A MYOPIC SHIFT IN AUSTRALIAN ABORIGINALS: 1977 – 2000

BY ***Hugh R. Taylor MD AC***,* *T. A. Robin MHS*, *V. C. Lansingh MD*, *L. M. Weih PhD*, AND *J. E. Keeffe PhD*

ABSTRACT

Background/Aims: The prevalence of myopia has been reported to have increased in a number of population groups. We compared the refraction of Australian Aboriginal adults in 2000 with data collected in 1977 to assess whether there had been a change in the prevalence of myopia.

Method: Australian Aboriginal adults aged 20 to 30 years old were selected from Central Australian communities in 2000. Refraction was determined by noncycloplegic autorefraction. This was compared to mydriatic retinoscopy data collected in 1977. "Observer trials" were undertaken to assess the comparability of noncycloplegic autorefraction measurements and cycloplegic retinoscopy. Spherical equivalence cylinder and spheric were determined for all right and left eyes and compared using an analysis of variance.

Results: A total of 128 adults (58 males, 70 females) were examined in 2000 and compared with 161 adults (107 males, 54 females) examined in 1977. The mean spherical equivalent in 2000 was –0.55 D ± 0.88 D and in 1977 was +0.54 D ± 0.81 D. The difference of –1.09 D was highly significant (F = 126, $P<.001$). Intraclass correlation coefficients showed good agreement between noncycloplegic autorefraction and cycloplegic retinoscopy. Neither gender, schooling, nor diabetes was associated with an increased risk of myopia.

Conclusions: There appears to have been a significant shift toward myopia in Australian Aboriginals between 1977 and 2000. The cause of this myopic shift is unknown but mirrors that observed in other populations in recent years.

Trans Am Ophthalmol Soc 2003;101:107-112

INTRODUCTION

In 1885, Fuchs[1] suggested that myopia was the result of "prolonged near work," although he recognized that heredity was also important. However, the relative contribution of nature versus nurture has been debated for over a century. It is now quite clear that both genetic factors and near work contribute to the development of myopia,[2] although the exact mechanisms through which they work are unknown. Potential environmental factors for the development of myopia include family history, formal education, nutrition, and near work.[2]

The prevalence of myopia varies significantly between racial populations and groups.[2] However, recent studies have suggested that the prevalence of myopia is increasing, particularly in Asian countries.[2-10] In addition, myopia is more common in younger cohorts in Australia and the United States.[11,12]

In general, indigenous populations have lower rates of myopia, but these rates have been reported to be increasing.[13-19] In 1977, we reported much lower rates of myopia in Australian Aboriginals than in Australians of European descent.[20] The aim of the present study is to reassess the prevalence of myopia in some of those Aboriginal communities studied in 1977.

From the Centre for Eye Research Australia, University of Melbourne.
This study was supported by the Christian Blind Mission International, Australia.
*Presenter.
Bold type indicates AOS member.

MATERIALS AND METHODS

In 1977, Aboriginal adults aged 20 to 30 years, inclusively, were selected from seven Aboriginal communities in Central and Western Australia. Individuals presenting with ocular pathology, with the exception of known refractive error or trachoma in which the central cornea was not distorted, were excluded. Only people believed to be of full Aboriginal ancestry were included.[20] Participants were asked "how much Aboriginal blood" their mothers and fathers each had.[21]

In 2000, Aboriginal adults aged 20 to 30 years inclusive were surveyed in two remote Aboriginal communities in Central Australia. Participants were selected using similar recruitment methods and exclusion criteria.[22] The study was conducted in adherence to the guidelines set forth in the Declaration of Helsinki for research involving

human subjects.[23]

In addition, in 1977, Australians of European ancestry aged 20 to 30 years were examined.[20] Based on the 1976 census data and data from local records, all eligible residents of a rural town in Western Australia were examined. The refractive status of those of European descent is included in Figure 1.

In 1977, refraction was determined by cycloplegic retinoscopy. However, in 2000, noncycloplegic refraction was obtained with a hand-held autorefractor (Nikon Retinomax 2, Nikon Instech Co, Ltd, Kanagawa, Japan). Comparability studies were performed to assess measurement artifact. A sample of 25 participants was first refracted by noncycloplegic autorefraction and then cycloplegic retinoscopy. These measurements were made independently by the examiner who undertook the 2000 or 1977 field measurements, respectively. Intraclass correlation coefficients for absolute agreement were calculated. The calibration of the autorefractor was also assessed at the end of fieldwork to verify that it was still accurately calibrated.

