

Associations between hyperopia and others refractive and visual errors in children

Associação entre hiperopia e outros erros refrativos e visuais em crianças

Merry Elizabeth Goedert¹, Juliana Tessari Dias Rohr¹, Luciana Dias Pinto¹

ABSTRACT

Purpose: To investigate the associations of hyperopia with amblyopia, strabismus, anisometropia and astigmatism. **Methods:** Hyperopia was classified: Group 1: greater than or equal to + 5.00D; Group 2: greater than + 3.25D to + 5.00D and lower difference in equivalent spherical greater than or equal to 0.50D; Group 3: high + 3.25D to + 5.00D and smaller than a difference of less than 0.50D spherical equivalent and group 4: more spherical equivalent and equal to + 2.00D. **Results:** The presence of greater and equal to hyperopia + 2.00D SE was associated with a significantly larger proportion of children with amblyopia (27.2 vs. 14.8%, OR = 2.150, $p < 0.001$) and strabismus (70.8 vs. 39.3%, OR = 3.758, $p < 0.0001$). The presence of hyperopia was also associated with a significantly greater proportion of anisometropia in groups with higher hyperopia and equal to SE +2:00 (29.1 vs. 9.9%, OR = 3.708, $p < 0.0001$) and astigmatism (24 vs. 9.9%, OR = 2.859 $p < 0.0001$). **Conclusion:** The presence and magnitude of hyperopia among children were associated with a higher proportion of refractive and visual errors such as strabismus, amblyopia, astigmatism and anisometropia.

Keywords: Hyperopia; Strabismus; Anisometropia; Astigmatism; Children

RESUMO

Objetivo: Investigar a associação da hipermetropia com ambliopia, estrabismo, anisometropia e astigmatismo. **Métodos:** A hiperopia foi classificada em Grupo 1: maior ou igual a +5.00D; Grupo 2: maior que +3.25D e menor que +5.00D, com diferença de equivalente esférico maior ou igual a 0.50D; Grupo 3: maior que +3.25D e menor que +5.00D, com diferença de equivalente esférico menor que 0.50D e Grupo 4: com equivalente esférico maior e igual a +2.00D. O Grupo controle pertencente ao equivalente esférico menor que +2.00D. **Resultados:** A presença de hipermetropia maior e igual a SE+2.00D foi significativamente associada à maior proporção de crianças com ambliopia (27,2 vs. 14,8%, OR = 2,150, $p < 0,001$) e estrabismo (70,8 vs. 39,3%, OR = 3,758, $p < 0,0001$). A presença de hipermetropia também foi significativamente associada à maior proporção de anisometropia nos grupos com hipermetropia maior e igual a SE+2.00 (29,1 vs. 9,9%, OR = 3,708, $p < 0,0001$) e astigmatismo (24 vs. 9,9%, OR = 2,859 $p < 0,0001$). **Conclusão:** A presença e magnitude da hipermetropia entre crianças foram associadas à maior proporção de erros refrativos e visuais, como estrabismo, ambliopia, astigmatismo e anisometropia.

Descritores: Hiperopia; Estrabismo; Anisometropia; Astigmatismo; Crianças

¹ Hospital de Base do Distrito Federal, Brasília, DF, Brazil.

The authors declare no conflicts of interests.

Received for publication 10/08/2015 - Accepted for publication 27/10/2015

INTRODUCTION

Hyperopia occurs when the image produced by light rays is focused behind the retina, and is a common refractive state in young children. Most newborns and infants are farsighted.¹

While most hyperopic eyes will end up ametropic, strabismus and subsequent amblyopia represent a real danger to children whose eyes do not normalize.² According to a research conducted at the University of São Paulo in 2011, the amblyopic eyes of 37 patients aged 5-8 years with bilateral hyperopia and amblyopia by esotropy showed higher hyperopia, lower power of the cornea, higher power of the crystalline, lesser depth of the vitreous chamber and lower axial length.³

However, in Brazil there are few studies on hyperopia and associations with visual and refractive errors. The present study was conducted in order to understand the prevalence of hyperopia and their association with amblyopia, strabismus, anisometropia and astigmatism in pediatric ophthalmology service of the Base Hospital of Distrito Federal in order to promote improvements in patient care and provide knowledge to the technical team about the magnitude of this important condition in our local reality.

