RESEARCH ARTICLE

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Evaluation of Normal Tear Volume and Intraocular Pressure in Saanen Goats at Different Periods

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Abstract

This study was aimed to determine whether the reference values affected by different times of the day and season in Saanen Goats. One hundred twenty-two goats were included to this study and, tear secretion (TS) and intraocular pressure (IOP) were measured in three different time periods as morning, noon and evening on the same day in each seasonal group. Temperature and humidity values were recorded during all measurements. There was no difference between the right and left eyes in terms of IOP and TS ($p>0.05$). While mean TS value was significantly increased in the winter group (12.23±0.28 mm/min) compared with the spring (9.9±0.18 mm/min) and summer (9.14±0.19 mm/min) groups ($p<0.001$), mean IOP was significantly decreased in the winter group (14.05±0.28 mmHg) compared with the spring (17.64±0.36 mmHg) and summer (17.32±0.43 mmHg) groups ($p<0.001$). While mean TS value was significantly increased at noon (10.08±0.28 mm/min) compared with morning (10.99±0.24 mm/min) ($p<0.001$), mean IOP was significantly decreased in the morning (14.95±0.31 mmHg) compared to the afternoon (17.63±0.35 mmHg) and evening (16.54±0.42 mmHg) ($p<0.001$). In conclusion, TS and IOP values in Saanen goats are affected by different times of the day and season, and it will contribute to the literature by determining the values that can be taken as reference for these different daytime and seasonal profile of the IOP and TS in Saanen Goat.

Keywords: Circadian, intraocular pressure, tear volume, saanen goat, season.

INTRODUCTION

Eye examination should be done in a specific order because tests and observations may affect the result of another or create complications (Featherstone and Heinrich, 2013). Determination of tear secretion (TS) and intraocular pressure (IOP) are the most important parts for ophthalmological examination. These tests play an important role in the diagnosis of diseases such as keratitis, keratoconjunctivitis, uveitis and glaucoma. Reference values should be known in order to evaluate these pathologies (Ribeiro et al., 2010).

Schirmer tear test (STT) measures the aqueous component of tear (Rosolen et al., 2009). Without anesthesia, it is called as Schirmer tear test I and measures reflex tear secretion in addition to basal tear secretion due to local stimulation of trigeminal nerve endings (Featherstone and Heinrich, 2013).

Measurement of IOP evaluates the pressure exerted by the aqueous humor on the sclera and cornea. There are different methods for measuring the IOP. Rebound tonometry has become popular as a non-invasive measurement of IOP. There are three measurement modes for TonoVet® rebound tonometry; "d" mode for cats and dogs, "h" mode for horses and "p" mode for other species (Pereira et al., 2011). In goats, the measurements obtained with the TonoVet® in "d" mode calibration give closer results to dogs in goats when compared applanation tonometer (Broadwater et al., 2007).

This study was aimed to determine the reference values by evaluating whether the measurements of IOP and TS in Saanen goats are affected by different times of the day and season.

MATERIALS AND METHODS

Animal Studied

The study was conducted in 122 females, aged 6-18 months, and weighing between 30-40 kg. It was determined that the goats included in the study had healthy eyes by performing detailed eye examinations such as reflex examinations, direct ophthalmoscopy, slit-lamp biomicroscopy, and fluorescein staining.

The ethical approval of the study was provided by the University's Institutional Animal Care and Use Committee (approval number: 64583101/2018/117). In this study, a signed Consent form was obtained from the owners for the study.

Study design

Fourty Saanen goats in winter, 48 in spring and 34 in summer which were kept under similar conditions in different farms were subjected to measurements. In addition, all measurements were performed in three different time periods as the morning, noon and evening on the same day in each seasonal group. Intraday measurements in all farms were made between 09.00-11.00 in the morning, 14.00-16.00 in the afternoon, and 19.00-21.00 in the evening and this procedure done for measurements taken all seasons. All measurements obtained from the right and left eyes for comparison. Meteorological data (temperature and humidity) was recorded with an Avec AV-HTC-23 (Outdoor/Indoor Digital Temperature and Humidity Meter) at the measurement times. Since the gestation period coincided with the autumn months, measurements could not be made to avoid stressing the goats.

