THE INCIDENCE AND DISTRIBUTION OF AMETROPIA IN BLACKS IN UMLAZI

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ABSTRACT

Age, sex, race, heredity, environment and nutrition have been found to influence ametropia. In this study, the distribution of refractive errors has been investigated in relation to age, sex, race, education and near work, and lighting conditions. Visual awareness and vision screening in pre-school and schoolchildren were also investigated.

Data were collected using the Nikon auto-refractor, retinoscope, Snellen V.A chart, and subjective techniques. 777 people were refracted, whose ages ranged between four and eighty years. Measurements were made in different sections of Umlazi township, therefore people of different socio-economic sectors were refracted.

Four year-old children were found to be hyperopic. Hyperopia decreased and refraction shifted towards emmetropia. Myopia started to appear at the age of ten. Myopia increased until the age of twenty, and thereafter decreased slowly until the age of thirty three, where the average refraction was emmetropia. From age forty onwards, hyperopia was predominant.

The incidence of high astigmatism, high hyperopia and high myopia is low in this community. Most people fall in the spherical refractive error region of between -1.00D and +1.00D. The curve is leptokurtotic with highest peak around +0.25D. The cylindrical error is between -0.50D and -1.00D.

No significant difference between sexes was found except at the fourth age group (40-51), where females are more hyperopic than

males. The other sex difference is at ages ten to twelve, where females develop myopia earlier than males.

Illumination plays no important role in the development of refractive errors in this community. Education and near work seem to account very little to the development of myopia.

The influence of heredity on the development of ametropia was not investigated in depth. However, there is no evidence of heredity influencing the development of ametropia.

There is a lack of vision screening and visual awareness.

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There is a lack of vision screening and visual awareness.

CHAPTER 1

INTRODUCTION

Ametropia is caused by anomalies of the dioptric system or by an abnormal axial length. Normal axial length is approximately 24mm. Shorter than normal axial length tends to produce an hyperopic eye and longer than normal axial length tends to produce a myopic eye.

The distribution of refractive errors is continuous and leptokurtotic with a peak at or about +0.50 dioptres. An approximately equal number of people have refractive errors extending on a myopic limb between plano and 4.00 dioptres and between 2.00 and 4.00 dioptres on the hyperopic side.

Various factors such as age, race, sex, heredity, environment, and nutrition have been found to influence ametropia. The normal development of the eye shows two hypermetropic shifts, the first in early infancy and the second in middle age, and two myopic shifts between adolescence and 30 years of age and then again in old age (Spooner, 1957).

Studies by Brown (1938) and Slataper (1950) showed that the initial hypermetropia found at birth increased by about +1.50 dioptres during the first seven years of life, giving a refractive error of +3.50 dioptres or more at seven years of age. These findings were contrary to the widely held belief that hypermetropia found at birth steadily declined during infancy. The subjects in the Brown and Slataper studies, however were all drawn from private ophthalmic practices, although Hirsch (1952) found similar results from a random sample. In a recent study by Saunders (1981), the +1.50 dioptres increase in hypermetropia reported by Brown and Slataper was not observed, though it must be said that Saunders's sample size of this age group was small compared to that of the previous studies.

Loss of hypermetropia in childhood has been explained by the biological-statistical theory and the theories of emmetropization. The eye enlarges by growth, then there is a loss of hyperopia and the eye tends towards emmetropia (Steiger 1913).

The use-abuse theory attempts to explain the onset of myopia as an adaptation to the use of the eyes in prolonged near work (Cohn 1886). Angle and Wissman (1978); Richler and Bear (1980), proposed that reading could explain most of myopia which arises between the ages of 12 to 17 years. In this case myopia is alleged to be the result of the extra-accommodative effort required in school-work.

Young (1975) believed that a child went into myopia because of an inability to relax accommodation to the far point as a result of long periods of near work.

According to the biological-statistical theory, the appearance and progression of myopia is produced by growth and is consequently related to age until the end of growth (Steiger 1913).

Hypermetropia in middle age is to be attributed to the increase in radius of the lens curvature with age (Weale 1963). Walton (1950) attributed senile myopia (after age 60) to the development of senile cataract.

Infants show greater amounts of astigmatism than adults. The amount begins to decrease in the second semester of life and the incidence declines during the third year (Mohindra et al, 1978). Slataper (1950) found that there is nothing constant about the average change in the strength of the cylinder as the result of age. "With-the-rule" astigmatism is more common in youth while "against-the-rule" astigmatism is more common in adults. Also the amount of astigmatism has no significant relation to age, sex or education (Parssinen, 1987; Kragha, 1987).

Although investigators have reported upon the distribution of refractive errors in American Blacks, Asiatics, Caucasians and other racial groups in various countries, no study has been done on the incidence and distribution of refractive errors in South African Blacks*.

Callan (1875) and Scott (1945) found lower prevalence of myopia among blacks residing in African countries and in United States when compared to students and general population groups living in the same country. Sperduto et al (1983) found a significantly lower prevalence rate of myopia for blacks than whites in the United States of America.

* FOOTNOTE: BLACKS OR AFRICANS IN THIS REPORT WILL REFER ONLY TO THE ABORIGINALS OF AFRICA.

Crawford and Hammar (1949) found that the Chinese showed a higher prevalence of myopia than other population groups. The lowest incidence seemed to be among Blacks, Eskimos, and North American Indians.

There appears to be no significant refractive differences between the sexes (Baldwin 1964; Hirsch 1953) even amongst population groups that show higher incidences of myopia. Duke-Elder (1970) stated that there is no correlation between sex and refraction in adults. Recent study by Baldwin (1981) shows that myopia seems to be more common among adolescent girls than boys.

It has been shown to be difficult to predict the refractive errors of children from that of their parents. Johnson, Matthews and Perkins (1979) found that there was no significant correlation between the refraction of the parents and offspring.

The influence of heredity on the development of refractive errors has been a source of controversy for many years. Although it seems certain from the work on identical twins that the characteristics of refractive components are inherited, this does not necessarily mean that the refractive error itself is inherited (Waardenburg, 1950; Wixson, 1958).

Environmental and postural influences allegedly induce refractive errors (Harmon, 1946). Donders, 1864; Rasmussen, 1936; Dashevsky, 1962) found that low level of illumination is inducive to myopia. Thus in lower illumination, the pupil dilates, with a consequent reduction in depth of field which in turn appears to cause an increase in myopia.

General malnutrition has been shown to be associated with higher incidence of myopia by several investigators, but no investigation has provided significant evidence that specific nutritional deficiencies are associated with myopia.

McLaren (1960) found a much higher incidence of myopia among children of an African tribe who had suffered two years of famine when compared to children of a neighbouring tribe who were not undernourished. Johnstone and McLaren (1963) and Halasa and McLaren (1964) found a similar relationship.

In summary, ametropia is classified into hyperopia, myopia and astigmatism. Infants are hyperopic astigmats at birth, hyperopia and astigmatism decreases with age. At the adolescent stage, myopia is prevalent until the age of thirty. Thereafter refraction is emmetropic. Myopia in adolescent stage is due reither to prolonged reading or other close work (use-abuse theory) or due to growth of the eye and is related to age (biological-statistical theory). Myopia is found to be more common in adolescent girls than boys. Hyperopia appears again in the middle age and increases until the age of sixty. Thereafter refraction moves towards myopia.

Amount of astigmatism found in the infants decreases with age. "With-the-rule" astigmatism is common in youth, whilst "against-the-rule" is common among adults.

Race has been found to influence ametropia. Blacks have a low prevalence of myopia.

Environmental and postural changes are believed to induce refractive errors.

However it is difficult to predict the refractive errors of children from that of their parents.

CHAPTER 2

THE OBJECTIVES OF THE STUDY

The objectives of this research are to:

(1) establish the incidence of refractive errors in relation to age, sex, race, environnment, education and near work, and lighting conditions.

(2) determine the importance of vision screening in pre-school and schoolgoing children.

(3) emphasize the importance of creating a public awareness of the need for ocular hygiene and eye-care.

(4) provide the optometric profession and the universities with accurate data upon which to base manpower requirements.

(5) provide the optical manufacturer with data upon which to base their fundamental stock requirements.

CHAPTER 3

SIGNIFICANT PRIOR RESEARCH

Studies have been carried out in many countries on the incidence and distribution of ametropia among various racial groups. No study has been reported on South African blacks. We may therefore only view the other studies done in other African states.

In a study to determine the prevalence of myopia in Africans living in Monrovia and Dar-es-Salaam, Av-Shalom et al (1964) found the prevalence of myopia among school children to be 1.68% which is one tenth of that reported from other racial groups. Prevalence of myopia among adults was found to be one third of that found in comparable studies done in Europe. Av-Shalom et al studied two samples. The first sample was drawn from different schools. School children whose ages ranged between six and eighteen were refracted. The second sample was drawn from eye clinic population. These were mainly adults. Their exact ages could not be determined. Retinoscopy techniques were used. It was a cross-sectional study.

In a recent study of distribution of refractive errors in Nigeria, Kragha (1987) observed high prevalence of myopia among school children. A steady reduction in myopia commenced as early as the mid-twenties. Thereafter there was a tendency towards hyperopia with advancing age. The shift towards hyperopia occured earlier in females (40-44) than in males (45-49). Kragha's results were consistent with other studies done all over the world.

Kragha analysed the data from a random sample of clinical records of patients. The patients ages ranged from three to sixty-nine. The patients were refracted using the retinoscope and refined binocularly and monocularly. The spherical equivalents were used to analyse the data. It was a cross-sectional study.

CHAPTER 4

METHODOLOGY AND INSTRUMENTATION

The research was carried out at Umlazi. Umlazi is a black township twenty kilometers South West of Durban in the Province of Natal. It was established in 1961 as a resettlement area of people staying in the slum areas around Durban. It has a population of about 450 000. Most of the residents are working in the Durban metropolitan area. Living conditions in some parts of the township are relatively poor. Thus there is no proper housing.

777 people, who consisted of 383 females and 394 males, were refracted.

Subjects were drawn from schools, charity organisation offices, rent offices and a technikon. Notices were placed in the township superintendent's offices inviting people to come for visual screening. Many people of different age-groups turned up. Thus the study sample is spread across all socio-economic groups, although the spread is not equal.

In schools, creches and technikon, only those who resided in Umlazi were refracted. The systematic random sampling method was applied, thus selecting every r individual, where the r value was found by dividing the number of children in the class by the number of subjects that were required.

A questionnaire was administered in order to obtain specific information concerning the following:-

(i) subject's age

(ii) lighting system used

(iii) hours spent reading or doing work within arm's reach

(iv) gender

(v) educational status

(vi) occupation

(vii) family history

viii) and also to assess if the subject has been examined before or not. This was to assess if the subjects were "visually aware" (cf. p 51).

Sample was divided into five different age groups :-

(i) 4-15 years old

(ii) 16-27 year olds

(iii) 28-39 year olds

(iv) 40-51 year olds

(v) over 51 years .

The oldest person refracted was eighty years of age. Subjects with dense opacities and visual acuity of less than 6/60 were excluded.

Subjects were refracted using the Nikon Auto-refractor. This was used in order to obtain a large number of subjects in a reasonable period of time. Pre-school children, lower primary school children and elderly people (51 years and over) were refracted by means of a Welch-Allyn streak retinoscope with the aid of a Snellen Visual Acuity chart. Subjective refraction was by cross-cylinder method and HIC techniques. Retinoscopy and subjective refraction were performed because these subjects were not co-operative with respect to the auto-refractor.

Prior to the research, fifty people were refracted using the auto-refractor, retinoscope and subjective techniques. The results obtained by the auto-refractor were compared to those results obtained using the retinoscope and subjective techniques. A high correlation was found, which suggested a satisfactory working correlation between the auto-refractor and the conventional refracting methods (retinoscope and subjective techniques). This is shown in Table 1 and also in figures 1, 2, and 3.

Refractive errors were divided into:-

(1) emmetropia, which is indicated by values that range from -0.25 dioptres to +0.25 dioptres.
(2) myopia, which is indicated by values above -0.25 dioptres.
(3) hyperopia, which is indicated by values above +0.25 dioptres.
(4) astigmatism, which is indicated by cylinder powers above -0.25 dioptres.

All lenses were expressed as minus cylinders, and those within 15 degrees of 90 degrees and 180 degrees were considered as "against-the-rule" and "with-the-rule" respectively. Lenses with axes falling between 15 and 75 degrees and between 165 and 105 degrees were considered as oblique astigmatism.

The refractive error was written as: sphere power / cylinder power x axis.

