7: Association of shoulder back pain and duration of smartphone usage continuously without changing position

Symptoms	Duration of smartphone usage continuously without changing position				
Shoulder Pain	<30minute	30min to <1 hour	1-<2 hours	2-<3 hours	3 hours or more
Once	19.4%	17.4%	10.3%	22.2%	9.1%
≤5 times	17.5%	20.2%	28.2%	0.0%	9.1%
≥ 5 times	11.7%	13.8%	15.4%	66.7%	27.3%
Never	51.5%	48.6%	46.2%	11.1%	54.5%
Chi-square test	p= 0.012				

Table 8: Association of shoulder pain with computer usage

Symptoms	Duration of computer usage				
Shoulder pain	6 months -<1 year	1-<2 year	2-<3 year	3-<4 year	≥4 year
Once	37.5%	16.7%	10.0%	18.9%	13.8%
≤5 times	12.5%	11.1%	36.0%	16.2%	23.3%
≥ 5 times	12.5%	13.0%	12.0%	16.2%	18.1%
Never	37.5%	59.3%	42.0%	48.6%	44.8%
Chi-square test	p= 0.021				

Table 9: Association of upper back pain with duration of computer usage continuously without changing position

Symptoms	Duration of computer usage continuously without changing position				
Upper Back pain	<30minute	30min to <1 hour	1-<2 hours	2-<3 hours	3 hours or more
Once	47.7%	15.9%	9.1%	21.4%	14.3%
≤5 times	34.2%	31.8%	29.1%	21.4%	42.9%
≥ 5 times	30.9%	17.0%	32.7%	35.7%	0.0%
Never	53.5%	35.2%	29.1%	21.4%	42.9%
Chi-square test	p= 0.036				

Table 10: Association of shoulder pain with duration of computer usage continuously without changing position

Symptoms	Duration of computer usage continuously without changing position				
Shoulder pain	<30minute	30min to <1 hour	1-<2 hours	2-<3 hours	3 hours or more
Once	16.8%	17.0%	23.6%	0.0%	0.0%
≤5 times	16.0%	28.4%	20.0%	21.4%	28.6%
≥ 5 times	11.2%	18.2%	16.4%	35.7%	0.0%
Never	56.0%	36.4%	40.0%	42.9%	71.4%
Chi-square test	p= 0.042				

Table 11: Association of arm pain and duration of tablet usage without changing position

Symptoms	Duration of tablet usage without changing position				
Arms pain	<30minute	30min to <1 hour	1-<2 hours	2-<3 hours	3 hours or more
Once	0.0%	25.0%	0.0%	0.0%	0%
≤5 times	30.8%	6.3%	42.9%	0.0%	0%
≥ 5 times	19.2%	6.3%	42.9%	50.0%	0%
Never	50.0%	62.5%	14.3%	50.0%	0%
Chi-square test	p= 0.021				

IV. DISCUSSION

The objective of this study was to find out the association of frequency of musculoskeletal symptoms due to the usage of smartphones and other digital devices. There is limited literature evaluating the relationship between digital devices and musculoskeletal problems among youth. The literature suggested overusage of the digital gadgets by the students over an extended period of time when compared to computer professionals thereby presenting premature symptoms of pain and discomfort.[22]

Understanding this relationship is an important milestone in the prevention or early intervention for musculoskeletal issues. In our study, out of the total population of students included, 99% were smartphone users, 77% were computer users and 14% were tablet users. This high percentage indicates the dependence of college students on digital devices. Previous literature on prevalence revealed about 53.3% of all young adults who were computer users and mobile phones often had pain or numbness in the neck and 32.2% had pain in the hip and lower back with predominance in females. [1] Another study among adolescents states that the neck, shoulder and

back pain correlated with digital devices usage, physical activity and psychological status of the individual. [5]

A systematic review conducted by Davey S and Davey A [21] in the Indian smartphone users revealed that the smartphone addiction among Indian teens ranged from 39% to 44% which not only damages interpersonal skills, but is also associated with health risks and psychological problems. In our study, majority of the users have an extremely long duration of interaction with these digital devices. A high percentage of smartphone users and computer users have been using these devices for four years or more, while tablet users were using for less than one year. Most of the participants in our study were daily users of digital devices for upto three hours. Among the vast number of computer users, the duration of daily usage was found to be less than one hour and most tablets users were using less than two hours daily. The majority of digital device users agreed about using these devices continuously for more than thirty minutes without changing position. This emphasizes the maintenance of prolonged static postures and their association with digital devices.

The symptoms as reported by our study participants revealed that most of them had pain in the evening and night indicating these symptoms could be mechanical in origin and nature. The majority of the individuals presume the cause for pain or discomfort among the users was due to gadget usage but the contributing tissue mechanics and ergonomics was not considered.

Our study also found correlation between the duration of smartphone usage and neck pain. Subjects using a smartphone for more than four years had pain or discomfort in the neck. It shows that longer duration of smartphone usage results in increased frequency of symptoms in the neck. There is a significant association found with the duration of smartphone usage with upper back pain and lower back pain. Those who were using smartphones for four hours or more daily had a higher frequency of neck pain as compared to the ones who used less than one hour daily. There was a significant association found with the average time spent on smartphones per day and upper back pain and lower back pain. There was a significant association found with the duration of continuous smartphone usage without position change with lower back and shoulder pain. Respondents using smartphone continuously for two to three hours without changing position showed five or more times more frequent occurrence of lower back or shoulder pain. This suggests that the longer periods of uninterrupted usage of smartphones without changing positions resulted in higher occurrence of symptoms.

