**Nearwork-Induced Transient Myopia in Indian subjects**

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**Abstract**

Purpose: To determine the characteristics of nearwork-induced transient myopia (NITM) in asymptomatic Indian subjectsand the influence of target size and contrast.

Methods: Two studies were conducted: (1) 24 myopes and 24 emmetropes viewed 4 targets (N8 and N12 with 50% and 90% contrasts) placed at 0.2m for 5 minutes. The refractive status was assessed objectively, before and after carrying out the near task, with the Grand Seiko WAM-5500 open-field auto refractor under monocular viewing conditions. (2) A different group of 24 myopes and 24 emmetropes viewed a N12 target with 90% contrast for 60 minutes with pre- and post- refractive state measurements repeated as above. NITM was defined as the difference between pre-task and post-task distance refraction.

Results: In the first study, myopes demonstrated an initial post-task myopic shift of 0.21D whereas emmetropes demonstrated a small hyperopic shift of 0.07D (p<0.001).The myopes demonstrated a decay time constant of 6.07 seconds. There was no effect of target size or contrast on the NITM magnitude or decay time constant (p>0.05). In the second study, myopes showed an NITM of 0.31D which was significantly greater than emmetropes (0.00D: p<0.001). The myopes demonstrated a decay time constant of 8.16 seconds.

Conclusion: NITM magnitude was higher in myopes compared to emmetropes for both 5 minute and 60 minute viewing time. The NITM decayed slightly faster than that found in previous literature for some other ethnic groups. Potential reasons for these findings are discussed.

Keywords: myopia, nearwork-induced transient myopia, target size, target contrast, decay time constant

**Introduction**

Nearwork-induced transient myopia (NITM) refers to the myopic shift in distance refractive error immediately after a prolonged near vision task.1 It can arise after a near task of a few minutes2-7, or after more prolonged periods ranging between one8 to four9 hours. Its cumulative effects can be avoided if the near task is interrupted.6

The magnitude of the NITM has been reported to range from 0.12D to 1.30D with a mean value of about 0.40D1, although some studies have found initial NITM to be as low as 0.09D in some cohorts.9,10 The myopic shift decays to baseline levels following an exponential decrease with a time course of up to about 60 seconds.1 NITM appears to be greater when the near vision task is of a high accommodative demand11 or high cognitive demand.5 It appears to be related to refractive error with myopes being more susceptible than emmetropes,2,4-9 and with hypermetropes often demonstrating a hypermetropic refractive shift.9 Progressing myopes (defined by their refractive error increasing more than 0.50D over the previous two years) display a greater NITM with a longer decay time than stable myopes.3

There is evidence that target spatial detail influences accommodative accuracy.12 It is plausible that target properties such as spatial detail and contrast may influence the magnitude of NITM. Schmid et al.13 investigated these effects using text of N4, N6 and N8 size, and contrasts of 60% and 90%, and found that larger letters resulted in greater NITM and a longer decay time compared to smaller letters. However, they also found that NITM was unaffected by changes in the contrast of the letters. We are interested if these effects are consistent in Indian subjects.

Ciuffreda and Ordonez14 suggested that NITM may result from dysfunction of the sympathetic system. The sympathetic system acts in an inhibitory fashion on accommodation, thus a reduced sympathetic response would result in a greater decay time for accommodation to return to normal levels after a prolonged period of reading.

Vasudevan et al.15 supported this hypothesis when they demonstrated a significant increase in NITM magnitude and decay time in myopes following the instillation of a sympathetic inhibitor (timolol). Extensive near work is regarded as a risk factor for the development of myopia16 and the association between NITM and progressive myopia has been demonstrated in UK and American university students, with progressing myopes exhibiting greater amounts of NITM.3,8,9 These studies have also suggested a link to a reduced sympathetic response in progressing myopes. In a series of papers, Hung and Ciuffreda17-19 have suggested that NITM might stimulate axial elongation and therefore myopia progression. The ‘Incremental Retinal-Defocus Theory’ (IRDT) proposes that retinal defocus modulates the genetically programmed growth of the eye. The IRDT is based on the supposition that changes in the magnitude of retinal defocus, during periods of genetically programmed growth, provides the information for either an increase or a decrease of axial growth rate. For example, during a period of genetically programmed ocular growth, if the magnitude of retinal defocus increases then the rate of axial growth decreases, and vice versa. The authors suggest that any residual NITM still present after distant viewing will be carried over to the subsequent period of near viewing. With repeated cycles of distant to near viewing the NITM will accumulate and will have the effect of a plus lens at near. This then results in a decrease in retinal defocus. Vasudevan et al.15 suggest that if this occurs during one of the periods of genetically programmed growth then axial elongation will occur. Hung and Ciuffreda19 suggest that NITM results in a reduction in retinal defocus during near vision, slowing the rate at which neuromodulators are produced which reduces the synthesis of proteoglycans, thereby weakening the structural integrity of the sclera and leading to axial elongation.

