NEARWORK-INDUCED TRANSIENT MYOPIA (NITM) FOLLOWING MARKED AND SUSTAINED, BUT INTERRUPTED, ACCOMMODATION AT NEAR

MS Research Project

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Abstract

Purpose: It has been speculated that non-decayed NITM (accommodatively-based nearwork-induced transient myopia) may be myopigenic in nature. Thus, the purpose of the present investigation was to determine objectively the initial magnitude and decay of NITM, and its potential additivity, following successive but interrupted periods of marked, sustained accommodation at near in asymptomatic young-adult myopic subjects.

Methods: Fifteen visually-normal, asymptomatic young adults (ages 18 – 28 years) were tested with full distance refractive correction. They included 9 early-onset (EOM) and 6 late-onset (LOM) myopic subjects. Accommodation was assessed objectively with a Canon R-1, open-field, infrared auto-refractor under monocular viewing conditions (RE). The distance refractive state was measured immediately before and after a ten minute period of focusing upon a moderate contrast (50%), very near target (12 cm; 8D) subtending a visual angle of 1 degree. The task was repeated twice with a 5-minute inter-task rest period of imposed far viewing. NITM was defined as the post-task minus pre-task change in distance refractive state immediately following each task.

Results: Significant amounts of NITM were generated following nearly each trial in each subject. These ranged from 0.11 to 0.71D, with a mean of 0.31D. The group mean NITM was 0.32, 0.29, and 0.31D for trials 1, 2, and 3, respectively. For the EOMs subgroup, NITM was 0.28, 0.30, and 0.34D, while for the LOMs subgroup, it was 0.38, 0.29, and 0.26D, for for trials 1, 2, and 3, respectively. Decay of NITM was prolonged in many of the subjects (67%). However, additivity of NITM was not found following the sequences of interrupted near tasks.

Conclusions: There was no evidence of NITM additivity following a marked and sustained, but interrupted, near task. Although NITM has been reported to be additive following long periods of uninterrupted and sustained reading at lower dioptric levels, providing rest periods between each near task trial appears to prevent a cumulative effect (i.e., additivity effect). These findings support the idea of far viewing being protective in nature from myopia development.

Introduction

Nearwork-induced transient myopia (NITM) refers to the closed-loop accommodative aftereffect at distance following a sustained near task (Ciuffreda and Vasudevan, 2008). That is, the accommodative response at far exhibits an initial slight over-accommodation with respect to the pre-task baseline level, with a typical exponential decay of approximately 30 seconds (Rosenfield *et al.*, 1992) back to this pre-task hyperfocal baseline refractive state. Study of what has become known as "NITM" dates back to 1914 (Lancaster and Williams, 1914). They found NITM to be as large as 1.30D under extreme monocular near viewing conditions for 45 minutes in young adults, with a decay to baseline lasting up to 15 mins. Following longer sustained periods of nearwork (60 minutes), NITM may remain significantly elevated for at least one hour (Ehrlich, 1987).

However, NITM in visually-normal individuals has been typically found to range from approximately 0.12D to 0.90D, with a mean of about 0.3D (Owens and Wolf-Kelly, 1987; Ciuffreda and Vasudevan, 2008). In visually-normal individuals, blur at distance is typically not reported, as the NITM does not exceed the depth-of-focus of the eye, and thus these individuals remain blur-free and asymptomatic. However, it has been found to be considerably larger (up to 1.5D), with a much slower (up to a few minutes) and irregular decay pattern in individuals with abnormal NITM having the symptom of distance blur following relatively short periods (<15 minutes or so) of sustained nearwork (Ciuffreda and Ordonez, 1998). Accommodatively-based vision therapy has been found to improve NITM decay dynamics (Ciuffreda and Ordonez, 1998; Vasudevan *et al.*, 2009).

NITM results from the dual innervation of the accommodative system derived from the autonomic nervous system (Gilmartin and Winfield, 1995; Gilmartin, 1986). It is comprised of the fast-acting parasympathetic system, which is used for rapid (~1sec) accommodative changes, and the very slow-acting (~10-40sec) sympathetic system involved in sustained visual activities. Thus, any inhibition of accommodation by the sympathetic system is slow, and is most active during continuous and uninterrupted near visual tasks (Van Alphen, 1968; Bullimore and Gilmartin, 1988). Therefore, a deficit in the sympathetic system would likely result in a large accommodative aftereffect, such as NITM. This has been confirmed in 2 other more recent studies (Ciuffreda and Lee, 2002; Vasudevan *et al.,* 2009). NITM has been attributed to an inability to relax accommodation completely at distance, and it has been postulated to be neuropharmacological in origin, as suggested above (Ciuffreda and Vasudevan 2008; Ong *et al.,* 1997). There may be an impaired sympathetic innervation causing increased variability and/or slowness in NITM decay duration, as well as overall reduced pharmacological output. Decrease in sympathetic activity would cause an increase in accommodative adaptation and related NITM, and thus a longer decay; furthermore, if there were a decrease in the parasympathetic activity, this too would result in a considerably larger transient myopia, but this remains unproven. Variability and reduction in sympathetic inhibition was suggested in a recent study by Vasudevan *et al.* (2008), where 30% of the young-adult subjects exhibited slowed decay back to baseline. Involvement of an impaired sympathetic system causing an increase in NITM decay duration was recently confirmed, with administration of the sympathetic inhibitor timolol in young-adult myopes (Vasudevan and Ciuffreda, 2009).

Myopes are particularly susceptible to nearwork accommodative aftereffects, such as NITM (Ciuffreda and Wallis, 1998; Ciuffreda and Lee, 2002; Fuensanta *et al.,* 2002; Ciuffreda and Vasudevan, 2008; Vasudevan *et al.*, 2009). For example, it has been found that NITM occurs in 90% of young-adult myopes, both of the early-onset myopes (EOM) and late-onset myopes (LOM), but in only 33% of emmetropes and in 11% of hyperopes (Ciuffreda and Wallis, 1998) following a short (10 minutes) and sustained near task (5D). Furthermore, NITM decay to baseline was prolonged in the myopes; the EOM and LOM subgroups manifested decay time constants of 35 and 62 seconds, respectively (Ciuffreda and Wallis, 1998). Thus, NITM is refractive error dependent. This has been confirmed in two more recent studies (Ciuffreda and Lee, 2002; Vasudevan and Ciuffreda, 2008). In addition, recent studies have found progressive myopes to be more susceptible to NITM than non-progressive myopes (Fuensanta *et al.,* 2002; Ciuffreda and Vasudevan, 2008; Abbott *et al.* 1998), thus resulting in increased levels of NITM as compared with stable myopes.