METHODS

Retrospective, cross-sectional, control-case study through the electronic medical record review (Trak care®) of children aged 0-15 years treated in the pediatric ophthalmology clinic of the Base Hospital of Distrito Federal from January 2013 to January 2015. For a better data analysis, the age groups were matched as: 0 to under 3 years; 3 to 5 years; 6 to 12 years, and 13 to 15 years. Hyperopia was classified as:

Group 1: Hyperopia greater than or equal to +5.00D

Group 2: Hyperopia greater than +3.25D and lower than +5.00D with difference in spherical equivalent greater than or equal to 0.50D

Group 3: Hyperopia greater than +3.25D and lower than +5.00D with difference in spherical equivalent lower than 0.50D

Group 4: Hyperopia spherical equivalent (SE) greater and equal to +2.00D.

Control group: spherical equivalent lower than +2.00 D.

Aspects as the classification of variables in combination were also defined, being defined as:

Astigmatism: refractive error greater than 1.5 D of the prime meridian.

Anisometropia: interocular difference greater than 1.00D in hyperopia, or more than 1.50D in astigmatism.

Strabismus: any heterotopia in primary eye position.

Amblyopia: two or more lines of interocular difference in the measurement of visual acuity.

Of the 1405 medical records reviewed, 509 individuals who had undergone complete eye examination were included in the survey, including the exam of monocular visual acuity with and without best correction to 6 meters, cover test, cycloplegic refraction and fundoscopy.

The study excluded 896 medical records as they had incomplete data, change in the fundoscopy, cataract, myopia, special needs, and syndromes such as Down or Duane.

The odds ratio and the 95% confidence interval were calculated from the logistic regression model. In order to check

for differences between the groups studied we used the Cochran-Armitage trend test.⁴ For the statistical analysis we used the software SPSS version 18.0, and the tests with a p-value lower than 0.05 were considered statistically significant.

This research follows the principles of the Declaration of Helsinki, and respects the privacy of those involved, with confidential data in possession only of their authors. **CAAE:** 42385715.1.0000.5553.

DISCUSSION

Among the 509 children assessed in the study, 158 (31%) had hyperopia greater and equal to SE +2.00D. Of these, 48 (30.37%) were in group 1, 22 (13.92%) in group 2, 22 (13.92%) in group 3 and 66 (41.77%) in group 4 (Figure 1). In addition, 95 (18.6%) children had amblyopia, 250 (49.1%) had strabismus, 81 (15.9%) anisometropia, and 73 (14.3%) had astigmatism. (Figure 2)

The presence of hyperopia greater and equal to SE+2.00D was significantly associated to a larger proportion of children with amblyopia (27.2 versus 14.8%, OR = 2.150, p <0.001) (Table 1) and strabismus (70.8 versus 39.3%, OR = 3.758, p <0.0001) (Table 2). Furthermore, hyperopia greater than +3.25 D was associated to higher proportions of amblyopia (33.3% for group 1, 31.8% for group 2, and 36.3% for group 3, trend p <0.001) compared to group 4 (18.1%, OR = 1.278, p >0.4) and the control group (14.8%, trend p = 0.075).

