Near induced transient myopia parameters with mobile use compared to printed text among school children

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Research Article

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Posted Date: March 16th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1208027/v1

ORIGINAL RESEARCH

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Near induced transient myopia parameters with mobile use compared to printed text among school children

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ABSTRACT

Background:

Hyperopic blur due to temporary myopic shift after sustained near activity due to near induced transient myopia act as a cue for myopia progression. The study aimed at comparing near induced transient myopia parameters after reading with smartphone and print material among children.

Method:

Children (8-13years) with only refractive error were enrolled into the study. All subjects underwent initial comprehensive eye examination. Pre-task refractive error was measured using Grand Seiko WAM 5500 following a 5-minutes dark adaptation. The subjects were then asked to read a text equivalent to N8 text size at 20 cm on mobile phone for 5 minutes. Immediately after reading, the subject's post-task distance refractive error was measured for 2 minutes. The procedure was repeated with print reading material.

Result:

Total of 13 myopes and 13 emmetropes were enrolled. The average NITM magnitude after mobile and print reading for myopes was 0.16 D and 0.20 D respectively. Emmetropes showed a hyperopic shift of 0.11 D and 0.05 D after mobile and print reading respectively. Analysis of variance revealed a statistically significant difference in NITM magnitude between myopes and emmetropes with mobile ($F(1)=99.660;p<0.001$) and print ($F(1)=102.206;p<0.001$) usage. Decay time was less after reading with print material when compared to reading with mobile which was statistically significant ($Z=-3.18;p=0.01$).

Conclusion

Longer dissipation time was noted after reading with mobile when compared to reading a print text. Given the additive nature of NITM, long hours of near work with mobile phone could pose a greater risk of myopia progression.

Keywords: Near Induced Transient Myopia (NITM), Myopia, Risk factor, Near work.

Introduction

Myopia is considered as a major global burden of eye disease due to its high prevalence especially in East Asian countries [1,2]. In 2019, prevalence of myopia was 21.1% in Indian children of 5-15 years of age [3]. Near work is one of the major environmental factors that contribute to increased myopia prevalence and progression [3], and one of the proposed theories that link near vision with myopia development is Near-work Induced Transient Myopia (NITM). NITM is a transient increase in eye's refractive power towards myopic side after a period of intense near work [4]. NITM occurs due to resultant hyperopic blur from delayed sympathetic response (inability of crystalline lens to reduce its dioptric power for distance viewing after near work), which serves as a cue for myopia progression [6,7,8]. Magnitude and decay time of NITM are used to assess the accommodative aftereffect for a period of sustained near work [5]. NITM in myopes is shown to present with increased magnitude and delayed decay time [4,6,9]. NITM showed additive characteristics with increasing duration of target presentation, while it did not depend on target characteristics i.e., size, contrast and illumination, cognitive demand [4,10].
Lin et al in 2013 found that NITM did not show any association with parental refractive error and it could be purely environmental with no role of parental refractive error emphasizing the role of increased near activity and other environmental characteristics in myopia progression [11]. 87% of world's student population from 160 different countries have shifted school learning to online modes during COVID lockdown [12]. This has resulted in reduced outdoor activity and increased near activity especially the use of smartphone and other digital devices [12]. Increase in myopia prevalence especially in young children have been noted post COVID lockdown with the term of quarantine myopia gaining prominence [7,8]. Sañudo B et al in Spain noticed increased smart phone usage during COVID-19 lockdown in young adults [13]. Mccrann et al found students (myopes and emmetropes) spent an average of four-hours and 32 ± 169-minutes per day on their phone [7]. Myopic students used double the amount of smartphone data at 1,130.71 ± 1,748.14-MB per day compared to non-myopes at 613.63 ± 902.15-MB ($p = 0.001$) [7]. To the best of our knowledge there is a paucity of literature regarding the change in NITM parameters after near work with mobile phone and its role in increasing myopia prevalence. This study aimed to compare NITM magnitude and decay when children read through mobile device and conventional print material and if there was any difference in the NITM parameters between the two activities. This study also quantified near work with the use of clou clip which is an infrared based wearable device to quantify the amount of near work, working distance and illumination level. The device has been shown to be accurate with good repeatability [14].

METHODS

Sample size calculation

9 subjects were needed in each group for confidence level of 95% for a mean difference of 0.34D and standard deviation of 0.22D [4]. Therefore, a minimum of 18 subjects were required.

