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ORIGINAL ARTICLE

Evaluation of Subjective Visual Vertical and Cervical Neuromotor Control in Young Nomophobians: A Cross Sectional Study

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Abstract
Misperceptions of subjective visual vertical are associated with poor balance, increasing the risk of falls and accidents. The aim of the present study was to evaluate the effect of nomophobia on verticality perception using subjective visual vertical (S.V.V.) test and cervical neuromotor control of the deep neck flexors (DNF) in adults aged 18–29 years old. This cross-sectional study employed convenience sampling and was conducted at a tertiary health institute over an eight-month period.After obtaining the written informed consent, 102 participants were asked to fill the Nomophobia Questionnaire (NMP-Q) and based on the responses participants were stratified into mild (n1 = 34), moderate(n2 = 34), and severe(n3 = 34) nomophobian group. Each nomophobian group underwent testing for verticality perception by using the SVV test and cervical neuromotor control. 102 healthy age and gender matched controls were recruited and underwent testing for verticality perception by using the SVV test and cervical neuromotor control. The mean age of the study participants was 22 ± 3.15 years with 35(33.98%) males and 67(65.04%) females. There was a statistically significant difference between the median scores across the three nomophobian groups with S.V.V. ($p = 0.005$), activation score ($p = 0.012$), and endurance score ($p = 0.000$) of the deep neck flexors in the severe nomophobia group. This study demonstrated that SVV and cervical neuromotor control was predominantly affected in the severe nomophobian group.

Keywords Smartphone · Vertiginous symptoms · Posture · Spatial disorientation · Vestibular system · Neck pain.

Introduction

The irrational use of smartphone and its highly addictive nature has given rise to a new pathology known as Nomophobia. The term Nomophobia or NO Mobile Phone Phobia is a fear of being detached from mobile phone connectivity, thereby leading to problematic phone use, and inability of the person to stay without their smartphone [1]. Perception of verticality, one of the primary functions of the vestibular system, is extremely important in maintaining an upright stance, body posture and balance [2].

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The subjective visual vertical (SVV) is one such test, which tests the ability of a person to perceive the gravitational vertical. A tilt in SVV is the most prominent indication of vestibular imbalance in the roll plane, caused by injuries to the utricle or its connecting nerves [3]. Physiological stressors such as constant head down attention to the small screen of a smartphone, prolonged forward head & neck down postures, spatial mal-positioning of head can lead to gravitational insecurity, vertiginous symptoms, ultimately leading to spatial disorientation. Misperceptions of subjective visual vertical are associated with poor balance, increasing the risk for falls and accidents.

Excessive smartphone use is associated with forward head posture that impairs the craniovertebral [4] and leads to altered biomechanics of neck musculature leading to neck related disorders [5] such as altered proprioception, delayed feedforward mechanism leading to impaired neuromotor control due to impaired activation of the deep cervical flexor muscles [6]. Evidence [5, 7] has already stated the impact of smartphone use on cognitive abilities, mental

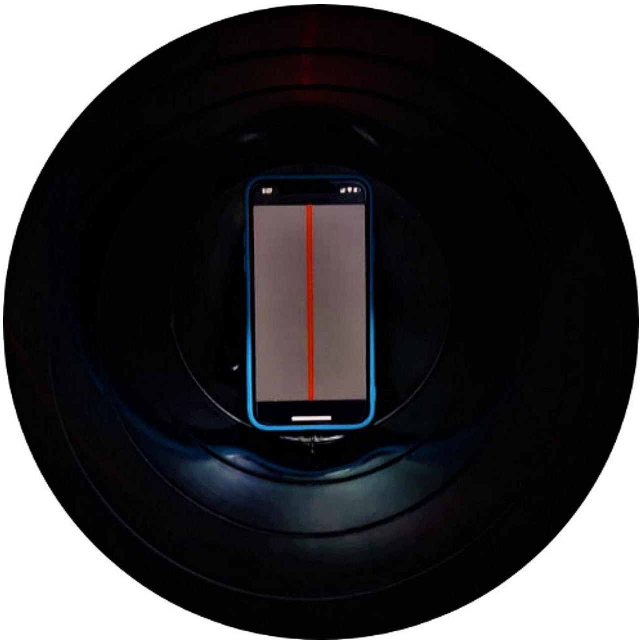

Fig. 1 – The iOS Smartphone (i10 iOS version 14.4.2) with the Visual Vertical Lite (version 2.2) was secured on the inferior base of the bucket, displaying a vertical line

Fig. 2 The participants were asked to focus on the line displayed on the screen on the inside of the bucket

health, musculoskeletal system, respiratory function, visual and auditory systems, etc.

