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Original Article

EFFECT OF MILK CHOCOLATE AND DARK CHOCOLATE ON INTRAOCULAR PRESSURE: A PROSPECTIVE COMPARATIVE STUDY

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ABSTRACT

Background: Intraocular pressure (IOP) is a critical physiological parameter that maintains ocular integrity and visual function. Dietary factors have been shown to influence vascular and ocular physiology. Dark chocolate contains high concentrations of flavonoids, methylxanthines, and antioxidants that may affect ocular blood flow and aqueous humor dynamics, thereby influencing IOP.

Objective : To evaluate and compare the short-term effects of milk chocolate and dark chocolate consumption on intraocular pressure among healthy young adults.

Methods: A prospective comparative study was conducted among 70 healthy participants aged 18–25 years at Ahalia College of Optometry and Research Centre, Palakkad, India. Participants were allocated into two groups: milk chocolate (n=28) and dark chocolate (n=29). Baseline intraocular pressure was measured using a Perkins applanation tonometer. Each participant consumed 20 g of the assigned chocolate, and IOP was reassessed one hour later. Statistical analysis was performed using SPSS version 31. Non-parametric tests including the Wilcoxon signed-rank test and Mann–Whitney U test were applied. Statistical significance was established at $p < 0.05$.

Results: The mean age of participants was 19.79 ± 2.69 years. The milk chocolate group demonstrated a non-significant reduction in mean IOP from 11.91 ± 1.94 mmHg to 11.45 ± 1.80 mmHg ($p > 0.05$). Conversely, the dark chocolate group exhibited a significant increase in IOP from 12.16 ± 2.07 mmHg to 12.97 ± 2.04 mmHg ($p < 0.001$). Intergroup comparison demonstrated a statistically significant difference in post-consumption IOP values.

Conclusion : Dark chocolate consumption was associated with a significant short-term increase in intraocular pressure, whereas milk chocolate consumption did not significantly affect IOP. These findings suggest that cocoa-rich dark chocolate may transiently alter ocular physiology and should be considered when interpreting IOP measurements in clinical settings.

Keywords: Intraocular pressure, dark chocolate, milk chocolate, cocoa flavonoids.

Introduction:

Intraocular pressure (IOP) is the hydrostatic pressure exerted by aqueous humor within the eye and serves as one of the most important determinants of ocular health. Physiological IOP is essential for maintaining the structural integrity of the globe, preserving corneal curvature, and ensuring proper retinal function. The normal range of IOP is generally considered to be between 10 and 21 mmHg, although fluctuations may occur due to circadian rhythm, body posture, blood pressure, age, and systemic physiological changes [1]. Elevated intraocular pressure is the most significant modifiable risk factor associated with glaucoma, a progressive optic neuropathy that remains a leading cause of irreversible blindness worldwide [2]. The maintenance of normal intraocular pressure depends on a delicate balance between aqueous humor production and aqueous humor drainage. Aqueous humor is continuously produced by the ciliary body and exits the eye through the trabecular meshwork, Schlemm's canal, and uveoscleral outflow pathways [3]. Disturbances in either production or drainage may result in alterations in intraocular pressure. In addition to local ocular factors, systemic physiological conditions and dietary habits can influence ocular blood flow and aqueous humor dynamics, thereby affecting IOP regulation [4].

Dietary interventions have increasingly gained attention in ophthalmic research because of their potential influence on ocular physiology. Among various dietary products, chocolate has attracted considerable interest owing to its high content of biologically active compounds. Chocolate is derived from cocoa beans and is commercially available in several forms, including dark chocolate, milk chocolate, and white chocolate. Dark chocolate contains a significantly greater proportion of cocoa solids compared with milk chocolate and is therefore richer in flavonoids, catechins, epicatechins, procyanidins, and methylxanthines [5]. Flavonoids are naturally occurring polyphenolic compounds known for their potent antioxidant and vasodilatory properties. Cocoa-derived flavonoids enhance endothelial nitric oxide production, resulting in improved vascular function, increased tissue perfusion, and reduced oxidative stress [6]. Numerous studies have demonstrated beneficial cardiovascular effects of cocoa consumption, including improvements in endothelial function, blood pressure regulation, and vascular reactivity [7]. These physiological benefits have prompted investigations into the effects of cocoa on ocular circulation and visual performance.

