Body mass index and intraocular pressure in adults: implications for glaucoma risk

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Індекс маси тіла та внутрішньоочний тиск у дорослих: значення для ризику розвитку глаукоми

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Abstract

Purpose. *This study aimed to investigate the relationship between body mass index (BMI) and intraocular pressure (IOP) and to assess whether hypertension status modifies the BMI–IOP association among adults aged ≥40 years.*

Methods. *This analytical observational cross-sectional study was conducted at the eye outpatient clinic of PKU Muhammadiyah Hospital Gamping from December 2023 to April 2024. Participants were recruited using purposive sampling. Inclusion criteria were healthy men and women aged ≥40 years with no known ocular disease who provided informed consent. Exclusion criteria included glaucoma/glaucoma suspicion, ocular trauma, chronic ocular surface inflammation/red eye disease, prior ocular surgery, moderate – high myopia (spherical equivalent ≤ −3.00 D), and topical/systemic corticosteroid use for ≥1 month. BMI was calculated from standardized weight and height measurements. IOP was measured in both eyes (right eye/OD, left eye/OS) using a non-contact tonometer under standardized seated conditions. Between-group comparisons used Mann–Whitney U tests, and BMI–IOP associations were assessed using Spearman correlation ($p < 0.05$).*

Results. *Ninety-six participants were included: 48 hypertensive (19 men, 29 women) and 48 non-hypertensive (15 men, 33 women). The hypertensive group was older than the non-hypertensive group ($p < 0.05$), and systolic/diastolic blood pressures were higher ($p < 0.05$). No significant differences were found for BMI, IOP OD, or IOP OS between groups ($p > 0.05$). BMI was not significantly correlated with IOP OD or IOP OS in either group ($p > 0.05$).*

Conclusion. *BMI was not associated with IOP in either eye among healthy adults aged ≥40 years, suggesting BMI alone may not reflect glaucoma risk through an IOP pathway in this population.*

Keywords: *Body Mass Index, Glaucoma, Intraocular pressure.*

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Резюме

Мета. *Дослідити зв'язок між індексом маси тіла (ІМТ) та внутрішньоочним тиском (ВОТ) та оцінити, чи впливає гіпертензія на зв'язок ІМТ–ВОТ у дорослих віком ≥40 років.*

Матеріали та методи. *Це аналітичне обсерваційне перехресне дослідження було проведено в офтальмологічній амбулаторії лікарні PKU Muhammadiyah Hospital Gamping з грудня 2023 року по квітень 2024 року. Учасників набирали за допомогою цілеспрямованої вибірки. Критерії включення включали здорових чоловіків та жінок віком ≥40 років без очних захворювань, які надали інформовану згоду. Критерії виключення включали глаукому/підозру на глаукому, травму ока, хронічне запалення поверхні ока/почервоніння очей, попередні операції на очах, міопію середнього та високого ступеня (сферичний еквівалент ≤ −3,00 D) та місцеве/системне застосування кортикостероїдів протягом ≥1 місяця. ІМТ розраховували на основі стандартизованих вимірювань ваги та зросту. ВОТ вимірювали в обох очах за допомогою безконтактного тонометра. Для міжгрупового порівняння використовувалися U-тести Манна-Вітні, а зв'язок між ІМТ та внутрішньоочним тиском оцінювався за допомогою кореляції Спірмена (p < 0,05).*

Результати. *Було включено дев'яносто шість учасників: 48 з гіпертензією (19 чоловіків, 29 жінок) та 48 без гіпертензії (15 чоловіків, 33 жінки). Група з гіпертензією була старшою за групу без гіпертензії (p < 0,05), а систолічний/діастолічний артеріальний тиск були вищими (p < 0,05). Не було виявлено суттєвих відмінностей для ІМТ, внутрішньоочного тиску OD або OS між групами (p>0,05). ІМТ не мав суттєвої кореляції з внутрішньоочним тиском OD або OS в жодній з груп (p > 0,05).*

Висновки. *ІМТ не був пов'язаний з внутрішньоочним тиском в жодному з очей у здорових дорослих віком ≥40 років, що свідчить про те, що ІМТ сам по собі може не відображати ризик глаукоми через шлях внутрішньоочного тиску в цій популяції.*

Ключові слова: *Індекс маси тіла, глаукома, внутрішньоочний тиск*

Introduction

Body mass index (BMI) is the most common way to measure obesity. It is worked out by taking body weight in kilograms divided by height in meters squared (kg/m²) [1]. Being obese is now a big public health problem around the world, even in Indonesia. About one out of every three Indonesian adults is obese, according to national health figures. From 2018 to 2019, the percentage of people over 18 years old who were obese rose from 14.8% to 21.8%. Women had higher rates than men [2]. As obesity becomes more common, people tend to follow their own eating habits, which may have a greater impact on health [3].