The mean spherical equivalent of each eye of each participant was calculated. The mean spherical equivalents of right eyes and left eyes in each cohort were similar. The mean spherical equivalent of right eyes from 1977 was compared to that of eyes from 2000. Comparisons of refraction by gender, diabetes status, and years of schooling were performed using an analysis of variance (ANOVA). Chi-square analyses were used to evaluate differences in proportions among categorical variables.

RESULTS

REPRODUCIBILITY OF REFRACTION

There was good agreement between noncycloplegic autorefraction and cycloplegic retinoscopy. Intraclass correlation coefficients for absolute agreement showed excellent agreement on sphere measurement (≥0.97) and very good agreement for cylinder measurement (≥0.87) for both right and left eyes (Table I). Similarly, spherical equivalent had excellent agreement (≥0.97, all) for both right and left eyes.

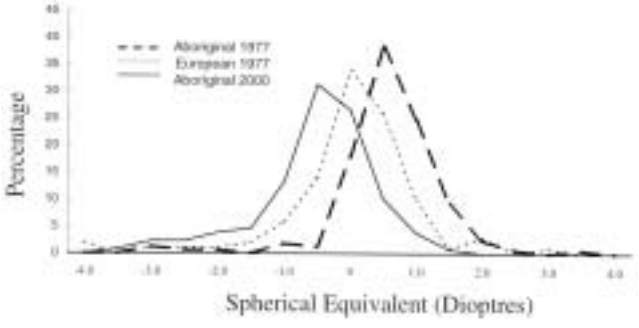

FIGURE 1
Distribution of right eye spherical equivalent in 1977 and 2000.

MYOPIA

In 2000, a total of 58 males and 70 females were examined. This is 99% of the eligible adults present at the time of the study and 87% of those listed as permanent residents. The average length of schooling was 4.5 ± 1.56 years, with 51% (65 individuals) of the population having less than 5 years of formal education. Seven individuals (5.5%) had diabetes.

In 1977, a total of 107 males and 54 females had been examined. This was 96% of the eligible population. The length of schooling was not ascertained, and none of the participants had diabetes.

In examining both eyes of the 2000 participants, there was no statistically significant difference between the mean spherical equivalent of the right eye (–0.55, SD 0.88) and left eye (–0.58, SD 0.89) ($F = 0.29$, $P = .5$). The mean cylinder of right eyes was 0.35 D (SD 0.44). Only 16% had more than 0.5 D of cylinder. There was no difference in either mean spherical equivalent or prevalence of myopia by gender ($F = 0.78$, $P = .18$), years of schooling ($F = 0.18$, $P = .67$), or diabetes status ($F = 1.14$, $P = .34$) (Table II).

There was a statistically significant difference of –1.09 D ($F = 126$, $P < .001$) in mean spherical equivalent of right eyes in Australian Aboriginal adults between 1977 and 2000 (Table III, Figure 1). A significantly higher proportion of eyes had more than 0.5 D cylinder in 2000 (16%) than in 1977 (9.3%; $\chi^2 = 2.66$, $P = .04$), although the mean cylinder was not different (0.35 ± 0.44; 0.29 ± 0.46, respectively; $P = .22$). Similar results were obtained for left eyes (data not shown).

DISCUSSION

We have documented a significant shift toward myopia in Australian Aboriginal adults aged 20 to 30 years old over a 23-year period. This change appears to be real and not

TABLE I: RELIABILITY OF AUTOREFRACTION COMPARED TO CYCLOPLEGIC RETINOSCOPY (N=25)

MEASURE	INTRACLASS CORRELATION(95% CI)
Right eye sphere	0.97 (0.92-0.99)
Right eye sphere cylinder	0.96 (0.91-0.98)
Left eye sphere	0.97 (0.94-0.99)
Left eye sphere cylinder	0.87 (0.70-0.94)
Right eye spherical equivalent	0.98 (0.90-0.99)
Left eye spherical equivalent	0.97 (0.94-0.99)

TABLE II: MEAN SPHERICAL EQUIVALENT BY DEMOGRAPHIC CHARACTERISTIC IN 2000

CHARACTERISTIC	MEAN (SD)	*P* VALUE	MYOPIA ≤ –0.5 D % (N)	*P* VALUE
Gender (n)		F (*df* 1, 128) = 1.78, *P* = .18		χ^2 = .58, *P* = .44
Male (58)	-0.43 (0.89)		36% (21)	
Female (70)	-0.64 (0.86)		43% (30)	
Diabetes (n)		F (*df* 1, 128) = 0.18, *P* = .67		Fisher exact *P* value = 1.0
Yes (7)	-0.41 (0.51)		43% (3)	
No (121)	-0.56 (0.89)		40% (48)	
Schooling (n)		F (*df* 5, 128) = 1.14, *P* = .34		Fisher exact *P* value = .21
†2 yr (14)	-0.88 (0.71)		64% (9)	
3 yr (21)	-0.31 (0.68)		29% (6)	
4 yr (30)	-0.59 (1.14)		33% (10)	
5 yr (23)	-0.48 (0.59)		35% (8)	
6 yr (32)	-0.66 (0.98)		50% (16)	
‡7 yr (8)	-0.17 (0.63)		25% (2)	

due to measurement artifact.

