ORIGINAL ARTICLE

Bali Journal of Ophthalmology (BJO) 2026, Volume 10, Number 1: 1-6
P-ISSN.2089-1180, E-ISSN.2302-2914

Bali Journal of Ophthalmology

The Effect Of Neck Position On Intraocular Presurre In Healthy Adults : A Cross – Sectional Study

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Received: 2026-02-17
Accepted: 2026-04-16
Published: 2026-05-18

ABSTRACT

Introduction: Intraocular pressure (IOP) is an important parameter in eye health evaluation, particularly in the detection and management of glaucoma. Variations in body position, including neck position, are suspected to influence IOP values and potentially cause bias in clinical measurements. This study aimed to assess differences in intraocular pressure in three neck positions: neutral (normal), flexion, and extension.

Methods: This study used a cross-sectional study design involving 39 healthy young subjects with a mean age of 23.53 ± 2.17 years and a mean spherical equivalent (SER) of 0.91 ± 1.03 diopters. IOP measurements were performed three times in each eye using the TonoPen AVIA (Reichert Inc., Depew, New York, USA) in the normal neck position, after 5 minutes of neck flexion, and after 5 minutes of neck extension.

Results: showed that the average IOP in the normal neck position was 13.66 ± 1.88 mmHg, increasing to 17.24 ± 1.94 mmHg in the flexed position, and 14.66 ± 2.28 mmHg in the extended position. Repeated-measures ANOVA analysis showed a significant difference between the three positions ($F(1.81; 67.01) = 94.46$; $p < 0.01$). Bonferroni's further test confirmed that the IOP in the flexed position was significantly higher than in the normal and extended positions.

Conclusion: this study shows that neck position significantly influences intraocular pressure, with the lowest value in the neutral position. Therefore, in clinical practice, neck position should be standardized when measuring IOP to avoid misinterpretation of results.

Keywords: intraocular pressure, neck position, flexion, extension, tonometry, clinical optometry.

Cite This Article: Suryawijaya, S., Kusumo, S.W.B., Ainy, N., Mabrouka, A.N., Wibowo, A.Y. 2026. The Effect Of Neck Position On Intraocular Presurre In Healthy Adults : A Cross – Sectional Study. *Bali Journal of Ophthalmology* 10(1): 1-6.

INTRODUCTION

Intraocular pressure (IOP) is a key physiological parameter in maintaining the stability of the structure and function of the eyeball. IOP plays a crucial role in maintaining the shape of the globus oculi and supporting the optical and physiological processes of the visual system. According to classic ophthalmology literature, the balance between aqueous humor production and outflow is a key determinant in the regulation of intraocular pressure (Kanski & Bowling, 2016).

Clinically, elevated IOP has been shown to be a major risk factor in the pathogenesis of glaucoma, a progressive optic neuropathy characterized by optic nerve damage and visual field impairment. Global health organizations, such as the World Health Organization (WHO), state that glaucoma is one of the leading causes of permanent blindness worldwide. Therefore, accurate IOP measurement is crucial for the early detection and management of this disease.

According to expert opinion, as stated by Weinreb et al. (2014) stated that IOP measurements are influenced not only by internal eye factors but also by external factors such as body position, episcleral venous pressure, respiration, and intrathoracic pressure. Furthermore, Sit and Liu (2009) explained that changes in body posture can affect body fluid distribution and hemodynamic pressure, which directly impacts intraocular pressure.

One external factor that receives relatively little attention in clinical practice is neck position. Physiologically, neck position is closely related to the vascular system, particularly the jugular vein, which plays a role in blood drainage from the head. Changes in neck position, such as flexion (bending down) and extension (looking up), can cause changes in jugular venous pressure, ultimately increasing episcleral venous pressure. According to the ocular hemodynamic theory proposed by Bill (1975), increased episcleral venous pressure will inhibit the outflow of aqueous humor through the trabecular duct, thereby increasing intraocular pressure.

Furthermore, a study by Malihi and Sit (2012) showed that increased intrathoracic pressure due to changes in head and neck position can also contribute to increased IOP. This suggests that the relationship between neck position and intraocular pressure is complex and involves interactions between the vascular, respiratory, and biomechanical systems.