Study participants

Young children of age group 8 to 13 years were considered for this study. Subjects were included with spherical equivalence of between -0.75D to -4.00D in both eyes for the category of myopia and spherical equivalence of between 0.50D to -0.50D in both eyes for the category of emmetropia.

Astigmatism greater than 1.50D, presence of any strabismic and non-strabismic binocular vision disorders and presence of any ocular diseases were excluded. The study adhered to tenets of the Declaration of Helsinki, and a written informed consent was obtained from parents of all participants with an oral consent from the participating subject. IRB and ethics approval was obtained from Medical Research Foundation.

Comprehensive evaluation

Twenty-nine subjects after obtaining oral consent, underwent a full comprehensive eye examination which included visual acuity measurement with Log MAR chart, objective and subjective refraction to ascertain the refractive error of subjects, slit lamp evaluation for anterior segment assessment, Intra-ocular pressure assessment and fundus imaging to rule out any posterior segment abnormalities using a non-mydriatic fundus camera. A comprehensive binocular vision assessment was also done to rule out the presence of any strabismic or non-strabismic binocular vision anomaly. The test battery included assessment of near stereopsis using Randot (Random-dot- stereogram), Near Point of Accommodation (NPA) using push-up method to determine amplitude of accommodation, Near Point of Convergence (NPC) test to determine maximum amplitude of convergence, Cover test and alternate cover test for phoria and tropia measurement, Muscle Imbalance Method (MIM) for quantitative phoria measurement, Monocular Estimation Method (MEM) to determine accommodative response for a given near stimuli and Accommodative facility to determine the ability of accommodative system to make rapid change when stimulated and relaxed. The normative values of binocular vision parameters were considered from BAND study [15]. 26 subjects who met the inclusion and exclusion criteria after comprehensive evaluation were enrolled into the study.

NITM measurement

Grand Seiko WAM 5500, an infrared based open field auto-refractor was used to measure NITM, based on the proposed method of Borsting et al [16].

All subjects were dark-adapted for 5 min before the start of NITM measurement. Baseline refractive error was measured for continuous 60 seconds, while subjects viewed the 6/60 line on a Snellen chart at 6 m distance. Subjects were then instructed to read a paragraph from mobile phone (Screen size: 6.41 inches, Resolution: 1080x2340 pixels) for 5 minutes at a viewing distance of 20 cm. The text was printed in Arial font and size comparable to N8. The subjects were instructed to keep the text in focus and read out loud as much as possible. Immediately after the reading task was completed, refractive error in the accommodative posture was measured for 2 minutes, while subjects viewed the 6/60 line on a Snellen chart at 6 m. This represented the post task distance refraction. The difference between the pre and post task distance refraction was noted to be the magnitude of NITM. The test was repeated again after a break of 30 minutes with a print material of size comparable to N8 for 5 minutes at 20cm. NITM magnitude and decay time was measured as before.

Near work quantification:

Clou clip was fitted to the subject's frame temple and provided to the subject after initialisation for 48 hours. Emmetropic subjects were made to wear a plano glass to fit the clou clip for 2 days. Data were synced and extracted from clou clip by means of clou clip medical app. Information regarding mean daily hours of near work (<60cm) and average daily near work distance was gathered. Only continuous working distance measurements in the range of 10 to 60 cm were considered as near work.

Statistical analysis

The 10 second bin magnitude of NITM was calculated as the difference between the first 10 second bin and the baseline refractive error (averaged over the first 10 second interval). The 2 second bin magnitude is the difference between the first 2 second bin and the baseline refractive error (averaged over the first 2 second interval) as described above. Exponential fit was used to calculate the decay time constant for the post task accommodative response measurement.

Initial magnitude and decay time was calculated for each subject and for each target. Analysis of variance was used to compare the magnitude of NITM between myopes and emmetropes and between NITM magnitude after mobile and print reading. Paired T test was used to compare NITM parameters between mobile and print task.