In 1977, Australian Aboriginal adults had significantly less myopia than Australians of European descent. The mean refraction for Aboriginals (+0.54 ± 0.81 D) was significantly greater, (more hyperopic) than Europeans (–0.15 ± 1.35 D).[20] Myopia in excess of –0.75 D was extremely uncommon and no Aboriginals had myopia greater than –4.00 D. It was suggested that Australian Aboriginals may not have the gene(s) associated with high myopia.[20]

The results in 2000 show that Aboriginal adults have become significantly more myopic, with a shift in the population mean of 1 D. However, we still did not find myopia in excess of –4.0 D in the relatively small sample of Aboriginal adults.

We used the same method for assessing Aboriginality in both occasions.[20,22] However, the accuracy of this self-reported ethnicity among Australian Aboriginals is not known, and we cannot exclude the possibility that there could be some change in the gene pool, although this seems quite unlikely.

Different methods were used to determine refraction, but reproducibility studies using the same examiners showed very good agreement between the two methods. The accurate calibration of the autorefractor was confirmed. It seems unlikely the results could be explained by a systematic measurement bias.

The apparent shift toward myopia is of considerable interest and concern. It reflects similar changes in other populations, particularly in Asia, where a "myopia epidemic" has been described.[9] In Singapore, for example, the prevalence and severity of myopia have increased significantly over the past two decades.[3] In military conscripts, the prevalence of myopia has increased from 26% in the late 1970s to 83% in the late 1990s.[8]

There have been many changes in the Australian Aboriginal communities over the last 20 years or so. Significant alterations in diet, particularly an increased consumption of both highly refined carbohydrate and calories, have occurred, and this has led to significant increases in obesity and diabetes.[24] No Aboriginal adults were diabetic in the 1977 study group cohort, but 7 (5.5%)

TABLE III: MEAN SPHERICAL EQUIVALENT OF AUSTRALIAN ABORIGINALS IN 1997 AND 2000

	1977		2000	DIFFERENCE
	N*	MEAN SE RIGHT EYES IN DIOPTERS (SD)20	N	MEAN SE RIGHT EYES IN DIOPTERS (SD)	DIFFERENCE IN MEAN SE (95% CI) RIGHT EYE IN DIOPTERS BETWEEN 1978 AND 2000
All participants	161	+0.54 (0.81)	128	-0.55 (0.88)	-1.09 (-0.89, -1.29)
Males	107	+0.57 (0.88)	58	-0.43 (0.89)	-1.00 (-0.72, -1.28)
Females	54	+0.50 (0.70)	70	-0.64 (0.86)	-1.14 (-0.86, -1.42)
Spherical eyes	146	+0.60*	109	-0.51 (0.75)	
Aspherical eyes	15	+0.22*	19	-0.76 (1.41)	

SE, spherical equivalent.
*Data not reported in 1981.

were diabetic in 2002. Increases in formal education in the population surveyed are more difficult to ascertain. Although schools were present in these communities in the 1970s, anecdotal evidence suggests that there was little formal education in the communities surveyed in 1977. However, the modest amount of formal education reported in 2000 (4.5 years) may still represent an increase in schooling and near work.

Although this study cannot determine the specific cause of the observed changes, it does document a significant increase in the amount of myopia of the Australian Aboriginal adults.

ACKNOWLEDGMENTS

The authors thank Dr Paul Torzillo, The Nganampa Health Council, and the Christian Blind Mission International, Australia, for their assistance.