In optometry and ophthalmology practice, IOP measurements are generally performed assuming the patient is in a standardized position. However, in reality, variations in head and neck position often occur, either unintentionally or due to the limitations of the patient's condition. This has the potential to introduce bias into measurement results and can impact clinical decisions.

Therefore, a deeper understanding of the effect of neck position on intraocular pressure is crucial, not only from an academic perspective but also for its practical implications for improving diagnostic accuracy and the quality of eye health care.

Empirical evidence suggests that variations in body and head position can cause significant fluctuations in intraocular pressure. The following is a summary of research findings based on previous studies (Table 1)

Based on the table above, it can be seen that the phenomenon of the influence of body position on IOP is clearly defined. Body position has been shown to influence IOP. The mechanisms involved are episcleral and intrathoracic venous pressure. However, specific research on neck position is still limited and not comprehensive. Based on the review of the phenomenon and the literature, several research gaps exist, as follows:

1. Limited variable specification
   a. Many studies focus on body position (sitting, standing, supine).
   b. Few studies specifically examine neck position (flexion vs. extension vs. neutral).
2. Population limitations
   a. Previous studies have been mostly conducted on glaucoma patients.
   b. Lack of research in healthy young adults as a physiological baseline.
3. Limited comparative approach
   a. Few studies with repeated measures designs directly comparing three neck positions.
4. Limited clinical implications
   a. There is no clear standard operating procedure for neck positioning during IOP measurement.

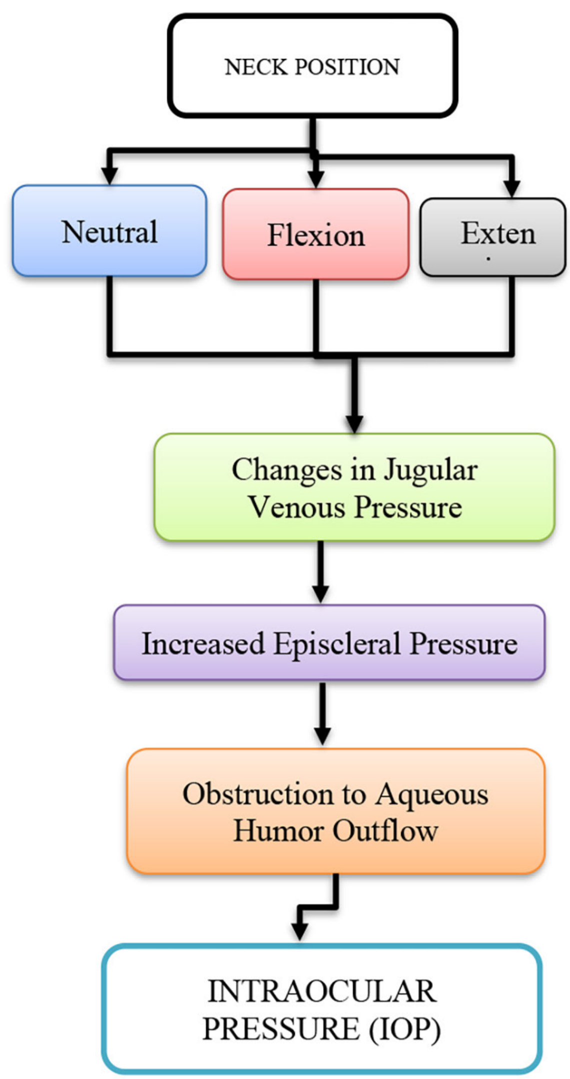
Recent literature reviews have demonstrated important advances in understanding the factors influencing IOP:

1. Weinreb et al. (2014) confirmed that IOP is a major risk factor for glaucoma and is strongly influenced by systemic

Table 1. Phenomenon of the Effect of Body Position on IOP

No	Author (s)	Year	Main Findings	Implications
1	Sit & Liu	2009	The supine position increases intraocular pressure (IOP) compared to the sitting position	Influence of gravity and venous pressure
2	Malihi et al.	2012	Increased intrathoracic pressure leads to elevated IOP	Relationship between respiration and IOP
3	Kotecha	2007	Biomechanical factors affect tonometry measurements	Variability in clinical measurement outcomes
4	Baskaran et al.	2016	Head-down posture significantly increases IOP	Risk of diagnostic bias
5	Wang et al.	2020	Body posture influences episcleral venous pressure	Hemodynamic mechanism

Source: Primary Data, 2026



Source: Primary Data, 2026

Figure 1. Research Conceptual Framework Diagram

and environmental factors.