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Schirmer tear test I (STT I) was used to determine the amount of TS and measured before the IOP measurement due to affected by eyelid manipulation. Commercially sterile test strips, (Erc Health Products®, Ankara, Turkey) with a printed millimeter (mm) scale for easy test interpretation was used and TS was measured in millimeter/minute (mm/min) Each strip was folded from the marked place and hooked on the middle to lateral third of the bottom eyelid, and the wetted part for 1 minute was read and noted. (Figure 1).

Figure 1. TS measurement by placing commercially sterile strips on the middle to lateral third of the bottom eyelid.

TonoVet® (ICare, Finland) in the "d" mod was used for IOP measurement (Figure 2). For IOP measurement, a 2-minute break was obtained after TS measurement and, it was determined in millimeter of mercury (mmHg) by performing the average of 5 consecutive measurements. During the procedure, no topical anesthesia was used, always the right eye measured first, head held in its natural position with chin slightly down, and no intervention or pressure was applied to the eye area so that the results would not be affected.

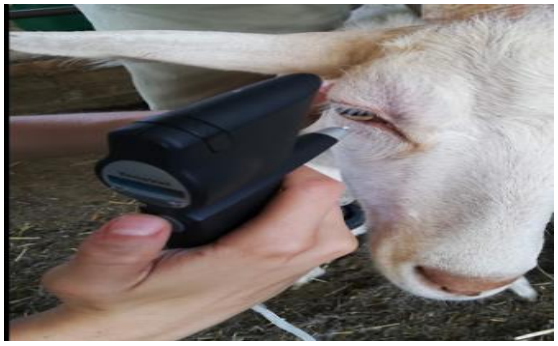

Figure 2. IOP measurements with rebound tonometer and positioning of the head in its natural position.

Statistical Analysis

First, the conformity of the data to the normal distribution was examined using the Shapiro-Wilk Test and the compatibility to the homogeneity assumption with the Levene Test. Descriptive statistics of the data were expressed as mean±standard error. Dependent Sample T Test was used to compare the measurements of the right and left eyes. The assumption of sphericity was checked in the parameters compared with the Analysis of Variance, and then the Tukey or Games-Howell advanced test was used to determine the source of the difference. All statistical analyzes were based on the $p<0.05$ criterion. SPSS (14.01) program was used to perform the statistics.

RESULTS

The meteorological data recorded during the measurements are presented in the table 1.

Table 1. Meteorological data recorded during the measurements

	Winter			Spring			Summer		
	M	**N**	**E**	**M**	**N**	**E**	**M**	**N**	**E**
Temparature (C)	11.6	17	8.6	21.4	27.3	19.4	30.7	41.8	38.1
Humidity (%)	51	40	50	37	45	42	50	28	31
M: morning, N: noon, E: evening									

In terms of both TS and IOP, no significant difference was found between the right and left eyes ($p=0.822$, $p=0.733$) (Table 2, Figure 3).

Table 2. Difference between right and left eyes in terms of TS and IOP.

Side	TS $\bar{X} \pm S_{\bar{X}}$	IOP $\bar{X} \pm S_{\bar{X}}$
Right	10.48±0.19	16.33±0.28
Left	10.43±0.19	16.42±0.32
p	0.822	0.733

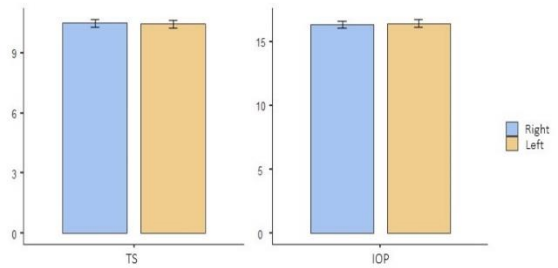

Figure 3. Difference between right and left eyes in terms of TS and IOP

When compared according to the seasons, TS was significantly increased in the winter group (12.23±0.28 mm/min) than in the spring (9.9±0.18 mm/min) and summer (9.14±0.19 mm/min) groups. ($p<0.001$), IOP was significantly lower in the winter group (14.05±0.28 mmHg) compared with the spring (17.64±0.36 mmHg) and summer (17.32±0.43 mmHg) groups ($p<0.001$) (Table 3, Figure 4).