When considering ethnicity and NITM, studies have shown increased NITM magnitude in myopes compared to non myopes in both Chinese children (6-12 years)4 and Caucasian young adults.2  Studies on South Asian populations suggest a faster decline in amplitude of accommodation than in other populations leading to an earlier onset of presbyopia.20,21 To the best of our knowledge there has been no study on NITM in an Indian cohort, despite there being evidence of accommodative differences and lower myopia prevalence in an Indian population.22 For example, in Indian children myopia prevalence varies between 7.7% in urban and 4.1% in rural areas23,24 compared to reported prevalence of 58.1% in urban and 41.0% in rural areas in Korea25 , and 78.4% in urban26 and 55.0% in rural areas in China27. Although Saw et al,28 suggest that regional differences in myopia prevalence may be environmental in origin, it is still more common in some ethnic groups than others.29 A study investigating NITM in Indian subjects is warranted.

The aim of the present study was to measure the NITM magnitude and decay time constant in myopic and emmetropic Indian subjects, for different time periods of near-work, and for targets of differing font size and contrasts.

**Methods**

**Instrumentation and experimental setup**

All myopic subjects had their refractive error corrected using PureVision (Bausch and Lomb) disposable silicone hydrogel contact lenses. Over-refraction was performed to ensure that the contact lens correction was optimal. The contact lenses were worn throughout the study.

An infrared open-field auto refractor (Grand Seiko WAM-5500, Ajinomoto Trading Inc., Tokyo, Japan) was used to measure the refractive status of the eye objectively while viewing targets described below. This instrument has been shown to produce valid and reliable measurements of refraction30 and has been shown to be reliable for the measurement of NITM.31.All accommodative measurements were collected at 5Hz.

**Subjects**

**Study 1: 5 minute reading task**

Forty eight subjects (24 emmetropes and 24 myopes) were recruited. Emmetropia was defined as a spherical equivalent of +0.50D to Plano, and myopia as -0.75D or greater. There were 5 high myopes (-6.00D to -10.00D). We have included these in the myopic group as none of the myopic subjects exhibited any retinal pathology and had visual acuity in both eyes of 6/6 and better. Subjects gave written informed consent for taking part in the study, which followed the tenets of the Declaration of Helsinki and was approved by our institutional review board and ethics committee. All subjects underwent a comprehensive eye examination at a Tertiary eye care hospital in Chennai, India, which included a cycloplegic refraction using 1% cyclopentolate hydrochloride. All subjects achieved better than 20/20 Snellen acuity when fully corrected. Subjects with greater than 1D of cylindrical error and other ocular pathologies were excluded.

**Study 2: 60 minutes reading task**

A separate cohort of 48 Subjects (24 emmetropes and 24 myopes) was recruited with the same inclusion and exclusion criteria as for study 1. No subjects participated in both studies.

**Procedure**

**Pretask**

To dissipate any preexisting transient accommodative effects12 subjects sat in a completely darkened room for 5 minutes. The subjects were then asked to look binocularly at a +0.2 logMAR letter (6/9 snellen equivalent) on an externally lit 3m logMAR chart. The chart illuminance was 485 lux. The baseline distance refraction was measured continuously for 60 seconds for the right eye only. The mean spherical equivalent was calculated and used as the pre-task distance refractive state.

