Acta Ophthalmologica

Acta Ophthalmologica 2011

Refractive errors in children and young adults with Down's syndrome

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ABSTRACT.

Purpose: **Down's syndrome (DS) is the most common chromosomal anomaly. Numerous ophthalmic features have been reported. The aim of our study was to investigate the incidence of refractive errors in children and young adults with DS in Macedonia.**

Methods: **Fifty-six children and young adults with DS, aged 2–28 years, from Macedonia, underwent slit-lamp examination, ocular motility and refraction.**

Results: **The overall incidence of refractive errors in the Macedonian children and young adults with DS was 96.4%. A total of 17.8% of the subjects had myopia, 23.2% had hypermetropia and 55.3% had astigmatism. Strabismus was seen in 13 (23.2%) of the subjects (nine had esotropia, three had exotropia, one had hypertropia).**

Conclusions: **The incidence of refractive errors in Macedonian children and young adults with DS was similar to that in Asian children. Compared with White (Caucasian) and Asian children with DS, Macedonian children and young adults exhibited lower incidences of hypermetropia and myopia, and a higher incidence of astigmatism, in which oblique astigmatism represented the predominant type.**

Key words: Down's syndrome – refractive errors – astigmatism – strabismus

Acta Ophthalmol. 2011: 89: 324–327

doi: 10.1111/j.1755-3768.2009.01676.x

Introduction

Down's syndrome (DS) is the most common chromosomal anomaly. Numerous ophthalmic features have been reported, including abnormalities of the anterior, medial and posterior ocular segments, as well as refractive errors, strabismus, amblyopia and nystagmus (Jones 1997).

The incidence of each ocular abnormality varies in different studies. Most reported studies of ocular findings in DS were performed in White (Caucasian) populations. There are only a few reports in the literature that make reference to ocular findings in Asian subjects with DS (Wagner 1962; Wong & Ho 1997; Kim et al. 2002). Down's syndrome subjects have been reported to have a higher incidence of refractive errors (Berk et al. 1996; Woodhouse et al. 1997). Reports on the prevalence of refractive errors vary in the literature, but it is generally agreed to exceed 40% (Gardiner 1967) and this high prevalence occurs among school-age children with DS as well as among adults (Woodhouse et al. 1993; Salati et al. 1995). Down's syndrome subjects are also at higher risk for other ocular anomalies, such as strabismus, nystagmus, cataract and keratoconus. The presence of any of these defects in early childhood may be implicated in the aetiology of refractive errors (Hestens et al. 1991).

Refractive errors and/or squint may be present from an early age and persist into childhood (Woodhouse et al. 1997; Haugen et al. 2001; Cregg et al. 2003). Refractive errors, most commonly hypermetropia, which often reduce spontaneously in other children, are likely to persist beyond infancy in DS subjects (Haugen et al. 2001). Despite the high prevalence of large refractive errors in children with DS, longitudinal data show that these are not always present in early infancy (Cregg et al. 2003).

The prevalence of astigmatism among infants (0–12 months) has been reported to be 45–53% (defining astigmatism as ≥ 1.00 D) in studies using non-cycloplegic techniques (Mohindra et al. 1978; Gwiazda et al. 1985) and as 65% (astigmatism of ≥ 0.75 D) using photorefraction (Howland & Sayles 1984).

In the present study, we studied refractive errors in children and young adults with DS in Macedonia and compared the results with those from

studies of White and Asian children with DS. However, no previous observation on ocular manifestations in the DS population in Macedonia has been documented. This is part of a longitudinal study into aspects of visual development in persons with DS.

Materials and Methods

Longitudinal population-based data collection was conducted with reference to DS subjects seen in the private polyclinic 'Medika Plus' in Skopje, Republic of Macedonia, from March 2007 to August 2008. A total of 56 children and young adults from the capital city of Skopje and from three other towns in the region were enrolled in this study. The current study consisted of totally non-institutionalized Macedonian children and young adults with DS, seen in an outpatient setting. Most of the children were sourced from the special education system or from parent associations.

The diagnosis of DS was made either on the basis of clinical characteristics or by cytogenetic analysis. All parents originated from Macedonia, except one mother who came from Bulgaria.

A total of 56 children and young adults with DS (37 male, 19 female; aged 2–28 years) were examined for ocular findings. Protocols for general health examination (Van Cleve & Cohen 2006; Van Cleve et al. 2006), birth dates and ocular examination, including separate examinations of ocular motility and refraction, were prepared.

The ocular examination included a visual acuity assessment, slit-lamp biomicroscopy, ocular motility (using the alternate cover/uncover test without a prism), cycloplegic refraction and ophthalmoscopy.

Cycloplegic refraction was performed after three to five installations of one drop of cyclopentolate 1%. In the study we used photorefraction (Auto Ref-Keratometer PRK-5000; Potec Co. Ltd, Daejeon, Korea). Emmetropia was defined as a refractive error between − 0.75 D and + 0.75 D spherical equivalent. Myopia was defined as < − 0.75 D spherical equivalent and hypermetropia was defined as > + 0.75 D spherical equivalent.

