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The effects of moderate-level altitude change on intraocular pressure

Abstract

This study investigated the relationship between short duration moderate-level altitude changes and changes in the internal pressure of the eye. The Mentor Tono-Pen™ was used to measure intraocular pressures of seventeen non-glaucomatous patients at ground level, in a plane at 5,000 and 10,000 feet, and again at ground level. A repeated measures analysis of variance ($P < 0.05$) was used to analyze the data. Altitude change was found to have no significant effect on intraocular pressures of subjects in this study.

Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Alan Reichow

Subject Categories

Optometry

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THE EFFECTS OF MODERATE-LEVEL ALTITUDE CHANGE ON
INTRAOCULAR PRESSURE

By

CHRISTINE SEMLER
DANIEL VIDLAK

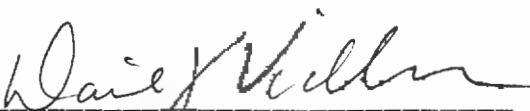
A thesis submitted to the faculty of the College of Optometry Pacific
University Forest Grove, Oregon for the degree of Doctor of
Optometry May, 1996.

Advisor: Alan Reichow, O.D., M.Ed., F.A.A.O.

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BIOGRAPHY

Christine Semler was raised in the small Midwestern town of Story City, Iowa. Christine attended Central College in Pella, Iowa, where she received a bachelor's degree with a major in biology, in 1993. While not studying, she enjoyed competitive volleyball, softball and running. Christine also studied abroad for three months in Yucatan, Mexico, during her final year at Central College. Soon after, she began studying at Pacific University College of Optometry. Upon graduation, she hopes to join her husband, David Dowe, also an optometrist, in practice in Eugene, Oregon.

Daniel Vidlak attended the University of Oregon for five years where he received his B.S. in general science and biology in 1992. While attending the University of Oregon he was a NCAA All-American wrestler as well as a PAC-TEN champion. Daniel was also the 1993 Pan-American champion. Upon graduation Daniel plans to join an existing private practice in Grants Pass, Oregon.

ABSTRACT

This study investigated the relationship between short duration moderate-level altitude changes and changes in the internal pressure of the eye. The Mentor Tono-Pen™ was used to measure intraocular pressures of seventeen non-glaucomatous patients at ground level, in a plane at 5,000 and 10,000 feet, and again at ground level. A repeated measures analysis of variance ($P < 0.05$) was used to analyze the data. Altitude change was found to have no significant effect on intraocular pressures of subjects in this study.

ACKNOWLEDGMENTS

The authors of this study would like to extend a special thanks to Charles Semler, M.D. and Cheryl Semler, Jennifer Semler, M.S., and David Dowe, O.D. for their help in obtaining and providing necessary equipment, recruiting participants, and assisting in the creation of this thesis, respectively, An extra thank you to Dr. Alan Reichow for the time and effort he provided to help bring this study to completion.

ABSTRACT

This study investigated the relationship between short duration moderate-level altitude changes and changes in the internal pressure of the eye. The Mentor Tono-PenTM was used to measure intraocular pressures of seventeen non-glaucomatous patients at ground level, in a plane at 5,000 and 10,000 feet, and again at ground level. A repeated measures analysis of variance ($P < 0.05$) was used to analyze the data. Altitude change was found to have no significant effect on intraocular pressures of subjects in this study.

INTRODUCTION

It is well researched that glaucoma is often characterized by an increase in intraocular pressure (IOP), which then may lead to significant damage of ocular health.¹ With the recent advance in the scope of optometry, including the management of glaucoma, it is important that all potential risk factors be adequately researched so optometrists, as well as ophthalmologists, will be able to properly educate glaucomatous and non-glaucomatous patients of these risk factors. This study explored one of these potential risk factors: a moderate increase in altitude. Many recreational activities such as heli-skiing, as well as unpressurized air flight involve this type of altitudinal change.

Although Nakagawara, West, and Fulk² proved that simulating moderate altitude changes in glaucoma patients had no effect on visual fields, we wanted to explore the relationship between IOP and short duration moderate altitude change on non-glaucomatous patients.

This study is intended to investigate if a relationship exists between short term moderate-level altitude changes and changes in the internal pressure of the eye. To our knowledge, no direct studies have addressed this exact relationship.

METHODS AND MATERIALS

On the twenty-second and twenty-third of March, 1996, seventeen participants arrived at the Ames Municipal Airport in Ames, Iowa, at their pre-determined time. Each signed an Informed Consent Form before any procedures were commenced. The process began inside the airport terminal with each subject receiving a single drop of Ophthetic[®] (proparacaine HCL 0.5%) anesthetic in each eye. When the cornea was fully anesthetized, tonometry was performed using the Mentor Tono-Pen XL[™]. IOP readings were recorded in millimeters of mercury (mmHg) for each eye.

