Magnitude and determinants of refractive error in Omani school children

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ABSTRACT

Objective: To estimate the magnitude and determinants of refractive error in school children, a study was undertaken to review the school screening and refraction data.

Methods: Trained physicians screened 416,157 students to evaluate their visual status and identified 28,765 students with defective vision. Refractionists refracted 25,733 (89.5%) of them, determined the refractive error and prescribed spectacles. Students with ocular co-morbidity and visual disability were re-examined and treated by the ophthalmologists. This study was conducted between June 2003 and December 2003 in the Ministry of Health, Muscat, Sultanate of Oman.

Results: The prevalence of myopia was 4.1% (95% confidence interval [CI] 4.06-4.18). It was higher among female than male students [rate ratio (RR) 1.69 (95% CI 1.64-1.74)]. The rate was more in students of higher age groups (x^2 = 11,179 degrees of freedom = 2 p<0.00001). Regional variation in myopic trend was marked. The prevalence of hypermetropia was 0.4% (95% CI 0.37-0.41). However, it could be an underestimation as presence of accommodative spasm was not taken into account. The risk of 'low vision' disability was significantly higher in male students than female students. The prevalence of ambiopia was 0.3%. It was significantly higher in male than female students. First primary students had strabismus of 0.5%.

Conclusion: The study enabled to undrestant trends of refractive error in Omani children (Arabic tribe) and demonstrated the importance of vision screening in providing timely eye care and identifying visually disabled school children.

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Refractive error if not corrected in time could affect the vision and hamper the development of a child.[1] Both genetic and environmental factors influence the progress of the refractive error.[2,3] Height, gender, geographic distribution, familial history, nutrition, abuse of visual apparatus, and so forth could influence the development and the progress of refractive error in children.[4] In view of limited information on the magnitude and determinants of refractive error, research in this field in different countries is promoted.[5] However, estimation of the magnitude and determinants of refractive error among Middle Eastern population using the outcome of ongoing visual screening activities is not attempted. Sultanate of Oman is a country in the Middle Eastern peninsula with nearly 45% of its population below 15 years of age. Primary education is mandatory. Education until secondary level is free of cost to all Omani children. Nearly 50,000 students are enrolled annually in schools. Any health problem in this population would be of public health importance in Oman. Therefore, refractive error among school children has been addressed since the 1980's through eye screening in schools and through ophthalmic services at health institutions. However, nationwide

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organized screening of school students by trained school health staff as per the revised recommendations of the World Health Organization[6] was initiated by the eye health care program in 1992. Oman has prioritized refractive error as one of the eye problems in its 'Vision 2020 Plan'.[7] Accordingly, health information on refractive error would be useful for the health planning in Oman and other countries with similar situation and demography. Hence, to estimate the magnitude and determinants of refractive error in school children, a study was undertaken to review the school screening and refraction data. Based on the result, the eye screening and refractive services could be reorganized.

Methods. This is a review of 3 year's cross sectional data of the eye screening that was conducted in Omani schools. All the 421,215 students of first primary, first preparatory and first secondary levels in school academic year 1999-2000, 2000-2001 and 2001-2002 were the target population. Approximately 100 physicians, 100 nursing staff, 8 school refractionists and ten ophthalmologists at regional hospitals were the study staff. The school health staff (a team of physician and a nurse) trained in eye and vision screening screened first primary, first preparatory and first secondary school students every year. Thus, subjects of the study underwent vision screening once in 3 year of the study period. Snellen's distant vision illiterate 'E' chart kept at 6 meter distance was used to test the visual acuity. Each eye was tested separately. A student was tested with his/her visual aid also. A student who cannot read the last line (vision 6/6) of the chart with both the eyes open on repeat test was considered to have defective vision. All students with vision less than 0.9 (those who cannot read second last line) were referred to the school refractionist. The qualified refractionists working as school refractionists in each region visited the schools, confirmed visual status, performed manual refraction and determined refractive status. Dark room was prepared in one of the school rooms. Portable trial set and streak retinoscope were used for the refraction. Subjective testing was performed to determine the acceptance of spectacle power. The school principals were given the prescriptions of the students and they forwarded the prescriptions to the student's parents. Selected optical shops provided spectacle at concession rate of 15 US dollar. The school authorities were requested to ensure that spectacles are procured and used by the students. The students with strabismus, myopia of more than 5 diopters and suspected hypermetropia were taken by school authorities to the ophthalmic units for further examination and management. The records of visual status and refraction were maintained in school health booklets and school refractionist's report. The process of school screening is initiated in month of September and concludes by April of next year so that activities are completed in a single school year. The information of target population, screened students, defective vision students, refractive status, strabismus and visual disabilities such as amblyopia, 'low vision' and bilateral blindness was maintained for each school and 'LOTUS 2' software was used for maintaining these records. Regional and national reports are prepared based on the computed data. The information of students referred to the ophthalmologist was collected from the ophthalmic unit by end of the school year and eye health care data was updated.

