Original Article

Effects of Hypoxia and Rapid Decompression on Contact lenses

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This study was carried out to see the effects of two major aviation stresses i.e, hypoxia and rapid decompression on three types of contact lenses having different physical properties. Ten subjects wearing three types of contact lenses (hard, soft and rigid gas permeable (GP lenses) were evaluated in hypobaric chamber at simulated altitude of 3048 m 6096 m and rapid decompression from 2438 m to 6706 m. Visual acuity recording, keratometry, bimicroscopy, flare testing and fluorescein staining were used for evaluation. Subjects wearing hard lenses had significantly high incidence of subjective symptoms, corneal oedema and bubble formation with three subjects having deterioration in visual acuity and two subjects positive for fluorescein staining at 6096 m. Incidence of these test markers were quite low with soft and rigid GP lenses in comparison to hard lenses. Soft and rigid GP lenses were considered compatible with flying environment at high altitude.

Key words : Ametropia, emmetropia

Inspite of selection of only emmetropic candidates at the time of entry, large number of aircrew develop refractory errors in their flying career. Corrective flying spectacles (CFS) are not found compatible in flying with different types of head borne equipment i.e, pressure helmets, night vision goggles and helmet mounted displays[1]. Contact lenses are viable alternative to CFS especially with rapid advancement in their technology. But their use in aviation is controversial because of peculiar types of problems associated with aviation environment like decreased atmospheric pressure, hypoxia, low humidity, high 'G' forces and heat stress.

Decreased ambient pressure inside the cabin due to raised altitude and sudden loss of pressure inside the cabin due to chances of failure of pressurization system or structural failure may enlarge the bubble micronuclei present between the cornea and contact lens. Also, oxygen supply to the cornea, which is a major concern in the presence of contact lens on its surface, be further reduced by the relative hypoxic environment inside the cabin leading to corneal hypoxia.

This study is carried out to see the effects of hypobaric hypoxia and rapid decompression on wearing of hard contact lenses (Poymethylmethacrylate type), rigid gas permeable (GP) lenses and high water content soft lenses.

Material and Methods

Fifteen subjects voluntarily participated in this study. Five out of fifteen subjects were emmetropic without any eye pathology. They formed the control group. Ten ametropic subjects were fitted with three types of lenses i.e, hard lenses, rigid GP lenses, high water content soft lenses. Each type of lens was prescribed to minimum 5 subjects. Thus, 5 out of 10 subjects were given trial with two types of lenses. Every subject wore his contact lenses on daily wear basis for 6-8 hours in a day for 2 weeks prior to hypobaric chamber trial. Each subject had visual acuity 6/6 after correction and were found well adapted and asymptomatic with lenses.

Trials were conducted in hypobaric chamber installed in High Altitude Physiology Department. It consists of a main chamber for simulating hypoxia at desired altitude and an air lock chamber for simulating rapid decompression.

Reversed Snellen's chart, equipment for flare testing and bimicroscopy were taken inside the chamber for visual testing.

The hypobaric exposure protocol was as follows :-

(a) 2 hour exposure to simulated altitude of 3048 m breathing normal air.

(b) 1 hour exposure to simulated altitude of 6096 m breathing 100% O_2.

(c) Rapid decompression from 2438 m to 6706 m breathing 100% O_2.

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Eye test Schedule consisted of the following :

(a) Reporting of symptoms as per following grading explained to subjects:-

0 - No symptoms
1 - Only eye/lens awareness or tiredness
2 - Dryness and/or irritation
3 - Pain/haziness of vision

(b) Visual acuity measurement, flare testing, bimicroscopy examination before, after and during hypoxia chamber run. Post run Slit lamp examination included instillation of sodium fluorescein for corneal staining.

Results were analysed by using X^2 test with Yate's correction.

Results

Eye percentage developing subjective or objective finding with three types of lenses on exposure to 3048 m altitude have been compiled in Table I. Significant number of hard contact lens wearers ($p<0.05$) developed Grade I mild symptoms. 20% eyes developed bubbles which were peripheral, and disappeared after some time during the exposure itself. Visual acuity deterioration and fluorescein staining was noticed in one eye. There was no subjective or objective finding among rigid GP lens and soft contact lens wearers except one eye developing mild conjunctival injection.

Eye percentage wise results with three types of lenses at 6096 m have been compiled in Table II. Incidence of symptoms, visual acuity deterioration and bubbles formation were significant ($p<0.05$) in hard contact lens wearers. Bubbles were peripheral as well as central and eyes with bubbles also had visual acuity deterioration. Lens fitting became tighter in two eyes having visual acuity deterioration to 6/18.