Clinically significant astigmatism was defined as refractive error > 1.0 D of the cylinder. In the evaluation of astigmatism group, the minus form of the cylinder was used.

The axis of astigmatism was classified as 'with-the-rule' (WTR; 90-degree meridian), 'against-the-rule' (ATR; 180-degree meridian) or oblique astigmatism (OBL; axis between 100–170 degrees and 10–80 degrees). Eyes with cylindrical power of < 1.0 D were excluded from the astigmatism group.

Results

In the majority of this population, the diagnosis of DS was based on clinical features (Table 1). Only one patient agreed to undergo cytogenetic analysis. A total of 78.6% of the subjects were of Macedonian origin (Orthodox), 19.6% were of Albanian origin (Muslim) and 1.8% were of Roma origin. This ethnic distribution reflects the local ethnic composition of Macedonia.

The mean age of the subjects at first visit was 14.9 ± 6.7 years; 66% were male and 34% female. A sample of 3.3% of the subjects had a positive family history for DS (Table 1).

The overall incidence of refractive errors in the Macedonian children and young adults with DS was 96.4% (54/56). The refractive status (spherical equivalent) is summarized in Table 2.

Table 1. Demographic data.

Variable	Value
Age, years, mean ± SD	14.9 ± 6.7
Maternal age, years, mean ± SD	29.4 ± 6.4
Sex	
Male, *n*	37 (66.1%)
Female, *n*	19 (33.9%)
Ethnicity	
Macedonian (Orthodox), *n*	44 (78.6%)
Albanian (Muslims), *n*	11 (19.6%)
Roma (Muslims), *n*	1 (1.8%)
Positive family history, *n*	2 (3.3%)
Reason for eye clinic consultation	
Completion of special school form, *n*	48 (85.7%)
Referred for ocular problems, *n*	2 (3.6%)
Community eye service, *n*	6 (10.7%)
Confirmation of diagnosis	
Cytogenetics study, *n*	1 (1.8%)
Clinical features, *n*	55 (98.2%)

SD = standard deviation.

Myopia was observed in 17.8% of subjects and hypermetropia in 23.2%. Astigmatism was observed in 55.3% of subjects (n = 31). This was not studied in terms of spherical equivalent.

Most of the myopic DS subjects had myopia > − 6.00 D and were aged > 15 years. Table 3 shows the degree of myopia in terms of spherical equivalent in the study population, stratified according to age.

Hypermetropia mostly presented in the range of + 3.00 D to + 5.75 D and was more prevalent in subjects aged 10–15 years and > 15 years (Table 4).

The most frequent refractive error was astigmatism, which was seen in 31 of 56 (55.3%) subjects. The most consistent form of astigmatism was oblique astigmatism (54.8%) (Table 5).

Strabismus was present in 13 (23.2%) subjects, of whom nine had esotropia, three had exotropia and one had hypertropia.

In the group of 10 subjects with myopia, four had strabismus (three exotropia, one hypertropia). Hypermetropia was observed in 13 subjects, five of whom had strabismus (four esotropia, one exotropia). Astigmatism was found in 31 subjects, four of whom had strabismus (three exotropia, one esotropia).

Discussion

This study shows differences in refractive errors in DS according to race and age. The overall incidence of refractive errors in Macedonian children and young adults with DS (96.4%) was markedly higher than in US studies, but similar to findings in Brazil and Turkey (Table 6). The incidence of refractive errors in Macedonian children and young adults with DS was similar to that in Asian children with DS (Table 7).

The incidence of hypermetropia in our study was 23.2%, which is lower than those reported in other studies performed in White and Asian subjects.

The incidence of myopia in our study was 17.8%, which is also lower than incidences reported in other studies performed in White and Asian

Table 2. Refractive status (spherical equivalent) of 56 subjects with Down's syndrome in Macedonia.

Refractive status	Subjects, *n*	Subjects, %
Emmetropia (− 0.75 D to + 0.75 D)	16	28.5
Hyperopia (+ 1.00 D to ≥ + 6.00 D)	21	37.5
Myopia (− 1.00 D to ≥ − 6.00 D)	19	34.0
Total	56	100

Table 3. Myopia (spherical equivalent) in 56 subjects with Down's syndrome in Macedonia.

	Myopia, range power			
Age, years	− 1.00 D to − 2.75 D	− 3.00 D to − 5.75 D	≤ − 6.00 D	Total, *n* (%)
0–4	0	0	1	1 (5.3%)
5–9	1	0	0	1 (5.3%)
10–14	2	1	2	5 (26.3%)
≥ 15	2	4	6	12 (63.1%)
Total	5 (26.3%)	1 (26.3%)	9 (47.4%)	19 (100%)

Table 4. Hyperopia (spherical equivalent) in 56 subjects with Down's syndrome in Macedonia.

	Hyperopia, range power			
Age, years	+ 1.00 D to + 2.75 D	+ 3.00 D to + 5.75 D	≤ + 6.00 D	Total, *n* (%)
5–9	2	2	1	5 (23.8%)
10–14	1	5	2	8 (38.1%)
≥ 15	4	4	0	8 (38.1%)
Total	7 (33.3%)	11 (52.4%)	3 (14.3%)	21 (100%)

subjects, except for a study from Hong Kong (Wong & Ho 1997).