Mann-Whitney U test was used to assess the difference in the amount of near work between myopes and emmetropes. Statistical analysis was done using SPSS version 20 (SPSS Inc., Chicago, Illinois, USA)

RESULTS

26 children (13 myopes and 13 emmetropes) met the inclusion and exclusion criteria and were enrolled into the study. The mean age of myopes was 11 ± 0.48 years, and that of emmetropes was 9.75± 1.82 years. There was no significant difference between gender of both refractive groups by means of chi-square test (p=0.41). The mean spherical equivalent in the emmetropic group was 0.25± 0.31D and -2.50 ± 0.31D in the myopic group. Parental refractive error was assessed, 30.77% of myopes had one or both parents myopic while 9.09% of emmetropes had at least one myopic parent

NITM magnitude:

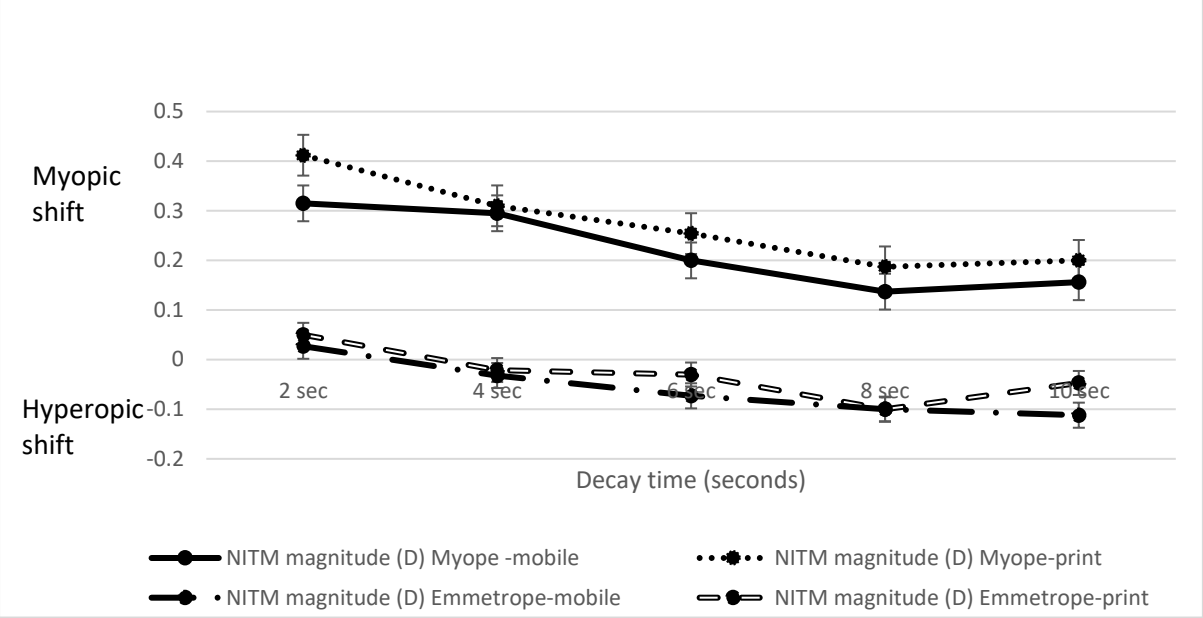
Initial NITM magnitudes for both refractive groups with mobile phone and print are shown in 'Table I' and variations in post-task NITM between mobile and print are plotted in 'Figure I'.

Table I: NITM Magnitude of Myopes and Emmetropes

		Myopes	Emmetropes	P value*
Mobile	NITM Magnitude-2 second bin (D)	0.32±0.07	0.03±0.12	<0.001
	NITM Magnitude-10 second bin (D)	0.16±0.03	-0.11±0.06	<0.001
Print	NITM Magnitude-2 second bin (D)	0.41±0.07	0.05±0.10	<0.001
	NITM Magnitude-10 second bin (D)	0.20±0.01	-0.05±0.10	<0.001

NITM: Near Induced Transient Myopia, D: Diopter * Two-way ANOVA performed revealed a statistically significant difference between myopes and emmetropic NITM magnitude, between print and mobile and between interaction of groups. A positive value indicates a myopic shift in refractive error.

Figure 1: Post task shift in refractive error of Myopes and Emmetropes



Post task shift in refractive error (D) for emmetropes and myopes after 5 minutes of mobile reading and print reading.A positive value indicates a myopic shift in refractive error. Error bar indicate ±1SEM

Myopes exhibited a myopic shift at 10 second bin while emmetropes showed a hyperopic shift. Analysis of variance revealed a statistically significant difference in NITM magnitude between myopes and emmetropes with mobile ($F(1) = 164.706$; $p<0.001$) and print ($F(1) = 102.577$; $p<0.001$) usage. Paired t test showed a statistically significant difference in NITM magnitude ($t(12) = 2.271$; $p<0.032$) between near task with mobile and print.

