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The Impact of Examination-Induced Stress on Intraocular Pressure of Ophthalmology Residents

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Abstract

Recent studies have shown that stress can elevate intraocular pressure in subjects exposed to academic tasks. In particular, an oral presentation has been shown to increase intraocular pressure, as well as other markers of stress such as heart rate, blood pressure, salivary cortisol, and subjective experience of anxiety measured through questionnaires. Our pilot study included a sample of 6 ophthalmology residents undergoing departmental examination. Intraocular pressure (IOP), blood pressure, and heart rate were measured at five-time points: (1) 2 weeks before the exam, (2) the day before the exam, (3) the day of the exam, (4) the day after the exam, and (5) 2 weeks after the exam. Median values for IOP in the right and left eyes, heart rate, and blood pressure were compared between 2-time intervals for all outcome variables. Median values for IOP in the right and left eyes on the day before the exam were 12.25 ± 2.89 and 11.15 ± 3.31, respectively; on the day of the exam they were significantly higher at 13.50 ± 2.99 and 13.50 ± 3.12, respectively ($p<0.05$). Limited resources, including small sample size and potentially confounding external stressors experienced by subjects throughout the study period highlight the need for future research on this topic.

Key words: Ophthalmology; Glaucoma; Intraocular pressure; Stress.

INTRUDUCTION

Intraocular pressure (IOP) is defined as the pressure of aqueous humor inside the eye. It is an important measurement used by ophthalmologists to diagnose and monitor glaucoma [1]. Glaucoma is a progressive optic neuropathy and is one of the leading causes of blindness in the world [2,3]. Significant attention has been paid to variables that contribute to the development of glaucomatous changes, such as IOP, age, ethnicity, refractive error, family history, and certain systemic co-morbidities [1,4-8]. A 2014 systematic review and meta-analysis determined that one important variable involved in the progression of glaucoma is fluctuation in IOP [1]. The role of stress, a homeostatic disruption with several end organ effects, on fluctuating IOP has been questioned recently [4,5]. At this time additional research is required before the relationship between acute stress and IOP fluctuations can be accurately determined.

Vera, Alvarez-Rodriguez, Molina & Jimenez., showed higher IOP in a sample of university students before a public defense of their research theses [4]. This elevation in IOP is also associated with a subjective increase in public speaking anxiety, as measured with the State-Trait Anxiety Scale (STAI). In another study, students were assigned to undergo the Trier Social Stress Test to simulate public speaking-induced stress [5]. Outcome variables of their study included IOP, heart rate, cortisol, and subjective stress levels. The results show elevated IOP and perceived stress levels after exposure to the stress stimulus. From a therapeutic perspective, studies aimed at reducing stress have shown that mindfulness training reduced IOP and other biomarkers of stress in patients with primary open-angle glaucoma [6].

It has yet to be shown whether oral components of academic examinations, for example, those undertaken by surgical residents, contribute to IOP fluctuations in eyes with or without the glaucomatous disease. Further,

it remains unclear if anxiety questionnaires such as the STAI are the best subjective measure for stress within this population. The present study aims to elucidate the relationship between stressful tasks and fluctuations in IOP and blood pressure in healthy ophthalmology residents undergoing a standardized departmental exam. The null hypothesis predicts no significant difference in median IOP, heart rate, or blood pressure between measurements taken before, during, or after the exam.

METHODS

The subjects of this prospective study include healthy ophthalmology residents aged 25-38. All subjects are licensed medical physicians under-going their 5-year specialty training program. Participation in the study was voluntary, in accordance with standards of the local research ethics board (REB), from which approval was obtained. All subjects underwent informed consent with the research coordinator prior to the initiation of the study. Measurements of IOP, blood pressure, and heart rate were taken on five different days. Measurements were routinely taken between 8:30 – 11:00 AM to mitigate the effects of diurnal fluctuations. IOP was measured in both eyes using Goldmann Applanation tonometry and was taken by two independent investigators at each time point.