Statistical analyses were carried out using the standard procedures such as the mean, standard deviation, X^2* and the student's t-test. The five percent probability level of acceptance ($p < 0.05$) was adopted as the critical value. The degree of freedom was taken as $df = n_1 + n_2 - 2$, where n_1 and n_2 denote the sample sizes.

The correlation between the refraction of right eyes and left eyes was found to be high ($r = + 0.90$). To analyse both eyes would be a duplication. To avoid the inflation of significant findings, the data of the right eyes were only used.

The spherical and the cylindrical components were analysed separately. To obtain the mean spheres, mean cylinders and the total mean refractive errors I used the matrix form.

The formulae are as follows: $(Fs / Fc)\ a = F = \begin{vmatrix} x & y \\ y & z \end{vmatrix}$

Where $x = Fs + Fc \sin a$; $y = -Fc \sin a \cos a$; $z = Fs + Fc \cos a$

Fs= spherical power; Fc= cylindrical power; a= cylindrical axis.

After converting to matrix form, corresponding terms are added and converted back to their normal form using:

$$F = \begin{vmatrix} x & y \\ y & z \end{vmatrix} \Rightarrow (Fs / Fc)\ a, \quad \text{where } Fc = - (x-z) + 4y$$

$$a = (\arcsin (-2y) / Fc) / 2$$

$$Fs = \frac{(x + z - Fc)}{2}$$

This method was suggested by Harris (1988).

* X^2 DENOTES CHI-SQUARED TEST.

CHAPTER 5

RESULTS

The spherical powers range from -8.25D to +4.50D. Females appear in both the hyperopic and myopic tails (Table 2). 38.22% of the people are emmetropic, 37.71% are hyperopic and 24.07% are myopic. Only 0.51% people exhibit high myopia (above -4.00D), and 0.26% people exhibit high hyperopia (above +4.00D). The mean spherical error is +0.07D.

The incidence of the cylindrical error is shown in Table 3. 63.58% of the people did not require an astigmatic correction, whilst 36.42% did. Of this 36.42%, 33.33% needed an astigmatism correction of between -0.50 and -1.00D and 3.09% needed an astigmatism correction of between -1.25 and -2.25D. The mean cylindrical error is -0.26D. Females appear to have a prevalence of high cylinder power. The highest cylinder power for females is -2.25D, whilst for males is -1.50D. However, the incidence of high cylinder power is very low. The mean refractive error is +0.07 / -0.26 x 115.

The prevalence of refractive errors in percentage form for each age group is shown in Table 4. In the first age group (4-15), most of the people are hyperopic. Hyperopia decreases in the in the second age group (16-27).Most people are emmetropic in the age grouping (28-39). Hyperopia reappears again in the fourth age group (40-51) and increases with advancing age.

The prevalence of astigmatism tends to increase with age (Table 4). Most of the people are astigmatic in the fifth age group ($>$ 51 years).

Figure 4 shows the distribution of spherical components in the first age group. The highest peak is at +0.50D. The spherical powers range from -3.75D to +2.25D. There appears to be little difference between the sexes. A comparison of the spherical components of males and females shows no significant difference, ($p > 0.05$, $t = 1.77$, $df = 220$). The cylindrical powers range from -2.00D to -0.50D. 95% of the sample has a cylindrical correction of between -0.50D and -1.00D. The highest peak is at zero (figure 5). The mean cylindrical error for males and also for females is -0.25D. There is no significant difference between the sexes ($p > 0.05$, $t = 0$, $df = 220$). The mean refractive error for the first age group is +0.12 / -0.25 x 137 (Table 7).

Figures 6 and 7 illustrate the incidence of the refractive error in the second age group. The curve is skewed towards the myopic side. The spherical powers range from -8.25D to +1.00D. A comparison of the spherical component of males and females shows no statistical difference. ($p > 0.05$, $t = 1.65$, $df = 205$). The mean cylindrical error for female is -0.29D whilst for males is -0.30D. The highest peak is at plano. Comparison of the cylindrical component between males and females shows no significant difference ($p > 0.05$, $t = 1.61$, $df = 205$). The mean refractive error for this age group is -0.54 / -0.25 x 180 (i.e "with-the-rule" astigmatism).

The distribution of the refraction for the third age group is shown in figures 8 and 9. The leptokurtotic curve shows a shift from the myopic side towards emmetropia compared to the curve of the second age group. The mean spherical error for males is -0.03D, whilst for females is -0.01D. There is no statistical difference between males and females ($p > 0.05$, $t = 0.12$, $df = 127$). The greatest frequency of the cylindrical component occurs at -0.50D. The mean cylindrical error for males is -0.32D, whilst for females is -0.28D. There is no significant difference between sexes ($p > 0.05$, $t = 0.65$, $df = 127$). The mean refractive error for this age group is -0.02 / -0.30 x 75 (i.e "against-the-rule" astigmatism).

Figures 10 and 11 illustrate the distribution of refractive errors in the fourth age group. The mean spherical error for males is +0.20D, whilst for females is +0.50D. There is a statistical difference between males and females ($p < 0.05$, $t = 2.50$, $df = 108$). The mean cylindrical error for females is -0.29D whilst for males is -0.38D. The highest peak is at zero. There is no significant difference between males and females ($p > 0.05$, $t = 0.96$, $df = 108$). The mean refractive error is +0.39 / -0.35 x 90 ("against-the-rule" astigmatism).

In the fifth age group, the curve is skewed towards the hyperopic side (figure 12). The mean spherical error for males is +0.79D and +1.07D for females. There is no significant difference between sexes ($p > 0.05$, $t = 1.22$, $df = 108$). In this age group, 19% of the people exhibited myopia.

Figure 13 illustrates the distribution of the cylindrical components. The highest peak is at plano. The mean cylindrical error for females is -0.44D, whilst for males it is -0.36D (Table 6). Comparison of the cylindrical component of males and females shows no significant difference ($p > 0.05$, $t = 1.30$, $df = 108$). The mean refractive error for this age group is +0.90 / -0.40 x 100 (i.e "against-the-rule" astigmatism).

Figures 14 and 15 illustrate the distribution of refraction in pre-school children. The ages of pre-school children range between four and five. The curve is skewed towards the hyperopic side (figure 14). The highest peak is at +1.00D. The spherical powers range between -0.25D and +2.00D. The mean spherical error is +1.08D for females and +0.96D for males. The mean cylindrical error is -0.34D with the highest peak at zero (Figure 15). The highest cylindrical power found was -1.75D. The mean refractive error is +1.01 / -0.34 x 110 (Table 10).

Figure 16 illustrates the distribution of the spherical components in primary school children. The ages of the primary school children range from six to twelve years. The spherical errors range from -3.00D to +1.25D. The mean spherical error for males is +0.16D, whilst for females it is +0.09D (Table 8). More females are myopic than males. (17.19% females were myopic and 11.86% males were myopic). More males are hyperopic than females. (44.07% of males are hyperopic , whilst 32.94% of females are hyperopic). There is no statistical significant difference between males and females ($p > 0.05$, $t = 0.95$, $df = 121$). The distribution of the cylindrical components is shown in figure 17. The highest peak is in the zero region. The mean cylindrical error for males is -0.25D, and for females is -0.17D (Table 9). The average refraction is +0.12 / -0.21 x 120 (Table 10).

The ages for secondary school children seen in this study, range between thirteen and twenty years. The mean spherical error for males is -0.78D and for females is -0.74D. The spherical powers range between -6.25D and +1.50D (figure 18). There is no significant difference between females and males sphere powers ($p > 0.05$, $t = 0.25$, $df = 119$). The greatest frequency of the cylindrical component is in the -0.25D region. Females exhibit high cylindrical errors than males (figure 19). The mean cylindrical errors for females is -0.30D and for males -0.23D. A comparison of male and female cylinder powers yields no statistical significant difference ($p > 0.05$, $t = 1.06$, $df = 119$). The average refraction for the secondary school children is -0.75 / -0.25 x 145 (Table 10).

Figure 20 illustrates the distribution of the spherical components among students. The term "students" refers to all the people studying in tertiary institutions. Their ages range between nineteen and twenty-eight years. The spherical powers range between -3.75D and +1.50D. There is a lower prevalence of myopia among students compared to that of the secondary school children. There is no significant difference between females and males sphere powers ($p > 0.05$, $t = 0.75$, $df = 67$). Figure 21 illustrates the distribution of the cylindrical components among students. The highest peak is at the zero region and the highest cylinder power exhibited is -1.50D. The mean cylindrical error is -0.17D axis 110 (Table 10).

Figure 22 illustrates the distribution of the spherical components with respect to lighting. Mean spherical components for people using candles or paraffin is +0.06D. The mean spherical error for people using electrical lamps is +0.08D (Table 11). Comparison between people using candles or paraffin lamps and those using electrical lamps shows no significant difference ($p > 0.05$, $t = 0.24$, $df = 775$).

Figure 23 illustrates the distribution of the cylindrical components with respect to lighting. The mean cylindrical error for those using electrical lamps is -0.29D and -0.24D for those using candle and / or paraffin lamps at their homes (Table 12). There is no significant difference between those using candles or paraffin lamps and those using electrical lamps ($p > 0.05$, $t = 1.75$, $df = 775$).

QUESTIONNAIRE ANALYSIS

27.90% of the pre-school children have been to optometrists for eye testing. It was because they had eye problems like tearing, blepharitis, conjunctivitis, and frowning when looking at far objects. 11% of these children had glasses prescribed for them. 5% of these children who wear glasses, have parents who are also wearing glasses or contact lenses. 72.1% of the pre-school children had had no eye examination before. In this study, 20% children were referred to optometrists for a thorough eye examination.

Primary schools in Umlazi do not have electricity. They use natural lighting. The classrooms are brightly lit during sunny days, and are dim or dark on cloudy days. The pupils spend about five hours every day in these classrooms. 54.50% of these pupils use electricity as the lighting system at their homes. They also spend between half an hour and an hour watching television at home. 45.50% use candles and/or paraffin lamps as the lighting system at their homes, and of course these people do not have television sets. Only the standard three to standard five pupils spend an hour per day studying at home.

16% had had an eye examination before, and glasses had been prescribed. Only 2% of those who had their eyes tested before have parents who wear glasses. Of those who have never been examined, 10% were referred for further eye examination. From these statistics we may see that visual screening is not done among school children. They are only screened for medical defects upon entrance to school.

Secondary schools do have electricity. The classrooms, therefore have constant electrical lighting. The pupils spend six hours per day in these classrooms. Most of them spend three to four hours per day studying at home. 40.50% use candle and/or paraffin lamps at home. 24.79% had had their eyes examined and glasses prescribed. These were mainly those pupils who could not see the writing on the blackboards. 5% of those who wear glasses have parents who are also wearing glasses. 16.48% of those who never had their eyes tested were referred for a further eye examination.

Lecture rooms in the technikon are all electrically illuminated. The students spend about 7 hours per day in these lecture rooms. Students spend between four and six hours everyday studying at their homes. The majority of students use electrical lamps as the lighting system at their homes. Only 3% use candle and/or paraffin lamps.

The rest of the subjects were either pensioners, unemployed, or working. The working group ranged from domestic maids and labourers, to doctors, engineers, and businessmen and women. They spent as little as one hour to as much as six hours per day doing near work. Therefore people from different socio-economic sectors were refracted. Most of these subjects were "visually aware" as they have had eye examinations before. (This applies to those who could afford to pay for an eye examination and also those who are literate). Those who cannot afford to have an eye test, like the unemployed, pensioners and labourers, have to abandon their near work . This occurs mainly in the middle-age people, where near work like knitting and sewing help to supplement family income. However, these people were referred to the Umlazi Eye Clinic. This is a clinic run by the Department of Optometry of the University of Durban-Westville and voluntary optometrists.

60.10% of the subjects in this study, use electric lights at their homes. 39.90% use paraffin lamps and/or candles as the lighting system at their homes.

Figure 24 illustrates the comparison between myopes, hyperopes, and emmetropes and the amount of time they spend doing near work at their homes. Emmetropes seems to spend more time doing near work than hyperopes and myopes. There is a statistical significant difference between emmetropes, hyperopes and myopes ($p < 0.05$; $X^2 = 18.96$, df = 2). Myopes spend less time compared to hyperopes and emmetropes. However, there is no significant difference between myopes and hyperopes ($p > 0.05$; $X^2 = 1.51$, df = 2).