Recent findings of NITM additivity are of particular interest to the present study (Vasudevan and Ciuffreda, 2008). Additivity of NITM has been found following 1 and 2 hour periods of sustained reading, but again only in the myopes. That is, the NITM following the second hour of reading was significantly greater than that found after the first hour (Ciuffreda and Vasudevan, 2008). It has also been found to be additive for sustained periods of up to 4 hrs, but again only in the myopic subgroups (Ciuffreda and Lee, 2002).

Lastly, there has been speculation regarding the possibility of a link between NITM and permanent myopia (Ciuffreda and Vasudevan 2008; Ong and Ciuffreda, 1995;

Ong *et al.,* 1997). Hung and Ciuffreda (2003) have proposed such a mechanism. They suggested that any non-decayed NITM would act like addition of a small plus lens when looking at near once again. That is, it essentially reduces the accommodative stimulus and accommodative error at near. Such a change in retinal defocus would activate the emmetropization process, and hence result in axial elongation, that is myopia progression. Furthermore, two recent studies have shown that purposeful undercorrection of myopia resulted in 0.66D of myopic progression vs 0.38D of progression when given the full correction, thus indicating that myopic defocus can also be a myopogenic factor (Chung *et al*., 2002; Adler and Millodot, 2006), and not only hyperopic defocus as suggested by animal studies (Smith *et al.,* 1999; Wallman and Winawer, 2004). This would be consistent with the ideas described above for non-decayed NITM.

NITM is an important factor to consider with respect to both basic and clinical aspects of accommodation, as well as its possible role in refractive development. Hence, the purpose of the present investigation was to impose a high accommodative demand and repeated near task, but with intervening periods of distance viewing, to assess for NITM additivity effects in EOMs and LOMs. The NITM parameters of interest were its initial amplitude and immediate post-task decay dynamics.

Methods

Subjects:

Fifteen visually-asymptomatic individuals at the SUNY State College of Optometry participated in this study. Their ages ranged from 18 to 28 years, with a mean of 22 years and a standard deviation of ±5 years. There were 11 females and 4 males; all were myopes. They were sub-grouped into either early-onset myopes (EOMs) or late-onest myopes (LOMs) based on age of onset of their first refractive correction (McBrien and Millodot, 1986; Ciuffreda and Wallis, 1998). There were 9 EOMs and 6 LOMs. The EOMs had a spherical equivalent refractive error ranging from -2.50DS to -6.25DS, with a mean of -4.04±0.24DS. The LOMs had a spherical equivalent refractive error ranging from -0.25DS to -4.50DS, with a mean of -2.08±0.40DS. All subjects had less then 1D of astigmatism. There were six progressive myopes and nine stable myopes. Subjects with the following conditions were excluded from the study: presence of accommodative and/or binocular dysfunctions, intake of medications that may effect accommodation or attention, presence of ocular or neurological disease, or the inability to read for at least 10 continuous minutes without visual discomfort (ie. asthenopia). All had visual acuity of 20/20 or better in each eye at distance and near with their current refractive correction. All had push-up monocular amplitudes of accommodation of at least 8 diopters, monocular accommodative facility (+/-2D) greater than 11 cycles per minute, and binocular accommodative facility (+/-2D) greater than 8 cycles per minute, thus demonstrating normal accommodative static and dynamic function based on standard clinical criteria (Griffin and Grisham, 2002).

Written informal consent was obtained from each subject prior to testing. This research followed the tenets of the Declaration of Helsinki and was approved by the college's internal review board.

Apparatus:

Refractive error was measured objectively using the Canon R-1, open-field, infrared autorefractor. This device is commonly used in vision research (McBrien and Millodot, 1985). The presence of an open-field aspect allows for a wide range of positions of the target in the visual field with either monocular or binocular viewing under relatively naturalistic viewing conditions. Measurements of refractive error can be obtained as rapidly as every 2 seconds. The power range is ±15DS and -7DC in 0.12D steps, and cylinder axis resolution is 1 degree (Vasudevan and Ciuffreda, 2008). The autorefractor has a noise level of 0.07D (Vasudevan and Ciuffreda, 2008).

Procedure:

Subjects were required to refrain from performing more than 10 continuous minutes of nearwork (40cm or closer) for a minimum of one hour prior to a test session.

Initial Set-Up: Subjects were seated comfortably in the headrest/chinrest of the Canon R-1 with their distance refractive correction in place in the form of contact lenses, with the left eye fully occluded with a tightly fitting black eye patch. The chinrest was then adjusted, so that their outer canthus was aligned with the markers on the headrest, which assured proper height adjustment for all subsequent measurements. To allow for dissipation of any residual accommodative transients, subjects remained seated in total darkness for 5 minutes (Krumholz *et al.,* 1986*)*.

Pre-Task: Following this period in the dark, subjects viewed a projected 20/30 Snellen optotype target at a distance of 6m using a Nikon chart projector (NP-3) under subdued room illumination (~2 foot-candles). They were requested to keep the letters in focus at all times. Fifteen measurements of their distance refractive state were taken every 2 seconds for 30 seconds. Mean spherical equivalent was calculated and used as the pre-task baseline of their distance hyperfocal refractive state.

Task: Subjects were instructed to continuously view and maintain clarity of a near target of 50% contrast comprised of intersecting thin horizontal and vertical black lines on a white background positioned along the line-of-sight of the right eye. The target subtended a visual angle of 1 degree at a distance of 12 cm (8D) and had a luminance of 40 cd/m^2. Subjects performed this continuous near task for 10 minutes monocularly. They were periodically reminded to maintain the target in focus at all times. In two of the subjects, dynamic retinoscopy was periodically performed to assess accuracy of focus.

