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## Study of Gene-Environment Effects on Development of Hyperopia: A Study of 191 Adult Twin Pairs from the Finnish Twin Cohort Study

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**Abstract.** The Finnish Twin Cohort material was used to estimate genetic and environmental effects in the etiology of hyperopia (farsightedness). All twin pairs in the cohort born before year 1927 (age 60 years and over at the time of the study), with both members alive, were sent a questionnaire. The questionnaire included questions of past and present eye diseases, visits to ophthalmologists, use of glasses and other vision-related questions. The hyperopia was assessed by asking the patients to send their last prescription for glasses to the authors. Twins with any eye disease affecting refraction (cataract, corneal damage), operation or trauma to their eyes were discarded from the present study. In 191 pairs (80 monozygotic and 111 dizygotic pairs) one or both members of the pair had a hyperopic refractive error. The correlations of refraction between right and left eyes of both MZ and DZ pairs were high (Spearman Rank Correlations of 0.86-0.89). The intrapair correlations among MZ pairs were higher (0.44 for right and 0.45 for left eyes) than intrapair correlations among DZ pairs (0.24 for right and 0.15 for left eyes). The variances were not significantly different among MZ and DZ pairs. The classical analysis of heritability gave an estimate of 0.75 for hyperopia. The result suggests that genetic factors are important in hyperopia and especially in hyperopia of higher degree.

**Key words:** Hyperopia, Heredity, Twins

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### INTRODUCTION

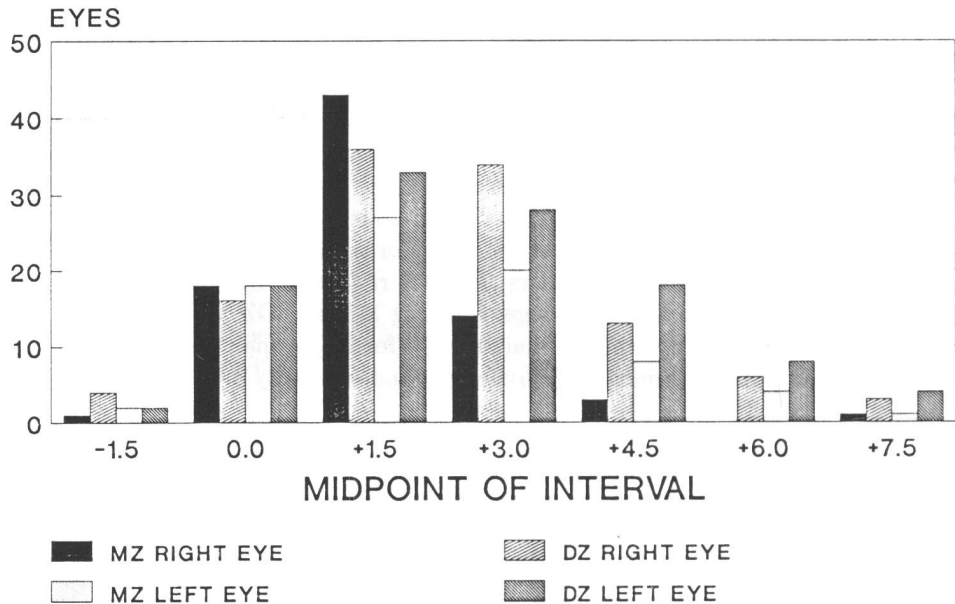
Hyperopia is a state in the refractive system in an eye, where parallel rays of light focus behind the retina and the image is not clear without spectacle correction.

Hyperopia is a risk factor for some ophthalmological diseases such as acute angle closure glaucoma. The heritability of this trait has not been studied before, so we decided to apply the twin method to hyperopia. The twin pairs were ascertained from the Finnish Twin Cohort Study.