CHAPTER 6

COMPARATIVE STUDY

AGE

The mean refractive error for the first age group is +0.12 / -0.25 x 137 (Table 7). Analysing within the first age group, we find that at the age of four, the refractive error is +1.11 / -0.31 x 116. The hyperopia decreases, and at age nine, the refractive error is +0.08 / -0.25 x 150. Thereafter the refraction moves toward myopia. At age fifteen, the refractive error is -0.64 / -0.27 x 120. Thus the refraction is skewed toward the hyperopic side until the age of nine, and then skewed towards myopic side thereafter. This is in agreement with Hirsch (1952). In his study of changes in refraction between ages of five and fourteen, he found the average refraction error to be hyperopia and the amount of hyperopia was decreasing steadily with age. In this study, the average refractive error at age fourteen is myopia compared to hyperopia found in Hirsch study.

Myopia is more prevalent in the second age group. Even in the first age group, myopia appears at the age of twelve. The rate of myopia increases until age twenty, and thereafter starts to decline towards emmetropia. This is in agreement with Brown (1938) who found that from age eight to fourteen, refraction moved rapidly towards the myopic side up to the age of twenty and thereafter slowly increased up to the age of thirty-three. However this reported increase in myopia up to the age of thirty-three was not observed in the third age group of this study.

Brown (1938) observed hyperopia from age thirty-four to forty-two, and thereafter there was an increase in refraction towards myopia. Myopia was again reported in the elderly people. The major weakness of Brown's study is that the data was drawn from clinics and private practices. The other reason for the difference between this study and Brown's study is that Brown made observations on atropinised eyes.

A return to an average hyperopic refrative error commences in the fourth age group and the hyperopia increases with age. This agrees with the findings of Kragha (1987), Richler and Bear (1980), and Saunders (1981, 1986).

Myopia in the elderly people (fifth age group) was not observed in this study. This is in agreement with Kragha's studies (1987), and contrary to the studies by Brown (1938), Slataper (1950) and Saunders (1981). They observed a reduction in hyperopia and the appearance of late myopia. Brown reported myopia as early as the age of forty-three. Slataper reported that after age sixty-four, the refraction became minus. These refractive changes were only slightly myopic, though fairly constant, until the age of seventy-one was reached, where there was a marked myopic changes. Richler and Bear (1980) observed myopia at the age of ninety and over. Myopia was then associated with senile cataract.

Table 13 shows the comparison between this study and the previous studies, whose data are available. Only spherical equivalents were used in this table. However studies in which the method for analysing the data was not specified, were excluded. From Table 13 we may say that there is a fair to good correspondence between the refraction values of this study and those of Kragha and Richler & Bear.

Average oblique astigmatism was observed in the first age group and shifted toward "with-the-rule" astigmatism in the second age group. Thereafter there was a shift towards "against-the-rule" astigmatism with advancing age (Table 7). This is in agreement with Grosvenor (1976) who found that a given individual tended to develop "against-the-rule" astigmatism throughout the remainder of the life-span. Hirsch (1953) in his study of changes of astigmatism after age forty, observed higher prevalence of "against-the-rule" astigmatism.

There is no correlation between age and the power of the cylinder. Astigmatism is more prevalent in elderly people. 95% of the subjects have cylindrical power of between -0.25D and -1.00D. Mohindra et al (1978) observed a high incidence of large amounts of astigmatism in infants, then these amount of astigmatism declined with age; particularly after six months.

There is no correlation between high spherical and high astigmatic errors. Most investigators have observed a correlation between high spherical and high astigmatic errors, especially on the hyperopic side. In this study, however the occurrence of astigmatism is similar in both hyperopic and myopic eyes. Therefore I tend to disagree with Kronfeld (1930) who found that the hyperopic eye of a certain degree was more apt to have a higher grade of astigmatism than a myopic eye of a corresponding degree.

EDUCATION AND NEAR WORK

Pre-school children were found to be hyperopic. The highest amount of hyperopia found was +2.00D, and myopia was not observed. The mean refractive error is +1.01 / -0.34 x 110. Thus these pre-school children exhibit oblique astigmatism. This is in contrast to Grosvenor (1976), who found that pre-school children exhibited "with-the-rule" astigmatism.

Molnar (1961) obtained an average refraction of +2.40D for one to two year-old children, and +1.90D for two to five year-old children. Sorsby (1933) reported hyperopia of +2.30D at the age of four, +2.20D at the age of five and +1.77D at the age of six.

In this study, the average spherical error at the time of entrance to school (age six) is +0.56D. This is low compared to the findings in the previous studies. Kempf, Collins and Jarman (1928) found that upon entrance to school, the children's refraction averages +1.00D. Slataper (1950) reported hyperopia of

+1.61D at the age of seven. Hyperopia increasing until the age of seven, as found by Brown (1938), Slataper (1950), and Hirsch (1952), was not observed. Even though this present study starts from age four, a decrease in hyperopia at ages five, six and seven is evident. This agrees with Saunders's findings (1981).

Hyperopia observed upon entrance to school decreases, and refraction shifts towards emmetropia among primary school children (ages six to twelve).

Pendse et al (1954) reported that hyperopia observed at age six, changed towards myopia with increasing age. Girls were found to be more hyperopic than boys until the age of about nine, and more myopic in the age range of eleven and twelve. There was a statistical difference between boys and girls at the age of twelve. This statistical difference at age twelve was not found in this study.

Staflova (1959) conducted a research on Russian children from the age of six to fourteen. Staflova found an increase in incidence of myopia mostly marked at age twelve, with a decrease of myopia thereafter.

Heard et al (1976) reported an average sphere error of +0.87D, with the cylindrical error of 2.00D among uni Indian primary school children. These are Indians living in North America. Heard et al (1976) attributed the higher prevalence of astigmatism to the genetics, nutritional theories and the effect of the upper tarsal plate pulling across a cornea of low rigidity. In this study the highest cylinder power exhibited is -2.25D, and the mean cylindrical error is -0.21D x 120, (ie, oblique astigmatism).

Hirsch (1963) found that at the age of six, eighty one percent of children had less than 0.25D of astigmatism and then the percentage declined to 72% at about age twelve to fourteen. No children were observed with "with-the-rule" astigmatism in excess of 1.25D.

Amongst secondary school children, myopia is more prevalent. The highest minus power exhibited is -6.25D. There is an increase in myopia throughout this age group (thirteen to twenty). The cylindrical error has increased from -0.21D (primary school children) to -0.25D, axis oblique. This increase in myopia is in agreeement with Heard et al (1976) who observed the average sphere refraction of -0.67D. However the decrease in cylindrical refraction by 0.50D to 1.50D was not observed in the study. Angle and Wissman (1978) found the increase in myopia with a year of school for twelve to seventeen year olds to be 0.22D.

The expected increase in myopia was not observed amongst the student group. Actually there is a decrease in myopia, and the curve shifts towards emmetropia. There is more high myopia amongst secondary school children than amongst students. This is in disagreement with Angle and Wissman (1978) and Young (1965). They found that the highest level of education was strongly related to myopia. Also the percentage of myopia seemed to be greater in the higher elementary grades than in the lower, and higher in college students than in high school pupils. Parssinen (1987) found a relation between education and myopia amongst both twenty-six year olds and forty-six year olds.

Av Shalom et al (1967) compared the prevalence of myopia in school children of Monrovia and Dar-es-Salaam with that of school children from other countries. This is shown in Table 14 with the addition of the results from the present study.

From Table 14, we can conclude that the prevalence of myopia in Black school children is comparable with that of school children of other population groups. In this study, the ages of school children range between six and twenty, as we find older pupils in high schools due to the crisis in Black education. The previous studies in Table 14 included school children from age six to eighteen.

Comparing the prevalence amongst African school children (Tanzania, Monrovia and Dar-es-Salaam and present study), Monrovia and Dar-es-Salaam school children have a low prevalence of myopia.

Near work was reported in the questionnaire as hours spent studying, reading, writing, knitting or any work done within arm's length. The higher the level of education, the more time is spent studying. Students spend more time studying compared to secondary school children. However the average refraction for students is -0.38 / -0.17 x 110, and is lower than that of the secondary school children whose average refraction is -0.75 / -0.25 x 145.

Emmetropes spend more time doing near work than hyperopes and myopes. Hyperopes spend more time doing near work than myopes.

Nadell et al (1956) found no greater amount of reading among myopes than hyperopes. Nadell et al (1957) also found no relationship between the amount of reading and the distribution of refractive errors.

Young (1955) indicated that there was a little correlation between myopia and hours of reading. Schwartz (1940) found that there was a relationship between hyperopia and avoidance of reading or near work. Morgan (1960) indicated that female "bookishness" was related to refractive error. The relationship was between low "bookishness" and hyperopia.

ILLUMINATION

In this study , there is no significant difference in refractive error between people using electrical lamps and those using candles and/or paraffin lamps. Therefore we found no relationship between illumination and refractive error. This is contrary to the findings of Young (1975) and Rasmussen (1936).

Young (1975) reported that high and low levels of illumination induce increased accommodation, and cause myopia. He recommended that near work and reading should be done under median levels of illumination, in order to reduce any possible effects of illumination on the development of myopia.

Rasmussen (1936) attributed the greater incidence of myopia among Chinese to near work, poor lighting, and low desks at school. There are some similarities between the situation in China in 1936 and Umlazi primary classrooms of 1988. Most classrooms at Umlazi do not have electricity except in higher standards. However, higher prevalence of myopia was not observed among these primary pupils. Myopia started to appear among these school children at the age of ten. Only 14.60% of these primary school children exhibited myopia.

SEX

I found no significant difference between females and males, except in the fourth age group. In this age group, there is a significant difference between males and females in the sphere components only. This is contrary to Goldschmidt's observations (1968), he suggested that the sex difference in the refraction was usually seen only in children and not in adults. Duke-Elder (1970) found that there was no correlation between sex and refraction in adults. Kragha (1987) and Shapiro et al (1982) observed no significant difference between the sexes.

Females in this study have a greater prevalence of both high myopia and high hyperopia. They appear in both myopia and hyperopia tails with higher frequencies than males. At ages ten to twelve, girls exhibit higher prevalence of myopia than boys. There is, however no significant statistical difference in the means of refraction between males and females.

Hirsch (1953) observed that the only significant sex difference was a greater prevalence of high myopia among females than males. Sperduto et al (1983) found significant lower rates of myopia among men than women.

Pendse et al (1954) observed a significant difference in the means of refraction for males and females only at the age of twelve. This was not observed in this present study. Young et al (1954) and Morgan (1967) found that girls developed myopia at an earlier age than boys. The excess of myopia among females was attributed to earlier physical and psychological maturation of girls. Baldwin (1981) attributed an excess of myopia among females to the fact that an endocrine function is involved in refraction.

Saunders (1981) suggested that females were more hyperopic at birth through their teens and in old age; in the middle years, the refractive state assumes the same values as that of the males.

The incidence of cylindrical error is similar in males and females. Females have a slightly higher frequency of high levels of astigmatism than males.

HEREDITY

In this study, the influence of heredity on ametropia has not been investigated in depth. It was very difficult to obtain the refractive status of parents as some parents did not even know their refractive states. On the superficial results obtained from the questionnaire, it seems as if there is no relation between refractive error of the parents and their children. However, Ditmars (1967) found that there was little hereditary influence to account for myopic refractive error.

RACE

This study is comparable with other studies done on other racial groups. The prevalence of myopia indicates the same trend as that of other population groups. This is contrary to studies done on Africans in other African countries. Many investigators found lower prevalence of myopia and higher prevalence of hyperopia among Africans.

Studies by Holm (1937), Meyerhof (1914) and Drault-Tonfensco (1922) found a lower prevalence of myopia among Africans than amongst Caucasians. Mclaren (1961) compared the prevalence of myopia among Africans to that of Asiatics living in the same environment. He found a lower prevalence of myopia among Africans.

Stenstrom (1946), Kronfeld and Devney (1931) showed that 70% of Caucasians eyes fell in the refractive range of plano and +1.00D. In this study, 64,86% of people have refractive errors falling in the range of plano and +1.00D.

In this study, the mean refractive error was found to be +0.07 / -0.26 x 115. Saunders (1981) found the mean refractive error of +0.44 / -0.067 x 116, among people residing in the Cheshire and Lancashire areas in the United Kingdom. Kragha (1987) found the mean refractive error of -0.44 / -0.31 x 57.6, among the black population in Nigeria.

Some of the differences between this study and previous studies may be due to:

(1) The difference in the method of sampling of the population. Most of the studies are based on clinical samples, which do not reflect the refractive status of the general population.

(2) The differences in the statistical methods used to analyse data.

(3) The differences in the method of obtaining the mean refractive error. Most investigators used the spherical equivalents. The spherical equivalent ignores the direction of the cylinder axis and has no real physical meaning.

(4) Refractive techniques used. Some studies are done on atropinised eyes, or with the help of some other form of cycloplegia.

(4) The nature of the study. Studies can either be longitudinal or cross-sectional. This is a cross-sectional study, but has been compared to both longitudinal and cross-sectional studies.