Being obese raises your chances of having many other illnesses, such as type 2 diabetes (T2DM), heart disease, stomach problems, and breathing issues. Eating poorly can make these conditions worse [4,5]. Being overweight has been linked to many eye problems, like cataracts, diabetic retinopathy, age-related macular degeneration, and glaucoma [6], in addition to diseases that affect the whole body. Among these, glaucoma stands out as a major public health problem that causes people to go blind and stay that way [7]. A lot of people know that high intraocular pressure (IOP) is the most important changeable risk factor that can cause glaucoma and make it worse [8].

Earlier research has shown that there may be a link between BMI and IOP, with higher IOP readings reported for people with higher BMI [9]. Epidemiological studies have shown that BMI and IOP are positively linked to each other [10–13]. Some ideas about how this association works are: more fat in the eye sockets squishes the episcleral veins; thicker blood makes it harder for the aqueous humor to flow; obesity messes up the body's blood vessels, which changes the way blood flows to the eyes; and high leptitin levels can cause oxidative stress, which is linked to trabecular meshwork dysfunction [10].

IOP is also affected by age; IOP levels rise with both getting older and having a higher BMI. Since high IOP is a big risk factor for glaucoma, people over 40 years old and people who are overweight or fat should have their IOP checked regularly. Also, systemic conditions like high blood pressure can make glaucoma even more likely, which shows how important it is for older people to get both eye and full body evaluations [14,15].

Purpose. This study aimed to investigate the relationship between BMI and IOP and to assess whether hypertension status modifies the BMI–IOP association among adults aged ≥40 years.

Methods

This analytical observational study used a cross-sectional design and was conducted at the eye outpatient clinic of PKU Muhammadiyah Hospital Gamping from December 2023 to April 2024. Participants were recruited using purposive sampling from clinic attendees who met eligibility criteria.

Inclusion criteria were: (1) men or women aged ≥40 years; (2) in good general condition and able to complete examinations; (3) no known ocular disease based on history and routine clinical screening at recruitment; and (4) provided written informed consent. Exclusion criteria were applied to minimize confounding factors that could influence IOP. Participants were excluded if they had: a history of glaucoma or glaucoma suspicion, prior ocular trauma, chronic ocular surface inflammation or chronic red eye disease, previous ocular surgery (including cataract or refractive surgery), moderate to high myopia (spherical equivalent ≤ −3.00 D), or topical/systemic corticosteroid use for ≥1 month.

Table 1. Hypertension severity

Hypertension severity	n	%
Mild	25	52.1
Moderate	14	29.2
Severe	9	18.8
Total	48	100

Notes: Mild: 140–159/90–99 mmHg; Moderate: 160–179/100–109 mmHg; Severe: ≥180/≥110 mmHg.

Table 2. Subject characteristics by sex

Sex	Hypertension (n=48)	Non-hypertension (n=48)
Male, n (%)	19 (39.6)	15 (31.2)
Female, n (%)	29 (60.4)	33 (68.8)
Total	48 (100)	48 (100)

Participants were categorized into hypertensive and non-hypertensive groups based on blood pressure status; hypertension severity (mild/moderate/severe) followed the criteria presented in Table 1. Body weight and height were measured using the ZT-120 GEA Series device (or equivalent) with light clothing and no shoes, and BMI was calculated as kg/m². IOP was measured in both eyes right eye (OD) and left eye (OS) using a SNT-700 soft non-contact tonometer under standardized seated conditions.