The incidence of astigmatism in our Macedonian population with DS was 55.3%, which is higher that found by Woodhouse et al. (1993, 1997) and similar to that found in a Norwegian population with DS (Table 5) (Haugen et al. 2001). These studies included infants with DS, whereas our study mostly involved school-age children and young adults.

Oblique astigmatism, with striking right and left specificity, has been found to be the most common type of astigmatism among White children with DS (Doyle et al. 1998; Haugen et al. 2001). The present study strongly indicates that oblique astigmatism is the predominant type of astigmatism in children and young adults with DS in Macedonia.

This is contrary to findings in a Norwegian population of infants with DS, where WTR astigmatism appeared to be the most common type (Haugen et al. 2001).

Astigmatism may represent the first sign of keratoconus in young adults with DS.

The incidence of strabismus in our study was 23.2%, which is similar to that in other studies from Hong Kong (20%) (Wong & Ho 1997), Turkey (22%) (Berk et al. 1996) and Korea (25%) (Kim et al. 2002). However, the prevalence of esotropia in the whole strabismus sample was 69%, which is very similar to prevalences reported in other studies (Caputo et al. 1989; Berk et al. 1996; da Cunha & Moreira 1996), but quite different from that reported in Asian persons with DS, in whom exotropia was predominant and accounted for 42% of all strabismus (Kim et al. 2002). Asians are known to have a higher prevalence of exotropia than White or African people in the normal population (Jenkins 1992). Racial factors may play a role in this strikingly high incidence. Strabismus may be associated with refractive errors. In the general population, there is a strong association between hypermetropia and strabismus (Ingram 1975). Strabismus is commonly reported in DS (Caputo et al. 1989; da Cunha & Moreira 1996; Woodhouse et al. 1997). In our study group, strabismus would also appear to be equally associated with myopia and hypermetropia, as well as astigmatism, and several children with significant refractive errors did not have strabismus. Although the presence of strabismus in DS may be predictive of a significant error, a refractive error is not necessarily indicative of a strabismus.

Oblique astigmatism may be caused by the upward slanting of the palpebral fissure, first described by Down (1866). As a general hypothesis, not specific to DS, pressure from the eyelids has been proposed as a major aetiological factor for corneal astigmatism (Grosvenor 1976; Gwiazda et al. 1984).

Further studies may find a connection between a high incidence of oblique astigmatism in children and adolescents with DS and the quantity of upward slanting in DS.

In summary, compared with White and Asian children with DS, Macedonian children and young adults exhibited lower incidences of hypermetropia and myopia, and a higher incidence of astigmatism, in which the predominant type was oblique astigmatism. Our

Table 5. Astigmatism in infants, children and young adults with Down's syndrome.

Author(s)	Year	Method of refraction	Subjects, *n* (age)	Astigmatism ≥ 1.0 D	WTR	ATR	OBL
Woodhouse et al.	1997	Non-cycloplegic	23 (3–12 months)	26%	Axis not reported		
Haugen et al.	2001	Cycloplegic	40 (3–12 months)	53%	95%	5%	0%
Doyle et al.	1998	Cycloplegic	50 (15–22 years)	Not reported	22%	39%	38%
Present study	2008	Cycloplegic	56 (2–28 years)	55.4%	13%	32%	55%

WTR = with-the-rule astigmatism; ATR = against-the-rule astigmatism; OBL = oblique axis astigmatism.

Table 6. Comparison of refractive errors in Down's syndrome subjects in White populations.

	Present study	Caputo et al. (1989)	da Cunha & Moreira (1996)	Berk et al. (1996)
Subjects, *n*	56	187	152	55
Nationality	Macedonian	US	Brazilian	Turkish
Age range, years	2–28	0–26	0–18	0–25
Mean age, years	14.9	5.8	–	7.2
Refractive errors	54 (96%)	122 (65%)	149 (98%)	60
Hyperopia	13	39	39	29
Myopia	10	42	19	7
Astigmatism	31	41	91	24
Strabismus	13 (23%)	107 (57%)	57 (38%)	12 (22%)
Esotropia	9	97	51	11
Exotropia	3	4	2	1
Hypertropia	1	6	4	0

Table 7. Comparison of refractive errors in Macedonian and Asian subjects with Down's syndrome.

	Present study	Kim et al. (2002)	Wong & Ho (1997)
Subjects, *n*	56	123	140
Nationality	Macedonian	Korean	Hong Kong
Age range, years	2–28	0–14	0–13
Mean age, years	14.91	6.5	3.74
Refractive errors	54 (96%)	104 (85%)	137 (98%)
Hyperopia	13	35	42
Myopia	10	31	12
Astigmatism	31	38	8
Mixed	0	0	75
Strabismus	13 (23%)	31 (25%)	28 (20%)
Esotropia	9	18	–
Exotropia	3	13	–
Hypertropia	1	0	–

longitudinal study of refractive development will eventually provide valuable information on the aetiology of refractive errors in children with DS.

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Received on September 21st, 2009.
Accepted on May 18th, 2009.

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