(5) The small number of students (sixty-nine) refracted for this study. There are few Umlazi students studying in the technikon. This sample ia biased because many of the students residing in Umlazi, have gone to study in technikons and universities elsewhere. This may have affected the results.

(6) The differences in the classification of astigmatism. In this study, "against-the-rule" and "with-the-rule" astigmatism were defined as axes within 15 degrees of 90 and 180 degrees respectively. Axes between 105 and 165 degrees and between 15 and 75 degrees were considered as oblique astigmatism. Other studies made use of Borish's classification (1970) and Saunders's classification (1981 , 1988).

Borish defined "against-the-rule" and "with-the-rule" astigmatism as those lenses within 30 degrees of 90 and 180 degrees respectively, and those whose axes fell between 120 and 150 degrees and between 30 and 60 degrees were considered as oblique astigmatism.

Saunders classified the axis directions as follows:

(1) "With-the-rule" astigmatism, axes 0-22.5 degrees and 158-180

degrees.

(2) "Against-the-rule" astigmatism, axes 68-112.5 degrees.

(3) Oblique astigmatism, axes 23-67.5 degrees and 113-157.5 degrees.

CHAPTER 6

DISCUSSION

SPHERICAL COMPONENT

At age four, hyperopia is evident. This hyperopia decreases with age towards emmetropia. Although this study does not investigate the distribution of ametropia among infants, we may conclude that the normal infants are hyperopic at birth and hyperopia decreases with age, as previous studies have found hyperopia at birth which decreased with age.

The decrease in hyperopia can be attributed to the growth of the eye, and the stabilisation of the corneal curvature. This is the process of emmetropization.

In the case of premature infants, myopia is observed at birth. Weale (1982) suggested that myopia of prematurity was attributed to corneal hyper-refraction. The radius of curvature of the cornea increases faster than other ocular components during the period preceding birth.

Upon entrance to school, children have an average refraction of +0.56 (this is at age six). Hyperopia decreases and refraction moves towards emmetropia. At age ten, myopia starts to appear among girls.

The prevalence of myopia increases throughout the adolescent stage until the age of twenty. The question to be asked now is :

Does myopia develop as a result of intensive use of the eye in tasks performed at near distance (as a product of the environment) or does it come primarily as a biological phenomenon (as an end product of growth of the optical elements of the eye)?

The use-abuse theory explains that school experience is a significant factor in the cause of myopia. Myopia has been found as an outcome of continual focusing on a near object. Continual accommodation exerts stress on the choroid, and elongates the choroid and the sclera along the anterior-posterior axis of the eye, causing myopia. Myopia increases with the level of education or grade of schooling.

The amount of time spent doing near work corresponds to the level of education. Students spend more time studying compared to secondary school children. The use-abuse theory fails to explain the lower incidence of myopia among students, as compared to secondary school children who exhibited higher incidence of myopia. However, we have to note the bias student sample in this study (cf. p 36).

The biological-statistical theory explains myopia in teenage children as due to growth and is related to age. However, the eye is fully grown at the age of fourteen. The biological theory does not explain the continual increase in myopia from age fifteen to twenty. According to this theory, myopia could result even in children who are not schooling.

Even though the biological theory fails to explain the increase in myopia from age fifteen to twenty, it helps to explain the lower prevalence of myopia among students. Students's ages range from nineteen to twenty-eight. Therefore there is a decrease in myopia from age twenty onwards.

After age twenty, myopia decreases and the refractive error shifts towards emmetropia at the age of thirty-three. Thereafter the refraction shifts slowly towards hyperopia. Hyperopia is more evident at the age of forty and increases with advancing age. The increase in hyperopia is explained by the fact that the lens continues its growth throughout life (Weale, 1963).

There is no significant difference in the distribution of refraction between males and females except in the fourth age group. This difference between males and females may be due to menopausal changes in females. Females have higher frequencies in the hyperopic side than males.

The other sex difference was observed at the age range of ten to twelve. Although there is no significant difference, girls exhibit myopia earlier than boys. This may be attributed to earlier physiological maturation among girls, at puberty.

ASTIGMATISM

There is no correlation between the cylinder power, age and sex. The incidence of high astigmatism is low. The highest cylinder power exhibited is -2.25D.

Oblique astigmatism was observed in the first age group. "With-the-rule" astigmatism was observed in the second age group (16-27). "Against-the-rule" astigmatism was observed throughout the remainder of the life span.

The cornea becomes flatter with age. Therefore "with-the-rule" and oblique astigmatism are apt to be converted into "against-the-rule" astigmatism with age. The "against-the-rule" astigmatism appears to relate to a greater preference for eye scaning in the vertical meridian (Forrest, 1980).

Emmetropes seem to spend more time doing near work than myopes and hyperopes. There is no significant difference between myopes and hyperopes on the amount of time spent doing near work.

No relationship was observed between low illumination and myopia. Candles and paraffin lamps were regarded as low illuminated lamps compared to electrical lamps. High myopia (above -4.00D) was observed in people using electrical lamps.

A person using candles or paraffin lamps becomes adapted to low illumination. The problem obtained with low illumination is the strain placed on accommodation. Therefore a person using candles and/or paraffin lamps accommodates more compared to a person using electrical lamps (Young, 1975).

The effect of illumination on the refractive error can only be investigated among people who are totally exposed to a specific lighting system all the time. In this study, we found that most people use electricity in their different occupations during the day and use either candles / paraffin lamps or electric lamps at their homes in the evening.

The prevalence of myopia in this study is comparable to that of Caucasians. The incidence of refractive error is similar to that of Caucasians.

The influence of heredity on ametropia has not been investigated in depth. It is therefore difficult to come out with a definite conclusion from these results.

Vision screening in children is an important tool for early detection of refractive abnormalities, in order to institute corrective treatment at an early age. There is a relationship between visual function and learning. Visual anomalies in a child may restrict the development of the child's social and academic future.

Upon entrance to pre-school and school, children are only screened for medical defects. Vision screening in pre-school and school children has been neglected in this community. This has been shown by the number of school children referred from this study for full eye-examination. From the report back on referrals, many children had glasses prescribed for them.

There is also a lack of knowledge among parents about ocular hygiene and eye-care. Most people have not had eye- examinations, which indicates a lack of "visual awareness" in the community.

CHAPTER 7

CONCLUSION

Hyperopia has been observed in young children up to the age of seven, and also in the middle age and old age people. Myopia was observed from age ten to age thirty-three. Emmetropia was observed at ages eight to nine and ages thirty-three to thirty-nine.

The distribution of refraction is leptokurtotic, with the highest peak at the zero region. The hyperopic tail extends to +4.50D and myopic tail extends to -8.25D. There is a low incidence of high myopia and hyperopia.

57.29% of the people need a spherical correction of between +0.50 and +2.00 dioptres, whilst 32.50% need a spherical correction of between -0.50 and -2.00 dioptres. 5.63% need a spherical correction of between -2.25 and -4.00 dioptres, and 3.33% need a spherical correction of between +2.25 and +4.00 dioptres. 0.83% and 0.46% need spherical correction of above -4.000 and above +4.00 dioptres, respectively.

The prevalence of high astigmatism is low. The highest cylinder power exhibited is -2.25D. 91.52% of the people need astigmatic corrections of between -0.50 and -1.00 dioptres, and 8.48% need cylindrical corrections of between -1.25 and -2.25 dioptres.

The Umlazi community may be taken as a representative of urban black population. Therefore these statistics will be significant to the optical companies. They will be able to estimate stock levels according to the need of the urban black population. We may also estimate the need of the rural black population from these statistics. However, the living conditions in a rural village are different from those of the township. The rural villages are underdeveloped.

Significant differences in refractive errors between sexes occured only at the age group forty to fifty-one. There is no difference between sexes in the other age groups.

Education and near work seem to account very little for the incidence of myopia among pupils and students. For the remainder of the people, there is no significant difference between myopes and hyperopes in relation to the amount of time spent doing near work. Appropriate evaluation of near work-refraction relationship requires a longitudinal study and a comparison of the children who are schooling with those children who do not go to school (same age).

Ametropia is related to age. Both the biological-statistical theory and the use-abuse theory try to explain the incidence of ametropia in this study.

It is mandatory for all children to be immunized prior to entry into school, yet vision screening is not done. Visual screening in pre-school and schoolgoing children has been neglected in this community in comparison to other racial communities in South Africa. This is a great challenge to optometrists as people serving the community, to carry out our noble services into this neglected community. This can be done in collaboration with the school authorities and the department of education.

Training school nurses to take visual acuity using the standardized visual acuity chart may help to alleviate the visual screening problem.

Generally, visual awareness in the community is lacking. Public information on the necessity of ocular hygiene and eye-care is of vital importance. Visual unawareness can be improved by issuing pamphlets or brochures and posters on ocular hygiene and eye-care. These should be translated into different African languages. The pamphlets or brochures and posters should be exhibited in schools, clinics, and community offices.

There is a shortage of optometrists in this community. For the population of 450 000, there is only one private optometric practice and one eye clinic. Generally there is a shortage of black optometrists. For the population of 20 132 000, there are only 24 black opometrists. Therefore there is a need of training more black optometrists.

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APPENDICES

UNIVERSITY OF DURBAN-WESTVILLE

DEPARTMENT OF OPTOMETRY

QUESTIONNAIRE

1. NAME AND SURNAME : ....

2. HOME ADDRESS : ....

....

....

....

3. DATE OF BIRTH : ....

PLEASE TICK THE RELEVANT ANSWERS

4. SEX :

M	F

5(a). Economic status :

Preschool	
Primary School	
High School	
Student	
Household Duties	
Unemployed	
Worker	
Retired	
Other (State)	
....	....
....	....

5(b). If you are a worker, briefly explain what you do at work.

....

....

....

5(c). How many hours per day do you spend doing your work?

....

5(d). How many hours per day do you spend doing work within arm's reach at work. ....

5(e). What lighting system do you use at work?

Natural light	
Candles	
Electrical lamps	
Paraffin lamps	
Other (state)	
....	....
....	....

6. What is the highest level of education reached?

No schooling	
Up to Std 2	
Std 3 - Std 4	
Std 5	
Std 6 - Std 7	
Std 8	
Std 9 - Std 10	
Tertiary Education (specify)	
....	....
....	....

7. What are your hobbies? ....

....

....

....

8. How many hours per week do you spend doing activities within arm's length such as weaving, reading, writing and etc. (do not include hours spent at work, see Q5(d)).

0	1-5	6-10	11-15	16-20	21-25	26-30	>30

9(a). What lighting system do you use at home?

Candles	
Electrical lamps	
Paraffin lamps	
Other (state)	 ....

9(b). How many hours per week do you spend doing work within arm's length using this lighting system.

0	1-5	6-10	11-15	16-20	21-25	26-30	>30

10(a) Do you have any difficulty in seeing near objects?

YES	NO

10(b) Do you have any difficulty in seeing far objects?

YES	NO

11(a) Have you had an eye-examination before?

YES	NO

11(b) If yes, how many times have you been examined. ....

11(c) When was your last eye-examination done? ....

12(a) Do you wear spectacles?

YES	NO

12(b) If yes, when did you start wearing them?

2 years	
2-4 years	
5-7 years	
8-10 years	
10 years	

13(a) Do you wear contact lenses?

YES	NO

13(a) If yes, when did you start wearing them?

2 years	
2-4 years	
5-7 years	
8-10 years	
10 years	

14(a) Is there anyone in your family having eye-problems?

YES	NO

14(b) If yes, describe the eye-problems.

....

....

....

....

15. Is there anyone in your family wearing glasses or contact lenses?

YES	NO

Table 1: Correlation between the auto-refractor and conventional refracting methods.