Several studies have reported that dark chocolate consumption improves retinal blood flow, contrast sensitivity, and visual acuity due to enhanced ocular perfusion [8]. Increased retinal and choroidal circulation may influence aqueous humor production through improved ciliary body perfusion, thereby affecting intraocular pressure. Furthermore, methylxanthines such as caffeine and theobromine present in dark chocolate may influence autonomic nervous system activity and vascular regulation, potentially contributing to changes in IOP [9]. Despite increasing evidence regarding the vascular and visual benefits of cocoa consumption, limited information is available regarding its effect on intraocular pressure. Existing studies have reported inconsistent findings, and the short-term effects of chocolate consumption on ocular pressure remain poorly understood [10]. Given the widespread consumption of chocolate products and the clinical significance of accurate IOP assessment, understanding these effects is important for both clinicians and researchers. Therefore, the present study was undertaken to evaluate and compare the effects of milk chocolate and dark chocolate consumption on intraocular pressure among healthy young adults

Materials and Methods:

Study Design and Setting: This prospective comparative cohort study was conducted at the Department of Optometry, Ahalia College of Optometry and Research Centre, Palakkad, Kerala, India, over a period of six months. The study was designed to investigate the short-term effects of milk chocolate and dark chocolate consumption on intraocular pressure (IOP) in healthy young adults. Institutional permission was obtained before commencement of the study, and all participants provided written informed consent prior to enrolment. The study adhered to the ethical principles outlined in the Declaration of Helsinki for research involving human subjects.

Study Population

A total of 70 healthy participants aged between 18 and 25 years were recruited through convenience sampling. Participants were screened through comprehensive ocular and systemic examinations before inclusion in the study. Eligible participants were allocated into two groups based on the type of chocolate administered during the experimental procedure.

Inclusion Criteria

Participants fulfilling the following criteria were included:

1. Age between 18 and 25 years.
2. Emmetropic individuals or those with refractive errors not exceeding ± 2.00 diopters.
3. Absence of systemic or ocular disease.

Exclusion Criteria

Participants were excluded if they had:

1. Diabetes mellitus.
2. Hypertension.
3. Glaucoma or ocular hypertension.
4. History of ocular surgery or trauma.
5. Corneal pathology affecting tonometry measurements.
6. Pseudophakia or aphakia.
7. Lactose intolerance.
8. Known allergy to chocolate or cocoa products.
9. Current use of medications known to influence intraocular pressure.

Sample Distribution

Among the 70 participants included in the study, 55 were females and 15 were males. The mean age of the study population was 19.79 ± 2.69 years. Participants were divided into two experimental groups:

Group 1 (Milk Chocolate Group): Participants received 20 g of commercially available milk chocolate.

Group 2 (Dark Chocolate Group): Participants received 20 g of commercially available dark chocolate.

Study Materials

The following materials were used during the study: Perkins Applanation Tonometer, Fluorescein sodium strips, 0.5% Proparacaine hydrochloride eye drops, Milk chocolate (20 g per participant), Dark chocolate (20 g per participant), Sterile cotton swabs.

Data collection sheets

Measurement of Intraocular Pressure

Intraocular pressure was measured using a Perkins applanation tonometer, which operates on the same principle as the Goldmann applanation tonometer and is widely regarded as a reliable instrument for clinical IOP assessment. Prior to measurement, one drop of topical proparacaine hydrochloride was instilled into each eye to achieve corneal anesthesia. Fluorescein staining was then performed using sterile fluorescein strips to facilitate visualization of the applanation mires. To minimize the influence of diurnal variation, all baseline IOP measurements were obtained at approximately 1:45 PM. Measurements were performed by the same examiner throughout the study to reduce inter-observer variability. Both eyes were assessed, and the recorded values were documented for statistical analysis.