**Task**

**Study 1: 5 minutes readingtask**

The pre-task assessment was followed by a 5-minute near task performed binocularly. The near targets comprised text from a collection of Tenaliraman stories. Tenaliraman was a 16th century Indian poet who wrote witty tales for the king's court. The text targets were viewed along the midline at a distance of 0.2m (5D). There were four text targets in total. Two targets were N8 of 50% contrast (N8-50) and 90% contrast (N8-90), and the other two were N12 at 50% contrast (N12-50) and 90% contrast (N12-90) respectively. The four targets were presented in a randomized order using a random number generator, with a 5 minute interval in complete darkness between each presentation for the dissipation of NITM. The subjects read silently but were periodically reminded to keep the target in focus throughout the task.

**Study 2: 60 minutes reading task**

The pre-task assessment was followed by a 1-hour near task performed binocularly at 0.2m. The subjects again read silently and were periodically reminded to keep the target in focus throughout the task. The near targets comprised text from optometry lectures, similar to the N12-90 target used in study 1.

**Posttask**

Immediately after each period of reading, the subject’s monocular distance refractive state was measured continuously for 120 seconds. Continuous refractive data for each subject were divided into 10-second bins. The average difference between the post-task and pre-task distance refractive state in the first 10 second bin represented the initial NITM dioptric magnitude. Data were analyzed with respect to baseline NITM magnitude and decay time constant.

**StatisticalAnalysis**

The initial NITM magnitude was calculated as the difference between the first ten second bin (averaged over the duration of the interval) and the baseline refraction as described above. Decay time was the time taken from the initial magnitude to dissipate to the baseline distance refraction value. Decay time constants were calculated for the post task accommodative response with an exponential fit. Ciuffreda and Wallis2 have shown the myopic shift (NITM) as a positive value and hyperopic shift as a negative value. We have used the same convention for ease of comparison.

Initial NITM magnitude and decay times were calculated for each subject and were averaged for each target presentation. Comparisons were made between emmetropes and myopes using repeated measures ANOVA to calculate the effect of target size and contrast on NITM initial magnitude (study 1). Independent t-tests were performed in order to compare the initial magnitude between emmetropes and myopes in study 2. Statistical analyses were performed using SPSS version 15.

**Results**

Study 1: 5 minute task

The study subjects were of 18 to 25 years of age. Average spherical equivalent in the emmetropic group was 0.10D and -3.32D in the Myopic group (Table 1).

Table 1: Demographic details of participants in Study 1: 5 Minute reading task

|  |  |
| --- | --- |
|  | Study 1 |
|  | Emmetropes(n=24) | Myopes(n=24) | p Value |
| Age (years) | 20 +1.32 | 19.63+2.12 | 0.46 |
| Male : Female | 7 :17 | 4:20 | 0.49\* |
| Refractive Error( mean+ SD) | 0.10+0.09(range+0.21 to -0.14) | -3.32+2.76(range-0.75 to -10.00) | <0.01 |

**\***Chi-square

Initial NITM

Initial NITM magnitudes for both refractive groups and all target types are shown in Table 2 and variations in post-task NITM for different targets are plotted in Figures 1a-b.

Table 2: NITM magnitude (in diopters) for emmetropes and myopes for different targets following the 5 minute reading tasks. A positive value indicates a myopic shift in refractive error.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NITM 5m | N8 with 50% contrast(Mean±SD) | N8 with 90% contrast(Mean±SD) | N12 with 50% contrast(Mean±SD) | N12 with 90% contrast(Mean±SD) |
| Emmetropes | -0.08±0.15 | -0.09±0.22 | -0.07±0.22 | -0.01±0.20 |
| Myopes | 0.22±0.27 | 0.25±0.24 | 0.16±0.21 | 0.23±0.26 |

Fig. 1a: Post task shift in refractive error (D) for emmetropes following the 5 minute reading tasks. Error bars indicate±1 SEM.



Fig. 1b: Post task shift in refractive error for myopes following the 5 minute reading tasks. Error bars indicate ±1 SEM.



When averaged across all targets, myopes displayed a mean myopic shift of 0.21D, whereas the emmetropes displayed a hyperopic shift of 0.07D. Analysis of variance revealed a statistically significant main effect of refractive error group (F1, 46 = 28.07, p < 0.001) on NITM. There was no significant interaction between refractive error group and target type, and the effect of target type was not statistically significant.

