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# Physical examination stress: an overlooked factor for increasing intraocular pressure in cats

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**Abstract**

Intraocular pressure (IOP) is essential for eyeball health, and abnormal values may cause detrimental effects on ocular structures. The reliable measurement of IOP provides high diagnostic value, as each mmHg increase in IOP is associated with a 10% greater risk of glaucoma development and progression. This study evaluated the effects of physical examination stress on short-term variations in IOP in 42 healthy intact cats. IOP was measured with a Schiotz tonometer before and after physical pre-vaccination examinations. Physical examination stress significantly increased IOP in the left and right eyes of male and female cats. Also, in both measurement steps, the mean IOP in male cats was significantly higher than in females ($p < 0.05$). Based on these results, measuring IOP at the beginning of physical examinations is recommended, and it is necessary to consider the effects of stress in the interpretation of tonometry results.



## Introduction

Increased intraocular pressure (IOP) is the commonest independent risk factor for the onset and further development of glaucoma, an ophthalmic disease characterized by degeneration of retinal ganglion cells and their axons, causing optic nerve head lesions and blindness (Jiménez and Vera, 2018; Turner *et al*., 2019). The essential cause of increased IOP is an imbalance between the production and drainage of aqueous humor, with the latter primarily responsible for the imbalance and mainly mediated by the sympathetic nervous system (Brody *et al*., 1999). Medically, stress is defined as a disturbance in the homeostatic state of an organism. Following stress, the activation of the sympathetic nervous system causes a series of metabolic reactions known as the stress response. This response, mainly via the hypothalamic-pituitary-adrenal axis, interferes with physiological levels of circulating hormones such as cortisol. Variations in the levels of these hormones may cause systemic disorders such as high blood pressure (Gillmann *et al*., 2019). Clinically, it seems that stress increases IOP, particularly in patients with glaucoma, and it has also been suggested as a trigger or exacerbating factor for both angle-closure and open-angle glaucoma (Miyazaki *et al*., 2000). Therefore, it is essential to determine the baseline IOP and to identify and understand the causes of IOP variation and the physiological mechanisms affecting IOP regulation (Nicou *et al*., 2021).

It has been shown that acoustic and optical stress can increase IOP in laboratory animals (Brody *et al*., 1999). However, the effect of routine physical examination stress on the IOP of small animals is unclear. Stress typically occurs in cats when they lose their safety-providing territory and effective control of their environment as well as vital resources, which can invariably happen during the pre-vaccination examination, even for a short time (Karn-Buehler and Kuhne, 2022). This study aimed to investigate the effects of physical examination stress on IOP in healthy

cats referred for vaccination.

## Materials and Methods

This study was conducted on 42 intact healthy adult cats (84 eyes) of both sexes equally, which were referred to the veterinary hospital of Urmia University for vaccination. Exclusion criteria included a history of eye diseases (e.g., glaucoma), eye surgeries, cardiovascular or neurological disorders, or consumption of medications likely to affect eye physiology (Brody *et al*., 1999). The IOP measurement was done after 15 minutes of the animals' familiarization with the environment and immediately after the physical pre-vaccination examinations, including measuring rectal temperature, respiratory rate, heart rate, capillary refill time, palpation of lymph nodes, and observing the color of mucous membranes.

Before measuring the IOP, one drop of 0.5% Tetracaine (Sina Darou Co., Iran) was instilled into both conjunctival sacs for local corneal anesthesia (Wrześniewska *et al*., 2018). After getting the owners' consent, a board-certified small animal internist performed all measurements according to the instruction of the tonometer. The cats were restrained by an assistant in the suggested way to guarantee effective and safe IOP measurement. The IOP was measured firstly in the left and then in the right eye (OS and OD, respectively), using the Schiotz tonometer (Riester Co., Germany) with the vertical scale and a weight of 5.5 g (Fig. 1). Each measurement was repeated three times, and the average results were recorded (Miller, 1992; Wrześniewska *et al*., 2018). After each IOP measurement, the tonometer was disinfected and kept in the supplied airtight bag until the next case.

All data were analyzed using SPSS statistical package, version 22 for Windows (Chicago, USA) and described as mean and standard deviation (SD). Significant differences were calculated using the paired t-test. A *p*-value less than 0.05 was considered statistically significant.

## Results

In the current research, the studied cats were domestic shorthairs with an average age of 4 years (ranging from 1 to 10 years). The results of measuring IOP in cats with a Schiotz tonometer were summarized in Table 1. Previously, the mean IOP in normal cats was reported to be 21.6 ± 5 mmHg using the Schiotz tonometer (McLellan and Miller, 2011). The stress of physical examinations led to a significant increase in IOP in male and female cats' left and right eyes. Also, during both measurement steps, the mean IOP in male cats was significantly higher than that of females ($p < 0.05$).