Subject Selection

Ophthalmology residents at Dalhousie University undergoing their departmental exams were eligible for inclusion in this study. A history of glaucoma, ocular hypertension, systemic hypertension, history of eye surgery, or other ocular pathology followed by an ophthalmologist excluded subjects from enrolling in this study. Further, any participant who did not write their departmental exam for any reason was ineligible. The population of interest was considered in order to describe stress-related changes in intraocular/blood pressure in individuals without ocular pathologies (such as glaucoma or ocular hypertension). By enrolling healthy participants undergoing the same stressful event at the same time, the researchers sought to characterize intraocular and blood pressure changes prior to and following an examination with greater accuracy. By limiting this study to residents of ophthalmology, there may be less unfamiliarity with intraocular pressure testing paradigms. Therefore, the impacts of a stressful event on IOP would not be confounded by unfamiliarity with testing procedures.

The Stressful Activity

The stressful activity in this study was the ophthalmology resident departmental examination. This exam has both a written multiple-choice component in the morning and an oral component in the afternoon of the same day. The oral component is administered by a variety of ophthalmology faculty from the same department.

Data Collection

The first measurement was a baseline measure taken 2 weeks before the examination. The second measurement was the day before the exam. The third measurement was the day of the event, between the written and oral components of the exam. The fourth measurement was the day after the event. The final fifth measurement was 2 weeks after the event. Accordingly, all data collection took place over 4 weeks, as outlined in Table 1. Each time point analyzed in this study is identified as “baseline”, “pre-stress”, “stress”, “post-stress”, and “follow-up”, as indicated by Table 1.

IOP was measured using the standard method of applanation tonometry, involving the installation of one drop of Fluorescein (Minims®) into each eye. This method was chosen for its accepted accuracy and reliability compared to other methods of obtaining IOP. The standard method of applanation tonometry involves the use of a tonometry fitting on the slit lamp, located in all assessment rooms of the Eye Care Centre in the QEII Health Sciences Centre. Intraocular pressure was measured by two research personnel, and the average of the two values measured within ten minutes of each other was calculated. Taking the average IOP of each eye, the mean IOP of both eyes was calculated. Blood pressure was measured using an upper arm automated blood pressure monitor (Omron Health Care®). Blood pressure and heart rate were measured by the research coordinator only.

Table 1. Time table for data collection.

2 weeks before the exam *(“baseline”)*	1 day before the exam *(“pre-stress”)*	Day of the exam *(“stress”)*	1 day after the exam *(“post-stress”)*	2 weeks after the exam *(“follow-up”)*
✓ TA x 2 BP HR	✓ TA x 2 BP HR	✓ TA x 2 BP HR	✓ TA x 2 BP HR	✓ TA x 2 BP HR

Statistical Analysis

Descriptive statistics characterized demographic trends such as age, and the Wilcoxon Signed Rank Test was used to compare median group values between separate days, represented by the Z score statistic. This was applied using IBM SPSS statistics for Mac v.25 (IBM Corp., Armonk, NY., USA). This analysis was chosen due to the small sample size included in this study, and the ability to assess non-parametrically distributed scale variables, by comparing 2 median values taken at 2 discrete time intervals.

RESULTS

After obtaining informed consent, six subjects were enrolled in the study. Median group values for each outcome variable, including standard deviations are outlined in Table 2. In the present study, Z scores are non-significant when comparing baseline values with pre-stress, stress, post-stress, and follow-up values. Z scores for left and right IOP are significantly different when comparing pre-stress and stress interval measurements ($p<0.05$), as per Table 3. The mean IOP of both eyes together when comparing the pre-stress and stress intervals were also significant ($p<0.05$) as shown in Table 3. The pre-stress heart rate was significantly different from the follow-up heart rate ($p<0.05$), also shown in Table 3. No other variables achieved significance when comparing pre-stress median values with other time intervals. Median values for all variables at the stress, post-stress, and follow-up intervals were not significantly different.

