Relationship between night myopia and night-time motor vehicle accidents

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ABSTRACT.

Purpose: To investigate the relationship between night myopia and the occurrence of night-time motor vehicle accidents in a group of professional drivers. 

Methods: We examined 136 professional drivers. Refraction was determined in full illumination (100 cd/m²) and after sitting in darkness for 5 mins. The change in refraction, indicative of night myopia, was correlated with the number of motor vehicle accidents in which each driver was involved (detailed in their personal files) and with the results of a visual complaints questionnaire. 

Results: The mean age of the study group was 21.0 years. Mean spherical refraction changed from +0.11 dioptres (D) in light to −0.17 D after dark adaptation for 5 mins. Night myopia was found in 34 drivers (25%), at a mean of −1.2 D (range −0.75 D to −3.50 D). There was no statistically significant difference between these drivers and the rest of the group in the results of the visual complaints questionnaire, or in the number of accidents occurring during the day. However, drivers with a myopic shift > 0.75 D were involved in more accidents at night than the rest of the group (p = 0.044). 

Conclusions: In this study population, drivers with night myopia of > 0.75 D were more likely to be involved in night-time accidents. This may imply that selected groups of drivers should be examined for night myopia.

Key words: myopia – night myopia – motor vehicle accidents – refraction – driving

Introduction

Night myopia is a physiological phenomenon that has been identified for centuries. The astronomer Maskelyne is reported to have first noticed his tendency to become nearsighted when looking at the stars at night in 1797, at which point he used minus lenses to correct his vision (Levene 1965). Under low illumination conditions the refractive status of the eye shifts towards myopia; this so-called myopic shift can be as large as 6.00 dioptres (D) (Hope & Rubin 1984). The exact mechanism by which this occurs is still not clearly understood. One leading hypothesis suggests that night myopia is a manifestation of a slightly myopic tonus of accommodation of the eye, which goes out of closed loop control in conditions of low illumination (Owens & Leibowitz 1976; Rosenfield et al. 1993, 1994). However, a report on night myopia in patients with implanted intraocular lenses indicates that chromatic and possibly spherical aberrations of the lens may also play a role in the pathogenesis of the phenomenon (Aoshima et al. 2000). Night myopia ≥0.75 D has been reported to affect 17% of randomly selected individuals aged 16–80 years and 38% of those aged 16–25 years (Fejer & Girgis 1992).

Because accurate vision is important for safe driving (Owsley & McGwin 1999; Owsley et al. 1999), concern has been raised regarding the association between night myopia and night-time accidents (Knoll 1952; Richards 1967a, 1978). Although information in the literature regarding this relationship is scarce (Hope & Rubin 1984), it has been suggested that, under most conditions of night driving, levels of illumination are unlikely to produce a significant magnitude of myopic shift and in fact the levels of night myopia measured under typical night lighting conditions have been shown to be small (Chauhan & Charman 1993; Charman 1996). In this study we aimed to evaluate the association/correlation between night-time accidents and night myopia in a homogenous population of professional drivers.
Materials and Methods

This study was performed at the Israel Defence Forces Transportation Centre between March and April 2004 and approved by the Israel Medical Corps Research Ethics Board. All truck drivers in a single transportation unit were included in the study. In this army unit, every accident, with or without casualties, is reported to a driving safety officer. The exact details of accidents, including time of occurrence, are recorded and kept in the personal files of the drivers involved. As vehicles are regularly inspected for damage, it is unlikely that a significant crash would go unnoticed or unreported. Furthermore, army regulations require the use of optical correction for driving if uncorrected visual acuity (VA) in either eye is < 6/12. Drivers in this unit regularly drive for about 6 hours per day but never for > 8 hours. The number of miles cannot be estimated, but all drivers have roughly similar workloads. As driving at night necessitates the approval of a senior officer, it does not take place regularly.

After each driver had signed an informed consent form, VA was determined using a Snellen chart, with the driver wearing current optical correction for driving if prescribed. Refraction was then examined, using the Nidek AR-1000 infrared autorefractometer (Nidek, Gamagori, Aichi, Japan), modified so that the fixation target, composed of a non-accommodative, dim red light, was seen only when turned on. Refraction was measured in an illuminated room (approximately 100 cd/m²) with the fixation target turned on. Subjects were subsequently asked to sit in a completely dark room and refraction was measured again after 5 mins, with the fixation target turned off. As Fejer (1995) suggested, drivers with a myopic shift ≥ 0.75 D were labelled as ‘night myopia suspects’.

Each subject was also asked to complete a questionnaire regarding symptoms of night myopia (Appendix). The symptoms cited in the questionnaire were all common symptoms that have been described in the literature regarding this condition (Fejer & Girgis 1992; Fejer 1995; Charman 1996). Completed questionnaires were scored by allocating one point for each option A chosen, two points for each option B and three points for each option C. The total sum of points for the questionnaire was then calculated for each driver.