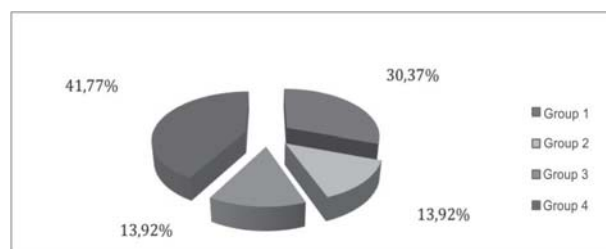


Figure 1: Proportion of hyperopia

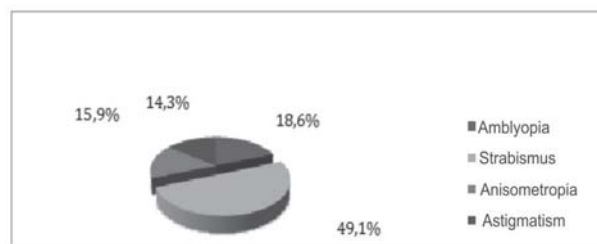


Figure 2: Proportion of refractive and visual errors

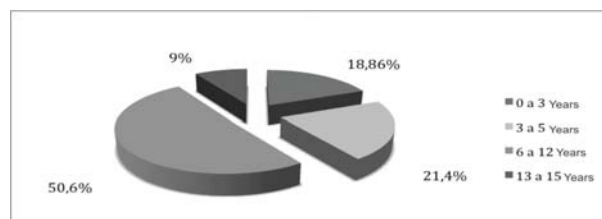


Figure 3: Proportion of age group

Table 1
Hyperopia versus amblyopia from 0 to 15 years

Groups	Amblyopia				
	N	positive	negative	OR (IC 95%)	P value
No	351	52	299	1	
Yes	158	43	115	2.150 (1,360 - 3,398)	0.001
Group 1	48	16	32	2.875 (1,473 - 5,610)	0.001
Group 2	22	7	15	2.683 (1,044 - 6,899)	0.034
Group 3	22	8	14	3.286 (1,313 - 8,222)	0.008
Group 4	66	12	54	1.278 (0,640 - 2,551)	0.486
Trend p				0.075	

Table 2
Hyperopia versus strabismus from 0 to 15 years

Groups	Strabismus				
	N	positive	negative	OR (IC 95%)	P value
No	351	138	213	1	
Yes	158	112	46	3.758 (2.508 - 5.632)	0.000
Group 1	48	43	5	13.274 (5.131 - 34.341)	0.000
Group 2	22	19	3	9.775 (2.839 - 33,657)	0.000
Group 3	22	17	5	5.248 (1,893 - 14.551)	0.000
Group 4	66	33	33	1.543 (0.910 - 2.617)	0.000
Trend p				0.000	

Table 3
Hyperopia versus anisometry from 0 to 15 years

Groups	Anisometry				
	N	positivo	negativo	OR (IC 95%)	Valor de p
No	351	35	316	1	
Yes	158	46	112	3.708 (2.273 - 6.051)	0.000
Group 1	48	23	25	8.306 (4.271 - 16.156)	0.000
Group 2	22	10	12	7.524 (3.032 - 18.672)	0.000
Group 3	22	9	13	6.251 (2.494 - 15.666)	0.000
Group 4	66	4	62	0.582 (0.200 - 1.698)	0.317
Trend p				0.000	

Table 4
Hyperopia versus astigmatism from 0 to 15 years

Groups	Astigmatism				
	N	positive	negative	OR (IC 95%)	P value
No	351	35	316	1	
Sim	158	38	120	2.859 (1.725 - 4.737)	0.000
Group 1	48	18	30	5.417 (2.742 - 10.700)	0.000
Group 2	22	8	14	5.159 (2.023 - 13.157)	0.000
Group 3	22	9	13	6.251 (2.494 - 15,66)	0.000
Group 4	66	3	63	0.430 (0.128 - 1.441)	0.160
Trend p				0.000	

We found no significant difference among the groups, despite the differences we noticed when we compared each group to the control. In some cases we have indication that there are differences between groups (as in the table that the p-value was 0.075) (Table 1) which shows that if we increase the sample of the groups we will probably have a significant difference.

Regarding strabismus, it was associated to higher proportions in the groups with hyperopia greater than +3,25D (89.5% for group 1, 86.3% for group 2, and 77.2% for group 3, trend $p < 0.0001$) compared to group 4 (50%) and the control group (39.3%).