Post-Task: Immediately following this sustained near task, the subjects were once again instructed to fixate the 20/30 Snellen optotype at far and maintain it in best possible focus, while 30 measurements of their distance refractive state were obtained every 2 seconds using the Canon R-1 autorefractor. This near task paradigm was repeated twice. Each trial was preceded by having the subject view the distant Snellen optotype for five minutes to relax accommodation. The difference in post-minus pre-task distance refractive state averaged over the first 10 seconds (i.e., 5 measurements) for each trial represented the initial NITM. This was then averaged for the myopic group and subgroups. All 30 measurements were used to assess NITM decay with an exponential fit.

In addition, two subjects (#11 and #15) were tested on a separate day without any 5 minute rest period between trials. This was done to assess the effect of continuous versus discontinuous near focusing on additivity of NITM. Both subjects were LOMs.

Results:

Initial NITM

The overall myopic group mean (±SE) initial NITM magnitude as a function of trial number is presented in Figure 1. NITM was 0.32±0.05D, 0.29±0.04D, 0.31±0.04D, and 0.31±0.01D for trial 1, 2, 3, and average of three trials, respectively. A one-way, repeated-measures ANOVA was performed for the factor of trial number. There was no significant effect of trial number on NITM [$F(2,42) = 0.114$, $p = 0.893$]. The group mean NITM summed across trials was significantly greater than the normalized pre-task group mean baseline level (t-test, $p=0.0008$). Furthermore, the individual mean NITM values were consistently larger than the instrument noise level of 0.07D (Vasudevan and Ciuffreda, 2008). Thus, consistent and substantial NITM was produced.

The subgroup mean initial NITM for the EOMs (n = 9) and LOMs (n = 6) as a function of trial number is presented in Figure 2. NITM for the EOMs was 0.27±0.05D, 0.26±0.04D, 0.30±0.04D, and 0.28±0.02D for trial 1, 2, 3, and average of three trials, respectively. NITM for the LOMs was 0.40±0.03D, 0.34±0.05D, 0.31±0.05D, and 0.35±0.03D for trial 1, 2, 3, and average of three trials, respectively. A two-way, repeated-measures ANOVA was performed for the factors of trial number and refractive group. There was no significant effect of either trial number [$F(2,40) = 0.207$, $p = 0.814$] or refractive group [$F(1,40) = 0.095$, $p = 0.76$] on NITM.

The NITM values of the individual subjects as a function of trial number sequenced in order of increasing NITM based the magnitude of the first trial are presented in Figure 3. Individual subject mean values across trials ranged from 0.11D to 0.71D. The data from one subject (#1) suggested a negative value of NITM.

The findings for the 30 minute discontinuous versus continuous focusing condition conducted in subjects 11 and 15 are presented in Figure 4. Subject 11 had NITM values of 0.29 D, 0.11 D, 0.24 D for trials 1, 2, and 3, respectively, for the discontinuous test condition. In contrast, the NITM values were considerably higher and were 0.58 D, 0.91 D, 0.80D for trials 1, 2, and 3, respectively, for the continuous test condition. Subject 15 exhibited NITM values of 0.59 D, 0.71 D, 0.60 D in trials1, 2, and 3, respectively, for the discontinuous test condition. However, the NITM values were similarly high and were 0.57 D, 0.72 D, and 0.71 D, for trials 1, 2, and 3, respectively, for the continuous test.

Decay of NITM

Subjects were categorized with respect to decay duration based on the response time constant. Figure 5a presents NITM decay durations in those subjects (n=5) exhibiting rapid-decay (≤ 30sec) in at least two of the three trials. Values ranged from 10 sec to 30 sec. An exponential equation, $y = 1.0063e^{-1.1675x}$, was fit with a goodness of fit of $r^2 = 0.9868$, where the time constant was 8.57sec. Figure 5b shows NITM decay durations in those subjects (n=10) manifesting slowed decay (> 30sec) in at least two of the three trials. Values ranged from 31 sec to 144 sec. An exponential equation, $y = 0.5011e^{0.2711x}$, was fit with a goodness of fit of $r^2 = 0.9982$, where the time constant was 36.89sec.

The decay time was also assessed separately in the two myopic subgroups. NITM decay duration in the LOMs and EOMs as a function of trial number is presented in Figure 6a and Figure 6b, respectively. The mean LOM decay duration across trials was 68.2±9.1sec, as fit with an exponential equation, $y = 0.386e^{-0.2252x}$, and having a time

constant of 44.40sec. The mean EOM decay duration across trials was 48.6±7.3sec, as fit with an exponential equation, $y = 0.6948e^{-0.5874x}$, and having a time constant of 17.02sec.

Figure 7a presents NITM decay duration in the myopic subgroups as a function of trial number. The average in the EOMs decay across subjects was 60.4±11.1 sec, 45.0±11.8 sec, and 62.1±10.7 sec in trials 1, 2, and 3, respectively. A one-way, repeated-measures ANOVA was performed for the factor of trial number. There was no significant effect of trial number on NITM [$F(2,39) = 1.0056$, $p = 0.375$]. Figure 7b shows NITM decay duration in the LOMs as a function of trial number. The average LOM decay across subjects was 77.2±13.5 sec, 54.6±10.1 sec, and 41±10.7 sec for trials 1, 2, and 3, respectively. A one-way, repeated-measures ANOVA was performed. There was no significant effect of trial number on NITM [$F(1,39) = 2.2482$, $p = 0.142$].