In our study, myopia was defined as an eye having refractive error of more than -0.75D spherical. Hyperopia was defined as a student having refractive error of more than + 0.5 D in either eye with asthenopia or strabismus and more than +0.75 without eye symptoms. Low vision disability was defined as a student having less than 6/18 vision in better eye after correcting his/her refractive error.

Vision screening was performed in limited sample (200 students with defective vision) to determine the sensitivity and specificity of first level screening by primary health staff and the outcome was compared to that of screening results of the experienced refractionists. Of the 200 students, 190 were declared having same level of visual impairment by both the teams. Two were declared normal by school health staff but had defective vision. Eight students had higher grade of vision impairment that declared by the school staff team. Thus, the vision screening by primary staff had 86% sensitivity and 99% specificity.

Every year, the primary health staff is trained for eye screening at the beginning of school year. The refractionists performing refraction are experienced in such camp related refraction activities. The regional school activities are supervised by the ophthalmologists. Qualified statisticians assist in maintaining the health information of these students. The health authorities at national and regional levels consented to use the information for the study. The results were distributed to eye health program managers at national and regional level to improve the eye care services. The recording of visual status per students were clubbed together to make school report for male and female student of each level. The refraction activities of defective vision were also recorded for each student with specific mention of type of refractive error and spectacle prescription for correction of vision. The data for each region comprising of the target students, screened students, refractive error profile were prepared. The frequencies and percentage were calculated for

refractive error for different variants. Ninety-five percent confidence intervals (CI) were calculated for statistical validation. To compare rates among variants, relative risk and its 95% CI were also calculated. The refraction activities in Musundam and Wousta are performed by the visiting or hospital refractionists. These 2 regions comprise less than 5% of total study sample. Due to difficult terrain and far distances, some students might not have approached the ophthalmic units. The refractive error of astigmatism type has been converted into spherical equivalent and then included in myopia and hypermetropia. Hence, information on high astigmatism in study population could not be estimated. The strabismus status was noted for only first primary students.

Results. Of 421,215 students included in the study, vision of 416,157 students (99%) was tested. Of them, 28,765 students were suspected to have defective vision, refractionists tested 25,733 (89.5%) students. The enumerated sample, examined sample for vision screening and coverage of refraction activities are given in **Table 1**. The coverage of vision screening is almost complete. Refraction activity was for nine tenth of the students with defective vision. The rest were absent during refractionist's school visit. Hence, rates of refractive error need to be adjusted.

The prevalence of myopia among students of 3 levels in 3 years was 4.1% (95% CI 4.06 to 4.18). Profile of myopia with epidemiological variants is given in **Table 2**. Myopia was more prevalent among female students than male students [RR 1.69 (95% CI 1.64 to 1.74)]. The prevalence of myopia was significantly higher in first secondary students than first primary and first preparatory students (x^2 = 11,179 df = 2 p<0.00001). The myopia prevalence increased with age more rapidly in female than in male students. The prevalence of hypermetropia was 0.4% (95% CI 0.37 to 0.41). The profile of hypermetropia with its epidemiological variants is given in **Table 2** The prevalence of hypermetropia was significantly higher in female students than male students [RR 1.24 (95% CI 1.12 to 1.37)]. Rates of hypermetropia differed significantly with the school level (x^2 = 283 df = 2 and p<0.00001).