However, there is a paucity of literature on the direct impact of the irrational use of smartphones and their possible detrimental effects on verticality perception and deep neck flexors. Thus, widespread awareness of the irrational use of smartphones and education on immediate or long-term consequences on health and well-being may promote more controlled use and prevent impairments related to the vestibular and musculoskeletal system even before its onset [8]. The present study provides a cost-effective assessment method to screen individuals for impairments of the vestibular system and to help with early diagnosis and prevention.

Materials and Methods

This cross-sectional study employed convenience sampling and was conducted over an eight-month period in the Department of Neurophysiotherapy at a tertiary health institute. The sample size was calculated using the sample size formula for the estimation of proportion [9, 10]. $N = Z2P (1-P) / d2$, where N = minimum sample size, Z = normal standard deviation at 95% confidence interval = 1.96, P = proportion of nomophobia in previous literature [11] was 40%, and d = degree of precision = 5%. This formula provided the minimum sample size of 102 participants. After obtaining approval from the Institutional Research Committee (MGM/COP/IRRC/38/2021), 102 participants in the age group of 18–29 years who consented to participate were recruited. Participants were excluded if they had a history of vestibular pathology, recent cervical spine injury, or neurological/neuro-otological/neuro-ophthalmological disorders. Informed consent was obtained, and demographic data were recorded.

The NMP-Q was administered, and based on responses the participants were stratified into mild(n1 = 34), moderate(n2 = 34), and severe(n3 = 34) nomophobian groups. Verticality perception was assessed in each group using the SVV test and cervical neuromotor control. Assessment of SVV was assessed by asking the participants to assume an erect sitting position and look inside the bucket with the visual field covered by the rim of the bucket. The iOS smartphone (i10 iOS version 14.4.2) with Visual Vertical Lite (version 2.2) was secured on the inferior base of the bucket, displaying a vertical line(Fig. 1). The participants were asked to focus on the line displayed on the screen inside the bucket(Fig. 2). The examiner rotated the bucket clockwise and anticlockwise to various end positions, followed by asking the participant to align the line back to the gravitational vertical according to their estimation [3]. The participants were given 10 s timer to align the line back to the vertical and hold the bucket in place until the timer stopped. On completion of the timer, the participants clicked on the option to show the results. The app displayed the SVV tilt of the participants in degrees. One trial was conducted, after which the mean of three readings was taken as the result.

Assessment of Cervical Neuromotor Control was done where participants assumed a supine crook-lying position, with the neck in a neutral position. The participants demonstrated the correct way of performing the action of the muscles by the examiner, and the movement was performed gently and slowly as a head-nodding action (as if saying "yes" against the BP cuff). The inflated pressure cuff was placed behind the neck and inflated to a stable baseline pressure of 20 mmHg [6]. Patients were instructed to nod and increase pressure on the cuff so that the pressure on the aneroid gauge of the sphygmomanometer increased to 22 mmHg and held steady for 10 s. If the patient could successfully hold the position with minimal superficial muscle activity, he/she was asked to relax and repeat the flexion, which increased the pressure to 24 mm Hg. The same was repeated for incremental activation up to 30 mmHg (total 10 mmHg increase). This test was used to interpret the activation and performance indices of the deep neck flexors. The activation score refers to the highest pressure level that the subject can achieve and hold for a duration of 10 s, and the performance index refers to the number of times the subject can maintain the pressure level achieved in the activation out of a maximum of 10 repetitions [12].

Statistical Analysis

Data were coded, tabulated, and analyzed using the Statistical Package for the Social Sciences (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp). Descriptive statistics are expressed as mean ± standard deviation (SD), and percentages are shown in Tables 1 and 2. Normality of the distributed variables was investigated using visual (histograms and probability plots) and analytical methods (Shapiro-Wilk test). The data were expressed as the frequency (%) for nominal and categorical variables, median (interquartile range) determined using the Shapiro Wiki Test, and since the data were not normally distributed, non-parametric Kruskal Wallis test was used for comparison of the variables across the three nomophobian groups, and pairwise comparisons were performed using Post HOC analysis (Tables 3 and 4).