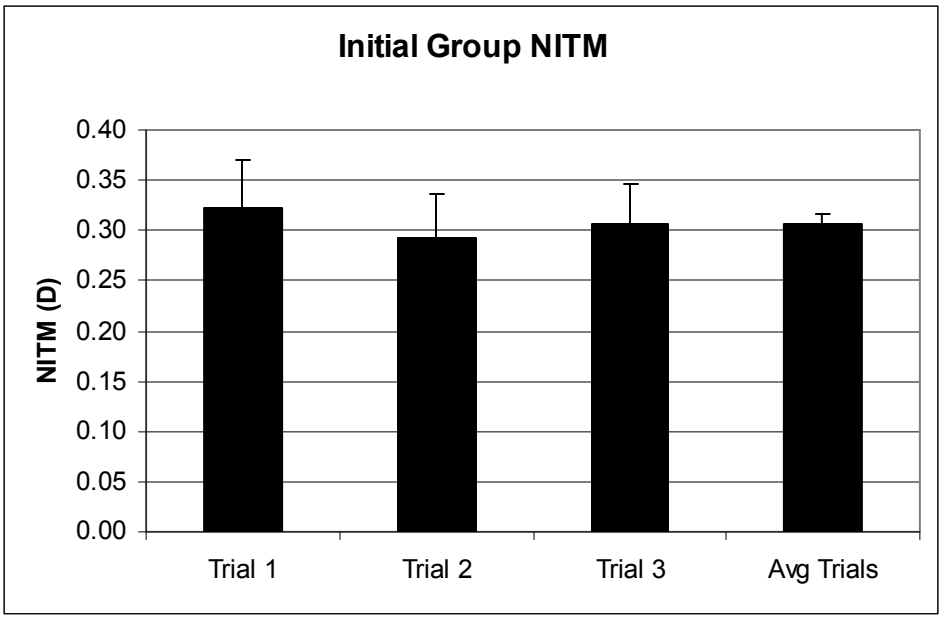

Figure 1: Initial NITM as a function of trial number. Plotted is the group mean +/-1 SEM (n=15).

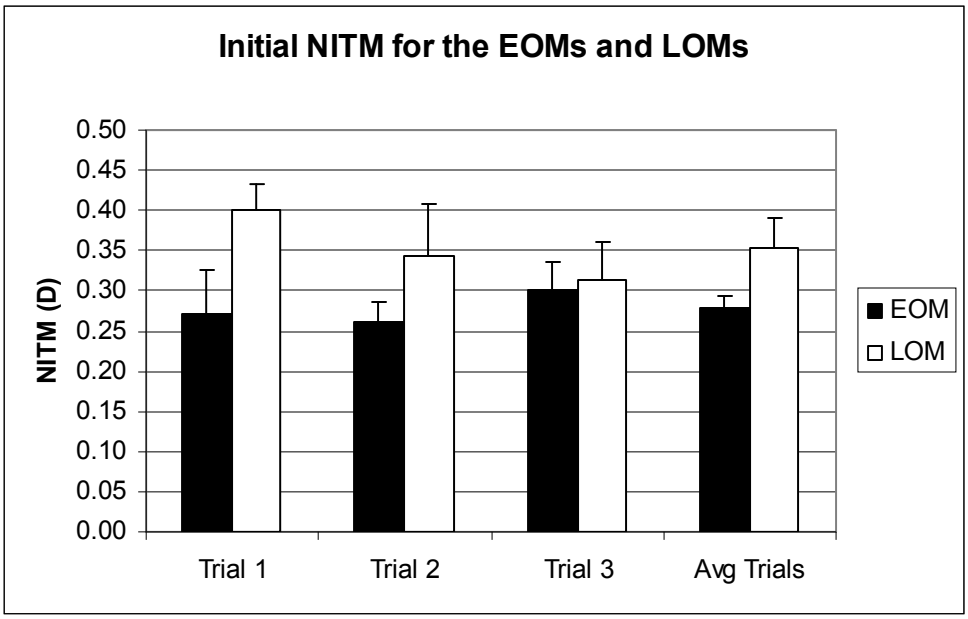

Figure 2: Initial NITM as a function of trial number and refractive group, LOM (n = 6) and EOM (n = 9). Plotted is the subgroup mean +/-1 SEM.

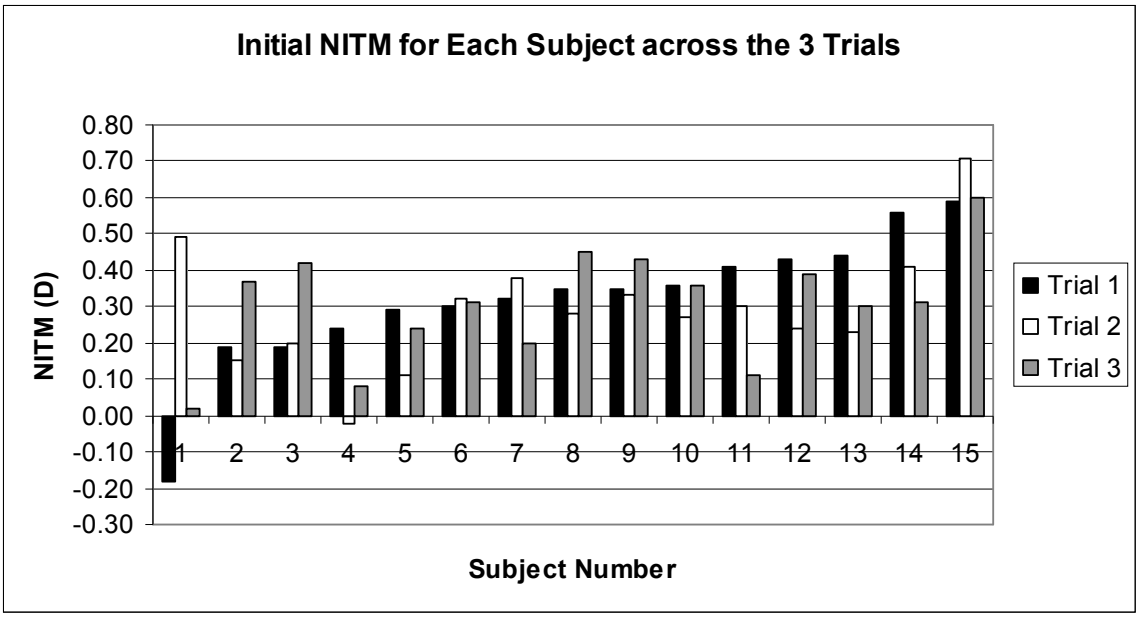

Figure 3: Individual subject data of initial NITM for each of the 3 trials. Positive values indicate a post-task myopic shift (NITM).