Decay time:

The average decay time for myopes after reading with mobile phone and print was 8.55 seconds and 6.34 seconds respectively and this difference was statistically significant (Wilcoxon test $Z= -4.292$; $p<0.001$). The decay time for emmetropes was not calculated since they showed a hyperopic shift at 10 second bin

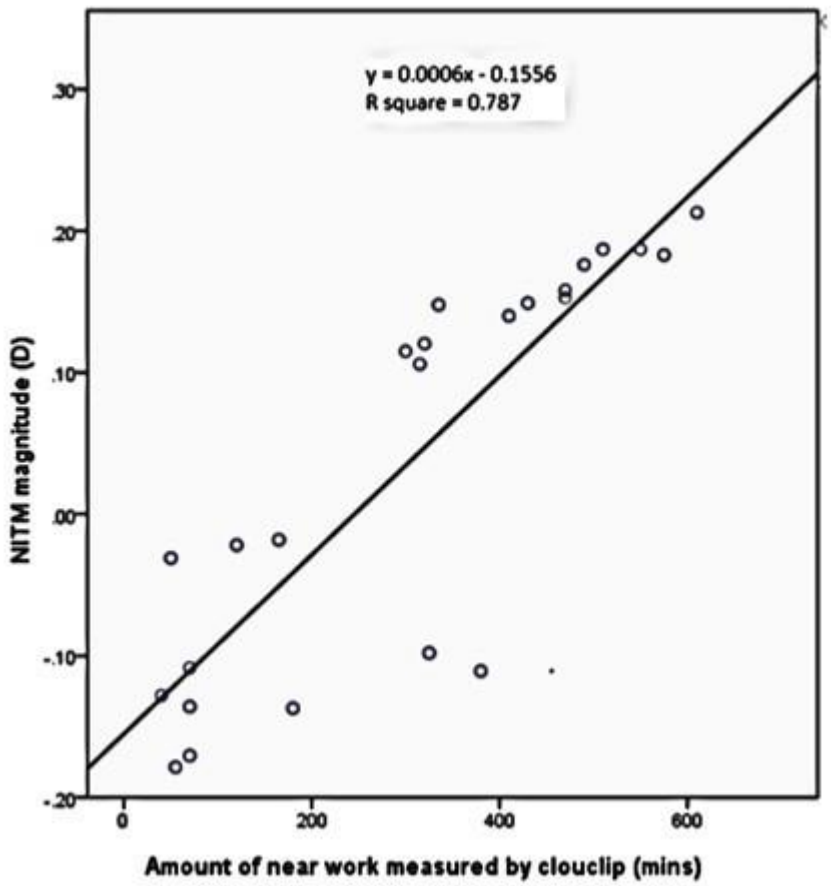
Accommodative response and NITM magnitude:

Accommodative response for near was measured with Grand Seiko open field auto-refractor (WAM5500). The mean accommodative response at 20cm of myopes and emmetropes was +0.91 ± 0.26 D and +0.63 ± 0.25 D respectively. Pearson correlation between accommodative response and NITM 10' second bin magnitude showed that there was a greater myopic shift after near work in subjects with increased lag of accommodation ($r= -0.656$; $p=0.01$). Analysis of Variance was carried out to note if there is a significant difference between the accommodative response of myopes and emmetropes. Myopes showed a larger lag of accommodation when compared to emmetropes ($F=36.304$; $p<0.001$).

Near work and NITM magnitude:

A continuous measurement of working distance in the range of 10-60 cm, for a minimum of 5 minutes was clubbed together for two-day data period and near work was estimated. The clou clip data of one emmetropic subject was not considered due to unreliable response. The average near work time for 13 myopes and 12 emmetropes was 445±190 minutes and 150±185 minutes respectively. Mann-Whitney U test showed statistically significant difference in the amount of near work performed between myopes and emmetropes (U=7; p<0.001). Spearman's correlation revealed a positive correlation between amount of near work performed and NITM magnitude (r=-0.796, p<0.001) *(*Figure II).