2. Malihi & Sit (2012) demonstrated that changes in intrathoracic pressure due to body posture can significantly increase IOP.
3. Baskaran et al. (2016) found that a lowered head position during daily activities (e.g., smartphone use) increases IOP.
4. Wang et al. (2020) described the relationship between episcleral venous pressure and increased IOP in the context of changes in body position.
5. Turner et al. (2021) highlighted the importance of standardizing IOP measurement procedures to avoid clinical bias.

The novelty of this study:

1. Specific focus on neck position
2. Use of a repeated measures design
3. Targeting a healthy young adult population
4. Providing direct implications for optometry clinical practice

The following is the research conceptual framework that describes the relationships between variables (**Figures 1**)

Description:

- Independent variable: Neck position (neutral, flexed, extended)
- Mediator variable: Jugular venous pressure, episcleral venous pressure
- Dependent variable: Intraocular pressure (IOP)

Research Hypothesis:

H1 : There is a significant difference in intraocular pressure between the neutral, flexed, and extended neck positions.

H2 : The flexed neck position results in higher intraocular pressure than the other positions.

METHODS

This study employed an analytical observational design with a cross-sectional approach and repeated measures design. This approach was chosen because it allowed researchers to evaluate differences in intraocular pressure (IOP) across multiple treatment conditions at relatively simultaneous times in the same subjects.

According to Setiawan (2016), a cross-sectional design is effective for identifying relationships between variables at a single observation point without experimental intervention. Meanwhile, Field (2013) stated that a repeated measures design increases statistical power because it controls for inter-individual variability.

The study was conducted in the optometry clinical laboratory at the Faculty of Optometry and Eye Health, SEGi University, Kota Damansara. Data collection was conducted over a controlled period to minimize diurnal variation in intraocular pressure.

According to Liu (2006), intraocular pressure has diurnal variation, so measurements should be taken at the same time to increase the validity of the results.

Population and Sample

The population in this study was all healthy young adults within the productive age range.

The research sample consisted of 39 subjects, selected using purposive sampling based on inclusion and exclusion criteria. According to Sugiyono (2018), purposive sampling is used to select subjects who align with the research objectives and possess certain relevant characteristics.

1. Inclusion Criteria
   a. Age 18 – 30 years
   b. No history of eye disease
   c. No use of medications that affect IOP
   d. No history of eye surgery
2. Exclusion Criteria
   a. Experiencing eye infection or inflammation
   b. Wearing contact lenses in the last 24 hours
   c. Having a systemic disorder that affects blood pressure or intraocular pressure

Subject Characteristics: Average age: 23.53 ± 2.17 years, and Average Spherical Equivalent (SER): 0.91 ± 1.03 diopters

Research Variables: Independent variables with dimensions of neck position include indicators of neutral position (normal), neck flexion, and neck extension. Dependent Variable: Intraocular Pressure (IOP) (mmHg).

Control Variables: Measurement time, body position (sitting upright), measuring instrument used, and environmental conditions (lighting and room temperature). According to Weinreb (2014), controlling external variables is crucial in IOP research to avoid bias in measurement results.Instrumen utama pada penelitian ini yang digunakan adalah: TonoPen AVIA (Reichert Inc., Depew, New York, USA)

This device was chosen because of its high accuracy and portability in measuring intraocular pressure.