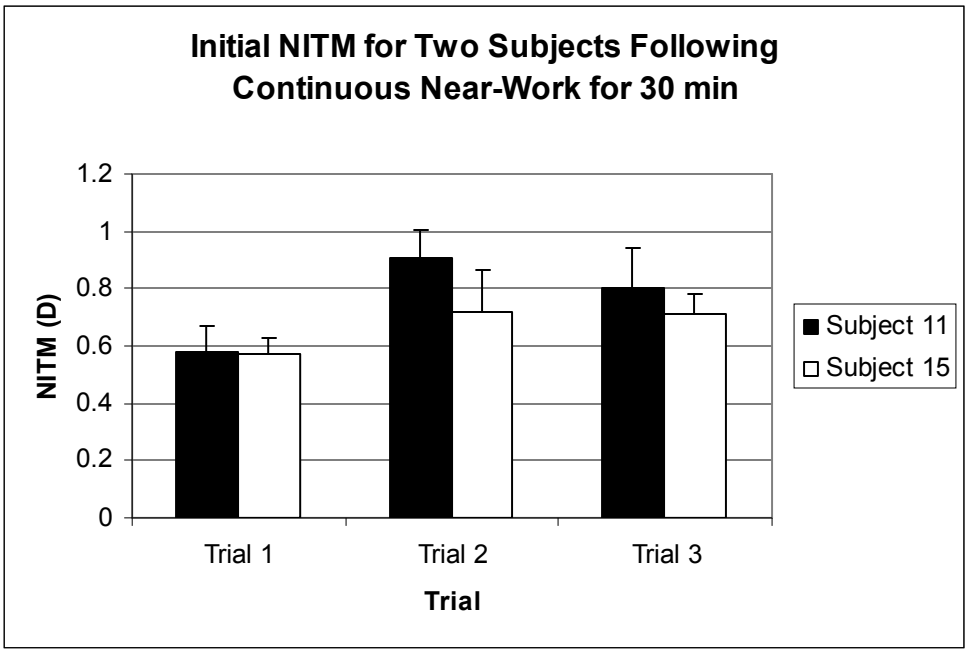

Figure 4: NITM in 2 subjects performing the near task for 30 continuous minutes. Plotted is mean +1 SD.

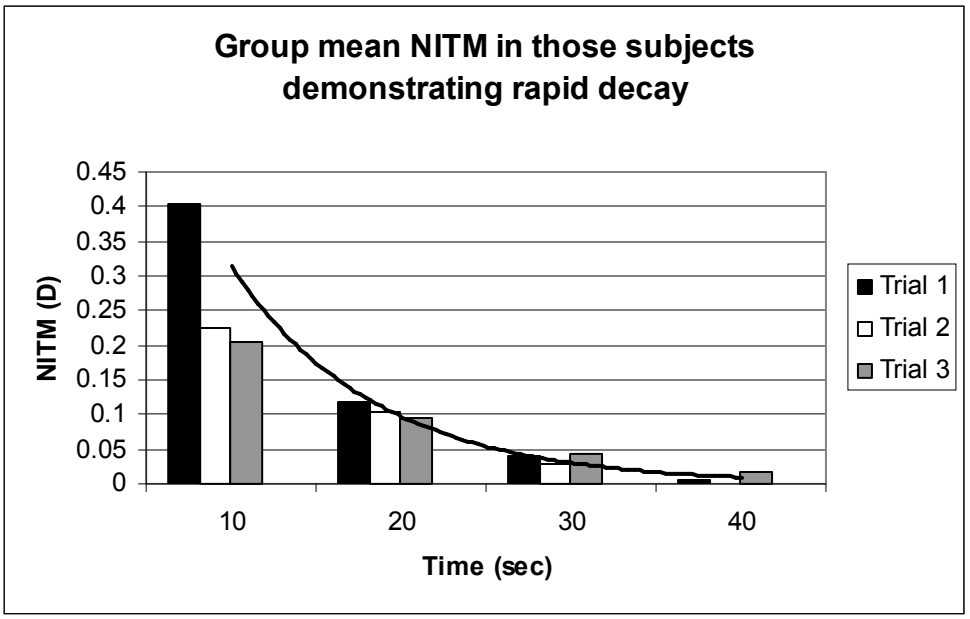

Figure 5a: Group mean NITM in those subjects demonstrating rapid decay (n=5).

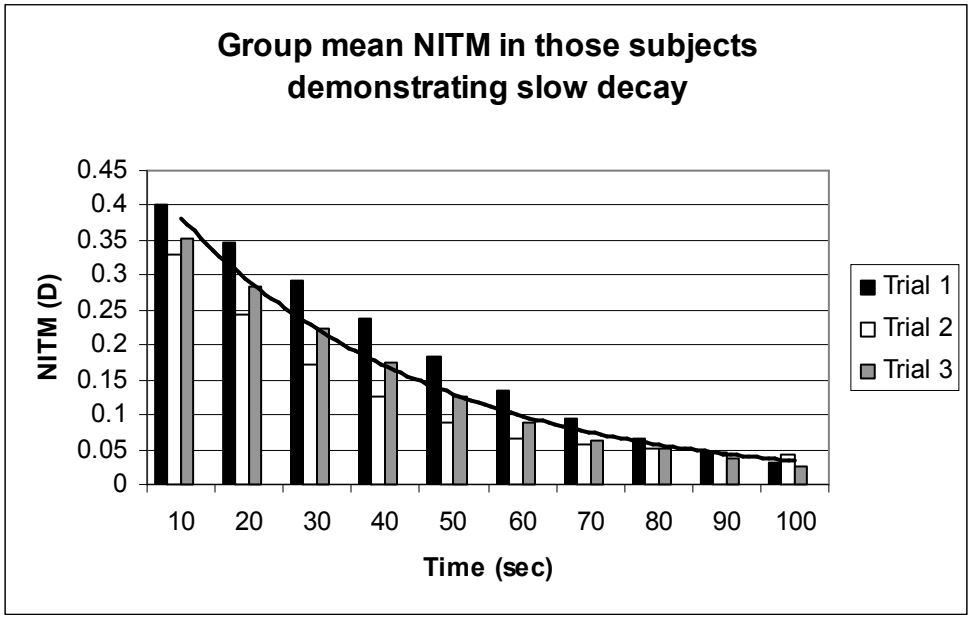

Figure 5b: Group mean NITM in those subjects demonstrating slow decay (n=10).