After initial measurements were completed, the subjects, as well as the investigator and pilot, boarded the Cessna 210 airplane. After take-off, the plane reached 3,000 feet in approximately fifteen minutes where another drop of Ophthetic[®] was instilled. When the plane reached 5,000 feet, approximately twenty minutes after take-off, the airplane's altitude was held steady while the investigator

completed the second tonometry reading on each participant. The plane then climbed to reach an altitude of 10,000 feet, approximately forty minutes after take-off, where the second in-flight IOP measurements were recorded (no additional Ophthetic® was instilled). When all procedures were completed, the plane descended to ground level, approximately fifty-five minutes after take-off, where one last instillation of the anesthetic and the final tonometry measurements were performed inside the airport terminal. Following this procedure, each participant received a box of artificial tears (Refresh Tears™) and ocular lubricants (Celluvisc®) along with verbal and written instructions on the use of these products. Volunteers were informed of the potential possibility of corneal epithelial involvement and if such a situation was to occur, they were instructed to notify the investigator immediately.

RESULTS

The clinical findings for the seventeen participants tested are listed in Table 1. The data analysis is then listed in Table 2, followed by a summary graph. The participants' IOPs from left and right eyes were averaged resulting in the mean IOP. The participants' mean IOP at pre-flight, at 5,000 feet, 10,000 feet and at post-flight were compared to one another to see if a significant relationship existed. We found no significant difference between mean IOP at the various altitudes measured (repeated measures analysis of variance $p < 0.05$).

	subjects	Pre OD	Pre OS	MEAN PRE	5000 ft. OS	5000 ft. OD	MEAN 5000	10000 ft. OS	10000 ft. OD
				MEAN PRE X ₁			MEAN 5000 X ₂		
1	Kp	15	14	14.5	16	15	15.5	14	14
2	SUL	16	15	15.5	19	18	18.5	18	19
3	RB	17	15	16.0	12	13	12.5	11	13
4	SB	16	13	14.5	18	17	17.5	16	19
5	MS	14	12	13.0	15	12	13.5	15	18
6	JS	16	15	15.5	13	15	14.0	15	12
7	GT	18	19	18.5	17	18	17.5	18	19
8	RH	21	20	20.5	16	15	15.5	19	20
9	KH	16	15	15.5	13	15	14.0	19	20
10	MR	13	14	13.5	11	12	11.5	13	12
11	LY	13	14	13.5	15	13	14.0	17	18
12	RB	18	19	18.5	20	18	19.0	18	15
13	RODB	16	13	14.5	16	15	15.5	22	18
14	MB	18	16	17.0	18	20	19.0	17	16
15	TR	15	15	15.0	14	15	14.5	12	13
16	JR	20	20	20.0	17	16	16.5	18	17
17	JB	13	13	13.0	12	13	12.5	12	12

	MEAN 10000	Post OD	Post OS	MEAN POST
	MEAN 10000 X ₃			MEAN POST X ₄
1	14.0	15	13	14.0
2	18.5	13	14	13.5
3	12.0	14	15	14.5
4	17.5	15	15	15.0
5	16.5	13	11	12.0
6	13.5	16	13	14.5
7	18.5	16	17	16.5
8	19.5	18	20	19.0
9	19.5	14	15	14.5
10	12.5	11	12	11.5
11	17.5	14	14	14.0
12	16.5	16	17	16.5
13	20.0	17	18	17.5
14	16.5	14	14	14.0
15	12.5	15	13	14.0
16	17.5	19	17	18.0
17	12.0	14	12	13.0

TABLE 2

One Factor ANOVA-Repeated Measures for X₁ ... X₄

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Between subjects	16	241.191	15.074	5.275	.0001
Within subjects	51	145.75	2.858		
treatments	3	16.676	5.559	2.067	.117
residual	48	129.074	2.689		
Total	67	386.941			

Reliability Estimates for- All treatments: .81 Single Treatment: .517

One Factor ANOVA-Repeated Measures for X₁ ... X₄

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
MEAN PRE	17	15.794	2.346	.569
MEAN 5000	17	15.353	2.344	.568
MEAN 10000	17	16.147	2.816	.683
MEAN POST	17	14.824	2.054	.498

