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Seasonal Variations of Intraocular Pressure in Normal Sapsaree Dogs

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Abstract : This study was performed to evaluate the seasonal variation of intraocular pressure (IOP) values in normal Sapsaree dogs. Sapsaree dogs (n = 474) clinically free from ophthalmic disease were included in this study, and both eyes were examined in each dog. An applanation tonometer (Tonopen® XL) was used to measure IOP values in both eyes. Data obtained from both eyes were stratified by factors thought to affect IOP values including age, gender, hair coat type as well as season of measurement. The IOP results were compared by ANCOVA to verify the effect each factor had on IOP, and an ANOVA test followed by a Bonferroni post hoc test was used for further analysis. The overall mean ± SD IOP value was 19.1 ± 3.7 mmHg (range: 8 to 28 mmHg) in the present study. Only seasonal variation showed a significant effect (P < 0.001), on IOP values. IOP values measured in winter (20.4 ± 3.4 mmHg) and summer (17.1 ± 3.6 mmHg) were significantly higher and lower, respectively, than those measured in other seasons. These results suggest a seasonal variation has a significant effect on the IOP of normal dogs. This may prompt further research and possible modification of current veterinary ophthalmic references.

***Key words* :** dog, intraocular pressure, Sapsaree, seasonal variation, tonometry.

Introduction

The measurement of intraocular pressure (IOP) is an essential diagnostic technique to evaluate ocular disease in veterinary practice. High and low IOP values can be associated with glaucoma and anterior uveitis, respectively, both of which can result in visual impairment (29). A reliable IOP measurement is an indispensable procedure for optimal clinical management (12). Assessment of the IOP value is an important indicator of ocular health and method of diagnosis for the severity and possible treatment of glaucoma. IOP is determined by the volume of intraocular fluid (aqueous humor), choroidal blood volume, vitreous humor volume, globe rigidity, scleral compliance, extraocular musculature tones, and external ocular pressure (1). Physiological and environmental variations, including age (4,9,11), gender (28), race (19,22,33,35), blood pressure (18), nutrition and diet (30,38), body position (6,20, 23), daylight (2,25,27) and season (3,5,16,37), can influence IOP. These variations could result in clinically significant fluctuations of IOP in humans and animals.

The effect of seasonal variation in IOP is not consistent between reports. Several studies have reported the effect of seasonal variation on IOP values in humans and rabbits. The studies have generally reported similar results, higher IOP values in winter and lower IOP values in summer (3,5,16, 37). However, one report on rabbits showed two peak IOP values among the seasons (2).

This study focuses on the Sapsaree, a native Korean dog, widely known since 400 AD. The Sapsaree dog was declared National monument No. 368 by the Korean Ministry of Culture in 1991. This medium size dog is mild mannered and considered friendly with people. There are five sub-types of the Sapsaree dog, classified by hair color: blue, chestnut, yellow, yellow-white, and white types, and each sub-type has a close genetic background (7,15).

To our knowledge, no studies have evaluated seasonal variation in IOP values in dogs. This study was performed to investigate seasonal effects on IOP value in a population of healthy Sapsaree dogs.

Materials & Methods

Experimental Animals

A total of 474 clinically normal Sapsaree dogs (206 male, 268 female, 948 eyes), free from ophthalmic disease in both eyes, living outdoors and registered by the Korean Association of Sapsaree were included in this study. All procedures were followed ARVO guidelines and animals which is not willing to be measured, castrated, neutered, or without clear signalment and information were excluded. The mean ± SD age of dogs in the study was 2.4 ± 2.3 (range 4 months ~9

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years old) years old.

To ensure the animals were free from ophthalmic disease, two examiners (KS, JJC) performed an ophthalmic examination on each animal. A portable handheld slit-lamp biomicroscope (Kowa SL-14®, Kowa, Tokyo, Japan) was employed to examine the anterior segment of the eye, and an indirect ophthalmoscope (Vantage®, Keeler, Berkshire, UK) was used to evaluate the vitreous and retina approximately 20 minutes after applying 1% tropicamide (Ocutropic®, Samil Pharm Co, Ansan, Korea).

Tonometry

IOP values were measured by one examiner (JJC) and one instrument throughout the course of the entire study. Before taking measurements, the instrument was calibrated according to the manual, and one or two drops of proparacaine (Alcaine®, Alcon, Puurs, Belgium) were applied to both eyes. IOP values were measured at the center of the cornea using the applanation tonometer (Tonopen® XL, Mentor, Norwell, MA) with a maximum of 5% variance in four valid readings. All readings were obtained between 10 AM and 2 PM on clear days.