According to Kotecha (2007), the TonoPen is a valid and reliable tonometry device for clinical measurements, especially under non-ideal conditions. The research procedure was carried out systematically as follows:

1. Subject Preparation
   a. Subjects were given an explanation and informed consent was obtained.
   b. Subjects were instructed to sit in a relaxed position.
2. Initial Measurement (Neutral Position)
   a. Head in an upright (neutral) position.
   b. IOP measurements were taken three times in each eye.
   c. Values were averaged.
3. Neck Flexion Treatment
   a. Subjects were asked to lower their heads (flexion ±30 – 45°).
   b. Maintain this position for 5 minutes.
   c. IOP measurements were taken three times.
4. Neck Extension Treatment
   a. Subjects were asked to raise their heads (extension ±30 – 45°).
   b. Maintained for 5 minutes
   c. IOP measurements were performed three times
5. Control of Variables
   a. The time interval between measurements was controlled
   b. All measurements were performed by the same operator

According to Malihi (2012), a body position lasting several minutes is necessary to achieve intraocular pressure stabilization before measurements are taken.

Validity and Reliability Testing of the measurements was performed three times to increase internal reliability. The instrument was then calibrated before use, and the operator was trained in its use.

According to Polit (2012), repeated

measurements are an effective method for improving data consistency in clinical research.

Data were analyzed using statistical software with the following steps:

1. Descriptive analysis including the mean and standard deviation for each position.
2. Normality test using Shapiro-Wilk.
3. Hypothesis test using repeated measures ANOVA to compare the average IOP at the three positions.
4. Follow-up test using Bonferroni post hoc to determine differences between pairs of groups.
5. Significance level (partial) with $p < 0.05$.

According to Field (2013), repeated measures ANOVA is an appropriate method for comparing more than two conditions in the same subject. This study complied with ethical research principles, including informed consent from all subjects, confidentiality of respondent data, and the absence of significant risks to subjects. Referring to the World Medical Association guidelines through the Declaration of Helsinki, all research involving humans must uphold the principles of ethics, safety, and the rights of research subjects.

Table 2. Characteristics of Research Subjects (n = 39)

Variable	Mean ± SD	Minimum	Maximum
Age (years)	23.53 ± 2.17	20	28
Spherical Equivalent Refraction (SER, diopters)	0.91 ± 1.03	-1.50	+2.00

Source: Research Results

Table 3. Comparison of Average IOP in Three Neck Positions

Neck Position	Mean IOP (mmHg)	Standard Deviation	Difference from Normal
Normal	13.66	± 1.88	—
Flexion	17.24	± 1.94	+3.58
Extension	14.66	± 2.28	+1.00

Source: Research Results

Table 4. Results of the Repeated Measures ANOVA Test

Source of Variation	F-value	df	p-value
Neck Position	94.46	(1.81; 67.01)	< 0.01

Source: Research Results

Table 5. Comparison Between Neck Positions

Comparison	Mean Difference	p-value	Description
Flexion vs Normal	**+3.58**	**<0.01**	**Significant**
Flexion vs Extension	**+2.58**	**<0.01**	**Significant**
Extension vs Normal	**+1.00**	**<0.05**	**Weakly significant**

Source: Research Results

RESULT

Characteristics of Research Subjects

The following table presents the general characteristics of the respondents in the study (Table 2)

Interpretation:

The majority of subjects were young adults with refractive conditions relatively close to emmetropia, thus representing a normal physiological condition without significant disturbances to intraocular pressure.

Average Intraocular Pressure Based on Neck Position

Interpretation:

- The neck flexion position showed the highest increase in IOP (+3.58 mmHg).
- The neck extension position showed a moderate increase (+1.00 mmHg).
- The normal position showed the lowest IOP.

Results of the Repeated Measures ANOVA Statistical Test

Interpretasi:

The test results showed a statistically significant difference in intraocular pressure based on variations in neck position ($p < 0.01$). This means that the research hypothesis (H1) was accepted.

Follow-up Test Results (Post Hoc Bonferroni)

Interpretation:

- The flexed position was significantly higher than all other positions.
- The extended position was also higher than normal, but by a smaller difference.

