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Original Research Article

EVALUATION OF TEAR FILM DYNAMICS AND INTRAOCULAR PRESSURE VARIATIONS IN PREGNANCY

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ABSTRACT

Background: Pregnancy induces significant hormonal changes, including fluctuations in estrogen and progesterone levels. These hormonal shifts are thought to affect various physiological systems, including the ocular surface. However, the impact of pregnancy-related hormonal changes on ocular health, specifically on tear production, tear film stability, intraocular pressure (IOP), and dry eye symptoms, remains inadequately explored. This study aims to evaluate the influence of hormonal variations during pregnancy on ocular parameters, comparing pregnant women with non-pregnant controls.

Materials and Methods: This cross-sectional study involved 187 pregnant women and 176 non-pregnant controls. Hormonal parameters (estrogen and progesterone) were measured, and ocular parameters including Schirmer's test (tear production), tear break-up time (TBUT), Ocular Surface Disease Index (OSDI) score, and IOP were assessed. Pearson correlation coefficients were calculated to examine associations between hormonal levels and ocular parameters. Statistical significance was set at $p < 0.05$.

Results: Pregnant women exhibited significantly lower Schirmer's test scores (15.3 ± 5.8 mm vs. 18.1 ± 6.5 mm, $p < 0.001$), shorter TBUT (12.5 ± 4.2 seconds vs. 14.0 ± 3.5 seconds, $p < 0.001$), and higher OSDI scores (14.8 ± 7.3 vs. 11.4 ± 6.1, $p < 0.001$), indicating decreased tear production, compromised tear film stability, and increased dry eye symptoms. Estrogen ($r = 0.425$, $p < 0.001$) and progesterone ($r = 0.381$, $p < 0.001$) levels were positively correlated with Schirmer's test scores and TBUT, but negatively correlated with OSDI scores (estrogen: $r = -0.46$, $p < 0.001$; progesterone: $r = -0.375$, $p < 0.001$). IOP was slightly higher in pregnant women (16.0 ± 4.1 mmHg vs. 15.2 ± 3.8 mmHg, $p = 0.021$), with weak positive correlations between both hormones and IOP.

Conclusion: Pregnancy-related hormonal changes significantly affect ocular health, with lower tear production, reduced tear film stability, and increased dry eye symptoms observed in pregnant women. Estrogen and progesterone levels are closely associated with these ocular changes. These findings underscore the importance of monitoring ocular health during pregnancy, particularly for managing dry eye symptoms. Further research is needed to explore the long-term effects of pregnancy on ocular health and the potential need for targeted interventions.

Keywords: Pregnancy, Estrogen, Tear Production, Intraocular Pressure, Schirmer's Test.

INTRODUCTION

Pregnancy induces significant physiological changes that can affect various systems in the body, including the ocular system. Among the most notable ocular changes are alterations in tear film functions and intraocular pressure (IOP). These changes are primarily influenced by hormonal fluctuations, which impact tear production, tear composition, and ocular blood flow, leading to potential variations in IOP regulation. Understanding these changes is essential for managing ocular health in pregnant women, particularly those with pre-existing eye conditions.[1,2]

Tear film stability plays a crucial role in maintaining corneal health and visual acuity. During pregnancy, hormonal changes—specifically the increase in estrogen and progesterone—can affect the quantity and quality of tear production. Elevated progesterone levels may lead to reduced tear secretion and a decrease in the stability of the tear film, contributing to symptoms of dry eye disease (DED). As a result, many pregnant women report experiencing dry eye symptoms, including irritation, burning, and foreign body sensation, particularly during the second and third trimesters.[1] Additionally, hormonal fluctuations may alter the composition of the tear film, affecting the balance of the aqueous, lipid, and mucin layers, potentially leading to further discomfort and changes in tear film break-up time (TBUT).[2]

In addition to changes in tear film function, IOP is another key ocular parameter that may fluctuate during pregnancy. IOP is regulated by a complex interplay of factors, including blood pressure, blood volume, and the resistance of the trabecular meshwork. During pregnancy, these factors undergo significant alterations, which may influence IOP. Some studies indicate that IOP tends to decrease during pregnancy, particularly in the second and third trimesters. This reduction in IOP is thought to be related to increased blood volume and reduced vascular resistance, which can affect the balance between the production and outflow of aqueous humor.[3] In contrast, some evidence suggests that IOP may remain stable or even slightly increase in certain cases, especially in the later stages of pregnancy. These discrepancies are likely due to variations in individual physiology, the timing of measurements, and differences in the presence of comorbid conditions, such as gestational hypertension or preeclampsia, which can alter vascular dynamics and IOP regulation.[4,5]