Classification and Statistical Analysis

Obtained data were classified by season of measurement, age, gender and hair coat type (Table 1) to analyze the effect of each variation. The seasons: spring (March to May), summer (June to August), autumn (September to November) and winter (December to February) were classified based on the definition by the Korean Mythological Administration. The mean values of temperature and the amount of daylight time of each season in Korea are shown in Table 2 (21). To analyze the effect of age, age distribution was divided into four age groups: younger than 1 year, 1 to 3 years, 4 to 6 years, and over 7 years. In addition, to evaluate the effect of sexual maturation, the groups consisting of dogs less and more than 1 year of age were compared. Hair coat types were classified based on the official certification of pedigree from the Korean Sapsaree Association.

Table 2. Mean temperature, length of daylight and humidity in four seasons in Korea

	Spring	Summer	Autumn	Winter
Temperature (°C)	11.7	23.7	13.4	0.1
Length of daylight (min)	785	857	704	606

The IOP values from both eyes were included separately in the statistical analysis. Data were analyzed by statistical computer software (SPSS 15.0 for Windows, SPSS Inc., Chicago, IL). The factors assumed to affect IOP values including season, age, gender and hair coat type were examined for covariates of IOP by analysis of covariance (ANCOVA). After determining the effective factors for IOP with ANCOVA, they were analyzed by analysis of variance (ANOVA), followed by a Bonferroni post hoc test to evaluate the differences among the groups. Statistical significance was established at P values < 0.05.

Results

The overall mean ± SD IOP value of all eyes was 19.1 ± 3.7 mmHg (range, 8~28 mmHg). Only seasonal variation had a significant effect on IOP (P < 0.001). The mean IOP values obtained in winter (20.4 ± 3.4 mmHg) were significantly higher than those obtained during other seasons, while the mean IOP values obtained in summer (17.1 ± 3.6 mmHg) were significantly lower than those obtained during other seasons. There were no significant differences between IOP values measured in spring (19.4 ± 3.4 mmHg) and those measured in autumn (19.0 ± 3.8 mmHg). Aside from seasonal variation, other parameters including age, gender and hair coat

Table 1. The distribution of Sapsaree dogs according to season, age, gender, and hair coat type (n = 474)

		Spring		Summer		Autumn		Winter		Total	
		M	F	M	F	M	F	M	F	M	F
Age	< 1	19*	23	9	8	21	45	17	13	66	89
	1~3	21	30	19	21	32	41	8	6	80	98
	4~6	16	29	6	6	13	12	11	8	46	55
	7 ≥	1	5	1	3	5	6	7	12	14	26
Hair coat	Blue	28	36	21	15	25	33	11	17	85	101
	Yellow	27	40	10	14	38	51	26	20	101	125
	White	1	2	3	6	3	11	5	2	12	21
	YW	1	6	1	2	2	6	1	0	5	14
	Chestnut	0	3	0	1	3	3	0	0	3	7
Sub Total		57	87	35	38	71	104	43	39	206	268
Total		144		73		175		82		474	

*No. of dog. M: Male; F: Female, YW: Yellow-White

Table 3. The distribution of mean IOP values according to season, age, gender, and hair coat type