Experimental Procedure

Participants were instructed to abstain from consuming caffeine-containing beverages and foods, including coffee, tea, energy drinks, and chocolate products, for at least six hours prior to testing. This precaution was taken to minimize confounding effects on vascular physiology and intraocular pressure. Following baseline IOP assessment, participants consumed 20 g of their assigned chocolate under direct observation. Group 1 received milk chocolate, while Group 2 received dark chocolate. No additional food or beverages were permitted during the observation period. After chocolate consumption, participants remained seated and refrained from strenuous physical activity. Repeat intraocular pressure measurements were obtained exactly one hour after chocolate intake using the same tonometer and measurement protocol employed during baseline assessment.

Statistical Analysis

Data were entered into Microsoft Excel and subsequently analyzed using Statistical Package for Social Sciences (SPSS) version 21.0. Descriptive statistics including mean, standard deviation, frequencies, and percentages were calculated for demographic and clinical variables.

The Kolmogorov–Smirnov test was used to assess data normality. Since the data did not demonstrate a normal distribution, non-parametric statistical methods were employed. The Wilcoxon Signed-Rank Test was used to compare baseline and post-consumption IOP values within each group. The Mann–Whitney U Test was applied for comparisons between the milk chocolate and dark chocolate groups. Statistical significance was established at a p-value less than 0.05.

RESULTS:

Demographic Characteristics

A total of 70 participants completed the study protocol. Among them, 55 participants (78.6%) were female and 15 participants (21.4%) were male. The age of the participants ranged from 18 to 25 years, with a mean age of 19.79 ± 2.69 years. No participant reported adverse effects following chocolate consumption, and all participants completed the post-intervention assessment (Table-1).

Variable	Value
Total Participants	70
Female	55 (78.6%)
Male	15 (21.4%)
Mean Age (years)	19.79 ± 2.69
Age Range	18–25

Table 1. Demographic Characteristics of the Participants (N = 269)

Effect of Milk Chocolate Consumption on Intraocular Pressure:

Participants assigned to the milk chocolate group demonstrated a mean baseline intraocular pressure of 11.91 ± 1.94 mmHg. One hour following the consumption of 20 g of milk chocolate, the mean IOP decreased slightly to 11.45 ± 1.80 mmHg. Although a reduction in mean IOP was observed, statistical analysis revealed that the difference was not significant ($p > 0.05$). The findings suggest that milk chocolate consumption does not produce clinically relevant short-term changes in intraocular pressure among healthy young adults. The lower cocoa content and reduced concentration of bioactive flavonoids in milk chocolate may explain the absence of significant ocular physiological effects (Table-2).

Parameter	Mean \pm SD (mmHg)
Baseline IOP	11.91 ± 1.94
1-hour Post-consumption IOP	11.45 ± 1.80
Mean Difference	-0.46
p-value	>0.05
Interpretation	Not Significant

Table 2. Distribution of Participants According to Place of Residence

Effect of Dark Chocolate Consumption on Intraocular Pressure:

Participants in the dark chocolate group exhibited a baseline mean intraocular pressure of 12.16 ± 2.07 mmHg. One hour after consuming 20 g of dark chocolate, the mean IOP increased to 12.97 ± 2.04 mmHg. Statistical analysis demonstrated that this increase was highly significant ($p < 0.001$). The observed increase in IOP suggests that dark chocolate may exert measurable physiological effects on ocular hemodynamics. The higher concentration of cocoa solids, flavonoids, and methylxanthines present in dark chocolate may contribute to enhanced ocular perfusion and transient alterations in aqueous humor dynamics (Table-3).

Parameter	Mean ± SD (mmHg)
Baseline IOP	12.16 ± 2.07
1-hour Post-consumption IOP	12.97 ± 2.04
Mean Difference	+0.81
p-value	<0.001
Interpretation	Highly Significant

Table 3. Changes in Intraocular Pressure Following Dark Chocolate Consumption

Comparative Analysis Between Milk Chocolate and Dark Chocolate Groups:

Comparison of baseline intraocular pressure values between the two groups demonstrated no statistically significant difference, indicating that both groups were comparable prior to intervention. However, post-consumption analysis revealed a significant difference between the groups, with the dark chocolate group exhibiting higher IOP values compared to the milk chocolate group. The differential response observed between the two chocolate types highlights the potential role of cocoa concentration and flavonoid content in influencing ocular physiology. Dark chocolate, containing substantially greater quantities of cocoa-derived bioactive compounds, appears to have a more pronounced effect on intraocular pressure regulation than milk chocolate (Table-4).