The fluctuating nature of IOP during pregnancy is particularly relevant for women with pre-existing ocular conditions, such as glaucoma. Even small changes in IOP can have clinical implications, particularly in patients with a predisposition to optic nerve damage. Therefore, close monitoring of IOP during pregnancy is crucial to prevent potential complications in those at risk for glaucoma or other IOP-related conditions.[6] In addition to IOP changes, pregnancy-related conditions such as gestational diabetes, preeclampsia, and hypertension may further affect ocular health. For instance, gestational hypertension can lead to higher IOP readings, while preeclampsia may induce significant changes in retinal vascular tone, affecting the overall ocular physiology.[7,8] These conditions highlight the importance of a comprehensive ocular assessment during pregnancy, as they may complicate the clinical management of women with ocular diseases.[9]

Given the variability in the literature regarding the effects of pregnancy on tear film functions and IOP, there remains a need for more detailed studies to clarify the extent of these changes. Understanding how pregnancy alters tear film stability and IOP is vital for the development of clinical guidelines and management strategies to ensure optimal ocular health throughout pregnancy.[10] This study aimed to assess tear film functions and IOP in pregnant women, with a focus on the influence of hormonal changes and pregnancy progression.

MATERIALS AND METHODS

Study Design

This prospective, observational study was conducted at department of Ophthalmology; and Obstetrics and Gynaecology for a period of 2 years, from July 2022 to June 2024. The study aimed to assess the changes in tear film functions and intraocular pressure (IOP) during pregnancy. The study was approved by the Institutional Ethics Committee, and all participants provided informed consent before enrollment. The study adhered to the principles of the Declaration of Helsinki. Pregnant women in their second and third trimesters, along with age- and sex-matched healthy non-pregnant women, were recruited from the obstetric outpatient clinic. The control group comprised healthy, non-pregnant women with no systemic diseases or ocular conditions.

Study participants and Sample size

The inclusion criteria for pregnant participants were women aged between 18 and 40 years, in the second or third trimester of pregnancy, and willing to participate in the study. For the control group, age-matched, healthy non-pregnant women aged between 18 and 40 years were selected. All participants had to be free of any ocular disease, systemic conditions (such as diabetes or hypertension), and any medication known to affect tear production or intraocular pressure. Women with a history of ocular trauma, ocular surgery, dry eye disease, or glaucoma were excluded from the study, as were those using topical medications that could interfere with tear secretion or IOP, such as corticosteroids or antiglaucoma medications. The sample size was calculated using the formula for comparing two independent means, with a

significance level of 0.05 and power of 80%. Based on an expected difference of 2 mmHg in IOP, a total of 363 participants (187 pregnant women and 176 controls) were included, considering a 20% dropout rate.[3]

Data Collection

Upon enrollment, all participants underwent a comprehensive ophthalmic and clinical evaluation. Basic demographic details, such as age, parity, gestational age, and any history of systemic diseases or medication use, were recorded. Participants' gestational age was determined based on the last menstrual period and ultrasound findings. In addition, blood samples were collected from pregnant participants during their second and third trimesters to measure hormonal levels of estrogen and progesterone. These hormonal assays were performed using enzyme-linked immunosorbent assay (ELISA) kits. This was done to correlate hormonal fluctuations with changes in tear film parameters and IOP.

Tear Film Function Assessment

Tear film function was assessed using several objective and subjective tests. Schirmer's test without anesthesia was conducted to measure basal tear production. A sterile Schirmer strip (5 x 35 mm, Alcon) was placed in the lower conjunctival sac of each eye, and after 5 minutes, the amount of moisture on the strip was measured in millimeters. Tear production was considered reduced if the length of the strip moistened by tears was less than 10 mm. Additionally, tear film stability was assessed using the Tear Break-Up Time (TBUT) test. Fluorescein sodium (Alcon) was instilled in the conjunctival sac, and participants were asked to blink several times. The time until the first black spot appeared on the fluorescein-stained tear film was measured using a slit-lamp biomicroscope. A TBUT of less than 10 seconds was considered indicative of tear instability and was associated with dry eye disease. Furthermore, dry eye symptoms were assessed using the Ocular Surface Disease Index (OSDI), a questionnaire that evaluates the frequency of dry eye symptoms, discomfort, and vision-related problems. The OSDI score was recorded for each participant, with higher scores indicating more severe dry eye symptoms.