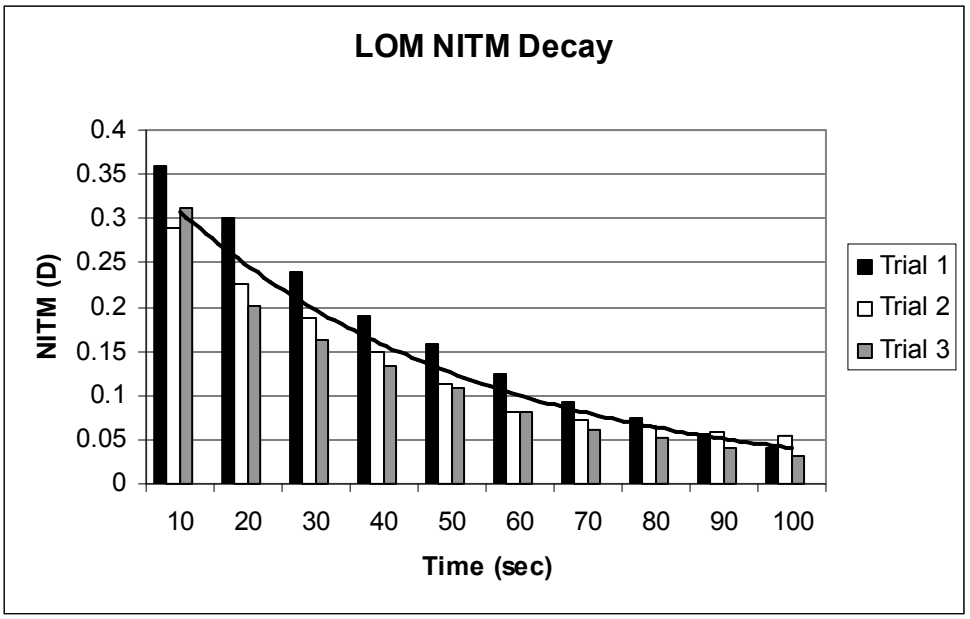

Figure 6a: Decay duration as a function of trial number for LOM.

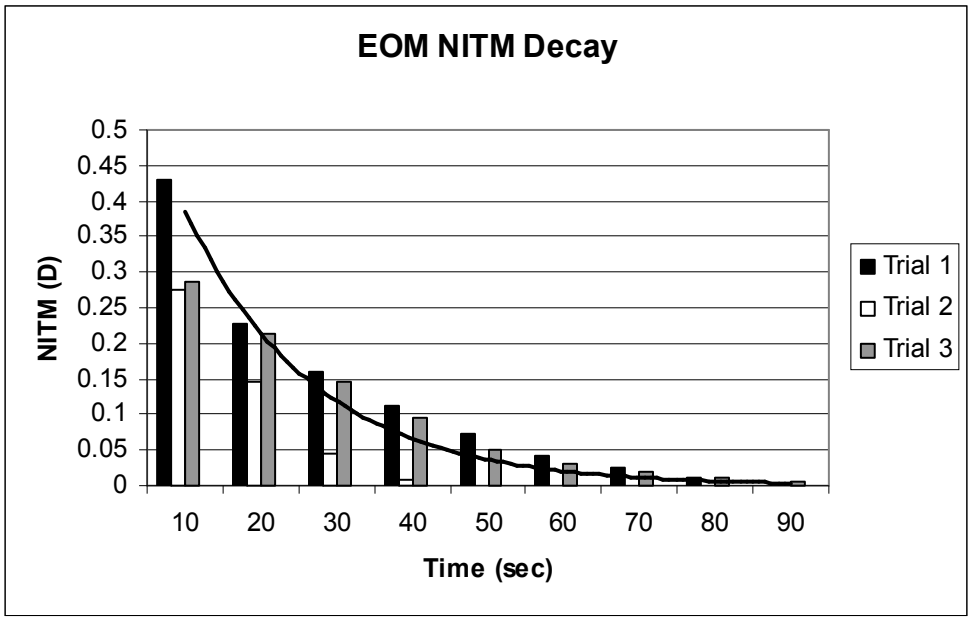

Figure 6b: Decay duration as a function of trial number for EOM.

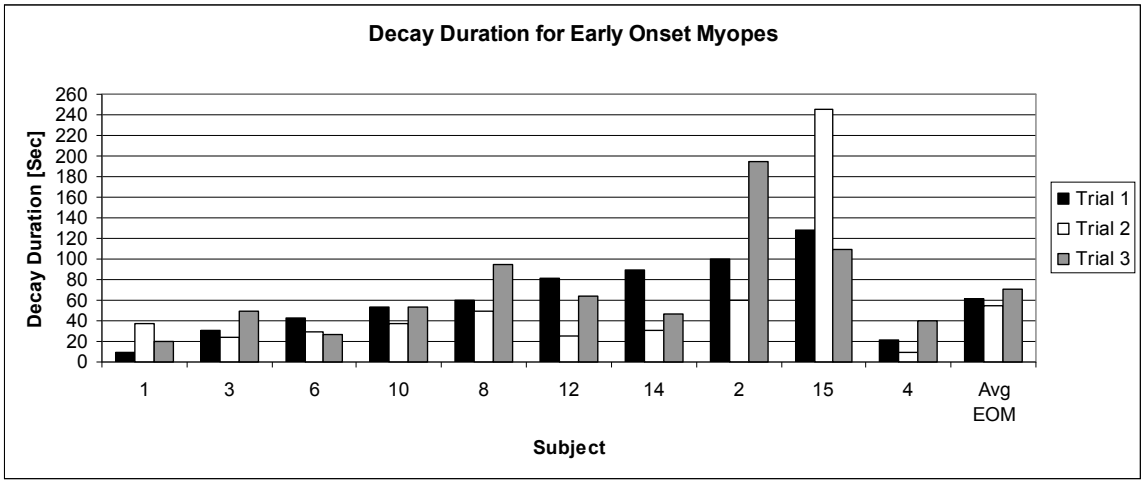

Figure 7a: Decay duration as a function of trial number in EOMs (labeled according to Fig 3).