Auto-refractor			Conventional refracting methods		
Sphere	Cylinder	Axis	Sphere	Cylinder	Axis
-5.50	-1.00	005	-5.75	-1.50	165
-5.00	0.00	000	-5.00	0.00	000
-4.75	-0.25	015	-4.25	0.00	000
-4.50	-0.50	006	-5.25	-0.50	015
-4.50	-0.25	180	-4.00	-0.75	180
-2.25	0.00	000	-2.00	0.00	000
-2.25	-0.50	175	-1.25	-0.25	180
-2.00	-1.00	010	-2.00	-0.50	015
-2.00	0.00	000	-0.75	-0.25	075
-1.50	-0.25	180	-1.00	0.00	000
-1.25	-0.25	011	-1.25	-0.25	015
-1.25	-0.50	012	-0.75	-0.25	010
-1.00	-0.75	014	-0.75	0.00	000
-1.00	-0.50	015	-0.50	-0.75	020
-1.00	-0.75	017	-0.25	-0.75	020
-1.00	-0.25	043	0.00	-0.25	030
-1.00	-0.50	055	-1.00	-0.25	045
-0.75	-0.25	080	-1.00	-0.25	090
-0.75	-0.75	065	-0.75	-0.50	060
-0.75	-0.50	066	-0.25	-0.50	075
-0.50	-0.75	055	-0.75	-0.25	070
-0.50	-0.75	068	-0.50	-0.75	105

/ cont

/ table 1 cont

-0.50	-0.50	076	-0.25	-0.25	080
-0.25	-0.25	085	-0.25	-0.25	090
-0.25	-0.75	087	0.00	-1.00	075
-0.25	-0.50	180	-0.50	-0.75	175
-0.25	-0.25	180	-0.25	-0.25	180
0.00	-0.25	087	0.00	-0.50	090
0.00	-0.75	180	0.00	-1.00	180
0.00	-0.25	180	0.00	0.00	000
0.00	-0.50	90	0.00	0.00	000
0.00	-0.25	096	+0.25	-0.50	090
0.00	0.00	000	0.00	0.00	000
+0.25	-1.00	111	0.00	-0.50	120
+0.25	-0.75	180	0.00	0.00	000
+0.25	-0.50	116	+0.50	-0.25	120
+0.25	-0.50	146	+0.25	-0.25	175
+0.50	-0.75	136	0.00	-0.50	150
+0.50	-1.00	142	+0.25	-0.50	120
+0.50	-0.75	145	+0.50	-0.75	015
+0.75	-0.25	149	0.00	-0.50	150
+0.75	-0.50	157	+0.25	-0.50	160
+0.75	-0.50	161	+0.75	-0.25	165
+1.00	-0.75	085	+0.25	-0.25	110
+1.00	-0.75	111	+0.75	-1.00	085
+1.00	-1.00	171	+0.50	-1.00	180
+1.25	-0.50	172	+1.25	-0.50	170
+1.50	-0.75	160	+1.50	-0.25	140
+1.75	-0.25	175	+0.75	-0.25	165
+1.75	-0.50	180	+1.50	0.00	000

The correlation between the auto-refractor and conventional refracting techniques was calculated. For the spherical components: $r = +0.97$, $r = +0.57$ for the cylindrical components, and $r = +0.81$ for the axes. The correlation values suggested a satisfactory working correlation between the auto-refractor and the conventional refracting methods.

Table 2: Incidence of Refractive Errors (spherical components)

Sphere	Total	Male	Female
-8.25	1	0	1
-6.25	1	0	1
-5.00	2	0	2
-4.00	1	1	0
-3.75	2	1	1
-3.50	3	3	0
-3.25	2	1	1
-3.00	2	0	2
-2.75	4	1	3
-2.50	3	2	1
-2.25	10	5	5
-2.00	12	5	7
-1.75	7	6	1
-1.50	9	7	2
-1.25	17	6	11
-1.00	24	13	11
-0.75	31	19	12
-0.50	56	28	28
0	297	149	148
+0.50	96	58	38
+0.75	51	21	30
+1.00	60	29	31
+1.25	27	13	14
+1.50	16	5	11
+1.75	13	7	6
+2.00	12	7	5
+2.25	6	4	2
+2.50	4	0	4

/cont

/Table 2 cont

+2.75	2	0	2
+3.00	3	1	2
+4.00	1	1	0
+4.25	1	0	1
+4.50	1	1	0
Total	777	394	383

Table 3: Incidence of Refractive Errors (cylindrical components)

Cylinder power	Total	Males	Females
-2.25	1	0	1
-2.00	1	0	1
-1.75	1	0	1
-1.50	6	3	3
-1.25	15	9	6
-1.00	51	25	26
-0.75	67	41	26
-0.50	141	68	73
0	494	248	246
Total	777	394	383

Table 4. The prevalence of refractive errors for each age group in percentages.

Age group	Sex	Emmetropia	Hyperopia	Myopia	% of total sample with astigmatism
1. 4-15	F	38.74	43.24	18.02	29.73
	M	35.14	44.14	20.72	28.83
2. 16-27	F	43.88	12.24	43.88	31.63
	M	56.48	12.04	31.48	36.11
3. 28-39	F	48.44	31.25	20.31	39.06
	M	40.00	32.31	27.69	38.46
4. 40-51	F	38.89	55.56	5.56	37.04
	M	33.93	46.43	19.64	44.64
5. >51	F	12.73	72.73	14.55	47.27
	M	9.09	67.27	23.64	49.09

Table 5: Mean sphere errors for each age group.

	FEMALE			MALE		
AGE GROUP	N	MEAN	SD	N	MEAN	SD
4-15	111	+0.15	0.90	111	+0.09	0.96
16-27	98	-0.66	1.37	108	-0.38	0.91
28-39	64	-0.01	0.89	65	-0.03	0.97
40-51	54	+0.55	0.65	56	+0.20	0.77
>51	55	+1.07	1.46	55	+0.79	1.28

Table 6: Mean cylindrical errors for each age group

	FEMALE			MALE		
AGE GROUP	N	MEAN	SD	N	MEAN	SD
4-15	111	-0.25	0.37	111	-0.25	0.96
16-27	98	-0.22	0.34	108	-0.30	0.37
28-39	64	-0.28	0.32	65	-0.32	0.38
40-51	54	-0.29	0.34	56	-0.38	0.49
>51	55	-0.44	0.52	55	-0.36	0.43

Table 7: Mean refractive error for each age group

AGE GROUP	SPHERE	CYLINDER	AXIS
4-15	+0.12	-0.25	137
16-27	-0.54	-0.25	180
28-39	-0.01	-0.30	75
40-51	+0.39	-0.37	90
>51	+0.90	-0.40	100

Table 8: Mean spherical error for students and school children.

	FEMALE			MALE		
	N	MEAN	SD	N	MEAN	SD
Pre-school	20	+1.08	0.45	23	+0.96	0.64
Primary school	64	+0.09	0.26	59	+0.16	0.55
Secondary school	59	-0.78	1.32	62	-0.74	1.11
Students	26	-0.28	0.49	43	-0.44	0.98

Table 9: Mean cylindrical error for students and school children.

	FEMALE			MALE		
	N	MEAN	SD	N	MALE	SD
Pre-school	20	-0.36	0.38	23	-0.33	0.43
Primary school	64	-0.17	0.26	59	-0.25	0.34
Secondary school	59	-0.30	0.42	62	-0.23	0.34
Students	26	-0.13	0.24	43	-0.20	0.34

TABLE 10: Mean refractive error for students and school children.

	SPHERE	CYLINDER	AXIS
Pre-school	+1.01	-0.34	110
Primary school	+0.12	-0.21	120
Secondary school	-0.75	-0.25	145
Students	-0.35	-0.17	110

Table 11: Mean spherical error; lighting.

	N	MEAN	SD
Electricity	467	+0.08	1.20
Candle/ paraffin	310	+0.06	0.98

Table 12: Mean cylindrical error; lighting

	N	MEAN	SD
Electricity	467	-0.29	0.40
Candle/ paraffin	310	-0.24	0.37

Table 13: Comparison of the spherical equivalents

AGE GROUP	PRESENT STUDY	KRAGHA	RICHLER & BEAR
4-9	+0.59	-	+0.62
0-14	-	-0.63	-
10-14	-0.45	-	-0.17
15-19	-0.82	-1.04	-0.92
20-24	-0.63	-0.78	-0.81
25-29	-0.25	-0.65	-0.28
30-34	-0.15	-0.66	-0.09
35-39	-0.02	-0.27	+0.08
40-44	+0.33	+0.04	+0.24
45-49	+0.21	+0.63	+0.53
>50	+0.88	+0.59	-
50-54	-	-	+0.76
55-59	-	-	+0.75
60-64	-	-	+1.41
65-69	-	-	+1.44
70-74	-	-	+1.01

TABLE 14 : COMPARISON OF THE PREVALENCE OF MYOPIA IN SCHOOL CHILDREN

COUNTRY	PERCENTAGE	PERCENTAGE (SECONDARY SCHOOL CHILDREN ONLY)
Sweden	17	
Sweden		19-25
Japan	27	
Japan		46
Germany	27	
Tanzania	11-28	
Egypt	70	
Monrovia and Dar-es-Salaam	1.68	
Present study	27	
Present study		50

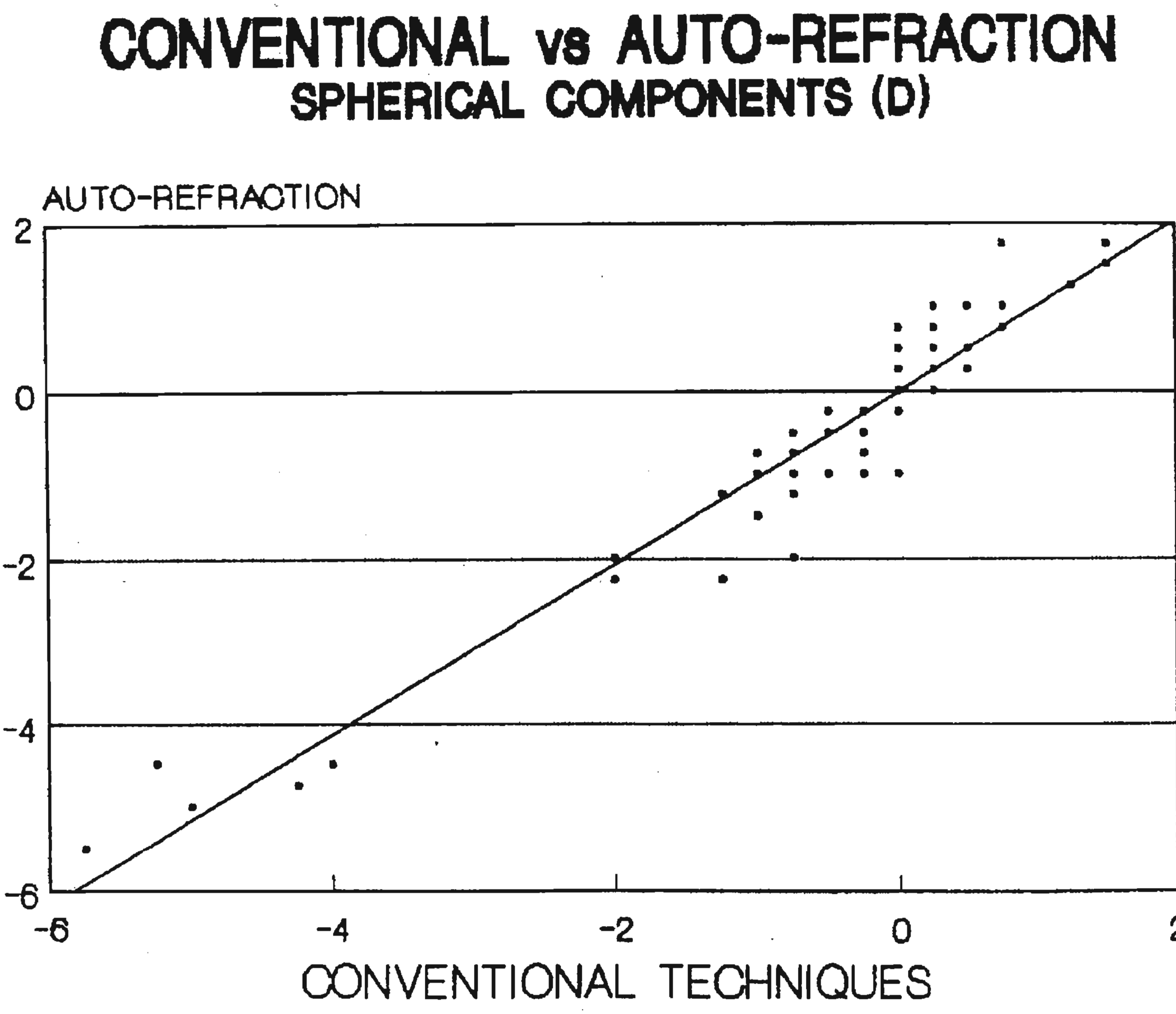

Figure 1: Conventional Techniques vs Auto-Refraction (Spherical Components)