Decay time constant

Table 3 shows the decay time constants for myopes across all target types.

Table 3: Decay time constant (seconds) for myopes for different targets following the 5 minute reading tasks.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time constant 5m | N8with50%contrastMean(±SD) | N8with90%contrastMean(±SD) | N12with50%contrastMean(±SD) | N12with90%contrastMean(±SD) |
| Myopes | 6.82± 8.35 | 7.58±10.03 |  5.44 ± 5.85 | 4.44±4.20 |

When averaged across all targets, decay time constant was 6.07 seconds for the myopes. Analysis of variance showed that the effect of target type was not statistically significant.

Study 2: 60 minute task.

The study subjects were between 17and 27 years of age. Spherical equivalent for the emmetropes was 0.13D and -2.75D for the myopes.

Characteristics of the Study 2 cohort are presented in Table 4.

Table 4. Demographic details of participants in Study 2: 60 Minute reading task

|  |  |
| --- | --- |
|  | Study 2 |
|  | Emmetropes(n=24) | Myopes(n=24) | p Value |
| Age (years) | 22.04 +1.94 | 20.71 +2.49 | 0.21 |
| Male : Female | 8:16 | 5:19 | 0.33\* |
| Refractive Error( mean+ SD) | 0.13+0.09(range+0.21 to -0.12) | -2.75+1.89(range-0.75 to -6.37) | <0.01 |

The initial NITM magnitude following the 60 minute reading task are given in Table 5. Figure 2 shows the variation in the myopes’ NITM following the 60 minute task in comparison to the NITM following the 5 minute task.

Table 5: NITM magnitude (diopters) for emmetropes and myopes following the60 minute near task. A positive value indicates a myopic shift in refractive error or NITM.

|  |  |
| --- | --- |
| NITM 60 min | NITMMean(±SD) |
| Emmetropes | 0.00±0.16 |
| Myopes | 0.31±0.15 |

Myopes again demonstrated a larger NITM than the emmetropes. The differences in initial NITM magnitude between emmetropes and myopes were compared using independent t-tests.There was a statistically higher NITM magnitudes in myopes compared to emmetropes (p<0.001).The decay time constant for myopes was 8.16±10.82 seconds.

Figure 2. Post Task Shift (D) for myopes at 5 minutes and 60 minutes for N12 with 90% contrast. Error bars indicate ±1 SEM.

**Discussion**

NITM was first investigated by Lancaster and Williams32 who found large magnitudes of NITM in a Caucasian population (up to 1.3D) that lasted up to 15 minutes. However, later studies have more often reported lower magnitudes of NITM that range between 0.2D to 0.6D.1 NITM has been shown to be of a greater magnitude and duration in myopes (especially late-onset myopes) compared to other refractive error groups.2,8 Moreover, progressing myopes appear more likely to exhibit NITM than myopes with stable refractive error.3,4,8

Table 5: Studies showing NITM magnitude and Decay in different population with task duration

|  |  |  |  |
| --- | --- | --- | --- |
| Studies (Population) | NITM(D)Mean±SD | Decay(Sec)Mean±SD | Task Duration – Task Distance |
| Ciuffreda and Wallis (1998) (US) | 0.35±0.16 | 63 | 10 minutes – 0.2m |
| Schmidt et al (2005) (AUS) | 0.36±0.31 | 15.12±6.58 | 3 minutes – 0.25m |
| Arunthavaraja (2010) (US) | 0.32±0.05 | 68.2±9.1 | 10 minutes – 0.12m |
| Present Study | 0.22±0.25 | 6.07±7.11 | 5 minutes – 0.2m |
| Present Study  | 0.31±0.15 | 8.16±10.83 | 60 minutes – 0.25m |