DISCUSSION

Our results show a statistically significant difference between median group IOP's when comparing measures taken the day before the departmental exam, with measurements taken on the day of the departmental exam. This result was significant for right and left eyes individually, as well as the mean of the two eyes. For each measurement, IOP was significantly lower on the day before the exam and increased on the day of the exam between written and oral components. A statistical difference in blood pressure or heart rate was not established when comparing values for the same time intervals, however. The findings of this study were unable to compliment changes in IOP and other measures of physiological or perceived stress, as shown by previous authors.

Results of a study by Vera et al. reveal increased IOP immediately before a thesis defense by university students, compared to measures taken from a control group. The authors report a concurrent significant change in perceived anxiety according to the STAI scale outcomes. These results are difficult to compare to those of the present study for a variety of reasons. The present study did not apply a survey to assess perceived anxiety, in order to reduce the number of tasks that subjects were subjected to near an important exam. Additionally, the present study did not include a control group. Outcomes of the cohort were compared across time points instead.

Data collection differed between the two studies on the basis of the timing of data collection. Vera et al., took 3 separate measures, before and after the defense, and

Table 2. Median value and standard deviation for cohort outcomes at each time interval.

	Right IOP	Left IOP	IOP OU	Heart Rate	BP Systolic	BP Diastolic
Baseline	13.75 ± 2.75	13.25 ± 2.51	13.37 ± 2.55	88.50 ± 8.13	128.50 ± 9.61	82.00 ± 4.60
Pre-stress	12.25 ± 2.89	11.75 ± 3.31	12.00 ± 3.07	90.50 ±11.37	126.50± 10.34	80.00 ± 5.88
Stress	13.50 ± 2.99	13.50 ± 3.12	13.50 ± 3.03	80.50 ± 6.51	128.50 ±16.12	79.00 ± 8.76
Post-stress	12.50 ± 3.72	11.50 ± 4.38	12.00 ± 3.97	85.00 ± 6.81	123.50 ±13.73	82.00 ± 5.81
Recovery	12.25 ± 3.20	12.25 ± 2.76	12.37 ± 2.92	81.00 ± 5.93	123.50 ±11.26	80.00 ± 6.38

Table 3. Pre-stress median values compared to follow-up interval values.

	Pre-stress vs stress	*p*-value	Pre-stress vs post-stress	*p*-value	Pre-stress vs recovery	*p*-value
Right IOP (mmHg)	*Z* =15 ± 3.6	0.04**	*Z* =16.5 ± 4.7	0.26	*Z* =10.0 ± 4.7	0.91
Left IOP (mmHg)	*Z* = 21.0 ± 4.7	0.02**	*Z* =17.5 ± 4.7	0.14	*Z* =12.0 ± 4.7	0.75
Mean IOP both eyes (mmHg)	*Z* =21.0 ± 4.8	0.02**	*Z* =17 ± 4.7	0.17	*Z* =11.0 ± 4.7	0.92
Heart rate (BPM)	*Z* = 3.0 ± 4.7	0.11	*Z* =4.0 ± 4.7	0.17	*Z* =1.0 ± 4.7	0.04**
Systolic BP (mmHg)	*Z* = 14.5 ± 4.7	0.40	*Z* =8.0 ± 4.7	0.59	*Z* = 16.5 ± 4.6	0.19
Diastolic BP (mmHg)	*Z* =16.5 ± 4.7	0.20	*Z* =15 ± 4.7	0.34	*Z* =15 ± 4.7	0.34

** = statistical significance

after 10 minutes of recovery, representing more acute changes in IOP when compared to measures taken over 4 weeks. The findings by Vera et al., reveal detectable IOP differences in response to stress, without other observed statistically significant physiological markers of stress in response to a stressor, as was found in the present study.