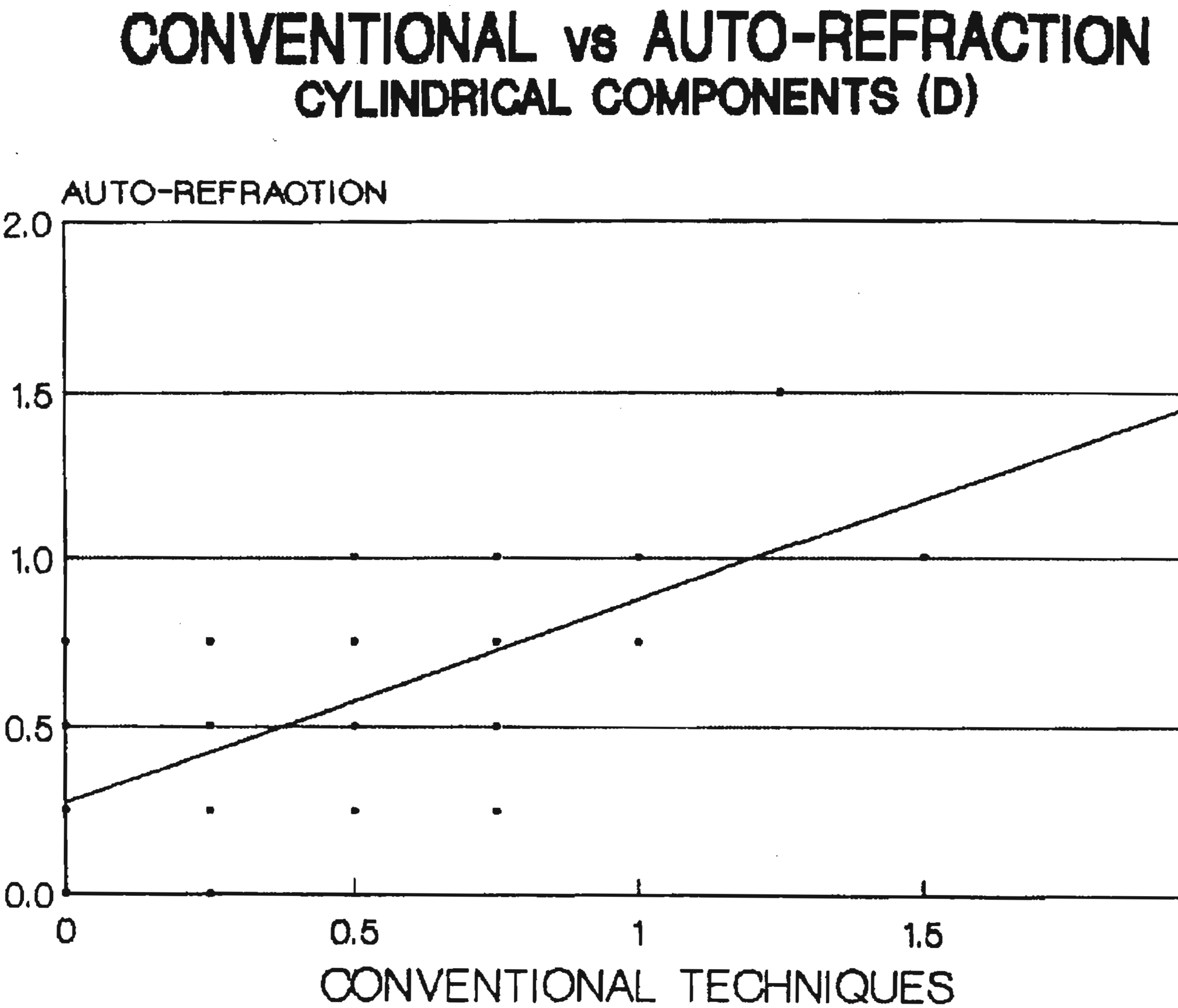

Figure 2: Conventional Techniques vs Auto-Refraction (Cylindrical Components)

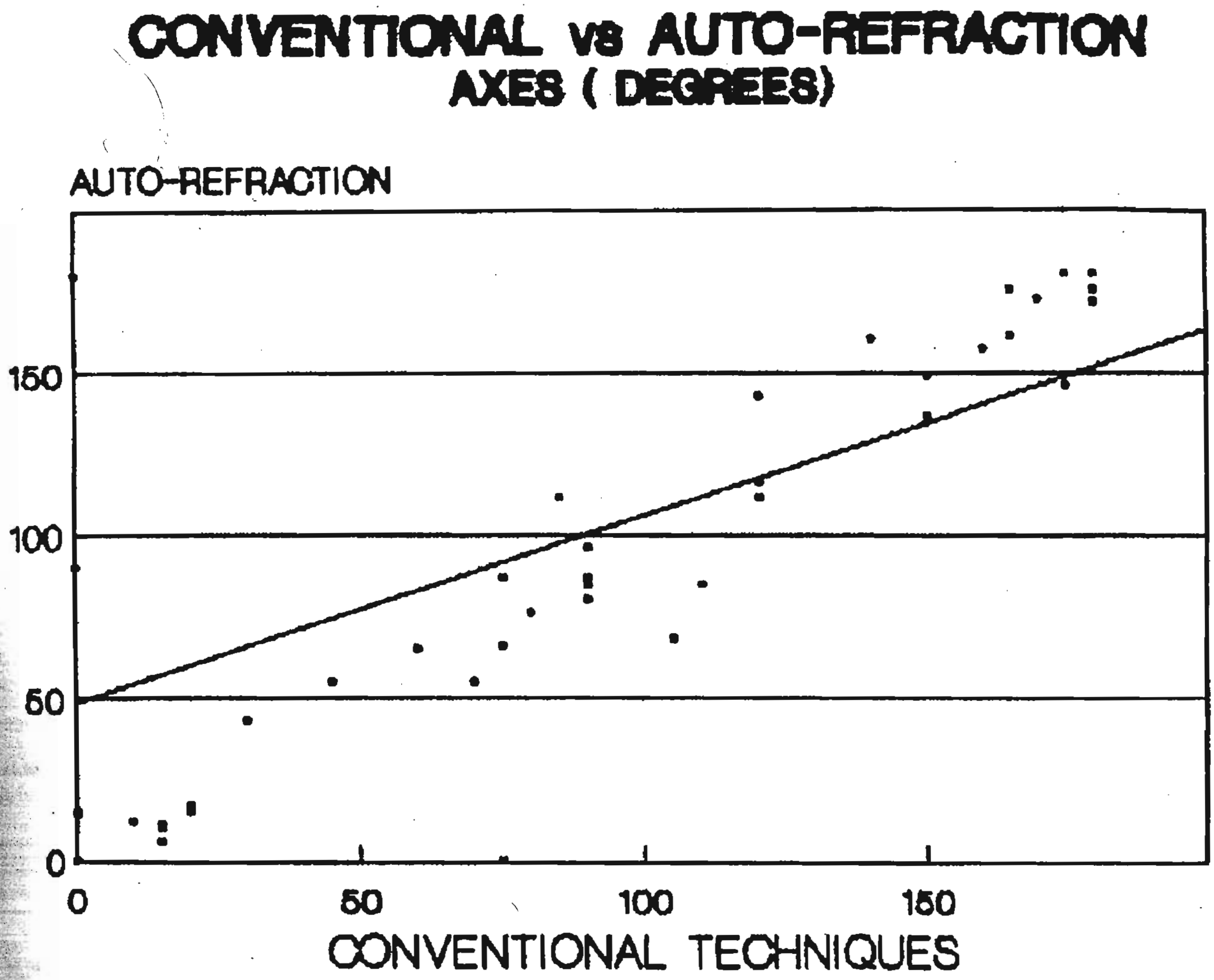

Figure 3: Conventional Techniques vs Auto-Refraction (Axes)