DISCUSSION

Effect of Neck Position on Intraocular Pressure

The results of this study indicate that neck position has a significant effect on intraocular pressure, with the highest increase occurring in the flexed position. This finding indicates that changes in neck angle can influence intraocular pressure dynamics through specific physiological mechanisms.

The increase in IOP in the flexed position can be explained by the increase in jugular venous pressure that occurs due to the head-down position. According to Bill (1975), increased episcleral venous pressure will inhibit the outflow of aqueous humor through the trabecular system, thereby causing increased intraocular pressure. Furthermore, the flexed position can also increase intrathoracic pressure, which indirectly increases central venous pressure. This is in line with the findings of Malihi (2012) who stated that changes in intrathoracic pressure are directly related to increased IOP.

Comparison with Previous Studies

The results of this study are consistent with research conducted by Baskaran (2016), which found that a lowered head position significantly increases intraocular pressure, especially during activities such as smartphone use.

Furthermore, research by Sit & Liu (2009) showed that changes in body position can increase intraocular pressure through changes in body fluid distribution and hemodynamic pressure.

However, this study provides novel contributions because: Using a repeated measures design and Studying a population of healthy young adults

Underlying Physiological Mechanisms

Physiologically, the increase in intraocular pressure due to changes in neck position can be explained through several mechanisms:

a. Increased Jugular Venous Pressure
   A flexed position causes partial compression of the jugular veins → increasing venous pressure → increasing episcleral pressure
b. Increased Episcleral Pressure
   Increased episcleral pressure will : Inhibit aqueous humor outflow and Increase trabecular resistance
c. Changes in Intrathoracic Pressure

Certain head positions affect: Intrathoracic pressure and Central venous pressure

According to Weinreb (2014), these hemodynamic factors are important determinants in the regulation of intraocular pressure. 4.4 Clinical Implications. The findings of this study have important implications for clinical practice:

a. Standardization of examination position
   1) The neck should be in a neutral position during IOP measurement
b. Avoiding diagnostic bias
   1) A flexed position can lead to IOP overestimation
c. Relevance in glaucoma screening
   1) Measurement errors can affect diagnosis
d. Patient education
   1) Head position during the examination should be considered

Strengths and Limitations of the Study

Strengths: Repeated measures design improves internal validity, Repeated measurements improve reliabilityand Well-controlled variables

Limitations:

a. Relatively small sample size
b. Only involved healthy young adults
c. Did not measure venous pressure directly

Theoretical Implications and Research Developmen

This study strengthens the ocular hemodynamic theory that episcleral venous pressure plays an important role in the regulation of intraocular pressure. Furthermore, this study opens up opportunities for further study development, such as: Analysis in glaucoma patients, Use of vascular imaging, and Structural modeling (SEM) approach.

CONCLUSION

Based on the research results and discussion, it can be concluded that:

1. Neck position has a significant influence on intraocular pressure (IOP) in healthy young adults. This was demonstrated through statistical analysis using repeated measures ANOVA, which showed a significant difference between positions ($p < 0.01$).
2. The flexed neck position resulted in the highest increase in intraocular pressure, with an average difference of +3.58 mmHg compared to the normal position. This indicates significant hemodynamic changes due to increased jugular venous and episcleral pressure.
3. The extended neck position also increased intraocular pressure, but to a lesser extent than the flexed position, indicating that changes in neck angle generally affect intraocular pressure dynamics.
4. The neutral (normal) neck position is the most stable and optimal condition for measuring intraocular pressure because it produces the lowest IOP value and is closest to actual physiological conditions.
5. Theoretically, these findings reinforce the concept of ocular hemodynamics, where increased episcleral venous pressure contributes to the obstruction of aqueous humor outflow, thereby increasing intraocular pressure.
6. Practically, this study confirms that inconsistent neck positioning during IOP examination has the potential to cause diagnostic bias, particularly in glaucoma screening and monitoring.

DISCLOSURES

Funding

None received.

Ethics Approval

This study had been ethically approved by the ethic committee of Akademi Optometri Yogyakarta

Conflict of Interest

None to state.

Author Contribution

All authors contributed equally in the writing of this article.

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