Comparison	p-value	Interpretation
Baseline IOP (MC vs DC)	>0.05	Not Significant
Post-consumption IOP (MC vs DC)	<0.001	Highly Significant

Table 4. Comparison Between Milk Chocolate and Dark Chocolate Groups

DISCUSSION

The present study investigated the short-term effects of milk chocolate and dark chocolate consumption on intraocular pressure among healthy young adults. The findings demonstrated that consumption of dark chocolate resulted in a statistically significant increase in intraocular pressure, whereas milk chocolate consumption did not significantly alter IOP. The observed increase in IOP following dark chocolate consumption may be attributed to the high concentration of cocoa-derived flavonoids and methylxanthines. Dark chocolate contains substantial quantities of epicatechin, catechin, procyanidins, caffeine, and theobromine, compounds known to influence vascular endothelial function and systemic circulation [5,6]. These bioactive molecules stimulate nitric oxide synthesis, leading to enhanced vascular perfusion and improved blood flow [7]. Improved ocular perfusion may increase blood supply to the ciliary body, potentially enhancing aqueous humor production. Increased aqueous humor formation could contribute to transient elevations in intraocular pressure, particularly during the immediate post-consumption period observed in the present investigation [11].

The findings of the present study are consistent with those reported by Raj et al. [10], who observed a significant increase in intraocular pressure following dark chocolate consumption. Similar studies evaluating cocoa-rich products have demonstrated improvements in retinal blood flow, visual acuity, and contrast sensitivity, further supporting the role of cocoa flavonoids in modulating ocular circulation [8]. In contrast, milk chocolate consumption did not produce statistically significant changes in intraocular pressure. This finding may be explained by the considerably lower concentration of cocoa solids in milk chocolate. The presence of milk solids, sugar, and fat reduces the proportion of flavonoids and methylxanthines, thereby limiting their physiological effects [12]. Although the increase in IOP observed in the dark chocolate group was statistically significant, the magnitude of change remained within normal physiological limits. Therefore, the clinical relevance of this increase among healthy individuals may be limited. However, in patients with glaucoma or ocular hypertension, even small elevations in intraocular pressure may contribute to disease progression and warrant clinical consideration [13].

Several strengths of the present study should be acknowledged. The use of a standardized measurement time minimized the influence of diurnal variation. Perkins applanation tonometry provided reliable and reproducible measurements. Furthermore, a controlled chocolate dosage reduced variability related to dietary intake. Nevertheless, certain limitations should be considered. The study involved a relatively small sample size and included only healthy young adults, limiting generalizability to older populations and glaucoma patients. The follow-up period was restricted to one hour, precluding assessment of longer-term effects. Additionally, systemic cardiovascular parameters such as blood pressure and heart rate were not measured. Future studies involving larger populations, longer follow-up periods, and advanced ocular blood flow assessment techniques are recommended. Investigations among glaucoma patients may further clarify the clinical significance of chocolate-induced alterations in intraocular pressure.

LIMITATIONS : This study was conducted on a relatively small sample of healthy young adults from a single center, limiting the generalizability of the findings. Intraocular pressure was assessed only one hour after chocolate consumption, and systemic parameters such as blood pressure and ocular perfusion were not evaluated. Additionally, the exact flavonoid and methylxanthine content of the chocolates was not quantified.

RECOMMENDATIONS : Future studies should include larger and more diverse populations, longer follow-up periods, and assessment of ocular blood flow and systemic cardiovascular parameters. Research involving glaucoma and ocular hypertension patients is also recommended to determine the clinical relevance of chocolate-induced IOP changes.

CONCLUSION

Dark chocolate consumption produced a statistically significant increase in intraocular pressure one hour after ingestion, whereas milk chocolate consumption did not result in significant changes. The findings suggest that cocoa-rich dark chocolate may transiently influence ocular physiology through vascular and hemodynamic mechanisms. Clinicians should consider recent dietary intake when interpreting intraocular pressure measurements, particularly in individuals undergoing glaucoma screening or ocular hypertension assessment

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