Table 3. Comparison of TS and IOP values by season

Measurement / Season	TS $\bar{X} \pm S_{\bar{X}}$	IOP $\bar{X} \pm S_{\bar{X}}$
Winter	12.23±0.28	14.05±0.28
Spring	9.9±0.18	17.64±0.36
Summer	9.14±0.19	17.32±0.43
P	<001	<001

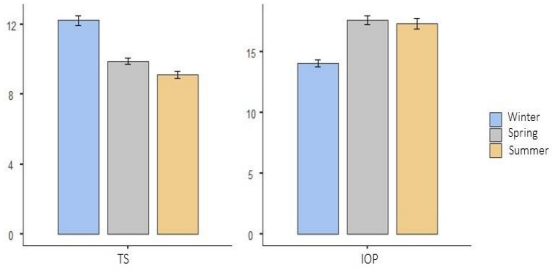

Figure 4. Comparison of TS and IOP values by season.

According to the time of intraday measurement, TS was significantly increased at noon (10.99±0.24 mm/min) compared with morning (10.08±0.28 mm/min) and evening (10.29±0.23 mm/min). ($p<0.001$); IOP was significantly decreased in the morning (14.95±0.31 mmHg) than compared with the noon (17.63±0.35 mmHg) and evening (16.54±0.42 mmHg) hours ($p<0.001$) (Table 4, Figure 5).

Table 4. Comparison of TS and IOP values by the time of intraday measurement

Measurement / Time	TS $\bar{X} \pm S_{\bar{X}}$	IOP $\bar{X} \pm S_{\bar{X}}$
Morning	10.08±0.28	14.95±0.31
Noon	10.99±0.24	17.63±0.35
Evening	10.29±0.23	16.54±0.42
P	< .001	< .001

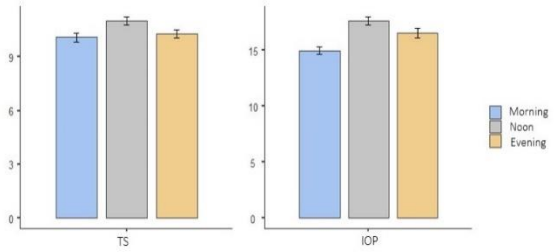

Figure 5. Comparison of TS and IOP values by the time of intraday measurement.

DISCUSSION AND CONCLUSION

Determination of IOP and TS provides important information about eye health and has an important role in the diagnosis of many eye diseases (Ribeiro et al., 2010; Featherstone and Heinrich, 2013). However, the results obtained from these tests can be valuable for diagnosis by comparing them with the correct reference values.

Studies in domestic animals show that the TS value differs between species in domestic animals. In these studies, TS values have been reported as 20.2±3.0 mm/min in dogs (Hamor et al., 2000), 15.8±5.7 mm/min in pigmy goats (Broadwater et al., 2007), 18.5±2.5 mm/min in sheep (Ghaffari et al., 2011), 12.72±9.07 mm/min in horses (Beech et al, 2003) and 5.6±3.7 mm/min in pigs (Trbolova and Ghaffari, 20011). In a study on Saanen goats, TS measured as 14.83±0.33 and 13.80±0.66 in 180- and 549 day aged goats, respectively (Ribeiro et al., 2010). When considered all measurements in the presented study, TS was 10.45±0.19 mm/min (the right and left eyes, 10.48±0.19 mm/min, 10.43±0.19 mm/min, respectively). The highest mean in our study was 12.23±0.28 mm/min obtained from the winter season and, it is lower that reported by Ribeiro et al., (2010). Moreover, TS values in obtained from the current study in summer season were quite lower than Ribeiro et al., (2010)'s study and our measurements of the winter season, and can be misleading in favor of dry eye if seasonal effect is not taken into account. Another study emphasizing that the mean TS change seasonally was conducted on horses by Beech et al., (2003) and reported values of 21±6 mm/min in summer and 26±6 mm/min in winter season.