**MATERIAL AND METHODS**

The Finnish Twin Cohort Study was established in 1975. It covers the whole country including all MZ and all same-sexed DZ twin pairs. All twins in the cohort were born before 1958, and both members of the twin pairs were alive in 1975. The cohort consists of more than 16,000 twin pairs out of whom some 30% are MZ. The compilation and procedures and algorithms in compilation along with methods of zygosity determination are presented in detail in previous publications [1-6].

A questionnaire was sent to all twins with both members alive aged 60 years or more. The questionnaire included questions of common health, eye symptoms and diseases and use of glasses. Those twin pairs who had glasses were asked to send their last prescription for glasses to the authors. The spherical refractive values were obtained from these prescriptions for this study. Confirming questions were



**Figure.** Distribution of refractive error in 80 MZ and 111 DZ twin pairs with hyperopia from the Finnish Twin Cohort Study by laterality and zygosity.

asked of ability of an individual with glasses to see clearly far and close with and without possible glasses. The questionnaire was answered by 947 twins (78.8% of those who received the questionnaire). Only those pairs where both members answered the questionnaire, and with both members without an eye disease, were chosen for this study. The analysis of this data was performed with the method of Christian et al [7].

## RESULTS

The distribution of refractive errors in this sample is given in the Figure. The correlations of refraction between right and left eyes of both MZ and DZ pairs and the intrapair correlations are presented in the Table. The correlations are presented for the total material and for those twin pairs with one member with hyperopia of more than two diopters.

**Table 1 - Spearman Rank Correlations of right and left eyes and intrapair correlations of refraction in twins**

	MZ pairs	DZ pairs
<b>Eye correlations for all pairs</b>		
Number of pairs	80	111
Right eye/Left eye	0.86	0.89
Right eye/Right eye	0.44	0.24
Left eye/Left eye	0.45	0.15
<b>Hyperopia of more than two diopters</b>		
Number of pairs	26	34
Right eye/Right eye	0.34	0.14
Left eye/Left eye	0.51	0.19

In the following calculations the mean refractive error of left and right eyes is used. The mean hyperopic refractive error was 1.58 among MZ and 1.51 among DZ pairs (no significant difference). Within-pair variance was 0.037 ( $F = 1.545$ ,  $P = 0.02$ ) and among-pair variance was 0.285 ( $F = 1.65$ ,  $P < 0.01$ ). Intraclass correlation for hyperopia was 0.61 among MZ and 0.23 among DZ pairs. The test of equal variance among MZ and DZ pairs gave an  $F$  value of 1.3 ( $P = 0.15$ ). The classical analysis of heritability [ $2(R_{MZ} - R_{DZ})$ ] gave an estimate of 0.75 ( $P < 0.001$ ).

## DISCUSSION

The ascertainment of twin pairs in this material may be considered valid. The nationwide registry offers an equal chance to both members of a given twin pair to be

included and no secondary ascertainment exists. The sample for the questionnaire in this study was chosen from all pairs alive at age 60 years or more, and the prevalence of hyperopia is known to be highest in this age group.

The assessment of hyperopia by questionnaire may also be considered valid in this material. All twins with hyperopia had an eye examination by an ophthalmologist or an optician. The spherical equivalents of refraction were obtained from their prescriptions. Some inter-examiner error may exist, but no systematic error should exist by zygosity.

The assumption of equal variance among MZ and DZ pairs was met in this sample. Our estimate of heritability (0.75) may be considered the upper limit for heritability. The assumption of equal intrapair correlation in environmental factors among MZ and DZ pairs has not been addressed in the present calculations. This possible source of bias has to be kept in mind. There seems to be still a strong genetic component in hyperopia. Previous twin studies have shown a high heritability (0.60 to 0.89) for myopia [8], but this is the first report concerning the heritability of hyperopia.

Hyperopia is a risk factor for certain disabling eye diseases, such as acute angle-closure glaucoma. It is important for a clinician to ask for history of such disease in the first-degree relatives of these patients.

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