		Spring		Summer		Autumn		Winter		Total	
		M	F	M	F	M	F	M	F	M	F
Age	< 1	18.8 ± 3.2*	18.6 ± 3.6	17.2 ± 4.9	16.3 ± 3.6	19.2 ± 3.6	18.8 ± 3.6	20.4 ± 3.4	22.4 ± 3.2	19.1 ± 3.4	19.1 ± 3.9
	1~3	19.3 ± 2.9	19.9 ± 3.5	18.1 ± 3.5	17.2 ± 3.5	19.3 ± 4.3	19.6 ± 3.7	21.4 ± 3.0	21.2 ± 3.9	19.2 ± 3.8	19.4 ± 3.7
	4~6	19.4 ± 3.6	19.3 ± 3.4	16.9 ± 4.3	15.8 ± 1.7	16.8 ± 2.9	18.8 ± 4.2	19.5 ± 3.3	20.1 ± 3.4	18.4 ± 3.6	18.9 ± 3.7
	7 ≥	23.0 ± 1.0	21.0 ± 3.8	16.5 ± 3.5	17.5 ± 4.5	19.3 ± 2.9	18.8 ± 4.3	18.1 ± 1.3	19.5 ± 3.2	18.7 ± 2.6	19.5 ± 3.6
Hair coat	Blue	19.0 ± 3.4	19.7 ± 3.7	17.8 ± 3.8	17.7 ± 3.5	19.5 ± 4.0	19.1 ± 4.0	19.5 ± 3.3	20.5 ± 3.8	19.0 ± 3.7	19.3 ± 3.9
	Yellow	19.3 ± 3.0	19.1 ± 3.2	16.9 ± 4.1	16.7 ± 3.4	18.5 ± 3.7	19.0 ± 3.7	20.0 ± 3.1	21.3 ± 3.7	19.0 ± 3.5	19.1 ± 3.7
	White	22.5 ± 2.1	22.8 ± 3.3	17.7 ± 4.7	15.8 ± 3.4	16.3 ± 3.1	19.7 ± 3.5	21.2 ± 3.3	19.3 ± 1.0	19.2 ± 4.1	18.3 ± 3.8
	YW	20.5 ± 2.1	21.0 ± 1.9	19.0	15.0 ± 2.2	19.5 ± 4.2	21.4 ± 3.7	18.5 ± 0.7	-	19.4 ± 2.6	20.3 ± 3.5
	Chestnut	-	17.2 ± 3.2	-	18.0 ± 1.4	18.0 ± 5.7	18.0 ± 3.9	-	-	18.0 ± 5.7	17.6 ± 3.2
Sub Total		19.3 ± 3.2	19.5 ± 3.4	17.6 ± 3.9	16.8 ± 3.4	18.8 ± 3.9	19.2 ± 3.8	20.0 ± 3.2	20.8 ± 3.7	19.0 ± 3.6	19.1 ± 3.8
Total		19.4 ± 3.4^{a}		17.1 ± 3.6^{b}		19.0 ± 3.8^{a}		20.4 ± 3.4^{c}		19.1 ± 3.7	

*Mean ± Standard deviation (mmHg), M: Male; F: Female, YW: Yellow-White
a,b,c: The same letter indicate non-signigicant differences between groups based on Bonferroni post hoc test. Only seasonal variation showed a significant effect on IOP values (P < 0.001).

type did not show any statistical significance (Table 3). In addition, there was no significant difference between dogs less than 1 year of age (19.1 ± 3.8 mmHg) and those more than 1 year of age (19.1 ± 3.7 mmHg).

Discussion

To our knowledge, this report is the first to document seasonal variation of intraocular pressure in normal dogs. We established seasonal variation of IOP in normal dogs; the mean IOP value was highest in winter and lowest in summer.

The Sapsaree was the only breed included in the current study. It is considered to be mild tempered and thus, a breed useful for such experimental studies. Based on this characteristic the data obtained in this study can be inferred to contain minimal false high IOP values which may be caused from excited animals.

Previous studies have demonstrated seasonal variation of IOP in both normal humans and rabbits. In humans, previous reports showed similar findings; IOP values were found to be significantly higher in winter compared to those in summer (5,35). Analogous results were obtained in human glaucoma patients as well (16,31). In rabbits, two previous studies have reported seasonal variations in IOP. One report demonstrated findings comparable to that found in humans; high winter IOP values and low summer IOP values (37). However, another source reported peak IOP values in summer and in winter (2). These discordant results could be due to environmental discrepancies, as the former study was performed without controlled conditions, while the latter was performed under controlled light and temperature conditions throughout the year. As this current study was conducted under uncontrolled environmental conditions, results were most comparable to those obtained in the human study and in the former report in rabbits.

The physiological mechanism for seasonal variation of IOP has not yet been characterized. However, we suggest this variation might result from primary physiological changes due to environmental variation. Temperature and the amount of daylight can be considered the most significant factors of seasonal IOP variation. In addition, hormonal variation, affected by both the amount of light and temperature, may also be potentially critical factors.

First, these results could be secondary to seasonal variations in light. A previous study in humans reported the mean hours of daily sunlight exposure was inversely related to mean IOP values (14). Another study suggested IOP in rabbits decreased after the injection of cerebrospinal fluid from human beings exposed to bright light, possibly due to miopiesin and hyperpiesin (secreted by the posterior pituitary) in the cerebrospinal fluid (32). The amount of miopiesin is positively correlated with IOP value, and the amount of hyperpiesin is negatively correlated with IOP value. Further, an excessive amount of light may stimulate hyperpiesin secretion, which may affect seasonal IOP variations (10). Similar diurnal fluctuations have been reported in dogs that demonstrate lower mean IOP values in the afternoon (36). Based on this study, it could be inferred that the amount of light may have an inverse relation with IOP valued.