The personal file of each driver was analysed. The number of motor vehicle accidents in which the driver had been involved was recorded, together with the exact time at which each accident occurred. Daytime and night-time accidents were counted separately by checking the times of sunrise and sunset on the specific day of an accident.

All subjects in the study were engaged in compulsory military service, which is usually carried out between the ages of 18 and 21 years. Three subjects aged 35–38 years, in regular professional service, were excluded. Statistical analysis was performed using Student’s t-test and Fisher’s exact test.

Results

A total of 136 drivers were examined. Their mean age was 21.0 ± 1.2 years (range 19–24 years). They had held their driving licences for a mean duration of 28.2 ± 5.1 months (range 2–42 months). All subjects had best corrected VA > 6/12 in each eye, in accordance with the requirements of driving regulations in Israel. Mean spherical refraction in illumination was +0.10 ± 0.985 D in the right eye and +0.10 ± 0.847 D in the left eye (p = 0.78). The distribution of discrepancy in refraction between eyes was < 1 D in 130 eyes (95.6%). The mean refraction of both eyes was used for further calculations.

Following dark adaptation for 5 mins, the mean refraction of both eyes decreased significantly to −0.17 ± 0.03 D (p = 0.04). The difference between refraction in illumination and in total darkness ranged from 0.00 D to 3.50 D. In 34 drivers (25%), refraction in both eyes changed by −0.75 D or more (mean −1.2 ± 0.42 D, range −0.75 D to −3.50 D). This group of drivers were labelled as night myopia suspects for further analysis. The mean age of this group was lower than that of the rest of the drivers (20.9 ± 1.4 years as opposed to 21.7 ± 2.1 years); however, this difference did not reach statistical significance. No significant difference was found between the levels of driving experience of the two groups (27.2 ± 3.4 months for night myopia suspects and 29.1 ± 2.1 months for non-suspects; p = 0.88). Data are presented in Table 1.

The night myopia suspects had a mean questionnaire score of 11.8 ± 2.1 points, whereas the rest of the study group had a mean score of 10.0 ± 1.4 points. Although this reflects a higher rate of visual complaints, the difference did not reach statistical significance.

When comparing rates of accidents between the groups, we found that 48% of the night myopia suspects had been involved in a daytime motor vehicle accident, compared with 63% of the rest of the group (totals of 17 accidents and 64 accidents, respectively; p = 0.22). On average, each driver in the night myopia group had been involved in 0.9 ± 0.5 daytime accidents, whereas each normal driver had been involved in an average of 1.2 ± 0.44 daytime accidents (p = 0.55).

Fewer night-time accidents had occurred. The entire study group had been involved in only 14 night-time motor vehicle accidents in total. The 34 drivers in the night myopia suspects group had been involved in seven accidents and the rest of the drivers (102 drivers) in another seven accidents. The difference between the two groups according to Fisher’s exact test reached statistical significance (p = 0.044) (Fig. 1).

Table 1. Demographic and symptom data for the two study groups.

<table>
<thead>
<tr>
<th></th>
<th>Average age (years)</th>
<th>Average driving experience (months)</th>
<th>Average symptoms score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Night myopia suspects</td>
<td>20.9 ± 1.4</td>
<td>27.2 ± 3.4</td>
<td>11.8 ± 2.1</td>
</tr>
<tr>
<td>No night myopia</td>
<td>21.7 ± 2.1</td>
<td>29.1 ± 2.1</td>
<td>10.0 ± 1.4</td>
</tr>
<tr>
<td>P-value</td>
<td>0.6</td>
<td>0.88</td>
<td>0.55</td>
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</table>
Different drivers were involved in all accidents. The mean myopic shift of the drivers who had crashed at night was \(-1.4 \pm 0.50\) D (range \(-1.0\) D to \(-2.25\) D) in the group of night myopia suspects and \(-0.50 \pm 0.20\) D in the normal drivers group. The small sample precluded statistical analysis of this difference.

**Discussion**

Although the phenomenon of night myopia has been known of for centuries, its actual impact on visual performance during night-time conditions is not fully understood. The extent of myopic shift in darkness was reported to range from \(-0.37\) D to \(-2.89\) D in a study of 59 subjects (Leibowitz & Owens 1975) and from \(+0.4\) D to \(-4.0\) D in another study of 220 subjects by the same authors (Leibowitz & Owens 1978). The range of myopic shift in our study falls well within these parameters (0.00 D to \(-3.50\) D). A total of 34/139 (24\%) of the drivers in our study had a myopic shift \(\geq 0.75\) D. As the age range of our population was 18–35 years, this prevalence is well within the range reported in a population of subjects aged 16–80 years (17\%), and that reported in a population aged 16–25 years (38\%) (Fejer & Girgis 1992).