Results

A total of 102 participants with nomophobia with a mean age of 22 ± 3.15 and 35 males and 67 females were included in the study and 102 healthy age and gender matched controls were recruited (Tables 1 and 2). For SVV, there was a statistically significant difference between the median values across the groups ($p = 0.005$). The median SVV values suggested that verticality perception was better in the mild nomophobian group. For the CCFT activation score, there was a statistically significant difference between the three groups, with a p-value of 0.012(< 0.05).

Table 1 Age of Study Participants

Age (years) $N = 102$	Mean (SD)
18–29	22 ± 3.15

Table 2 Gender of Study Participants

Gender ($N = 102$)	n	%
Male	35	33.98%
Female	67	65.04%

The median values suggest that the activation score of DNFs was better in the mild and moderate groups than in the severe group and for CCFT endurance, and there was a statistically significant difference between the three groups with a p-value of 0.000(< 0.05).

The median values suggest that endurance of DNFs is the most affected in the severe group, followed by the moderate and mild groups.

The mean rank of SVV in severe nomophobia group was highest indicating greatest affection in verticality perception, concurrently low mean ranks in CCFT activation score and endurance were equally affected in sever nomophobia group.

Discussion

This study aimed to evaluate the influence of nomophobia on subjective visual vertical and the activation and endurance of the deep neck flexors in young adults aged 18–29 years old. SVV scores were most affected in the severe Nomophobian group (mean rank = 60.71), that is, the severe Nomophobian group had the highest degree of verticality tilt. According to Lee D (2019) & Chin S (2018) continued visual fatigue due to smartphone use has a negative effect on visual feedback processing that integrates the vestibular organ system with the somatosensory network [13, 14]. Excessive and sustained near-point fixation causes a reflex adaptation accommodative triad (accommodation in both eyes, pupillary constriction, and convergence of the eyes). Hence, prolonged pupil contraction and ischemic strain and signaling errors between the ocular, vestibular, and proprioceptive systems lead to sensory conflicts. According to Maitreyi(2017) the perception of verticality requires the integration of visual, vestibular, and somatosensory cues [15]. Hence, any disruption between these systems may affect the ability of an individual to perceive an appropriate vertical gravitational force.

A study carried out by Zhuang (2021) concluded that excessive smartphone use may be associated with cervical disc degeneration and may lead to cervical spondylosis [16]. Abnormal neck proprioceptive input integrated from the signals of Ruffin corpuscles in diseased cervical discs

Table 3 Comparison of parameters between healthy controls and three nomophobian groups using Kruskal Wallis test

Component	Healthy controls		Mild ($n=34$)		Moderate ($n=34$)		Severe ($n=34$)		p value
TESTS	Median	IQR	Median	IQR	Median	IQR	Median	IQR	(sig)
SVV (degrees)	0.5	0.0–1.0	1.1	0.75–1.32	1.69	0.772.32	1.65	0.92–2.58	0.005
CCFT Activation Score (mm of Hg)	15	12-18.5	6	5.5–8	6	4–6.5	4	4–6	0.012
CCFT Endurance	55	52.5–59.8	42	36–54.5	33	19.5–48	24	15–34	0.000
Test	**Pair wise comparison across nomophobian groups**		**Adjusted Significance**		**Mean Rank**				
SVV	Mild-Moderate		0.050		SVV mild group			38.31	
	Mild-Severe		0.005		SVV moderate group			55.49	
	Moderate-Severe		1.000		SVV severe group			60.71	
CCFT activation score	Mild-Moderate		0.328		CCFT activation score mild group			61.51	
	Mild-Severe		0.009		CCFT activation score moderate group			52	
	Moderate-Severe		0.500		CCFT activation score severe group			40	
CCFT endurance	Mild-Moderate		0.034		CCFT endurance mild group			66.47	
	Mild-Severe		0.000		CCFT endurance moderate group			53.09	
	Moderate-Severe		0.184		CCFT endurance severe group			34.94	