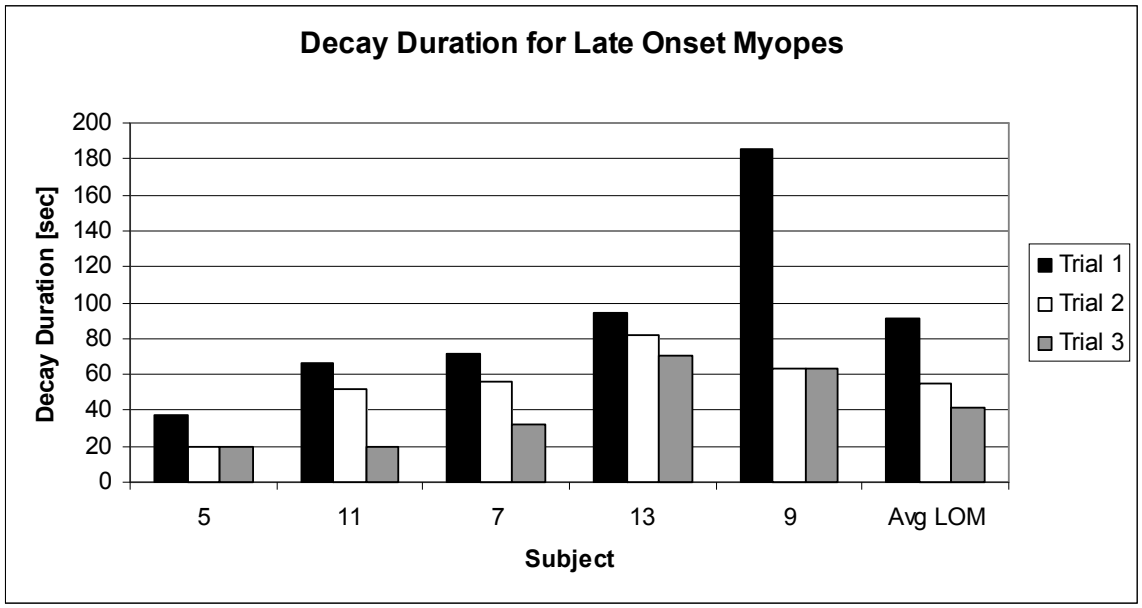

Figure 7b: Decay duration as a function of trial number in LOMs (labeled according to Fig 3).

Discussion:

This study investigated myopes, who are particularly susceptible to nearwork associated aftereffects, such as NITM (Ciuffreda and Wallis, 1998; Ciuffreda and Lee, 2002; Fuensanta *et al.,* 2002; Ciuffreda and Vasudevan, 2008; Vasudevan *et al.*, 2009). Several important factors were found in association with NITM. Firstly, nearwork under high amplitudes of accommodation consistently demonstrated significantly elevated levels of NITM. Secondly, repeated trials of nearwork with interspersed distance viewing demonstrated the presence of NITM after each trial, but with absence of additivity. Thirdly, many subjects demonstrated very slow decay of NITM.

There are similarities between earlier studies and the present investigation, with one key and consistent finding being the robustness of generating NITM. The first is related to NITM initial magnitude. The significant findings of a transient myopic shift in refractive error, well beyond the instrument noise level (0.07D), demonstrated the presence of the initial NITM. Similarly, Ciuffreda and Wallis (1998) found increased levels of NITM after 10 min of binocular viewing a target at 5 diopters. In addition, more recently, Vasudevan and Ciuffreda (2008) found the same, particularly in myopes, after reading for 2 hours but at a lower stimulus demand (~2.5-3D). The second is related to NITM decay. Ciuffreda and Wallis (1998) have demonstrated prolonged NITM decay to baseline, particularly in EOM and LOM subgroups, manifesting decay time constants of 35 and 62 seconds, respectively. This is relatively similar to that found in the present study, with EOMs and LOMs manifesting decay time constants of about 17sec and 44sec, respectively. In one subject, NITM decay over trials was found to extend beyond baseline to a relative hyperopic state. This too was found in a few subjects in Vasudevan and

Ciuffreda's (2008) work, and earlier in Ciuffreda and Wallis's (1998) study, where they attributed this change to a post-accommodative adaptive mechanism involving a sympathetic rebound effect.

Some variations with the earlier studies and the present investigation include the decay durations of NITM between EOMs and LOMs. In contrast to findings of the present study, some other studies have found LOM decay durations to be less than found in EOM. For example, Vasudevan and Ciuffreda (2008) found NITM decay time constants after the first and second hours of reading for LOMs and EOMs to be 5 and 22 seconds, and 8 and 34 seconds, respectively. There may be a variety of reasons for these differences, including task duration, stimulus amplitude, presence of rest periods, relatively small sample sizes, and inter-subject variability. However, the main finding across studies is that myopes have prolonged NITM decay times at compared to hyperopes and emmetropes (Ciuffreda and Vasudevan, 2008).

With regard to additivity of NITM between trials, there was no significant effect of trial number on NITM in the present study, in contrast to what was found by Vasudevan and Ciuffreda (2008) between the first and second hours of reading. Lack of additivity may be attributed to the interspersed rest periods comprised of 5 minutes of distance viewing between trials in the present study, and absence of any such rest period in the Vasudevan and Ciuffreda (2008) study. To test this point, two of our subjects were selected to perform 30 minutes of continuous nearwork, with measurements taken at 10 minute intervals, but without any imposed far rest periods. Additivity was found in both. Thus, both the present study and that of Vasudevan and Ciuffreda (2008) demonstrated

that nearwork without distance viewing could have a cumulative affect of NITM, at least in some myopic subjects.

