# The correlation between body mass index and intraocular pressure in children

*Correção entre o índice de massa corpórea e a pressão intraocular em crianças*

LUCIANO LIRA DE ALBUQUERQUE[1], MARIA ISABEL LYNCH GAETE[2], JOSÉ NATAL FIGUEIROA[3], JOÃO GUILHERME BEZERRA ALVES[1]

## ABSTRACT

**Purpose:** There is evidence from some studies that support an association between obesity in adults and higher intraocular pressure (IOP). However, this association has not been completely studied in children. Our aim is to evaluate the association between child body mass index (BMI) and IOP.

**Methods:** Ninety-six children attending the *Instituto de Medicina Integral Prof. Fernando Figueira* (IMIP) in Brazil were studied. Thirty-three were overweight/obese with a mean BMI of 29.7 ± 5.2 and 63 with a mean BMI of 20.8 ± 3.3. IOP was measured using the Goldmann applanation tonometer and was corrected for corneal thickness. The coefficient of correlation between BMI and IOP was calculated.

**Results:** There was no significant difference in the IOP of children with or without overweight/obesity. The mean IOP was 13.5 and 13.0 mmHg for the right eye and 13.1 and 12.9 mmHg for left eye, respectively (p=0.38 and p=0.71). The results remained the same after correction by pachymetry; 13.0 and 13.1 mmHg for the right eye and 12.4 and 12.9 mmHg for the left eye, respectively (p=0.88 and p=0.41). The coefficient of correlation between BMI and IOP was 0.070 (p=0.496).

**Conclusion:** These results do not show a correlation between body mass index and IOP in children. Further studies are warranted to clarify the association between BMI and IOP in children.

**Keywords:** Intraocular pressure; Tonometry; Body mass index; Obesity; Overweight; Child

## *RESUMO*

***Objetivo:*** *Alguns estudos apontam para uma associação entre obesidade e aumento da pressão intraocular em adultos. Entretanto, essa associação ainda não foi completamente estudada em crianças. O objetivo do estudo é avaliar a associação entre o índice de massa corpórea (IMC) e a pressão intraocular em crianças.*

***Métodos:*** *Noventa e seis crianças atendidas no Instituto de Medicina Integral Prof. Fernando Figueira (IMIP), Brasil, foram estudadas. Trinta e três apresentavam excesso de peso ou obesidade com uma média de IMC de 29,7 ± 5,2 e os outros 63 tinham uma média de IMC de 20,8 ± 3,3. A pressão intraocular foi medida por meio do tonômetro de aplanação de Goldmann, corrigida pela espessura da córnea. O coeficiente de correlação entre o IMC e a pressão intraocular foi calculado.*

***Resultados:*** *Não foi observada diferença significativa na pressão intraocular entre as crianças com e sem excesso de peso/obesidade. A média da pressão intraocular foi de 13,5 e 13,0 mmHg no olho direito e 13,1 e 12,9 mmHg no olho esquerdo, respectivamente (p=0,38 e p=0,71). Os resultados permaneceram os mesmos após a correção pela paquimetria; 13,0 e 13,1 mmHg para o olho direito e 12,4 e 12,9 mmHg para o olho esquerdo, respectivamente (p=0,88 e p=0,41). O coeficiente de correlação entre o IMC e a pressão intraocular foi 0,070 (p=0,496).*

***Conclusão:*** *O índice de massa corpórea não parece apresentar correlação com a pressão intraocular em crianças. Novos estudos são necessários para esclarecer a associação entre o IMC e a pressão intraocular.*

***Descritores:*** *Pressão intraocular; Tonometria; Índice de massa corpórea; Obesidade; Sobrepeso; Criança*

## INTRODUCTION

High intraocular pressure (IOP) is associated with glaucomatous optic nerve damage and its detrimental effect on vision[1,2]. IOP is currently the only modifiable risk factor for glaucoma[3]. Some epidemiological studies have described an association between obesity and IOP in adults[4,5]. A recent review concluded that there is an association between higher body mass index (BMI) and higher IOP in adults[6]. Although obesity is becoming a serious health problem in children with effects later on in adult life, there is only one study that has determined the IOP in obese children. Akinci et al. found that obesity was an independent risk factor for increased IOP[7]. The aim here is to evaluate the association between BMI and IOP in children.

## METHODS

Ninety-six children were recruited from the Department of Pediatrics of the *Instituto de Medicina Integral Prof. Fernando Figueira* (IMIP), Brazil, between September, 2009 and March, 2010. The research received prior approval from the Research Ethics Committee and all parents of participants signed an informed consent form.