One Factor ANOVA-Repeated Measures for X₁ ... X₄

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffe F-test:	Dunnett t:
MEAN PRE vs. MEAN 5000	.441	.943	.205	.784
MEAN PRE vs. MEAN 100...	-.353	.943	.131	.628
MEAN PRE vs. MEAN POST	.971	.943*	.993	1.726
MEAN 5000 vs. MEAN 10...	-.794	.943	.664	1.412
MEAN 5000 vs. MEAN PO...	.529	.943	.295	.941

* Significant at 90%

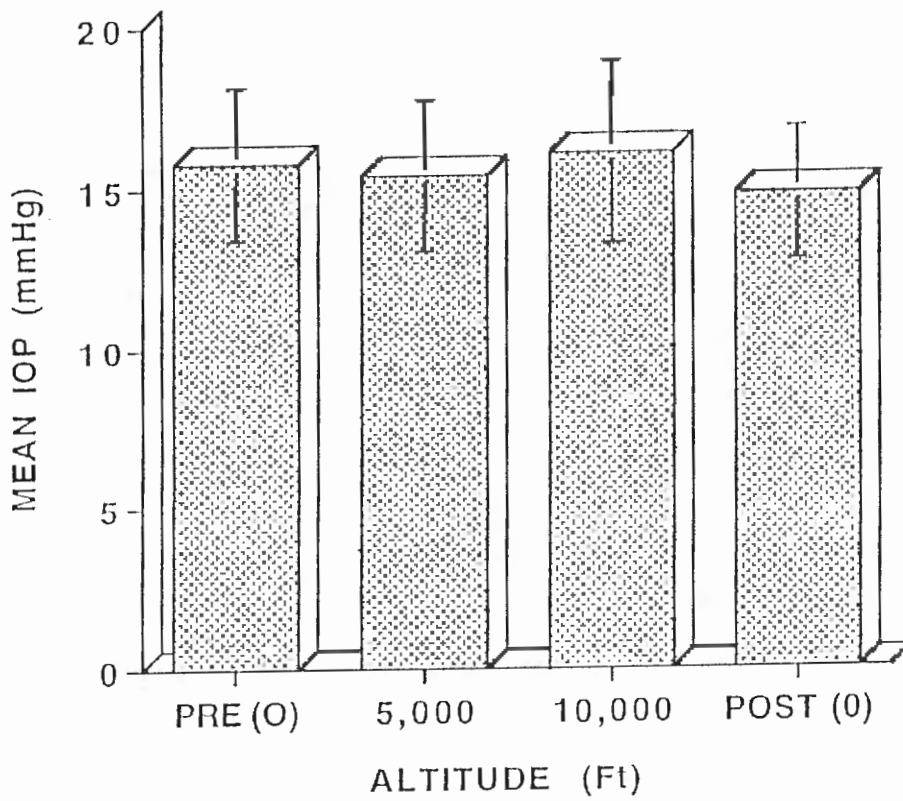
TABLE 2 (CON'T)

One Factor ANOVA-Repeated Measures for X1 ... X4

Comparison:	Mean Diff.:	Fisher PLSD:	Scheffé F-test:	Dunnnett t:
MEAN 10000 vs. MEAN P...	1.324	.943*	1.846	2.353

* Significant at 90%

SUMMARY GRAPH



DISCUSSION

The goal of this study was to explore if a relationship exists between IOP and short term (fifty-five minutes total) moderate altitude change. A significant relationship did not exist in this study.

Presently, we have not found any sources that have studied the relationship between IOP and short duration moderate altitude change. We suggest a follow-up study to serve as verification.

Another possible weak area in this study involves the methods used for obtaining IOP. Although the Tono-pen XLTM shows a consistent slight underestimation of IOP compared to the Goldman applanation method,^{3,4} it still may have significantly altered our results. Along with this, the participants while in the aircraft, moved around significantly during tonometry readings due to in-flight turbulence.

Baudouin⁵ showed that topical anesthetics consistently decrease IOP for up to fifteen minutes after instillation. In this study three drops of anesthetic were used. The drops were instilled at time zero, fifteen minutes, and fifty-five minutes. Bearing this in mind, future studies could be done using non-contact tonometry to eliminate anesthetics as a possible source of error.

Although fifty-five minutes of moderate altitude change had no significant effect on IOP of the seventeen subjects in this study, it would be interesting to investigate if a longer duration of altitude change, as well as an increased number of subjects would demonstrate a significant change in IOP.

CONCLUSION

Under short term exposure to moderate altitude change, this study found no fluctuation in IOP. This suggests that air travel or other activities with moderate altitude change have no significant effect on IOP, thus eliminating moderate altitude as a possible risk factor to discuss with patients.

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