Abe et all., administered the validated Trier Social Stress Test (TSST) to a total of 17 healthy subjects and compared IOP measurements to 11 healthy controls who did not undergo the TSST. Three measures were taken; immediately before and immediately after the TSST, and again after 40 minutes of recovery. Outcome variables include IOP, heart rate, salivary cortisol levels, and STAI scores. The results show a statistical increase in IOP following the TSST compared to baseline measures. These results are complemented by increases in heart rate and salivary cortisol immediately after the TSST. In this population, the STAI scores increase immediately after the TSST and reduce after 40 minutes of recovery.

The findings of the study by Abe et al., represent a more acute change in stress, similar to the results by Vera et al. Additionally, both results by Abe et all., and Vera et al., represent significant changes between groups rather than within a group. By contrast, the present study did not show a significant difference in heart rate when comparing baseline to post-stress, as is shown by Abe et al. Instead, the present authors showed a difference in heart rate, when comparing pre-stress with recovery measures (Table 2). Although the timing of the measurements differs between studies, the present study also showed an increase in IOP around the time of the stressor. No difference in IOP or heart rate is shown by Abe et al., immediately before the stressor task when comparing interventional and control groups.

Design Limitations

When comparing this study to previous publications, it is important to establish the lack of a prospective power analysis. Without an established minimum number of subjects to be enrolled, it can be difficult to establish statistical significance, or compare the results of the present study to existing prospectively powered to achieve significance, if an effect is present. Consequentially, a posthoc analysis of minimum detectable difference determined the probability was 80 percent that the study would detect a relationship between the independent and the dependent variables at a one-sided 0.05 significance level if the true change in the dependent variables was at least 1.242 standard deviations.

This within-group design analysis also lacked the presence of a control group and compared mean outcomes from separate time intervals within a single cohort. Where existing literature used control subjects and statistically analyzed data accordingly, this will further limit the comparability between the results. The design of this study, including a small sample of local ophthalmology residents, precluded researchers from collecting data pertaining to medication history. While the comfort and anonymity of subjects was a priority, the lack of an established medication history renders this study vulnerable to confounding prescription medications which may physiologically alter the stress response in any way. Potential subjects were encouraged to participate in the study if they felt their medication history would not interfere with the results of the study.

Additional limitations include the lack of a subjective measure of stress, such as the STAI questionnaire. Without this data, it was challenging to compare our results with existing studies or establish that residents were actually stressed when researchers expected them to be stressed, or less stressed when researches expected subjects would not be stressed.

Events external to the methodology and acute stressor of this study implicated additional stressors throughout the duration of the study, which could not be controlled for during data collection. For example, one participant went through the process of purchasing a home, causing increased stress around the time of baseline measurement, when stress was intended to be lower in subjects. Additionally, departmental research day presentations took place the day after our final follow-up measurements. This may have also generated stress in the subjects, potentially limiting the chance of detecting a significant difference in measurable stress between measurement intervals. Future studies may attempt to mitigate some of these limitations, or control for these confounds by collecting additional data from subjects at each measurement interval.

CONCLUSIONS

Due to a variety of limitations, the findings of this study require further replication with increased control of potential confound variables, and a larger sample size powered to achieve significance. However, despite the sample of only 6 participants, results in the present study revealed significantly higher intraocular pressure in subjects on the day of their exam, compared to

measures taken the day before. There did not appear to be a significant effect of stress on blood pressure or heart rate. These findings support the need for further research surrounding the relationship between stress and IOP.

LITERATURE SEARCH

MEDLINE, Google Scholar, and Science Direct were searched on October 28, 2020, using the search function with the following medical subject headings: exodeviation, intermittent exotropia, exotropia, exophoria, consecutive esotropia, surgery for exotropia, surgical outcomes of exotropia. No restrictions of language or date were applied. The electronic translation was used where literature was published in a foreign language. All valid studies and their references were considered in order to perform a thorough literature review.

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