Weight and height were measured with the children wearing light clothes and no shoes. Body mass index (BMI), weight (in kilograms) divided by height in meters squared (kg/m$^2$), was used as the indicator of fat mass. A child with a BMI in the 95$^{th}$ percentile or higher was considered to be obese, and a child with a BMI >85$^{th}$ and <95$^{th}$ percentile was considered to be overweight.

Exclusion criteria included previous glaucoma, orbital masses, severe myopia (>6D), diseases of the cornea or the presence of cardiovascular, renal, neurological, mental or metabolic disorders and genetic syndromes.

All measurements were performed between 9:00 am and midday, by one of the authors (LLA).

The IOP was measured using the Goldmann applanation tonometer. Three sequential measurements were recorded for each eye

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[1] Physician, Serviço de Oftalmologia Pediátrica, Instituto de Medicina Integral Professor Fernando Figueira, Recife, PE, Brazil.
[2] Professor, Universidade Federal de Pernambuco, Recife, PE, Brazil.
[3] Statistician, Instituto de Medicina Integral Professor Fernando Figueira, Recife, PE, Brazil.

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**Corresponding author:** João Guilherme Bezerra Alves. Instituto de Medicina Integral Prof. Fernando Figueira (IMIP). Rua dos Coelhos, 300 - Boa Vista - Recife (PE) - 50070-550 - Brazil
E-mail: joaoguilherme@imip.org.br

and the average was recorded. Corneal thickness was determined using a noncontact optical scanning slit pachymeter (Orbscan II). Hertel exophthalmometry was also carried out.

Blood pressure was obtained on the right arm, after 5 min rest, using a mercury sphygmomanometer and appropriate sized cuff. After three measurements, the lowest blood pressure value was chosen. Children were classified according to gender, height and age-specific charts.

Student t test was used to assess mean comparisons of continuous variables and the chi-square test for distributions of categorical variables. The association between BMI and IOP was assessed using the Pearson correlation coefficient. A multiple linear regression model was used to analyze the possible effect of confounding variables in the relationship between BMI and IOP. All tests used a p-value of <0.05.

## RESULTS

Ninety-six children (40 boys, 56 girls), aged from 6 to 17 years (11.0 ± 2.8), were included in the study. 33 were overweight and obese and biological and socio-economical characteristics of overweight/obese and non-overweight/obese children showed statistical differences (Table 1). Twelve children (12.5%) were obese and 21 (21.8%) overweight; with BMIs of 35.1 ± 5.3 $kg/m^2$ and 26.7 ± 4.1 $kg/m^2$, respectively.

There was no difference in IOP between the overweight/obese and non-overweight/obese children. The mean IOP was 13.5 and 13.0 for the right eye and 13.1 and 12.9 mmHg for the left eye, respectively (p=0.38 and p=0.71). The corneal thickness and exophthalmometry showed no difference among overweight/obese and non-overweight/obese children (Table 2). The coefficient of correlation between BMI and IOP was 0.070 (p=0.496). Multiple linear regression analysis with a significance level of 0.20 did not identify any possible confounding factor in the relation between overweight/obesity and IOP (Table 3).

## DISCUSSION

A positive correlation between IOP and obesity has been described in adults, although some studies have shown conflicting results[8,9]. The relationship between IOP and obesity in children has not as yet been adequately studied. As obesity tends to continue into adulthood, a positive correlation between BMI and IOP could indicate that obesity control in children is a crucial strategy for prevention of glaucoma. However, our results did not confirm an association between BMI and IOP. Akinci et al., however, in a study conducted in Turkey, showed a positive correlation between IOP and obesity[7]. Two factors may explain these different results. First, the mean difference in BMI among the obese children was 29 $kg/m^2$ in Akinci et al. compared with 36 $kg/m^2$ in the present study. Secondly, Goldmann tonometry in individuals with a high BMI (> 34 $kg/m^2$) may falsely increase IOP[9]. During the procedure a high BMI may cause compression of the chest and holding of the breath, both of which give rise to an increase in venous pressure and hence raise IOP.

Some authors argue that obesity increases IOP due to an excessive intraorbital adipose tissue deposit, leading to a rise in blood viscosity and episcleral venous pressure, and a consequent decrease in the facility of aqueous outflow. For other authors, obesity only increases IOP when it is associated with insulin-resistance[10]. The autonomic dysfunction and the osmotic gradient induced by hyperglycemia with a consequent fluid shift into the intraocular space have been proposed to explain the association between IOP and insulin-