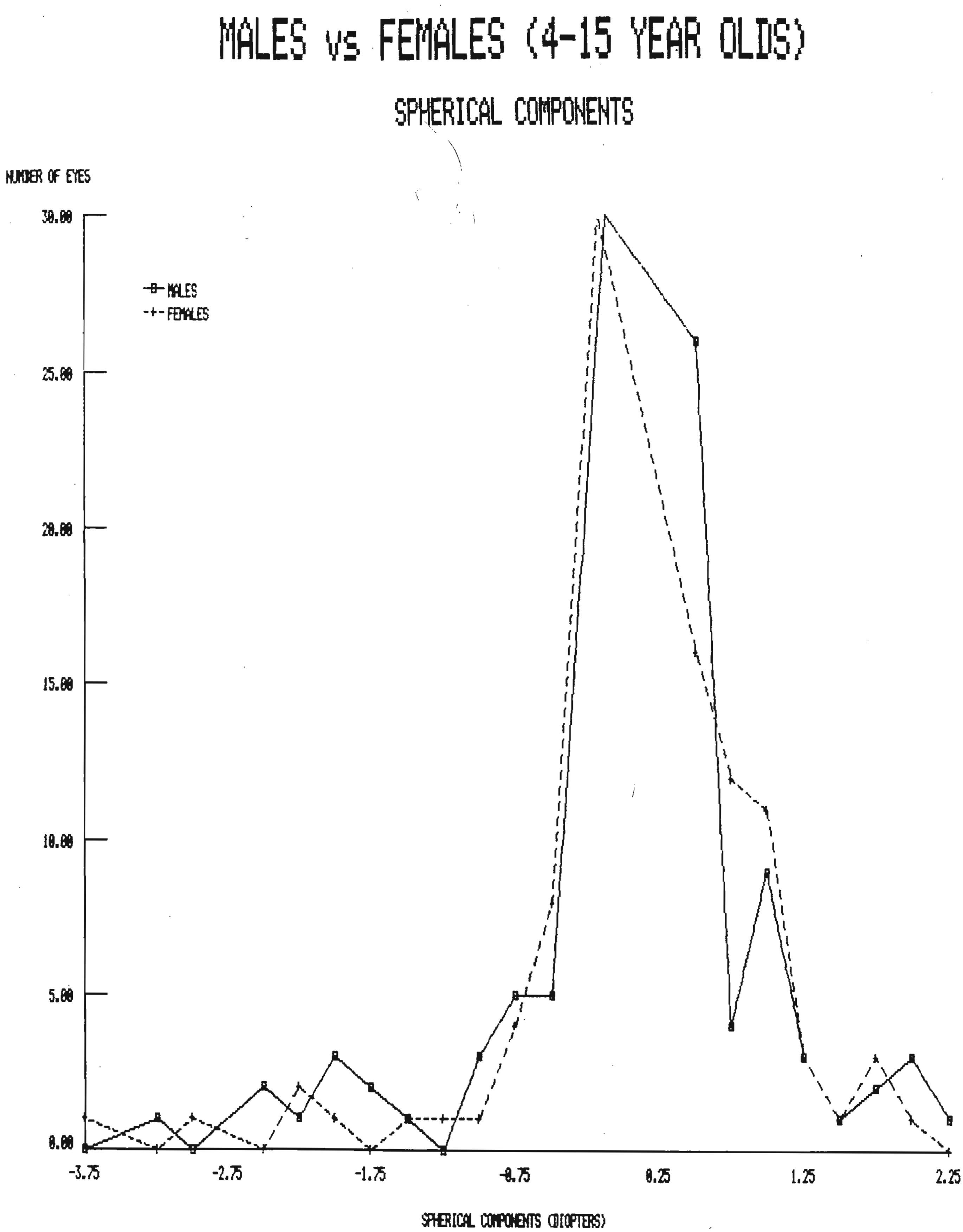

Figure 4: Distribution of the spherical Components in the first age group

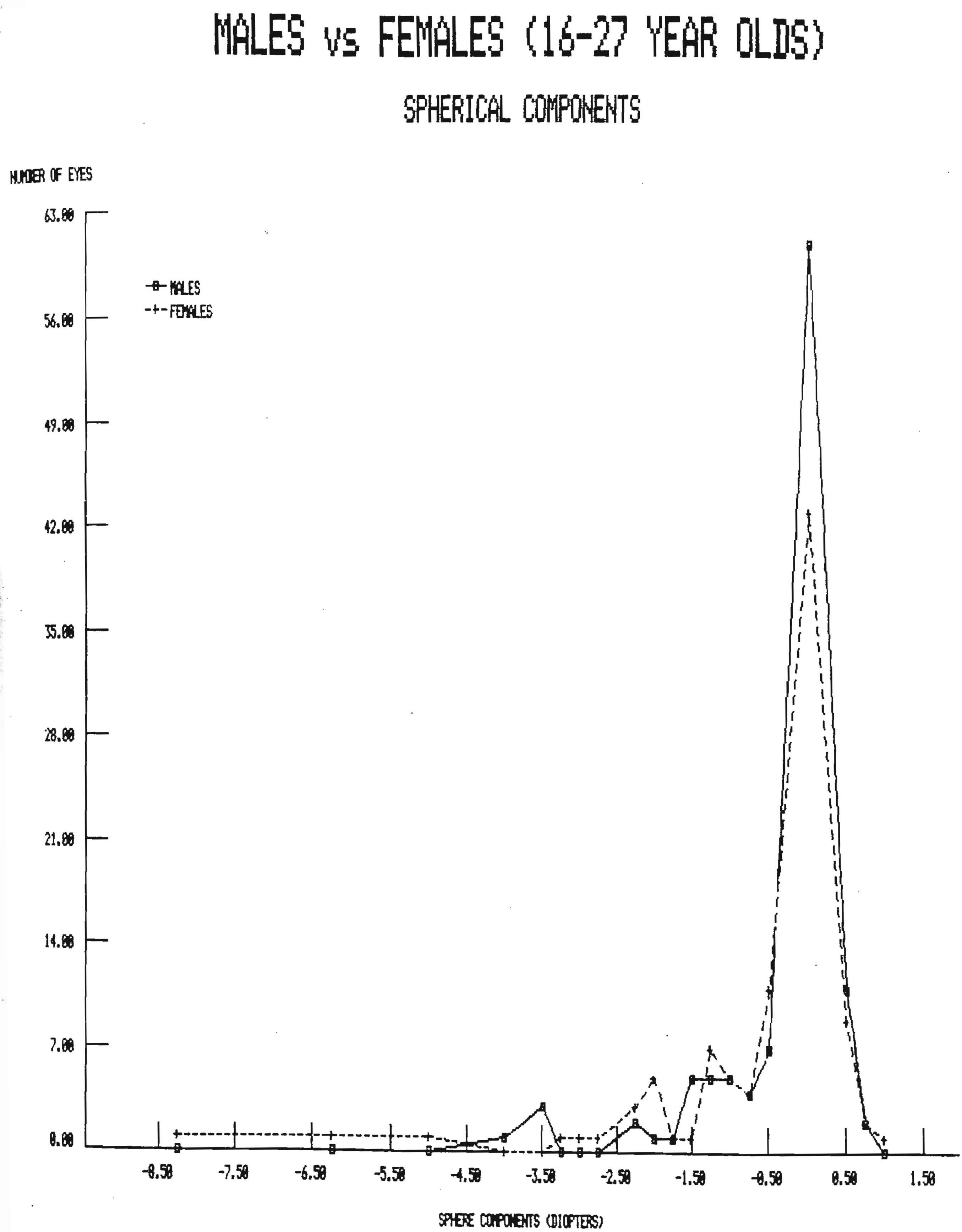

Figure 6: Distribution of the spherical components in the second age group

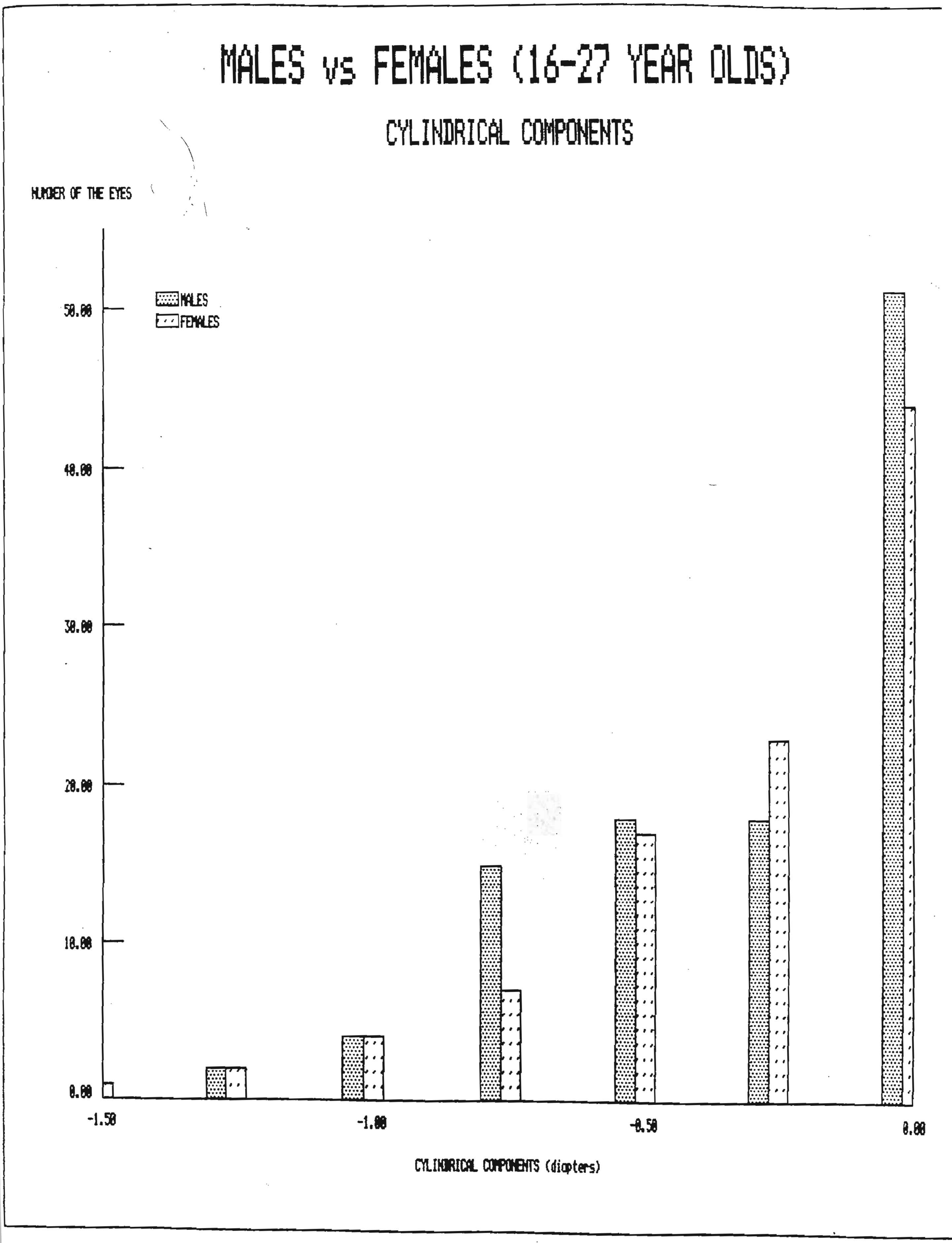

Figure 7: Distribution of the cylindrical components in the second age group

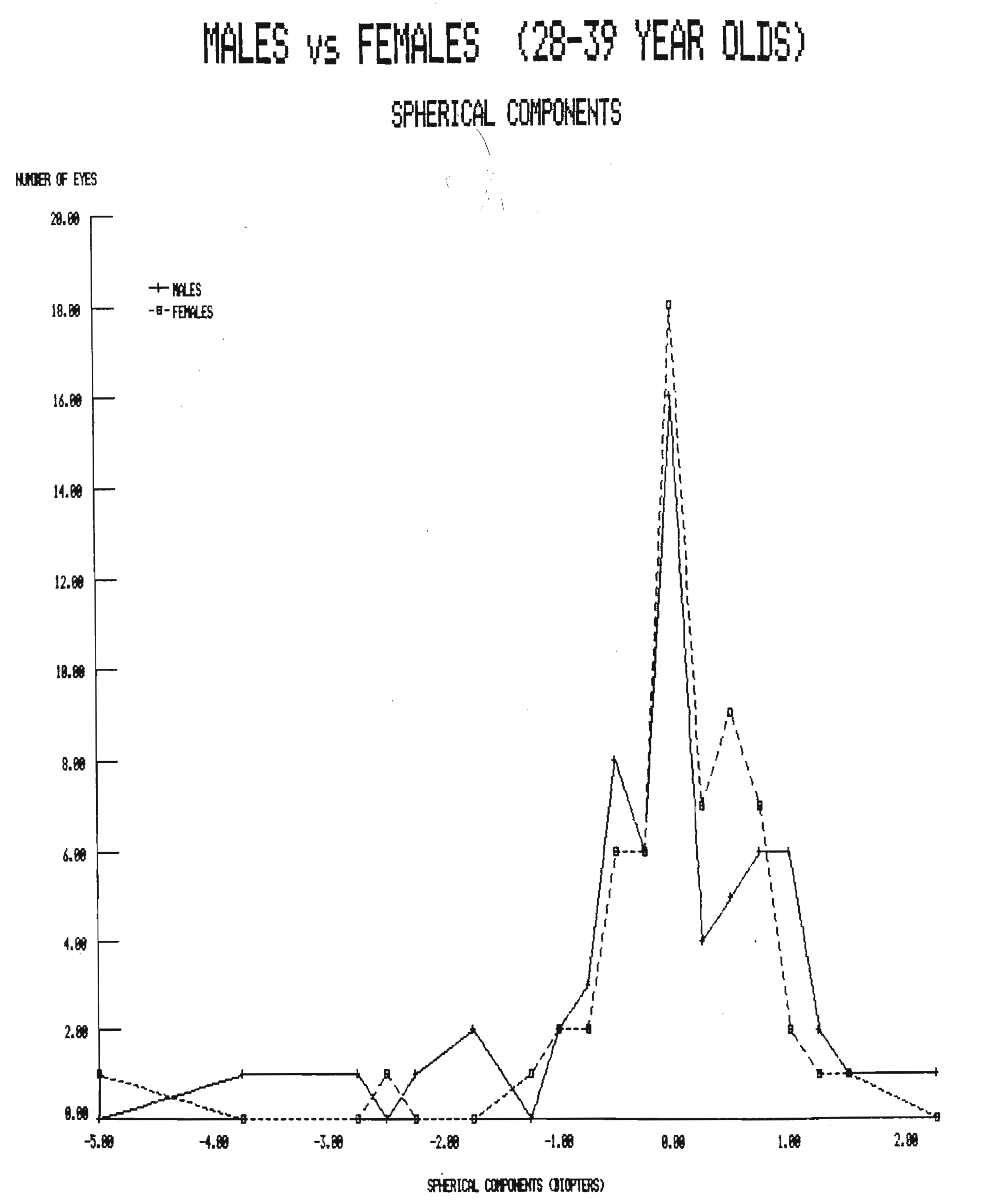

Figure 8: Distribution of the spherical components in the third age group