Concern regarding the impact of such a potentially large myopic shift on the visual performance of drivers was raised by several authors as early as the end of World War II (Wald & Griffin 1947; Koomen et al. 1951; Richards 1967a) and the use of corrective lenses was advocated (Richards 1978). To the best of our knowledge, and as was evident from a Medline search, our study is the first to directly examine the relationship between night myopia and night-time accidents. This relationship was indirectly investigated by Arumi et al. (1997), who studied the change in VA when luminance was reduced from 100 cd/m² to \(10^{-3}\) cd/m² and found that at the luminance level equal to road lighting (about \(1\) cd/m²), VA fell from its photopic level of \(\geq 6/6\) to \(6/9\) with little change in measured refraction. Significant changes in refraction were only observed when the luminance level fell to \(< 0.03\) cd/m², well below normal city night-driving conditions. After confirming these observations in a field study performed under street-lighting conditions, the authors hypothesized that acuity loss during night driving is related to neural changes and not to night myopia per se. This study, which was limited to six drivers only, is supported by earlier reports (Richards 1967b; Allen 1970; Chauhan & Charman 1993). However, in their discussion, Arumi et al. (1997) stated: ‘It is possible that outdoor effects when only vehicle lighting was available ... might give different results.’ The driving conditions in the army unit examined in our study were indeed different. Most night driving took place on roads outside city limits, usually without any road illumination.

Although night myopia is relatively prevalent, it was surprising to note that the drivers suffering from a large myopic shift in darkness did not report significantly more subjective visual complaints compared with the rest of the group. This low level of complaints was also reported by Fejer & Girgis (1992). Earlier, Leibowitz & Owens (1986) had hypothesized that night driving requires the simultaneous use of two modes: the guidance mode and the recognition mode. The guidance mode, used for steering along the path ahead, is not significantly affected by the relative darkness and creates a false feeling of security. It is the second mode, that of recognition, that is more affected during night conditions. However, not all subjects fully recognize and admit its degradation. It is conceivable, however, that non-recognized objects that suddenly appear in front of the driver may cause night-time accidents. The effect of induced optical blur was studied by Goode et al. (1998), who reported that it was associated with decrements in road sign recognition and road hazard avoidance.

Now that refractive surgery is a common procedure, it may be that some of the symptoms described in our questionnaire are related to refractive surgery procedures and not to night myopia. We do not know how many of the subjects in our study had actually undergone refractive surgery procedures. However, as all of them had been recruited at the age of 18 years and as refractive surgery is not permitted during active compulsory service, we assume that the number of subjects who had actually undergone the procedure was negligible.

The drivers in our study had significantly fewer accidents at night than during the day (91 accidents in daytime compared with 14 accidents at night). This difference can be attributed to the strict safety regulations applied in this army unit. Night driving is allowed only when approved by a senior officer and only after the driver has undergone a detailed briefing regarding the route and road conditions. These restrictions reduce night driving to the minimum required. Despite these restrictions, we found a significant increase in the prevalence.
of night-time accidents in drivers suffering from night myopia > 0.75 D.

Night myopia was previously reported to be more prevalent among young drivers (Fejer & Girgis 1992). In our study, the mean age of the night myopia suspects was only slightly lower than that of the rest of the group, a difference that did not reach statistical significance. This may be explained by the age range of our study subjects. Most of the drivers in this study (130/139) were aged 18–21 years, which is the age for compulsory military service in Israel. Therefore, age was not a normally distributed variable in this study and its effect on night myopia could not be determined. Another potential confounder is exposure to driving. All the subjects in this unit had spent approximately the same amount of time driving and therefore exposure was not a variable that affected the results in this study.

Our study had several advantages and limitations. One advantage concerned the availability of exact and reliable documentation of any car crash in which our drivers had been involved. This makes our study quite different from others, which have had to rely on unreliable resources such as driver declarations (Owsley & McGwin 1999). A major limitation of our study, however, concerned the small numbers of night-time accidents in which our drivers had actually been involved. This makes our statistical analysis prone to bias.

In conclusion, in our specific study group of professional drivers, we have shown a significant correlation between night myopia > 0.75 D and the incidence of night-time accidents. This may imply that dark focus examination should be used as a screening tool for professional drivers. Further study in a larger cohort of drivers is needed before such recommendations can be made.

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References


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Appendix

Night Myopia Symptoms Questionnaire

(Score: A = 1, B = 2, C = 3)

(1) How frequently do you drive at night?
A Frequently
B Sometimes
C Never

(2) How confident do you feel when driving in the dark?
A Always confident
B Sometimes not confident
C Extremely unconfident

(3) When driving in the dark, do you find it hard to recognize road signs that are not very far from you?
A Never
B Sometimes
C Always

(4) When driving in the dark, do you see halos around lights?
A Never
B Sometimes
C Always

(5) When driving in the dark, do objects suddenly appear within your field of vision?
A Never
B Sometimes
C Always