Data were analyzed using SPSS. Between-group comparisons used the Mann–Whitney U test for continuous variables as reported, and categorical variables were summarized as counts and percentages. The association between BMI and IOP (OD and OS) within each group was evaluated using Spearman rank correlation. A p-value < 0.05 was considered statistically significant. This study was approved by the Ethics Committee of RS PKU Muhammadiyah Gamping, Yogyakarta, Indonesia (Approval No. 191/KEP-PKU/XII/2023; 11 December 2023). Written informed consent was obtained from all participants prior to data collection.

A total of 96 participants were included: 48 hypertensive and 48 non-hypertensives. Women predominated in both groups (Table 2). Most participants in both groups had normal BMI, with fewer participants categorized as overweight or obese.

Results

A total of 96 participants were included in this study, consisting of 48 participants with hypertension and 48 participants without hypertension. Among participants with hypertension, most were classified as having mild hypertension, followed by moderate and severe hypertension (Table 1).

The distribution of participants by sex is presented in Table 2. Women predominated in both groups, with 29 women (60.4%) in the hypertensive group and 33 women (68.8%) in the non-hypertensive group.

Table 3. BMI categories

BMI category	Hypertension (n=48)	Non-hypertension (n=48)
Underweight (extremely thin + thin), n (%) <18.5	5 (10.4)	4 (8.4)
Normal, n (%) 18.5-24.9	30 (62.5)	32 (66.7)
Overweight, n (%) 25.0–29.9	8 (16.7)	5 (10.4)
Obese, n (%) ≥30.0	5 (10.4)	7 (14.6)
Total	48 (100)	48 (100)

Table 4. Clinical characteristics including right and left eye IOP

Parameter	Hypertension (Mean ± SD)	Non-hypertension (Mean ± SD)	p-value
Age (years)	63.02 ± 8.4	56.58 ± 10.0	<0.05
Weight (kg)	54.01 ± 11.6	57.40 ± 13.8	>0.05
Height (m)	1.53 ± 0.10	1.56 ± 0.10	>0.05
BMI (kg/m²)	22.78 ± 3.6	23.19 ± 4.3	>0.05
Systolic BP (mmHg)	161.67 ± 21.7	122.38 ± 10.3	<0.05
Diastolic BP (mmHg)	90.25 ± 14.3	71.29 ± 7.2	<0.05
IOP OD (mmHg)	16.66 ± 4.1	14.77 ± 3.5	>0.05
IOP OS (mmHg)	16.53 ± 4.8	15.22 ± 3.7	>0.05

Most participants in both groups had normal BMI, while underweight, overweight, and obese categories were also represented (Table 3). In the hypertensive group, 30 participants (62.5%) had normal BMI, 8 participants (16.7%) were overweight, and 5 participants (10.4%) were obese. In the non-hypertensive group, 32 participants (66.7%) had normal BMI, 5 participants (10.4%) were overweight, and 7 participants (14.6%) were obese.

Clinical characteristics, including age, weight, height, BMI, blood pressure, and intraocular pressure, are presented in Table 4. The hypertensive group was significantly older than the non-hypertensive group (63.02 ± 8.4 years vs. 56.58 ± 10.0 years, $p < 0.05$). As expected, systolic and diastolic blood pressures were significantly higher in the hypertensive group than in the non-hypertensive group ($p < 0.05$). However, there were no significant between-group differences in weight, height, BMI, IOP OD, or IOP OS ($p > 0.05$). The mean BMI was 22.78 ± 3.6 kg/m² in the hypertensive group and 23.19 ± 4.3 kg/m² in the non-

hypertensive group. The mean IOP OD was 16.66 ± 4.1 mmHg in the hypertensive group and 14.77 ± 3.5 mmHg in the non-hypertensive group, while the mean IOP OS was 16.53 ± 4.8 mmHg and 15.22 ± 3.7 mmHg, respectively.

Spearman correlation analysis showed no significant association between BMI and IOP OD or IOP OS in either the hypertensive or non-hypertensive group ($p > 0.05$). These findings indicate that BMI was not significantly related to intraocular pressure in either eye, regardless of hypertension status.

Discussion

This study found no significant correlation between body mass index and intraocular pressure in either hypertensive or non-hypertensive adults aged over 40 years. These findings suggest that BMI alone may not be a determining factor for elevated intraocular pressure in this population. The results are consistent with the findings who also reported no significant association between BMI and IOP. While Albuquerque's study involved a younger population, the present study extends these observations to an older age group, which is more clinically relevant given the increasing risk of glaucoma with advancing age.