Secondly, temperature may affect seasonal IOP variation. Low temperature causes vasoconstriction, and systemic hypertension is positively correlated with IOP in humans and animals (3,18,24). Therefore, low temperature could physiologically increase IOP values, leading to seasonal IOP variation in dogs.

Lastly, hormones, not including male and female sex hormones, may play a role in IOP values through the indirect consequence of both light and temperature. During periods of elevated temperature and light, animals and humans sweat, pant, and drink more fluids. Such physiological changes could affect the secretion of vasopressin (ADH) and angiotensin (8). This suggestion has been supported by experiments exposing rabbits at topical doses of ADH (1 to 2 units) which decreased the facility of outflow due to the role of ADH in sodium transport regulation across the ciliary epithelium (17).

There was no significant variation in IOP due to age in the present study. However, IOP variation with age has been reported in humans (35), monkey (4), and some canine breeds (11,13,26). In humans, age dependent IOP variation may differ according to ethnicity and region of residence. In a previous study, mean IOP values declined with age in a Japanese population (34). Conversely, in an African-American population, mean IOP values increased after 40 years of age (35). This discordance could be secondary to systemic factors including blood pressure, obesity and cardiac risk factors. In dogs, a study examining Samoyed dogs demonstrated a significant age-based variation in IOP. Values decreased in animals greater than 7 years old (11), and some breeds had a negative correlation between age and IOP in older dogs (13). However, a study in Labrador retriever dogs demonstrated there were no significant differences in IOP values between puppies and young adults (26), as in the present study. This could be because the age distribution of this study was not even, sparse in the older age groups. It could be suggested that the severe imbalance in age distribution, specific separation of age groups and discrepancies in systemic factors may have caused the diverse results.

Among the non-significant factors in this study, only gender variation was found to be significant in another study. In a study performed on lions, Ofri *et al* suggested gender variation had a significant effect on IOP values (28). The difference in the species and method of measurement, such as the condition of general anesthesia in the lion study, could be suggested as reasons for the discrepancy in results. Also, there were no significant differences in any adult groups older than 1 year of age in the present study. This indicates male and female sex hormones may not affect IOP variation in Sapsaree dogs. Further research pertaining to anesthesia's influence on the effect of gender variance and sex hormone on IOP values in dogs may be conducted. There are potential limitations in the present study. Even though the current study was based on a powerful statistical analysis with strict controls and a large sample size, this study is a non-paired study. Even a small paired study measuring the IOP values in a dog throughout a year could provide great supplemental data for our non-paired experiment.

We demonstrated the effect of seasonal variation on the IOP value in normal dogs and suggested such variation could be affected by various environmental differences between the seasons. This study may serve as a reference for future research evaluating intraocular pressure in dogs and for possible modification of current veterinary ophthalmic references.

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정상 삽살개 군에서의 계절별 안압 수치의 변화

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요 약 : 본 연구는 정상개에서의 계절에 따른 안압의 변화를 평가하기 위해서 실시되었다. 총 474마리의 안질환이 없는 삽살개의 양안에 대해서 편평안압계(Tonopen® XL)를 이용해서 안압을 측정하였다. 측정된 결과를 바탕으로, 안압에 영향을 줄 것으로 예상되는 요소의 유의성과, 각 요소의 군내 차이를 통계적 방법을 통하여 검증을 실시 하였다. 전체 삽살개의 평균 안압 및 표준 편차는 19.1 ± 3.7 mmHg (범위: 8 to 28 mmHg) 이었다. 계절적 요소에서만 안압 변화에 대한 유의성이 검증 되었고($P < 0.001$), 그 외 나이, 성별, 모색과 관련된 유의성은 확인되지 않았다. 겨울에 측정된 평균 안압 수치(20.4 ± 3.4 mmHg)와 여름에 측정된 평균 안압 수치(17.1 ± 3.6 mmHg) 는 다른 계절의 평균 안압에 비하여서 신뢰구간 내로 각각 높게 그리고 낮게 측정 되었다. 이상의 결과를 바탕으로 계절적 변화는 정상 개의 안압에 영향을 줄 것으로 판단되며, 본 연구는 후속되는 수의 안과 연구와 수의 안과 임상에 유용한 자료가 될 것으로 사료된다.

주요어 : 개, 안압, 삽살개, 계절적 변화, tonometry