REFERENCES

1. Fuchs E. *The Causes and the Prevention of Blindness*. London: Balliere, Tinall & Cox; 1885:24-82.
2. Saw SM, Katz J, Schein OD, et al. Epidemiology of myopia. *Epidemiol Rev* 1996;18:175-187.
3. Chow YC, Dhillon B, Chew PT, et al. Refractive errors in Singapore medical students. *Singapore Med J* 1990;31:472-473.
4. Dandona R, Dandona L, Srinivas M, et al. Population-based assessment of refractive error in India: the Andhra Pradesh eye disease study. *Clin Exp Ophthalmol* 2002;30:84-93.
5. Edwards MH. The development of myopia in Hong Kong children between the ages of 7 and 12 years: a five-year longitudinal study. *Ophthalmic Physiol Opt* 1999;19:286-294.
6. Goldschmidt E. Epidemiology of myopia: Scandinavian and Hong Kong experiences. In: Tokoro T, ed. *Myopia Updates*. Tokyo: Springer-Verlag; 1998:3-12.
7. Lin LL, Shih YF, Tsai CB, et al. Epidemiologic study of ocular refraction among schoolchildren in Taiwan in 1995. *Optom Vis Sci* 1999;76:275-281.
8. Seet B, Wong TY, Tan DT, et al. Myopia in Singapore: taking a public health approach. *Br J Ophthalmol* 2000;85:521-526.
9. Thorn F. Development of refraction and strabismus. *Curr Opin Ophthalmol* 2000;11:301-305.
10. Zhao J, Pan X, Sui R, et al. Refractive error study in children: results from Shunyi District, China. *Am J Ophthalmol* 2000;129:427-435.
11. Wang Q, Klein BE, Klein R, et al. Refractive status in the Beaver Dam Eye Study. *Invest Ophthalmol Vis Sci* 1994;35:4344-4347.
12. Wensor MD, McCarty CA, Taylor HR. Prevalence and risk factors for myopia in Victoria, Australia. *Arch Ophthalmol* 1999;117:658-663.
13. Boniuk V. Refractive problems in native people (the Sioux Lookout Project). *Can J Ophthalmol* 1973;8:229-233.
14. Fledelius HC. Is myopia getting more frequent? A cross-sectional study of 1416 Danes aged 16 years+. *Acta Ophthalmol* (Copenh) 1983;61:545-559.
15. Hosaka A. Population studies—myopia experience in Japan. *Acta Ophthalmol* 1988;185(suppl):37-40.
16. Morgan RW, Munro M. Refractive problems in northern natives. *Can J Ophthalmol* 1973;8:226-228.
17. Johnson GJ, Green JS, Paterson GD, et al. Survey of ophthalmic conditions in a Labrador community, II. *Can J Ophthalmol* 1984;19:224-233.
18. Sveinsson K. The refraction of Icelanders. *Acta Ophthalmol* (Copenh) 1982;60:779-787.
19. van Rens GH, Arkell SM. Refractive errors and axial length among Alaskan Eskimos. *Acta Ophthalmol* (Copenh) 1991;69:27-32.
20. Taylor HR. Racial variations in vision. *Am J Epidemiol* 1981;113:62-80.
21. Stanhope JM, Clarkson PM, Mangan AJ, et al. Rheumatic fever in New Zealand, the Wairoa College survey design and response rate. *N Z Med J* 1976;84:186-189.
22. Lansingh VC, Weih LM, Keeffe JE, et al. Assessment of trachoma prevalence in a mobile population in Central Australia. *Ophthalmic Epidemiol* 2000;8:97-108.
23. World Medical Association Declaration of Helsinki. 52nd WMA General Assembly, Edinburgh, Scotland, 2000. Available at: www.arvo.org/aboutarvo/helsinki.asp.
24. Taylor HR. *Eye Health in Aboriginal and Torres Strait Islander Communities*. Canberra, Australia: Commonwealth of Australia; 1997:70-72.

DISCUSSION

Dr Ivan R. Schwab. Uncorrected axial myopia has been the focus of much commercial interest over the last twenty-five years if not longer. Mercantile pheromones exuded by the excimer laser have spawned a wellspring of interest in this relatively common and almost universally recognized condition. Although we understand the optics of this condition very well, we have just begun to assess its epidemiology. In their manuscript, Hugh Taylor et al, have sought to further understand the epidemiology of myopia.

Recently, a well performed population-based epidemiologic study has documented that hereditary is the most important factor associated with juvenile myopia with a somewhat smaller and independent contribution from increased near work, higher school achievement and less time in sports activity. No evidence, for a myopigenic environment of susceptibility to the effects of near work has been found.[1] A strong case can be made that refractive error is genetically determined and influenced by near work. Parents who are myopic tend to have children with myopia. The prevalence of myopia in children who have two parents with myopia is 30% to 40% as compared to

20% to 25% in children who have one parent with myopia.[2] Yet other published studies have documented an association between myopia and higher percentage of near work during childhood. Education has often been used as a surrogate measure or proxy for near work with myopia associated with higher education levels. Asian investigators point to rigorous schooling and long hours of study as responsible causes for the high rates of myopia in Asia.