The presence of hyperopia was also significantly associated to a greater proportion of anisometropia in the groups of hyperopia greater and equal to SE+2.00 (29.1 versus 9.9%, OR =

3.708, $p < 0.0001$) (Table 3) and astigmatism (24 versus 9.9%, OR = 2.859 $p < 0.0001$) (Table 4).

Among the 509 children in the study, 96 (18.86%) were in the range from 0 to 3 years, 109 (21.4%) in the range from 3 to 5 years, 258 (50.6%) in the range from 6 to 12 years and 46 (9%) in the range from 13 to 15 years. (Figure 3)

It was not possible to demonstrate the association between visual impairment and hyperopia in the range from 0 to 3 years due to the small sample.

Among children from 6 to 12 years old, the association of hyperopia higher and equal to SE +2.00D with strabismus, astigmatism, and/or anisometropia were statistically significant (80.5%, 38.8% and 45.8 %, OR = 7.897; 3.747 and 4.983; $p < 0.001$, respectively) (Tables 5 to 8).

Table 5
Hyperopia versus amblyopia from 6 to 12 years

Groups	Amblyopia				
	N	positive	negative	OR (IC 95%)	P value
No	186	31	155	1	
Yes	72	30	42	3.571 (1.947 - 6.552)	0.000
Group 1	25	12	13	4.615 (1.925 - 11,063)	0.000
Group 2	11	4	7	2.857 (0.788 - 10.354)	0.097
Group 3	14	6	8	3.750 (1.216 - 11.569)	0.015
Group 4	22	8	14	2.857 (1.105 - 7.391)	0.025
Trend p			0.472		

Table 6
Hyperopia versus strabismus from 6 to 12 years

Groups	Strabismus				
	N	positive	negative	OR (IC 95%)	P value
No	186	64	122	1	
Yes	72	58	14	7,897 (4,093 - 15,240)	0,000
Group 1	25	24	1	45,750 (6,050 - 345,957)	0,000
Group 2	11	10	1	19,063 (2,387 - 152,245)	0,000
Group 3	14	12	2	11,438 (2,484 - 52,673)	0,000
Group 4	22	12	10	2,288 (0,937 - 5,582)	0,064
Trend p			0.001		

Table 7
Hyperopia versus astigmatism from 6 to 12 years

Groups	Astigmatism				
	N	positive	negative	OR (IC 95%)	P value
No	186	27	159	1	
Yes	72	28	44	3.747 (2.005 - 7.003)	0.000
Group 1	25	15	10	8.833 (3.598 - 21.686)	0.000
Group 2	11	4	7	3.365 (0.922 - 12.279)	0.053
Group 3	14	8	6	7.852 (2.525 - 24.414)	0.000
Group 4	22	1	21	0.280 (0.036 - 2.172)	0.195
Trend p			0.001		

Table 8
Hyperopia versus anisometry from 6 to 12 years

Grupos	Anisometry			OR (IC 95%)	P value
	N	positive	negative		
No	186	27	159	1	
Yes	72	33	39	4.983 (2.687 - 9.240)	0.000
Group 1	25	18	7	15.143 (5.777 - 39.693)	0.000
Group 2	11	5	6	4.907 (1.399 - 17.214)	0.007
Group 3	14	8	6	7.852 (2.525 - 24.414)	0.000
Group 4	22	2	20	0.589 (0.130 - 2.665)	0.487
Trend p			0.000		

DISCUSSION

This study evaluated the association of hyperopia to various refractive and visual errors (amblyopia, strabismus, anisometry and astigmatism) among children (N = 509) treated at the pediatric ophthalmology clinic of the Base Hospital of Distrito Federal. The study groups had different races, ethnicities and geographical region.

The results found in this study were similar to the VIP study (*Vision and Refractive Error Characteristics*), which showed that the hyperopic preschool children had higher chances of having anisometry, besides increased likelihood of having astigmatism, amblyopia and strabismus. Therefore, preschool children with hyperopia greater than 3.25 are more likely to have other significant visual changes⁵.