During the year 1999 and 2000, 2000 and 2001 and, 2001 and 2002, the prevalence of myopia was 3.7%, 4% and 4.6%. However the prevalence of hypermetropia was 0.4% in all 3 years. The prevalence of myopia and hypermetropia in health regions is given in **Table 3**. Myopia rate ranged from as high as 7% in Muscat and 5.4% in South Batinah regions to 1.8% in Musundam and 1.6% in Dhahira regions. Of the 796 first primary students with refractive error, 570 (71.6%) were detected for the first time. While 226 (28.4%) were advised to continue their spectacles. Of 7,460 first preparatory students with refractive error, 5,309 (71.2%) were prescribed spectacles and 2,151 (28.8%) were advised to continue their spectacles. Among 11,337 first secondary students with refractive error, 6,137 (54.1%) were prescribed spectacles and 5,200 (45.9%) were advised to continue their spectacles. The prescription of spectacles was based on change of refractive power of more than 0.75D in either eye of the student. The ocular conditions which are usually associated with refractive error such as low vision, ambiopia and strabismus were reviewed among study population. The frequencies, prevalence of these co-morbidities among male and female students are compared in **Table 4**. Two hundred and thirty-four students with 'low vision' were identified during study period. The risk of 'low vision' disability was significantly higher in male students than female students. The prevalence of ambiopia was 0.37%. It was significantly higher in male than female students. Approximately 0.5% of first primary students had strabismus.

The handicap children do not go to regular schools. Refraction of 108 such children in school of handicap was undertaken in 2002. Twenty students had defective vision, 14 (12.7%) had myopia, 4 (3.7%) had hypermetropia and one had amblyopia. These students were of age ranging from 13-16 years.

Discussion. A large sample and high coverage of school students for vision screening enabled to generate reliable information on refractive error among study population. Since admission in first primary is not at uniform age and many students leave school before first secondary level, number in first preparatory class in our study was higher than other 2 levels. The refraction activity had coverage of 90%. The 10% of students with suspected defective vision were absent during refractionist's school visit. The absenteeism was related neither to the presence of refractive error nor to its type. The comparison of the visual status of the students that were absent during refractionist's visit with the visual status of students screened by the refractionist was not markedly different. Hence the proportion of refractive error among absentees is not likely to differ from those examined. However, if all absentees are considered to suffer from refractive error, the rates of refractive error could be an underestimate ranging from 4.1-4.5%. The students with hypermetropia but having normal vision and without symptoms of asthenopia were not identified during first level vision screening and thus were not refracted. Hence, the rate of hypermetropia in the present study might be underestimated. The students of 3 levels had 4.5% prevalence of

Table 1 - Profile of the study sample (Oman refractive error study).

Study sample	Target population	Vision screening n	(%)	Suspected defective vision cases	Refraction n	(%)
Male	220,215	217,481	(98.8)	12,330	10,803	(87.6)
Female	201,000	198,676	(98.8)	16,435	14,930	(90.8)
1st Primary	143,485	143,112	(99.7)	2,249	1,970	(87.6)
1st Preparatory	163,566	160,769	(98.3)	12,443	10,929	(87.8)
1st Secondary	114,164	112,276	(98.3)	14,073	12,834	(91.2)
Total	**421,215**	**416,157**	**(98.8)**	**28,765**	**25,733**	**(89.5)**

Table 2 - Myopia and hypermetropia in Omani school children (Oman refractive error study)

Study sample	Examined sample	Students with myopia n	(%)	95% CI	Students with hypermetropia n	(%)	95% CI
Male	217,481	6,716	(3.1)	3.03 - 3.17	763	(0.3)	0.33 - 0.37
Female	198,676	10,348	(5.2)	5.13 - 5.33	864	(0.4)	0.41 - 0.47
6-7 years	143,112	588	(0.4)	0.38 - 0.44	246	(0.2)	0.15 - 0.19
12-12 years	160,769	6,630	(4.1)	4.02 - 4.22	751	(0.5)	0.44 - 0.50
16-17 years	112,276	9,843	(8.8)	8.60 - 8.94	630	(0.6)	0.52 - 0.60
Total	**416,157**	**17,064**	**(4.1)**	**4.06 - 4.18**	**1,627**	**(0.4)**	**0.37 - 0.41**

Table 3 - Prevalence of myopia and hypermetropia by health regions of Oman (Oman refractive error study).

Region	Prevalence of myopia %	Prevalence of hypermetropia %
Muscat	7	0.8
Dhofar	4	0.1
Dhakhiliya	3.8	0.6
North Sharqiya	2.1	0.3
South Sharqiya	4.5	0.3
North Batinah	3	0.3
South Batinah	5.4	0.4
Dhahira	1.6	0.1
Musundam	1.8	0.3
Al-Wousta	0.3	0.1

Table 4 - Visual disabilities in Omani school children by gender (Oman Refractive error study).