In dogs and horses, TS has been shown to be linked to the circadian rhythm. This rhythmicity is maintained even when subjects are exposed to cycles of 12-hour light and 12-hour dark, as well as continuous 24-hour dark cycles. However, such rhythmicity is lost when these species are housed in environments with constant light (Piccione et al., 2008; Piccione et al., 2009). In another study conducted in different age groups (Ribeiro et al., 2010), while TS value did not show a significant difference between the morning and evening measurements in 45-day-old goats, a significant difference emerged in 549-day-old goats between the morning and the evening. In our study, TS was significantly increased at noon compared with morning and evening. This the intraday variation was different from the study mentioned above as TS was significantly higher at noon compared to morning and evening (Table 4, Figure 5).

In the study performed by Ribeiro et al., (2010), mean TS between the right and left eye changed significantly in 549-day-old goats, but was similar in the 45 and 180-day-old goats. Although differences of similar size between the sides have been previously reported in horses (Piccione et al., 2008) and dogs (Piccione et al., 2009), there is no clear explanation for this binocular discrepancy (Ribeiro et al., 2010). The goats included in our study were between 6-18 months old and the TS difference between the right and left eyes was not significant ($p=0.822$, $p=0.733$). In a previous study carried on rabbits have reported that there is no statistical difference between the right and left eyes in terms of TS (Abrams et al., 1990).

In terms of IOP values obtained from the presented study, no significant difference was found between the right and left eyes (Table 2, Figure 3). In another previously study in dogs also found no difference between the right and left eyes (Giannetto et al., 2009). However, Ribeiro et al., (2010) suggested that the IOP of the left eye of 549- and 45-day-old goats was statistically higher than the right eye, but there was no difference between the sides in 180-day old goats. The goats included are in the age range of 6-18 months (approximately 180-540 days) in our study but, the relationship between age and IOP was not examined.

A study conducted in healthy Sapsaree breed dogs reported that, the significant effect of the season on IOP. Values of IOP measured in the winter and summer seasons were significantly different compared with other seasons

(Chae et al., 2013). In a study conducted with Arctic reindeer, it was stated that the winter season significantly increased the IOP of the animals (Stokkan et al., 2013). Conversely, in the presented study, mean IOP was significantly decreased in the winter season compared with the spring and summer seasons. However, these results show that seasonal variation has a significant effect on normal IOP.

According to the IOP data obtained from the presented study; morning values were significantly decreased compared with noon and evening. In a study conducted by Ribeiro et al., (2010), IOP showed significant changes in the morning and evening measurements in the 45-day age group, but no significant difference was found in the 180 and 549-day age groups. It is known that the IOP value increases in the evening hours in healthy horses and is lower in the morning hours. In addition, it has been shown that the IOP rhythm continues when animals are kept in the dark and disappears when they are kept in a constantly light place (Bertolucci et al., 2009). Although no similar studies were found in horses, mydriatics leads to a significant elevation of IOP in cats and humans, probably by causing a decrease in aqueous outflow (Hancox et al., 2002; Stadtbaumer et al., 2006). Based on this, it can be hypothesized that the nighttime increases are due to pupil diameter. Considering that the pupil anatomy of small ruminants and horses is similar; the suggestion supports our work. Healthy cats and cats with uveitis treated with ocular hypotensive agents showed increased IOP when kept in dark conditions (Ribeiro et al., 2010; Del Sole et al., 2007). Another study showed that after instillation of different parasympatholytics in sheep, pupil diameter increased and IOP values decreased, but the difference was not significant (Crivelaro et al., 2010).

Although all measurements taken in this study were made in females, this can be mentioned as study limitations, the study by Broadwatter et al., (2007) showed that gender did not have an important role on IOP and TS values in male goats.

In conclusion, it was determined that there was no statistical difference between the right and left eyes in terms of TS and IOP in healthy Saanen goats, TS and IOP values were affected by the circadian rhythm and the season. In this context, it is very possible that the simultaneous presence of the factors affecting IOP and TS in the same direction (reducing or increasing) at the time of measurement differs enough to be misleading in terms of diagnosis. For this reason, with this study, the importance of considering the effects of these factors when determining reference values for species is emphasized.

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Conflict of Interest
The authors declare that they have no competing interests.

Authorship contributions
Concept: A.O., Z.B., Design: A.O., Z.B., Data Collection or Processing: A.O., Z.B., Literature Search: A.O., Z.B., Writing: A.O., Z.B.

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