According to the literature, the study also associated hyperopia to increased chances of anisometry and/or astigmatism in preschool and school children.^{5,6} data also found in a study that assessed Australian school children showing that anisometry was present in 9.7% of 6 year-old children and 36.2% of 12 year-old youngsters.⁶

This study made evident the association between hyperopia greater than +3.25 D and higher proportions of amblyopia, but there was no significant difference among the groups despite the differences found when comparing each group to the control. In some cases there is an indication that there is a significant difference among the groups, which shows that with a larger sample a significant difference would probably be seen. Despite the methodological differences prevent the direct comparison between the level of associated risk and hyperopia, the results of the VIP study showed that the greater magnitude of hyperopia is associated to greater chances of amblyopia and strabismus in preschool children, as well as the present study.⁵

In addition, this study also supports, according to the previous literature, a strong association between strabismus and hyperopia also dependent on the severity of hyperopia.^{5,7}

These results confirm previous reports that showed an association between hyperopia and amblyopia and/or strabismus.^{5,6,8} These results explain in part why refractive errors screening tests can corroborate the detection of amblyopia and strabismus.

CONCLUSION

In conclusion, the presence and magnitude of hyperopia observed among children from 0 to 15 years of age treated at the pediatric ophthalmology clinic of the Base Hospital of Distrito

Federal were associated to increased chances of amblyopia and strabismus, and greater chance of anisometry and/or astigmatism, showing the coexistence of hyperopia with other vision disorders.

REFERENCES

1. Larsson EK, Rydberg AC, Holmstrom GE. A population- based study of the refractive outcome in 10-year-old pre- term and full-term children. *Arch Ophthalmol.* 2003;121(10): 1430-6.
2. Cotter SA, Management of childhood hyperopia: a pediatric optometrist's perspective. *Optom Vis Sci.* 2007;84(2):103-9. Review.
3. Debert I, de Alencar LM, Polati M, Souza MB, Alves MR. Oculometric parameters of hyperopia in children with esotropic amblyopia. *Ophthalmic Physiol Opt.* 2011Jul;31(4):389-97.
4. Agresti, Alan. (2002). *Categorical Data Analysis* (2nd Ed.). New York: Wiley.
5. Kulp MT, Ying GS, Huang J, Maguire M, Quinn G, Ciner EB, Cyert LA, Orel-Bixler DA, Moore BD; VIP Study Group. Associations between hyperopia and other visionand refractive error characteristics. *Optom Vis Sci.* 2014 ;91(4):383-9.
6. Ip JM, Robaei D, Kifley A, Wang JJ, Rose KA, Mitchell P. Prevalence of hyperopia and associations with eye findings in 6- and 12-year-olds. *Ophthalmology.* 2008;115(4):678-85.
7. Cotter SA, Varma R, Tarczy-Hornoch K, McKean-Cowdin R, Lin J, Wen G, Wei J, Borchert M, Azen SP, Torres M, Tielsch JM, Friedman DS, Repka MX, Katz J, Ibranke J, Giordano L; Joint Writing Committee for the Multi-Ethnic Pediatric Eye Disease Study and the Baltimore Pediatric Eye Disease Study Groups. Risk factors associated with childhood strabismus: the multi-ethnic pediatric eyedisease and Baltimore pediatric eye disease studies. *Ophthalmology.* 2011;118(11):2251-61.
8. Pascual M, Huang J, Maguire MG, Kulp MT, Quinn GE, Ciner E, Cyert LA, Orel-Bixler D, Moore B, Ying GS. Risk factors for amblyopia in the Vision in Preschoolers Study. *Ophthalmology.* 2013 Oct 18; doi: 10.1016/j.ophtha.2013.08.040. epub ahead of print.

Corresponding author:

Merry Elizabeth Goedert
 SQS 905, bl G apto 206 – Asa Sul , Brasília,
 DF, Brazil ZIP Code: 70390050
 E-mail: merry.goedert@gmail.com