SVV: Subjective Visual Vertical, CCFT: Cranio-Cervical Flexion Test

Table 4 Pairwise Comparisons using post HOC analysis across nomophobian groups

Test	Pair wise comparison across nomophobian groups	Adjusted Significance	Mean Rank	
SVV	Mild-Moderate	0.050	SVV mild group	38.31
	Mild-Severe	0.005	SVV moderate group	55.49
	Moderate-Severe	1.000	SVV severe group	60.71
CCFT activation score	Mild-Moderate	0.328	CCFT activation score mild group	61.51
	Mild-Severe	0.009	CCFT activation score moderate group	52
	Moderate-Severe	0.500	CCFT activation score severe group	40
CCFT endurance	Mild-Moderate	0.034	CCFT endurance mild group	66.47
	Mild-Severe	0.000	CCFT endurance moderate group	53.09
	Moderate-Severe	0.184	CCFT endurance severe group	34.94

The mean rank of SVV in severe nomophobia group was highest indicating greatest affection in verticality perception, concurrently low mean ranks in CCFT activation score and endurance were equally affected in sever nomophobia group

and muscle spindles in tense neck muscles due to neck pain is transmitted to the central nervous system, which leads to a sensory mismatch between vestibular and other sensory information, resulting in a subjective feeling of vertigo and unsteadiness. This ingrowth of many Ruffini corpuscles into the diseased cervical discs may be related to vertigo of cervical origin. Because of strong connections between the cervical dorsal roots and vestibular nuclei through the neck proprioceptors, it is understandable that the pathology of degenerative cervical discs may be associated with a sense of vertigo or disequilibrium (Peng 2018). In addition, poor posture and spatial mal-positioning of the head during long-term smartphone use could be contributing factors [12].

In our study, a statistically significant difference was observed among the three groups in terms of activation

($p = 0.012$) and endurance (p value-0.000) of DNFs. Flexing of the neck is the most common and regular posture adopted by mobile phone users. The length of time devoted to smartphone usage and adopting flexed neck postures may cause pain and discomfort in the neck region in the long term. Smaller screens might cause more forward bending of the neck, thereby reducing the distance between the screen and the user's eyes. A compensatory forward neck bending may be occasioned with increased neck muscle activity, which might have affected the endurance of the deep neck flexors in the smartphone-addicted group [17].

According to Eitivipart et al., (2018) neck flexion angle, head tilt angle, and forward head shifting increased during smartphone use and increased with the duration of smartphone use [18]. Forward head posture places the deep cervical flexor muscle in a lengthened position, creating a mechanical disadvantage and contributing to decreased muscle performance, leading to reduced activation and endurance of the deep neck flexors [19].

In addition, the weight supported by the spine increases proportionally when the head flexes forward to varying degrees. Therefore, heavy smartphone users lose the natural curve of the cervical spine and instead place increased stress on the cervical spine. Smartphone use is also closely related to increased fatigue of the neck and arm muscles and musculoskeletal problems [20]. According to a previous study by Kenneth et al. [21], when flexing the head forward at varying degrees, the forces experienced by the cervical spine considerably increase and lead to cervical curve loss, which may cause neck pain (Hansraj 2014). This suggest that poor cervical postures keep the deep cervical short flexors in a biomechanically disadvantageous position, which lead to lesser endurance in them [22, 23].

Since the present study was cross-sectional in nature, the data presented are the result of a one-time assessment with no follow-ups of the study participants. Future studies should consider keeping the findings of this study as a baseline to explore the trends in vestibular symptoms caused by excessive smartphone use and early screening for such impairments.

In conclusion, this study demonstrated that the severe nomophobia group had the highest effect on parameters such as subjective visual vertical, activation, and endurance of the deep neck flexors.

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Author Contributions The author(s) read and approved the final manuscript.

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Data Availability The dataset used or analyzed during the current study will be available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate This cross-sectional study was conducted in an institute-based rehabilitation centre and included healthy older adult participants. Approval of the Institutional Ethical Committee (IEC) was obtained before the commencement of the study (MGM/COP/IRRC/38/2021). Informed consent was obtained from all the participants who agreed to participate.

Competing Interests The authors declare no competing interests.

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