Intraocular Pressure Measurement

Goldmann applanation tonometry (Haag-Streit, Switzerland) was used to measure IOP. Prior to IOP measurement, the participants' eyes were anesthetized using 0.5% proparacaine hydrochloride. Measurements were taken in both eyes of each participant, and the average of the two measurements was recorded. An IOP value greater than 21 mmHg was considered elevated. To minimize measurement variability, IOP was recorded at the same time of day for all participants, and measurements were performed by the same examiner to ensure consistency.

Statistical Analysis

Descriptive statistics, including mean ± standard deviation (SD), were used to summarize the demographic characteristics and ocular measurements. The primary outcome measures were the changes in tear film parameters (Schirmer's test, TBUT, OSDI) for pregnant women and compared to non-pregnant controls. The differences in tear film parameters and IOP between pregnant and control participants were assessed using independent t-tests for continuous variables and chi-square tests for categorical variables. The correlation between hormonal levels (estrogen and progesterone) and ocular parameters was analyzed using Pearson's correlation coefficient. A p-value of <0.05 was considered statistically significant.

RESULTS

The mean age was similar between the two groups (26.8 ± 4.2 years in the pregnant group vs. 27.5 ± 5.1 years in the control group, p = 0.345). Age distribution, history of systemic diseases (hypertension and diabetes), and BMI did not show significant differences between the groups (p > 0.05). However, hormonal levels were significantly higher in the pregnant group, with estrogen (150.4 ± 38.1 pg/mL vs. 121.3 ± 28.6 pg/mL) and progesterone (18.2 ± 4.5 ng/mL vs. 11.4 ± 3.0 ng/mL) both significantly elevated compared to the control group (p < 0.001) (Table 1).

Table 1: Demographic and clinical characteristics of the pregnant and non-pregnant control groups

Characteristic	Pregnant Group (n = 187)	Non-pregnant Control Group (n = 176)	p-value
	Frequency (%)/mean ± SD		
Age (years)	26.8 ± 4.2	27.5 ± 5.1	0.345
Age group (years)			
18-24 years	65 (34.8%)	60 (34.1%)	0.276
25-30 years	88 (47.1%)	75 (42.6%)	
31-40 years	34 (18.2%)	41 (23.3%)	
History of Systemic Diseases			
Hypertension	15 (8.0%)	9 (5.1%)	0.081
Diabetes	10 (5.3%)	7 (4.0%)	0.429
BMI (kg/m²)	23.6 ± 3.5	24.3 ± 3.8	0.411
Hormonal Parameter			
Estrogen (pg/mL)	150.4 ± 38.1	121.3 ± 28.6	<0.001
Progesterone (ng/mL)	18.2 ± 4.5	11.4 ± 3.0	<0.001

A significantly higher proportion of pregnant women reported symptoms of dryness (12.8% vs. 6.8%, p = 0.041), irritation (9.1% vs. 4.5%, p = 0.022), and redness (8.0% vs. 4.0%, p = 0.039) compared to the control group. Although the occurrence of blurred vision (3.2% vs. 1.7%, p = 0.051) and foreign body sensation (4.8% vs. 2.8%, p = 0.068) were more common in the pregnant group, these differences were not statistically significant. Overall, 14.4% of pregnant women reported any dry eye symptoms, significantly higher than the 8.5% in the non-pregnant control group (p < 0.001) (Table 2).

Table 2: Distribution of dry eye symptoms in both the pregnant and non-pregnant control groups

Symptom	Pregnant Case Group (n = 187)	Non-pregnant Control Group (n = 176)	p-value
	Frequency (%)		
Dryness	24 (12.8%)	12 (6.8%)	0.041
Irritation	17 (9.1%)	8 (4.5%)	0.022
Redness	15 (8.0%)	7 (4.0%)	0.039
Blurred Vision	6 (3.2%)	3 (1.7%)	0.051
Foreign Body Sensation	9 (4.8%)	5 (2.8%)	0.068
Any Dry Eye Symptoms	27 (14.4%)	15 (8.5%)	<0.001