It is in line with a reported study about the association between BMI and IOP may vary according to body position, with significant correlations observed in the supine position but not in the seated position [16]. Since intraocular pressure measurements in the present study were performed in a seated position, postural influences may partly explain the absence of a significant association. Furthermore, the present results support the findings of Asaoka who reported no direct relationship between BMI, blood pressure, and intraocular pressure, emphasizing the complex and multifactorial regulation of IOP [17].

In contrast, several previous studies have reported a positive correlation between BMI and intraocular pressure, suggesting that higher BMI is associated with increased IOP [9–11,18–21]. Coster et al. demonstrated a statistically significant positive correlation between BMI and IOP in both eyes, while Ernawati et al. reported similar findings in an Indonesian population. These associations have been attributed to mechanisms such as increased fat deposition around the neck and orbit, which may reduce venous return, elevate episcleral venous pressure, and impair aqueous humor outflow, thereby increasing intraocular pressure [10,11].

The lack of a significant association observed in this study may be explained by several factors. First, intraocular pressure is influenced by multiple variables beyond BMI, including age, sex, blood pressure control, ocular health status, circadian variation, and measurement conditions. Second, more than 60% of participants in both hypertensive and non-hypertensive groups had normal BMI, resulting in limited representation of obese individuals, who are more likely to demonstrate obesity-related elevations in IOP. Previous studies have indicated that increases in IOP are more pronounced in individuals with obesity compared to those with normal or mildly elevated BMI [9,19]. Additionally, although the hypertensive group in this study exhibited slightly higher mean IOP values (approximately 2 mmHg) compared with the non-hypertensive group, this difference did not reach statistical significance. This finding may suggest that blood pressure among hypertensive participants was adequately controlled, thereby preventing substantial increases in ciliary artery pressure and aqueous humor production. The present study did not evaluate other metabolic parameters, such as lipid profiles or insulin resistance, which may also influence intraocular pressure and should be considered in future research. This limitation highlights the need for more comprehensive studies to better elucidate the complex relationship between BMI, systemic health factors, and intraocular pressure.

Conclusion

In this study, we examined whether body mass index (BMI) was related to intraocular pressure (IOP) in adults aged ≥40 years, comparing 48 participants with hypertension and 48 without hypertension. The two groups had broadly similar BMI profiles, with most participants falling in the normal BMI range. As expected, the hypertensive group was older and had higher systolic and diastolic blood pressure, but BMI and mean IOP in both eyes did not differ significantly between groups. Spearman correlation analysis showed no significant association between BMI and IOP OD or IOP OS in either hypertensive or non-hypertensive participants. Taken together, these findings suggest that, in this glaucoma-free population and within the BMI range represented in the sample, BMI alone does not meaningfully explain variation in IOP. Clinically, this implies that body size should not be relied upon as a surrogate marker for elevated IOP; instead, IOP assessment should remain part of a broader risk-based eye evaluation. Future studies with larger samples, wider adiposity ranges, repeated IOP measurements, and inclusion of central adiposity and glaucoma-related outcomes are needed to clarify whether adiposity influences glaucoma risk through IOP-dependent or IOP-independent mechanisms.

Author Contributions

N.S.M. contributed to concept development, data analysis, and manuscript preparation. A.R. was involved in concept development, data collection, and manuscript preparation. S.A.S. participated in data collection, data analysis, and manuscript preparation. M.K.P.A. contributed to data collection, data analysis, and manuscript preparation. All authors have read and approved the final manuscript and agree to be responsible for all aspects of the work.

Disclaimers

The views expressed in this article are solely those of the authors and do not necessarily represent the official position of their affiliated institution or any funding source.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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Conflict of Interest

The authors declare that they have no conflicts of interest related to this work.

Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. Due to institutional policy and patient confidentiality, raw data are not publicly available.

Abbreviations

BMI – Body Mass Index; IOP – Intraocular pressure; OD – Oculus Dexter; OS – Oculus Sinister; IOP OD – Intraocular pressure of the right eye; IOP OS – Intraocular pressure of the left eye; OCT – Optical coherence tomography; RNFL – Retinal Nerve Fiber Layer; T2DM – Type 2 Diabetes Mellitus.

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