A significant association was found with the duration of computer usage continuously without changing position and upper back and shoulder pain. Computer users who were using the computer continuously for two to three hours without changing positions had about five times more upper back and shoulder pain compared to the ones who didn't indulge in such long hours of computer usage. This depicts that longer the duration of computer usage

without changing position, more the frequency of upper back and shoulder pain. The duration of computer usage on a daily basis of approximately two hours or more may be a risk factor for shoulder and neck pain and usage of more than 5 hours per day is associated with low back pain as well. This study further adds to the knowledge regarding the frequency of symptoms and usage duration which indicates the correlation of higher daily usage hours with more frequency of symptoms. A significant association with the duration of tablet usage without changing position and arm pain was also established. This indicated that prolonged holding of tablets might cause arm pain due to its increased weight when compared with smartphones. Ge HY and colleagues [23] stated that the computer users with higher pain intensity and lower pressure pain threshold revealed decreased efficiency in descending pain modulation leading to shoulder and upper back pain.

Shin HH [24] conducted an experimental study on healthy smartphone users to measure the cervical Flexion Relaxation Ratio (FRR) and neck pain intensity in cervical erector spinae muscle and identify the differences according to the postural adaptations. They measured this after participants used smartphones for 15 minutes on the desk as well as on the lap. The Flexion Relaxation Phenomenon (FRP) refers to a reduced or sudden onset of myoelectric silence in the erector spinae muscles during full trunk flexion which means that a transfer of extension movement from the active muscular structures to passive structures of the spinal column. FRR has already proven to be a key marker of neuromuscular impairment. People in pain were found to have reduced FRRs possibly as a result of altered neural reflexes that activate the cervical erector spinae muscles during sustained full cervical flexion to protect the spine from secondary injury. They suggested that FRR may be an important criterion of neuromuscular impairment in chronic pain patients and they suggested need of future studies in symptomatic individuals. In this study, complaints of neck pain among smartphone users could be due to low FRRs in cervical erector spinae muscle.

A previous study stated that, young adults with mild neck pain were more mindful about keeping their neck in a neutral posture as compared to non-symptomatic smartphone users. This could be due to altered motor control of neck muscles.[15] Another study stated that the position while holding a phone can influence the neck-flexion angle and elbow-flexion angle and unilateral holding (right hand) of the phone may cause increase in right upper trapezius activity.[24] This could be a contributing factor for upper back and neck pain while using smartphones in this study. A study by Gon KY et al. suggested that long duration of smartphone usage can induce changes in cervical and lumbar spine posture and proprioception in the cervical spine. [12] Their findings supported our study result given the significant association found with the duration of the smartphone usage and neck, upper back and lower back pain. McKenzie proposed mechanical diagnosis and therapy for musculoskeletal pain in which he classified the pain into 3 categories and where postural syndrome is the result of prolonged positions or

postures that can affect muscles, tendons, or joint surfaces. Dysfunction may be intermittent or chronic, but it is associated with a consistent movement loss and pain at the end range of motion. [25] When the patient moves away from the end range their pain decreases. [26] The postural syndrome and dysfunction syndrome might be the cause of a significant correlation with prolonged duration of a constant position and computer or smartphone or tablet usage.

This study had a few limitations too. Although the frequency of occurrence of musculoskeletal symptoms was correlated with the frequency of usage, other variables like physical exercises, mental stress, depression and study habits which can have an impact on the frequency of musculoskeletal symptoms were not considered. The questionnaire used in the study was tested only for content validity thereby making an essential requirement of future studies to evaluate other psychometric properties like reliability and criterion validity of the questionnaire and emphasize the ergonomic aspect of these digital devices usage. In the present study, posture analysis was not objectively measured which would be an important aspect as most of the participants were exam going students. Since the questionnaire was distributed during student's academic time frame, a stretch of 2 to 3 weeks was given to complete the questionnaire. This might have led to response bias too, where the study could have created an awareness about how being physically active is more important than gadget bound life among college students. Further studies can be performed with the inclusion of ergonomic analysis, video analysis and electromyography analysis. Studies with more enhanced study designs, including wider age groups and accounting for homogeneity of population and gender can also be considered in the future.

V. CONCLUSION

This preliminary study describes the impact of digital devices (computers, smartphones and tablets) usage and its association with early occurrence of musculoskeletal symptoms in young Indian adults. Most of the digital device users had experienced pain or discomfort in the neck, upper back, lower back and shoulder which could be due to the daily prolonged usage of these digital devices. This highlighted the association of longer usage of digital devices and increased neck, upper and lower back pain frequency. Since most of the study subjects used at least one digital device, it is essential to study the ergonomics of digital devices usage in future with necessary precautions and preventive measures to decrease the prevalence of musculoskeletal symptoms like pain or discomfort in people using these devices.

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• **Conflict of Interest:** All the authors state no conflict of interest.

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