Epidemiologically, it is challenging to determine if near work and myopia are merely associated or is near work causative? Children with myopia tend to have higher intelligence test scores and higher achievement scores. It is possible that children with a special aptitude for school work may be inclined to engage in more near work over a longer time simply because they are nearsighted.

With this background, Dr Taylor and his associates review the myopia shift in Australia in Aboriginals between 1977 and the year 2000 to help answer these questions. This seems to be an ideal investigation to review data collected in 1977 and compare with those data collected again in 2000, some twenty-three years later.

These investigators found a significant shift towards myopia in Australia Aboriginals between those years as you have just witnessed in this presentation. I have some questions for the investigators. Cycloplegic retinoscopy is regarded as the gold standard to assess refractive errors and this was performed in 1977. One can assume that those data are approximately as good as could be found; however, since the assessment of refractive error in 2000 was done with a non-cycloplegic auto-refraction, I would ask the investigators if they are satisfied that this would provide an adequate comparison? The subjects in 1977 were more hyperopic than those examined in the year 2000 raising the question of whether or not cycloplegia on those same subjects in the year 2000 would have found additional hyperopia. Since only 25 subjects were evaluated to test the reliability of auto-refraction compared to cycloplegic retinoscopy, it becomes important as to the refractive error of those 25 subjects. If these were all myopic subjects, there may be some induced error.

Similarly, I would point out the classic rule in epidemiology is "only God can make a random selection". I would like to know how the Australian Aboriginals, age 20 to 30, were selected from central Australian communities in 2000, as well as those examined in 1977.

Last, but not least, have there been changes in this population? For example, have there been changes in the prevalence of diabetes, or changes in education levels or nutrition or other important variables?

The authors are to be congratulated for a study that is surprisingly long-lived having an original subject base in 1977 with repeat data on the same population in 2000. If this population remains roughly the same, this is an extraordinary accomplishment. I want to thank the authors for prompt delivery of the manuscript so that I could review it and prepare this discussion.

REFERENCES

1. Mutti Do, Mitchell GL, Moeschberger ML, et al. Parental myopia, near work, school achievement, and children's refractive error. *Invest Ophthalmol Vis Sci* 2002;43: 3633-3640.
2. Mutti DO, Zadnik K. The utility of three predictors of childhood myopia: a Bayscan analysis. *Vis Sci* 1995;35: 1345-1352

Dr Ronald Klein. I want to reemphasize Dr Schwab's comment about the importance of the representativeness of the population being studied. How many people participated at the original and follow-up, and how did participation differ at each examination? Why didn't you select a similar European community representative group to see if there had been a refractive shift, which might have been a very interesting control group?

Dr Douglas D. Koch. Did you do any other kinds of measurements, for example corneal measurements, in those two time intervals to try to ascertain what the cause might be? Your comparison between the cycloplegic refraction and the automated refractor was done using correlation. They can be highly correlated but still be a diopter apart. The way that is appropriate to compare two measurements is to first look at mean differences with standard deviations and do analyses such as Bland-Altman plots. I wondered what those showed?

Dr James C. Bobrow. Please comment on the introduction of electricity to these communities, since this innovation would have introduced the television set and/or the ability to do more near work for more hours of the day.

Dr Hugh R. Taylor. A major problem was the comparability of the two refractive methods. We did the best that we could to look at the comparability. In answer to Dr Koch's question, we also looked at scattergrams and there was no trend or deviation, as he was questioning about whether one method was consistently more myopic or more hyperopic. For simplicity in the presentation of those data I just presented the correlation coefficient.

The selection of subjects was not attempted to be random. What we aimed to do was to examine everybody in that age group 20-30 in those communities at that time. The Aboriginal people in these areas are very migratory and move around from one community to another. We

were doing a sort of head count, and our estimates were that examination rates of people in that age group present in the communities at the time were around 95-98 %.

It would have been interesting to compare another European community. We were in these Aboriginal communities during studies on trachoma and we were not studying trachoma of the European communities. In some ways that would be another method of validating the measurements and also confirm the trend observed in European communities, in Australia, in the US, and in Europe that there are increasing rates of myopia in younger cohorts. There are also increasing amounts of hyperopia in older people, which is something that has been very prominent in the population-based studies of eye disease such as the Beaver Dam Study and the Melbourne Visual Impairment project.

Concerning Dr Bobrow's comment: there is some electricity in these communities that comes from diesel generators, that is mainly used for electric light. Some families may have a VCR but there's no television in these communities. The amount of VCR watching is relatively small outside of the community centers or the school. I think that further detailed investigation of the time spent doing near work, which is often linked to education and also thought to influence myopia, would be interesting in these communities.