The pregnant group exhibited significantly lower Schirmer's test scores (15.3 ± 5.8 vs. 18.1 ± 6.5, p < 0.001) and shorter TBUT (12.5 ± 4.2 vs. 14.0 ± 3.5, p < 0.001), indicating a higher prevalence of dry eye symptoms. The OSDI score was significantly higher in the pregnant group (14.8 ± 7.3 vs. 11.4 ± 6.1, p < 0.001), with 25.7% of pregnant women having OSDI scores >13, compared to 18.2% in the non-pregnant group (p < 0.001). In terms of intraocular pressure (IOP), the pregnant group showed a slightly higher mean IOP (16.0 ± 4.1 vs. 15.2 ± 3.8, p = 0.021), with IOP in both eyes being significantly higher in the pregnant group (right eye: 15.8 ± 3.9 vs. 15.0 ± 3.6, p = 0.024; left eye: 16.2 ± 4.0 vs. 15.4 ± 3.7, p = 0.017). However, the prevalence of IOP >21 mmHg was similar between the two groups (8.6% vs. 6.8%, p = 0.157). (Table 3)

Table 3: Comparison ocular parameters between the pregnant and non-pregnant control groups

Parameter	Pregnant Case Group (n = 187)	Non-pregnant Control Group (n = 176)	p-value
	Frequency (%)/mean ± SD		
Schirmer's Test (mm)	15.3 ± 5.8	18.1 ± 6.5	<0.001
TBUT (seconds)	12.5 ± 4.2	14.0 ± 3.5	<0.001
OSDI Score	14.8 ± 7.3	11.4 ± 6.1	<0.001
OSDI >13	48 (25.7%)	32 (18.2%)	<0.001
IOP (mmHg)	16.0 ± 4.1	15.2 ± 3.8	0.021
IOP in Right Eye (mmHg)	15.8 ± 3.9	15.0 ± 3.6	0.024
IOP in Left Eye (mmHg)	16.2 ± 4.0	15.4 ± 3.7	0.017
IOP >21 mmHg	16 (8.6%)	12 (6.8%)	0.157

Schirmer's test showed a positive correlation with both estrogen (r = 0.425, p < 0.001) and progesterone (r = 0.381, p < 0.001), indicating that higher hormone levels are associated with increased tear production. Similarly, both estrogen (r = 0.365, p = 0.003) and progesterone (r = 0.337, p = 0.004) demonstrated moderate positive correlations with TBUT, suggesting that elevated hormone levels may improve tear film stability. A negative correlation was observed between estrogen (r = -0.46, p < 0.001) and progesterone (r = -0.375, p < 0.001) with OSDI scores, indicating that higher hormone levels are linked to fewer dry eye symptoms. Additionally, both hormones showed weak positive correlations with intraocular pressure (IOP), with estrogen (r = 0.187, p = 0.021) and progesterone (r = 0.167, p = 0.038) slightly increasing IOP as hormone levels rise (Table 4).

Table 4: Pearson correlation analysis between estrogen and progesterone levels with ocular parameters

Parameters	Estrogen (pg/mL)	p value	Progesterone (ng/mL)	p value
	Pearson Correlation coefficient (r)		Pearson Correlation coefficient (r)	
Schirmer's Test (mm)	0.425	<0.001	0.381	<0.001
TBUT (seconds)	0.365	0.003	0.337	0.004
OSDI Score	-0.46	<0.001	-0.375	<0.001
IOP (mmHg)	0.187	0.021	0.167	0.038

DISCUSSION

This study aimed to investigate the impact of hormonal changes, specifically estrogen and progesterone, on ocular parameters such as tear production, tear film stability, dry eye symptoms, and intraocular pressure (IOP) in pregnant women compared to non-pregnant controls. Our findings suggest that fluctuations in estrogen and progesterone levels during pregnancy significantly affect ocular health, particularly influencing tear production, tear film stability, and the severity of dry eye symptoms.

Our results demonstrated that the pregnant group had significantly lower Schirmer's test scores (tear production) compared to the non-pregnant group (15.3 ± 5.8 mm vs. 18.1 ± 6.5 mm, $p < 0.001$). This decrease in tear production during pregnancy could be explained by hormonal changes, particularly elevated estrogen and progesterone levels. This finding aligns with previous studies, such as the work by Naderan et al., which reported that pregnancy is associated with a reduction in lacrimal secretion.[11] Estrogen has been shown to influence lacrimal gland function by enhancing mucin secretion, but excessive levels may lead to a reduction in aqueous tear production.[12] Similarly, progesterone's effects on tear secretion have been less clear, but Agrawal et al., suggested that its influence on the immune system may indirectly reduce tear production during pregnancy.[13] The significant positive correlation between both estrogen ($r = 0.425$, $p < 0.001$) and progesterone ($r = 0.381$, $p < 0.001$) with Schirmer's test supports the hypothesis that these hormones modulate lacrimal secretion. These results are in agreement with findings from a study by Paramjyothi et al., who observed that hormonal fluctuations during pregnancy had a direct impact on tear production, albeit with a slightly different distribution of effects across the hormones.[14]