NITM is strongly influenced by the autonomic nervous system (Gilmartin, 1986). The sympathetic system mediates an inhibitory affect on accommodation, especially at near (McBrien and Millodot, 1986; Gilmartin, 1986; Vasudevan *et al.,* 2009). But its influence at far is of particular importance. The sympathetic system consists of alpha-1 receptors, which produce pupillary mydriasis, but more importantly and relevant are the beta-1 and beta-2 receptors, which inhibit accommodation. These adrenergic activities are controlled by the neurotransmitters epinephrine and norepinephrine. Beta-1 receptors have equal affinity for epinephrine and norepinephrine and are mainly found in the heart, whereas beta-2 receptors exhibit a higher selectivity to norepinephrine and are found in blood vessels and the iris-ciliary body muscles. Activation of the sympathetic system will stimulate these beta-2 receptors in the ciliary muscle. Such activation will function to relax the ciliary muscle, ie, inhibit accommodation, and thus result in more accurate focus for distance. In conditions of rapid far-to-near focus, however, the parasympathetic system is solely involved in the initial one second or so dynamic response phase, whereas the sympathetic system is very slow acting (10 sec or longer for initiation), and thus influences the response considerably later. This was nicely demonstrated by Tornqvist (1967), in which cervical sympathetic nerve stimulations produced slow, “negative” accommodation. Tornqvist (1967) also determined that such “negative” accommodation mediated by the sympathetic system was increased with increased levels of parasympathetic activity. Since sympathetic stimulation to the ciliary muscle is inhibitory, a decrease in activation of the sympathetic system and its output would cause

an increase in accommodative adaptation and NITM, and thus likely produce an increase in time for decay back to the pre-task baseline at far. We speculate that the abnormal sympathetic system may also manifest increased variability in its inhibitory action, which would also likely slow the decay time to baseline.

NITM associated symptoms may affect an individual's quality of life. The increased magnitude and/or slowed decay of NITM may present as blur, which on a functional level visually impairs an individual's ability to perform common tasks optimally (Rafael *et al.,* 2001). This may result in common symptoms, such as not being able to read material on the blackboard after a short period of nearwork or intermittent blur at near (Rafael *et al.,* 2001). For example, Rafeal *et al.* (2001) investigated asthenopia associated with reading, and they found the cumulative amount of nearwork adversely affected the dynamics of the accommodative system.

Vision training and other procedures have also been found to reduce NITM and their related symptoms. Ciuffreda and Ordonez (1998) studied the effects of accommodative vision therapy in symptomatic subjects demonstrating abnormal levels of NITM. These subjects reported decreased symptoms related to NITM, and furthermore remained asymptomatic in the 2 month follow-up. More recently, Vasudevan *et al.* (2009) found a negative correlation between flipper rate and NITM decay time constant subsequent to such training. Thus, simple vision training (i.e., oculomotor learning) (Ciuffreda, 2002) of the accommodative system reduced nearwork aftereffects, such as NITM. It has also been suggested that frequent rest periods during prolonged nearwork allows for total decay of NITM (Rosenfield *et al.* 1992; Ciuffreda and Vasudevan, 2008). Individuals with prolonged and symptomatic NITM (i.e, "after reading, when I look up at the clock,

it is blurry for several seconds") may also consider the use of low-powered (eg. +1D) plus lenses during nearwork. For example, Jiang *et al.* (2008) studied the effects of accommodative and vergence interactions in young adults while maintaining focus at near. They objectively determined that the optimal power of the near addition to produce the least accommodative error and 3pd of near exophoria. It ranged from +0.20 D to +1.28 D at viewing distances from 50cm to 30cm, respectively. Thus, relatively low-powered spectacle lenses to reduce NITM and/or delay the progression of myopia may have promising results, especially if each prescription is customized for each patient to establish an effective balance between the accommodative and vergence systems at near. Furthermore, the use of low-powered plus lenses during near activities reduces the accommodative demand, thus allowing for decreased potentially myopogenic retinal defocus attributed to NITM (Hung and Ciuffreda, 2003).

Several recent studies have suggested that outdoor activity involving far viewing distances may help reduce myopia development. This is consistent with the notion described earlier to take frequent rest periods with distance viewing. A study by Rose *et al.* (2008) assessed the relationship of activities at varying distances with the prevalence of myopia in school-aged children. They determined that students with combined low levels of near work and high levels of outdoor activity had the most hyperopic mean refraction, whereas students with high levels of nearwork and low levels of outdoor activity had the least hyperopic mean refraction. Thus, active involvement in distance viewing activities, for example certain sports such as hockey and football, appeared to reduce myopic progression. We speculate that this may have an NITM-based component. Dirani *et al.* (2009) also investigated the relationship of outdoor activities and myopia in

teenaged children. They found that children who spent more time outdoors were less likely to be myopic. Decreasing nearwork alone may reduce myopia, but in addition, Dirani *et al.* (2009) demonstrated that increasing outdoor activities was another critical factor to help combat the development of myopia.

There were three potential limitations to the study. First, the nearwork was performed for only a single relatively short inducing period at a single (but very high) dioptric demand level. Other realistic task durations could have been used (i.e., one continuous hour), as done by Erlich (1987), as well as other high stimulus demand levels (i.e., 5D). Second, the present study included 15 subjects, which is moderate in size. More subjects would allow for greater generalization to the young-adult myopic population. Third, accommodation was not monitored during the near task. Although subjects were verbally reminded to maintain the target in focus, a continuous and objective recording of accommodation concurrent with the task would have been optimal. However, dynamic retinoscopy was performed on two of the subjects at three minute intervals during the 10 minute near task. Subjects focused on the 8 diopter target with a maximum error of 2 diopters. This suggests that accommodation was consistently maintained at a relatively high level during the entire task in which the subjects were asked to maintain target clarity.

Future clinical trials with respect to preventative and therapeutic aspects of NITM should be conducted. Trials concurrently assessing NITM and refractive error development in young children, with an emphasis on its natural progression (Mei and Rong, 1994), will provide insight into any possible link between the two. Furthermore, NITM may be assessed after longer periods (several hours) of near work, which creates a

realistic situation in which it may not dissipate fully, and hence be additive (Vasudevan and Ciuffreda, 2008), and then potentially cause myopic progression (Hung and Ciuffreda, 2003).

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