With rigid GP lenses symptoms and visual acuity deterioration were insignificant but incidence of bubble formation was significant ($p<0.05$). Bubbles were both peripheral as well as central but eyes with central bubbles did not develop visual acuity deterioration. Signs and symptoms in soft contact lens wearers were insignificant.

Table I Percentage of eye with positive findings (Subjective and objective) at 3048 M

Subjective/ Objective Findings	Hard Lenses	Rigid GP Lenses	Soft Lenses
Symptoms present	40%	10%	10%
Conjuctival Injection	40%	10%	10%
Positive Fluorescein Staining	40%	0%	0%
Positive Flare Testing	10%	0%	0%
Bubble Formation Present	20%	0%	0%
Visual Acuity Deterioration	10%	0%	0%

Table II Percentage of eye with positive findings (Subjective and objective) at 6096 M

Subjective/ Objective Findings	Hard Lenses	Rigid GP Lenses	Soft Lenses
Symptoms present	80%	30%	20%
Conjuctival Injection	90%	30%	20%
Positive Fluorescein Staining	20%	0%	0%
Positive Flare Testing	20%	0%	0%
Bubble Formation Present	70%	40%	20%
Visual Acuity Deterioration	50%	10%	10%

On Rapid decompression incidence of bubble formation with hard lenses and rigid GP lenses were significant ($p<0.05$). Two subjects with hard lenses developed decrement in vision to 6/9 and positive fluorescein staining in eyes having central bubbles. With soft lenses, incidence of subjective and objective findings were not significant (Table III).

Discussion

The quantity of a gas that can be dissolved in a solution is directly proportional to its partial pressure and solubility coefficient in a given medium (Henry's law). With decreasing O_2 partial pressure in cockpit environment, less amount of dissolved O_2 will be available in tear film. It will further be lessened by the application of contact lens on corneal surface, more so, if contact lens material is not permeable to O_2. Without an adequate oxygen availbility, corneal oedema sets in resulting in various symptoms and signs.

Chances of bubble formation underneath the contact lenses are further increased with change in altitude especially in case of a sudden

Table III Percentage of eye with positive findings on rapid decompression

Subjective/ Objective Findings	Hard Lenses	Rigid GP Lenses	Soft Lenses
Symptoms present	40%	10%	0%
Conjunctival Injection	40%	10%	10%
Positive Fluorescein Staining	20%	0%	0%
Positive Flare Testing	0%	0%	0%
Bubble Formation Present	80%	50%	20%
Visual Acuity Deterioration	20%	0%	0%

decompression. Small bubble micronuclei present in tear film between lens and cornea can expand as the pressure decreases and large bubbles centrally positioned can deteriorate vision.

In the present study, hard contact lens wearers were having significantly more incidence of visual symptoms than rigid GP lenses or soft contact lens wearers at all profiles and symptoms were more severe and distracting at 6096 m. There were no statistically significant differences between the incidence of symptoms with rigid GP lenses and soft contact lens wearers. Symptoms were also grade I only. Other workers[2,4] carrying out hypobaric chamber study on soft contact lenses reported no symptoms in wearers.

The incidence of visual acuity deterioration with hard contact lenses at 3048 m (10%) and on rapid decompression (20%) was not significant statistically but it became significant in comparison to control group as well as to those with rigid GP and soft contact lenses on exposure to 6096 m. Our findings conforms with other workers[2,3,5] who reported no change in visual acuity in their study on soft contact lenses, but differs with Brennan et al[4] who reported two out of seventeen subjects developing reduction in visual acuity to 6/9 in one eye each at 3650 m exposure.

The difference of symptoms and signs between hard contact lens wearers and other two lens wearers can be attributed to the fact that hard contact lenses are practically impermeable to O_2.

The incidence of bubble formation in hard contact lens wearers as well as rigid lens wearers were significant at 6096 exposure and during rapid decompression. But with rigid GP lenses there was no visual acuity deterioration even in the eyes having central bubbles. This may be due to the smaller sizes of bubbles possibly due to the diffusion of gases through the GP lenses.

The present incidence of bubble formation with hard contact lenses is in agreement with Newsom et al[6]. However with rigid GP lenses our findings differ from Flynn et al[7] who reported 100% incidence at 6650 m altitude.

Conclusion

i) Hard contact lens (PMMA Type) produced more incidence of symptoms, visual acuity deterioration and bubble formation leading to decreased vision on exposure to hypobaric hypoxia and rapid decompression.

ii) There was no significant deterioration in visual acuity with rigid GP lenses as well as soft lenses at exposure profiles studied.

iii) Rigid GP lenses produced higher incidence of bubble formation than soft lenses, though not affecting vision.

iv) The soft and rigid GP lenses were found to have better compatibilities than hard lenses under the aviation stresses of hypoxia and rapid decompression.

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