**Table 1.** Mean ± standard deviation (SD) of intraocular pressure (IOP) measured in the studied cats.

| | IOP1 (mmHg) | IOP2 (mmHg) | *p*-value |
|---|---|---|---|
| OS (m) | 19.8571 ± 5.06247 | 20.6190 ± 4.92419 | 0.029 |
| OD (m) | 19.9524 ± 5.49068 | 21.1429 ± 5.70338 | 0.000 |
| OU (m) | 19.9048 ± 5.25980 | 20.8333 ± 5.28520 | 0.000 |
| OS (f) | 18.6190 ± 3.13809 | 19.1905 ± 3.50170 | 0.049 |
| OD (f) | 18.6190 ± 2.95764 | 19.5714 ± 3.10759 | 0.001 |
| OU (f) | 18.6190 ± 3.01208 | 19.4048 ± 3.26963 | 0.003 |
| OS (t) | 19.2380 ± 0.87547 | 19.9048 ± 1.01010 | 0.090 |
| OD (t) | 19.2857 ± 0.94286 | 20.3572 ± 1.11122 | 0.070 |
| OU (t) | 19.2619 ± 0.90920 | 20.1190 ± 1.01010 | 0.053 |

OS-left eye, OD-right eye, OU-both eyes, m-males, f-females, t-total, IOP1-inraocular pressure before physical examination, IOP2-intraocular pressure after physical examination.

**Fig. 1.** Measurement of IOP using Schiotz tonometer in a domestic short-hair cat.

## Discussion

Our hypothesis was supported: physical examinations' stress increased IOP. Some studies indicated a mild but significant effect of stress on increasing IOP; others showed that relaxation can have a contrary effect (Gillmann *et al*., 2019). Many internal and external factors can cause variation in baseline IOP on time scales of seconds to days. Internal factors include body temperature, blood pressure, respiration, circadian rhythms, cerebrospinal fluid pressure, and mental stress. External factors of variation include altitude, posture, immobilization, environment temperature, and psychoactive agents like cannabis, caffeine, and anaesthetics (Miyazaki *et al*., 2000; Nicou *et al*., 2021).

Two main reasons can be mentioned in explaining the changes in the IOP of the studied cats. Firstly, researchers have observed that blood pressure measured in cats at office visits is significantly higher than values recorded at home visits, a phenomenon known as the "white-coat effect," possibly related to the anxiety or stress associated with the clinical context (Koo and Carr, 2022). According to the findings of our study, IOP can also be affected by the patient's stress, which may cause variations in baseline IOP values and thus interfere with the clinical management of glaucoma. It is worth noting that stress has a two-way effect on the rate of aqueous humour production and its outflow resistance, as previously documented in a rabbit model (Gillmann *et al*., 2019).

Secondly, it has been shown in humans that subjects' personality types may considerably affect IOP variations, so type A personalities show the maximum variability (Gillmann *et al*., 2019). Although these characteristics were not well analysed in the veterinary literature; however, we studied intact animals, and it was documented that neutered cats are less aggressive and have lower cortisol levels than intact cats. Also, more aggressive intact cats have higher cortisol levels than less aggressive intact cats (Finkler and Terkel, 2010). Cortisol is necessary to maintain blood pressure and, in excess, leads to hypertension (Whitworth *et al*., 2005). Hypertension can increase both ciliary arterial blood pressure and aqueous humour ultrafiltration pressure, which are the most substantial factors in aqueous humour formation (Jiménez and Vera, 2018).

Increased IOP caused by stress has also been proven in humans. Brody *et al*. (1999) measured IOP before and after psychological stress with the mental arithmetic test as a stressor. IOP was increased by approximately 1.3 mmHg after the stressor. Another study evaluated the effects of exam stress on students by measuring IOP before and after exams. This study showed that acute stressors such as academic examination can lead to notable IOP elevation (Turner *et al*., 2019).

The difference in IOP between male and female cats can be due to physiological or anatomical discrepancies that affect the rate of aqueous humour formation or outflow, predisposing one gender to higher IOP (Ofri *et al*., 1998). Different genders react to acute stress variously. So, males respond with more blood pressure, and females experience more variations in heart rate (Jiménez and Vera, 2018).

In conclusion, obtaining a true stress-free IOP is impossible because all clinical IOP measurements need patient contact, which may induce stress and falsely increase baseline values. However, according to the results of this study, it can be recommended that IOP measurement be done at the beginning of physical examinations, and it is essential to consider the effects of stress in interpreting tonometry results. Also, IOP monitoring in animals under stress conditions, especially those with glaucoma, can be particularly important.

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## Conflict of Interest

The authors do not have any potential conflict of interest to declare.

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