Visual disabilities	Male n (%)	Female n (%)	Rate ratio	95% CI
Low vision*	131 (0.06)	103 (0.05)	1.16	0.90 - 1.50
Amblyopia†	440 (0.20)	347 (0.17)	1.16	1.01 - 1.33
Strabismus‡	328 (0.45)	328 (0.47)	0.96	0.82 - 1.11

* No case of bilateral blindness was detected in school screening.
†Low vision is defined as visual impairment of less than 6/18 in better eye after correction of refractive error.
‡Screening for strabismus is undertaken only for first primary students (6-7 years).
CI - confidence interval

refractive error. Students of urban schools in the United States of America (USA) had 8.2% rate of refractive error.[8] Eleven percent of nursery and primary students of Ankara, Turkey had refractive error.[9] Thus, literature showed wide range of refractive error magnitude in different age groups and the criteria of defining refractive error also varied. Therefore, comparison of magnitude of refractive error in different countries is difficult. However, racial variation has been noted to influence the rate of refractive error. It was reported that it was high in oriental population[10] and less among Indian natives of USA.[11,12] Myopia, the most common type of refractive error in growing children was prevalent in the study population at a rate of 4.1%. It was significantly more in female students than male students. Earlier study in Oman also had similar observation.[13] In Chile, male had higher rates of myopia than female.[14] Higher literacy rate among female in Oman might be subjecting their visual apparatus to abuse resulting into refractive error in more proportion. Oman has 38% of consanguinity rate.[15] Refractive error has known genetic etiology.[16] Link of female gene to refractive error in Omani population or female hormonal influence on refractive error could be hypothesized as responsible for high rates of myopia in female. With increase in the age, the height of the child increases. Physiological myopia also is known to increase in children with age. Thus age could be an effect modifier and in the present study 3 age group of school children distinctly differ in myopia rates. This was also observed in Oman in past[13] and in Chile.[14] Distinct regional variation was observed in distribution of refractive error. Muscat, South Batinah and Dhofar region had a high myopia while Dhahira, Musundam and North Sharqiya students had a low myopia rates. It is worth noting that the regions with a high myopia rates are having coastal areas and Dhahira and North Sharqiya do not have coastal areas. Musundam having sparse population had wide confidence interval of the myopia rate. The myopia or hypermetropia was not significantly different in northern and central regions - the trachoma endemic areas compared to Dhofar which is not having trachoma.

The proportion of students with refractive error given prescription and advised to continue the same spectacles at the time of refraction was 3 is to one in first primary and first preparatory levels, while, the ratio was nearly one is to one in first secondary level. The decision to prescribe new glasses was based on the difference of more than 0.75 D power between current correction and the power in the existing spectacle in either eye of the student. This suggests that vision screening campaign is more useful for students of lower levels. It could also be possible that students of higher classes in need of more precision vision might be availing facilities at ophthalmic services and optical shops to get their spectacles changed more often. In absence of such refraction services in schools, the load on services would increase to the extent of double to 3 times. Detection of 19,000 new cases of refractive error among school students in last 3 years reflects the importance of vision screening and refraction activities. In spite of free and easy access, these children who were mainly asymptomatic had not approached the ophthalmologists for their eye problems. In addition, detection of visual disabilities such as low vision, amblyopia and blindness enabled the national program to assist these children to undergo rehabilitative measures at an earlier age. Lack of such initiatives could delay early detection of visual impairment and also increase the workload subsequently on the ophthalmic institutions. Myopia was more common refractive error among Omani school children and its prevalence was 4.1%. The 6-7 years old students had 0.4% rate of myopia. Earlier study in Oman of same age group with limited sample had shown 0.6% rate.[13] It was 0.4% in first primary students aged 6-7 years. School children of Singapore of same age had 12.3% myopia while in China it was 9.1%.[10] Vision screening without relieving the accommodative spasm has resulted in missing the young children with hypermetropia. The national health programs should understand the limitation of the vision screening initiatives in identification of hypermetropes. Provision of visual aid in such asymptomatic cases is also not advised. Hence, as far as intervention is concerned, detection of such hypermetropic is of limited importance. Based on the cost benefit and feasibility in a country, attempt should be made to identify and manage these hypermetropics.

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