Our results demonstrate that the initial magnitude of NITM is higher in Indian myopes compared to Indian emmetropes for both task durations. The baseline NITM magnitude was also well within the expected magnitude of NITM (0.21D for the 5-minute task and 0.31D for the 60-minute task) found in Caucasian myopes33. The emmetropic group demonstrated a magnitude of between 0.00D and -0.09D (hyperopic shift). For the shorter task duration, NITM ranged between 0.16D to 0.25D for different target sizes and contrasts (p>0.05). In study 1, initial NITM for the N12 low contrast target was 0.16D and for the N12 high contrast target was 0.23D. Similarly, the initial NITM for the N8 low contrast target was 0.22D and for the N8 high contrast target it was 0.25D, whereas, in an Australian population, Schmidt et al.13 reported that after 3 minutes of a near task the initial NITM was 0.36D for both high and low contrast N8 targets. Interestingly, Schmidt et al.13 also found that target contrast had no effect on NITM and that target size produced only a small change in NITM that was not clinically significant. The NITM magnitude in this study on Indian subjects closely resembles that of the Australian population and our results agree with those of Schmidt et al.13 in that target types had no significant effect on NITM.

The NITM time constant describes the decay dynamics of accommodation. The decay duration in this study was faster than other studies that have found decay durations between 12.2 sec10 and 50 sec13. Moreover, a lower time constant of 6.07 seconds was observed for a shorter duration near task than for a longer near task that demonstrated a time constant of 8.16 seconds for myopes. We should note that we used different cohorts for the two studies. We initially investigated NITM after a 5-minute near work task but after the analysis of these data we wanted to extend the study by lengthening the near work task to 60-minutes. We were conscious of the training effects that can occur with studies investigating accommodation34 and as a consequence recruited a new cohort of participants. As a result the decay time constants are not directly comparable. However, the baseline characteristics of the cohorts were similar.

The difference in the values of decay between the present study and that of Vasudevan et al.8, for the 60 minutes near task duration suggests a faster relaxation to the baseline in the Indian subjects and this requires some consideration. It may be due to a genetically-driven difference in lens structure that may allow some subjects to relax their accommodation more quickly after near work.1 Alternatively, Indian subjects may have a faster sympathetic response compared to other ethnic groups. It has been well-documented that the accommodative system receives dual innervations, consisting primarily of a parasympathetic (cholinergic) and secondarily a sympathetic (adrenergic) component. An increase in parasympathetic stimulation results in an increase in accommodation. Prior investigation has demonstrated that the sympathetic system is slower in onset (40 secs) and smaller in effect than the parasympathetic system.12 Gilmartin35 and Mallen et al.36 have suggested that a deficit in this system may slow the decay of NITM. The longer decay time found in previous studies compared to the present study could be attributed to a differences in parasympathetic stimulation between our subjects and those of different ethnicity.12 Therefore, the sympathetic response efficiency in Indian subjects compared to other ethnicities with higher prevalence of myopia should be further investigated particularly as the prevalence of myopia (4-7%) in Indian populations is lower compared to other populations where decay duration is longer. The difference in NITM decay time may indicate a reduced susceptibility to myopia development in this population. There are several other possible mechanisms that have been postulated as protective mechanisms against myopia development including sunlight exposure.37 Sunlight exposure increases the production of vitamin D and alters retinal dopamine signaling.38 It has been suggested that spending time outdoors may at least in part inhibit myopia progression. Unfortunately, our study did not attempt to measure the progression of myopia among our subjects, so we are not able to investigate the relationship between their NITM characteristics and their rate (if any) of myopia progression.

The underlying reason for a lower prevalence of myopia in India is yet to be determined. While both the countries have a large population of young children and adults who perform significant magnitudes of near work during the day, the prevalence of myopia in Chinese population is much higher than that of Indian. Aside from the genetic predisposition, Indian children and adults living within the cities study using both English and native Indian language characters that might have a different spatial content in the text compared to that of the Chinese language characters. More research would help us understand the apparent protective mechanism present in the Indian population that enables a lower prevalence of myopia, and could possibly serve as a potential treatment option for countries with high myopia. Our data also show faster decay dynamics which may possibly explain why the presenting NITM does not persist which may in turn lead to lower myopia prevalence. This needs to be investigated further.

In conclusion, NITM magnitude in myopes in Indian subjects was comparable to other populations whereas the decay was faster. Since this is the first study to investigate NITM in an Indian cohort, further research is needed to better understand the effect of sympathetic and parasympathetic influence on accommodative response and NITM in different ethnicities.

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