**Table 1. Biological and socio-economical characteristics of overweight/obese and non-overweight/obese children**

| Variable | Normal (N=63) | Overweight (N=21) | Obese (N=12) | p value |
|---|---|---|---|---|
| Age, mean (sd) | 12.7[a] (0.4) | 12.0[a] (0.7) | 9.5[b] (0.4) | <0.001* |
| Skin color (not white) | 65.5 | 75.0 | 86.1 | 0.132† |
| Maternal schooling >4 years (%) | 58.6[a] | 100.0[b] | 75.0[b] | 0.016† |
| Income *per capita* ($ US ± sd) | 95.9 (9.4) | 101.9 (14.7) | 106.3 (8.5) | 0.713 |
| SAP (mmHg), mean (sd) | 107.9 (2.4) | 107.0 (3.7) | 107.7 (2.1) | 0.977 |
| DAP (mmHg), mean (sd) | 65.8 (1.7) | 61.6 (2.6) | 66.6 (1.5) | 0.247 |

sd= standard deviation; $ US= US dollars; SAP= systolic arterial pressure; DAP= diastolic arterial pressure.
*= ANOVA test; †= Fisher Exact test; a,b= Pairs of different letters were statistically different.

**Table 2. Intraocular pressure (IOP), corneal thickness (COT) and exophthalmometry (exo) in normal, overweight and obese children**

| | BMI | | | |
|---|---|---|---|---|
| | Normal (N=63) | Overweight (N=21) | Obese (N=12) | |
| Variable | Mean (sd) | Mean (sd) | Mean (sd) | p value |
| IOP right eye (mmHg) | 13.30 (0.3) | 13.30 ( 0.5) | 13.00 (0.3) | 0.758 |
| IOP left eye (mmHg) | 13.30 (0.3) | 12.90 ( 0.5) | 12.80 (0.3) | 0.578 |
| COT right eye (µm) | 545.20 (7.0) | 549.10 (10.9) | 543.20 (6.3) | 0.895 |
| COP left eye (µm) | 546.40 (7.0) | 549.80 (10.8) | 545.80 (6.3) | 0.950 |
| Exo right eye (mm) | 17.27 (1.7) | 17.31 ( 1.6) | 17.56 (1.8) | 0.893 |
| Exo left eye (mm) | 17.11 (1.9) | 17.88 ( 1.8) | 17.64 (1.7) | 0.877 |

**Table 3. Linear regression model for intraocular pressure (IOP) on body mass index adjusted for gender, skin color, maternal schooling, age and income *per capita***

| | Coefficient | Std. err. | p value |
|---|---|---|---|
| **IOP right eye** (mmHg) | | | |
| Female | -0.88 | 0.43 | 0.043 |
| Skin color (not white) | 0.032 | 0.49 | 0.947 |
| Maternal schooling >4 years (%) | 0.28 | 0.49 | 0.563 |
| Age | 0.045 | 0.093 | 0.631 |
| Income *per capita* | 0.00011 | 0.0042 | 0.980 |
| Body mass index (reference: normal) | | | |
| Overweight | -0.30 | 0.64 | 0.634 |
| Obese | -0.45 | 0.055 | 0.416 |
| Constant | 13.21 | 1.34 | <0.001 |
| **IOP left eye** (mmHg) | | | |
| Female | -0.69 | 0.43 | 0.113 |
| Skin color (not White) | -0.13 | 0.49 | 0.796 |
| Maternal schooling >4 years (%) | 0.31 | 0.49 | 0.528 |
| Age | 0.030 | 0.094 | 0.747 |
| Income *per capita* | -0.00028 | 0.0043 | 0.948 |
| Body mass index (reference: normal) | | | |
| Overweight | -0.57 | 0.64 | 0.374 |
| Obese | -0.55 | 0.55 | 0.325 |
| Constant | 13.34 | 1.35 | <0.001 |

Std. err.= standard error.

-resistance. Insulin-resistance is more frequent in children with very high BMI and the present study included overweight/obese children with a mean BMI of 29 kg/$m^2$.

All examinations were performed at the same time by the study's lead author (LL). All patients underwent pachymetry and exophthalmometry, examinations that increase the reliability of IOP measurement. There is no linear correlation between IOP and corneal thickness, so mathematic attempts to correct the IOP for corneal thickness are not valid. However in our study corneal thickness showed no differences among overweight/obese and non-overweight/obese children which decrease the influence of this variable on IOP.

A number of shortcomings of this study should be mentioned. First, the study included a few number of obese children with a high BMI, as Akinci et al. did[7]. For this reason it is not possible to carry out a comparative analysis among the obese children. It can be hypothesized that IOP increases only in children with extreme obesity. Another point is that the measurement of IOP was performed by only one ophthalmologist and it was not possible to determine the reliability of the test.

In conclusion, no association was found between BMI and PIO in this study. This finding did not confirm previous results that obesity in children is an independent risk factor for IOP. Further studies are warranted to clarify the association between BMI and IOP in children.

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