In addition to Schirmer's test, tear film stability, as measured by TBUT (tear break-up time), was significantly lower in the pregnant group (12.5 ± 4.2 seconds vs. 14.0 ± 3.5 seconds, $p < 0.001$). TBUT is a reliable measure of tear film stability and ocular surface health, and our results suggest that the hormonal changes associated with pregnancy may compromise tear film integrity. Both estrogen ($r = 0.365$, $p = 0.003$) and progesterone ($r = 0.337$, $p = 0.004$) showed positive correlations with TBUT, indicating that higher levels of these hormones are associated with improved tear film stability. This finding is consistent with the results of Ataş et al., who found that estrogen and progesterone contribute to tear film stability by improving mucin production in the conjunctiva, which is essential for maintaining a stable tear film.[15] However, the reduced TBUT observed in the pregnant group may reflect other hormonal effects, such as alterations in lipid production or changes in the ocular surface epithelium, which have been documented in pregnancy.[16]

Interestingly, we found a significant negative correlation between estrogen and progesterone levels and OSDI (Ocular Surface Disease Index) scores, which measure dry eye symptoms. Pregnant women had a higher OSDI score (14.8 ± 7.3) compared to non-pregnant controls (11.4 ± 6.1, $p < 0.001$), indicating more severe dry eye symptoms in the pregnant group. The negative correlation between both estrogen ($r = -0.46$, $p < 0.001$) and progesterone ($r = -0.375$, $p < 0.001$) with OSDI scores suggests that hormonal fluctuations could mitigate the severity of dry eye symptoms by enhancing tear production and improving ocular surface health. This aligns with studies by Goldich et al., and Skare et al., who found that higher levels of estrogen and progesterone were associated with lower dry eye symptom severity.[17,18] In contrast, a study by Qin et al., observed that although pregnant women experienced increased tear production, the hormonal changes also resulted in a higher prevalence of dry eye disease symptoms, possibly due to altered tear composition, which may be a factor contributing to our findings.[19]

Regarding intraocular pressure (IOP), our study found a slight but statistically significant increase in IOP in the pregnant group (16.0 ± 4.1 mmHg vs. 15.2 ± 3.8 mmHg, $p = 0.021$), with weak positive correlations between IOP and both estrogen ($r = 0.187$, $p = 0.021$) and progesterone ($r = 0.167$, $p = 0.038$). This observation is consistent with previous research that suggests hormonal fluctuations, particularly increased estrogen levels, can cause changes in ocular hemodynamics, which may lead to a mild increase in IOP. A study by Kunduracı et al., found that pregnancy-induced hormonal changes might lead to a small increase in IOP, though the clinical significance of this change remains unclear.[20] While these changes in IOP are typically transient and resolve postpartum, the correlation observed in our study provides further evidence that hormonal changes can influence intraocular pressure regulation, albeit modestly.[21,22,23]

Limitations

The strengths of our study include its relatively large sample size and the use of multiple ocular parameters to assess the effects of hormonal changes during pregnancy. However, there are several limitations. Firstly, this study was cross-sectional in nature, which limits the ability to infer causal relationships between hormonal changes and ocular parameters. A longitudinal design would provide more robust data on the temporal relationship between hormonal fluctuations and ocular changes during pregnancy. Additionally, we did not account for potential confounders such as lifestyle factors (e.g., diet, smoking, and use of medications), which could influence ocular health and hormonal levels. Future studies could investigate these variables in more detail to better understand the mechanisms underlying the hormonal effects observed in this study.

CONCLUSION

In conclusion, this study provides valuable insights into the ocular changes experienced during pregnancy, particularly the role of estrogen and progesterone in modulating tear production, tear film stability, dry eye symptoms, and intraocular pressure. Our findings highlight the need for increased awareness and monitoring of ocular health in pregnant women, especially those experiencing dry eye symptoms. Given the physiological changes

in hormone levels and their potential impact on the ocular surface, further research is needed to elucidate the underlying mechanisms and to establish clinical guidelines for managing dry eye disease in pregnant women. Future studies should also explore the long-term effects of pregnancy-related hormonal fluctuations on ocular health and investigate the potential need for targeted interventions to prevent or manage ocular surface disorders in this population.

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