Figure II: Amount of near activity vs NITM magnitude



NITM- Near Induced Transient Myopia, D- Diopter

DISCUSSION

In this study, reading with mobile phone takes longer time to dissipate the myopic shift after intense near work when compared to reading with print material. NITM magnitude after print and mobile reading showed statistical significance with higher magnitude noted after near activity with print material. Given the additive

nature of NITM [17], longer decay time after mobile usage could pose a greater risk for myopia development and progression.

Over the years, several studies have investigated the association of near work as an important factor in myopia development. Saw et al observed 210 Chinese children and noted myopic children to have greater amount of near work when compared to non-myopes [18]. The Singapore Cohort Study of the Risk Factors for Myopia (SCORM) reported that those who read more than two books in a week tend to have higher risk of myopia development (OR = 3.05; 95% CI = 1.80–5.18) [19]. The Sydney Myopia Study (SMS) reported close working distance (<30 cm) and continuous near work (> 30 minutes) were the factors which increased the odds of myopia prevalence by 2.5 times [20]. Among 681, 5-13-year-old Chinese children, Guo et al also demonstrated that myopes who spend more time indoor have 38% higher odds of having myopia after adjusting for age and maternal myopia [21]. A recent study among 161 Israel Jewish community people, reported an association of myopia progression with prolonged reading in 30% of population and with increased exposure to screen use in 66% of population, thus establishing the role of digital device in increased myopia prevalence [22].

Vera-Diaz et al. reported increased NITM magnitude and prolonged decay time were involved in progression of myopia and also emphasized that NITM parameters were high in subjects who indulge in more near work [23]. Abbott et al suggested that the lag of accommodation occurs during myopia progression, thus establishing NITM to be a key factor of near work and myopia progression [24]. NITM might be an effect of myopia, and this temporary retinal defocus, leading to axial elongation, thereby causing low degrees of axial permanent myopia and/or myopic progression [25].

In 2015, Sivaraman et al studied NITM parameters in Indian Children and reported a magnitude of 0.22±0.27D in myopes and slightly hyperopic shift of -0.08±0.05D in emmetropes for 5 minutes of near work. In this study, the magnitude of NITM was higher in myopes compared to emmetropes (0.30 ± 0.03D) consistent with previous literatures [4,24,25].NITM magnitude was greater after reading with print material when compared to mobile phones and this could be due to the differences in the illumination level of mobile and print task. Yang S et al in 2017 reported an increased lag in accommodation with low level of illumination justifying the greater myopic shift after print reading [26].

Decay time after prolonged near work in Indian subjects was less compared to other Caucasian population [4]. In this study, the decay time was prolonged after mobile reading task compared to print. Okada et al in 2013, reported discrepancy between the values of accommodation and convergence while viewing a well illuminated object. This discrepancy was due to the increased depth of field as a result of miotic pupil (therefore,

accommodation focused beyond convergence) [27]. The increased and focused illumination from mobile phone could have led to inaccuracy in accommodative and convergence system causing sluggish response of sympathetic system [27]. But one needs to further understand when involving in repeated cycle of mobile reading, whether residual NITM due to prolonged decay time adds up to cause progression of permanent myopia?

The difference in NITM parameters between print and mobile phone reading was against the findings of Liang et al where there was no statistically significant difference in NITM parameters after near work with mobile phone and print material [28], this could be due to the difference in the sample selection of both these studies and the fact that Liang et al study was more focused with respect to the change in the magnitude of NITM between near task with mobile phone and print rather than decay time. Myopes who had greater near work based on the objective measurement by clou clip displayed higher NITM magnitude which was consistent with previous studies [4,29,30]. Myopes exhibited larger lag in accommodation, this may be due to the increased depth of focus or due to inaccuracy of accommodation in myopes [31].

Classification of myopes into progressive and stable myopes was not done in this study. Randomization of target presentation in future studies is recommended. The level of outdoor activity from clouclip data was not calculated as all children were confined to home due to COVID-19 restrictions. Since all the participants were children, their accommodative fluctuation could have been more when compared to adult population [32].

CONCLUSION

NITM decay time exhibited longer dissipation after reading with mobile when compared to reading a print text. Given the additive nature of NITM, long hours of near work with mobile phone could pose a greater risk of myopia progression.

Disclosure

The authors report no conflicts of interest for this work and wish to confirm that there are no known conflicts of interest associated with this publication. There has been no significant financial support for this work that could have influenced its outcome.

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