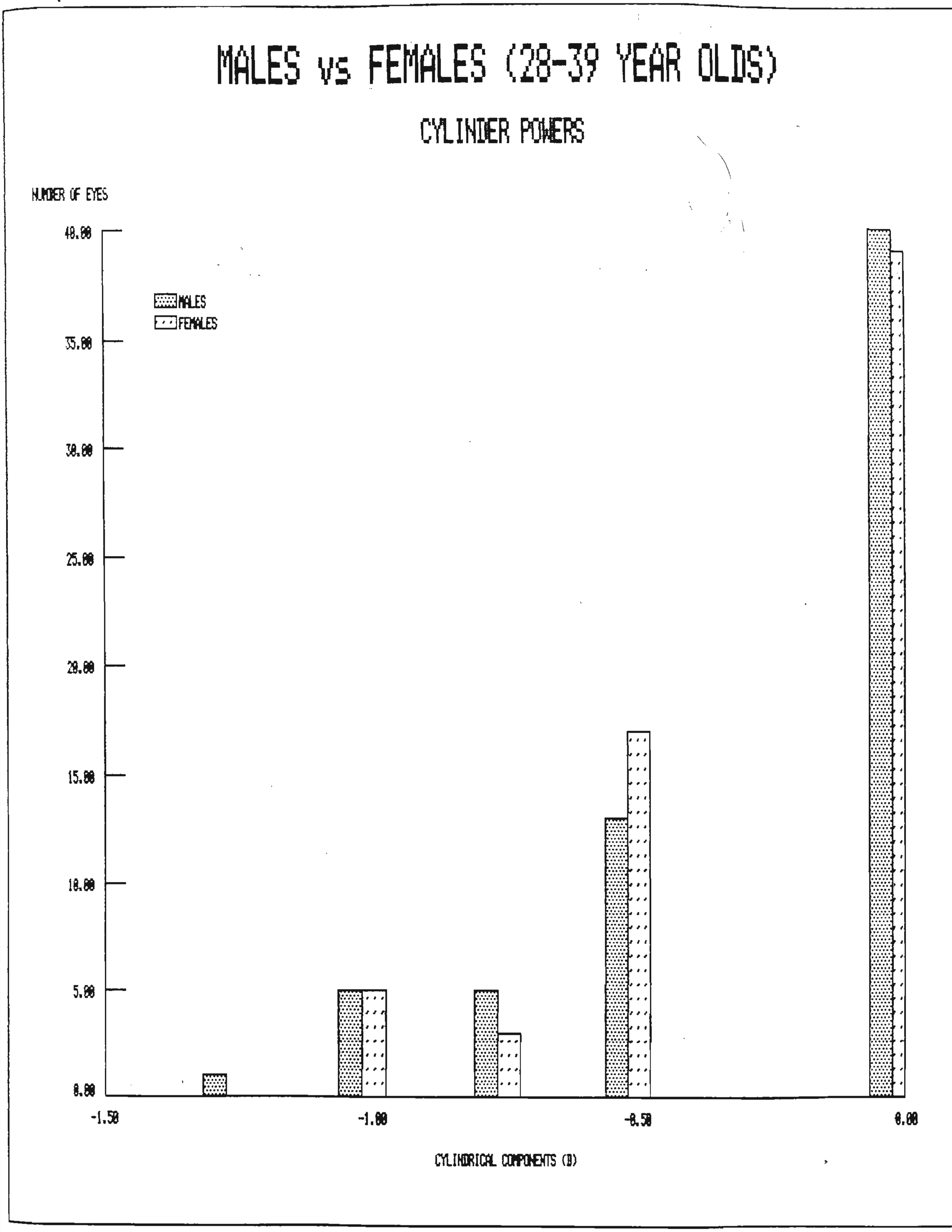

Figure 9: Distribution of the cylindrical components in the third age group

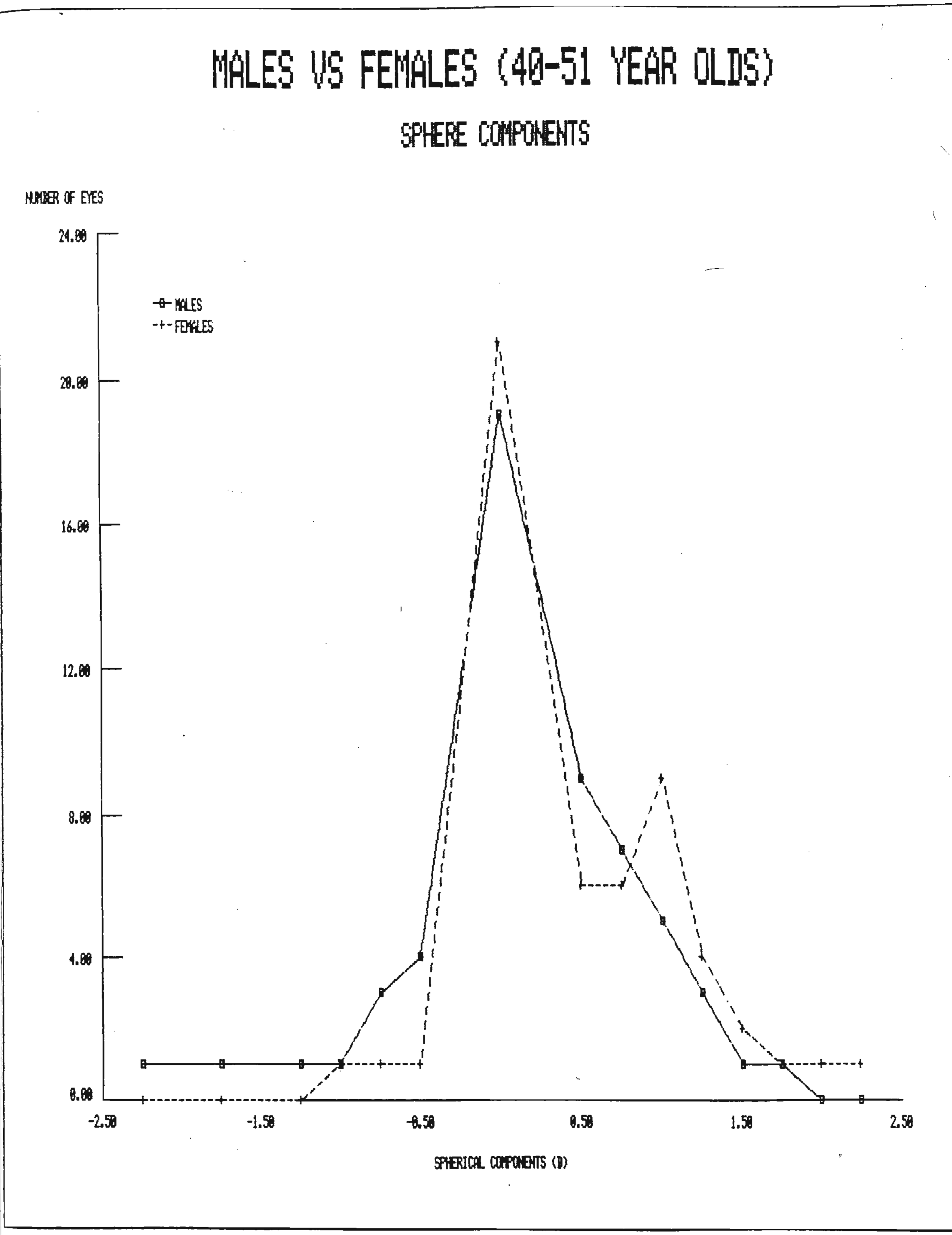

Figure 10: Distribution of the spherical components in the fourth age group

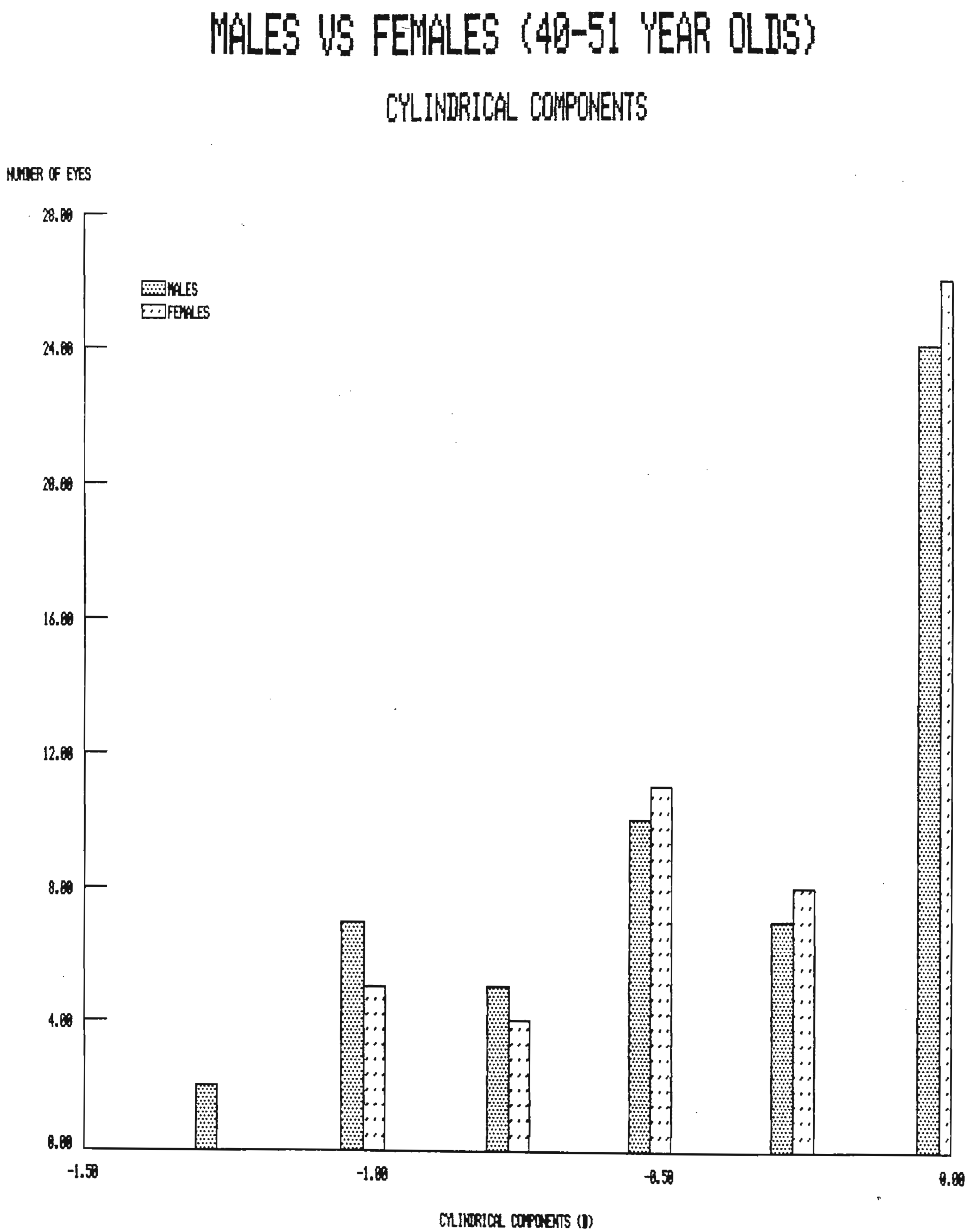

Figure 11: Distribution of the cylindrical components in the fourth age group

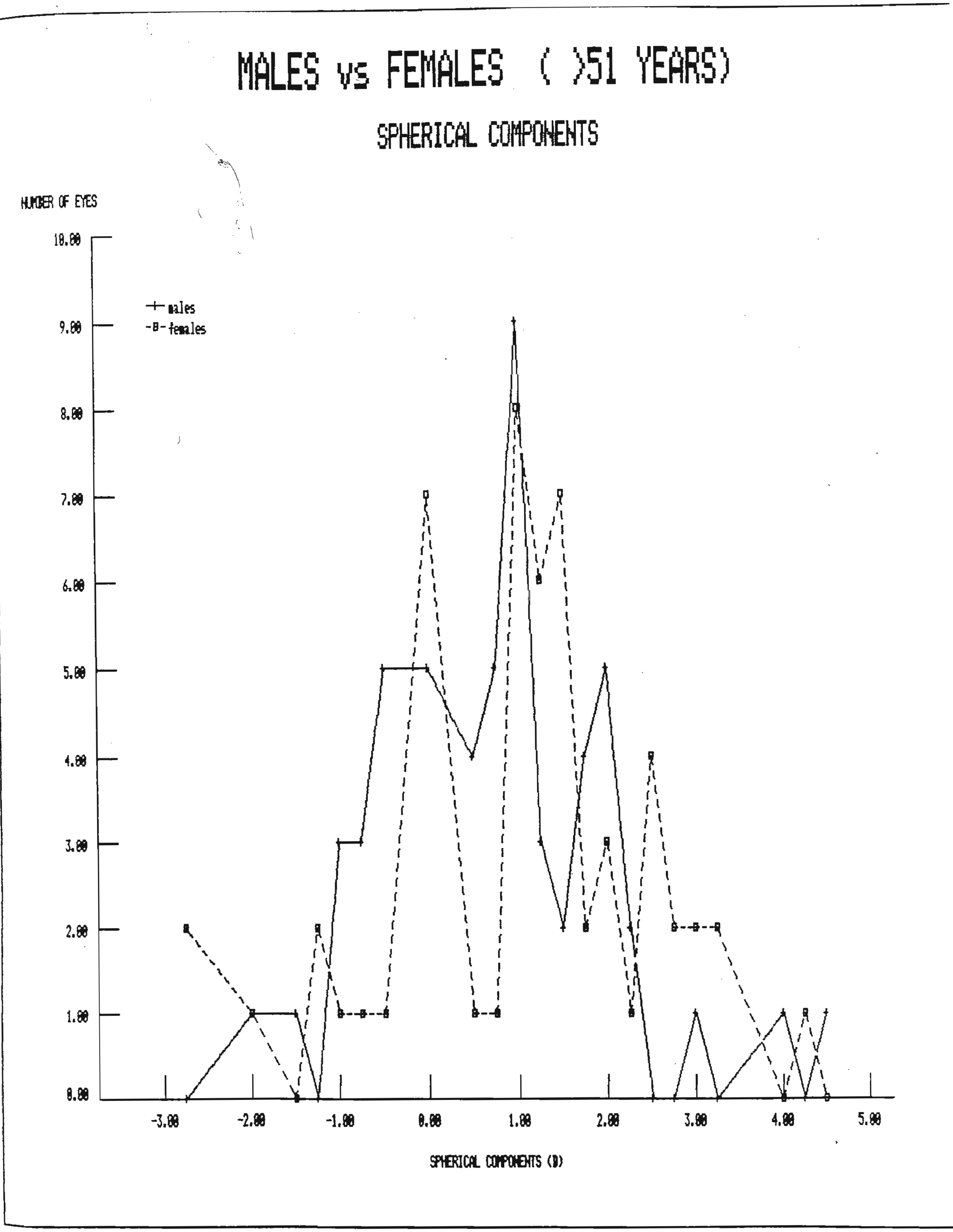

Figure 12: Distribution of the spherical components in the fifth age group

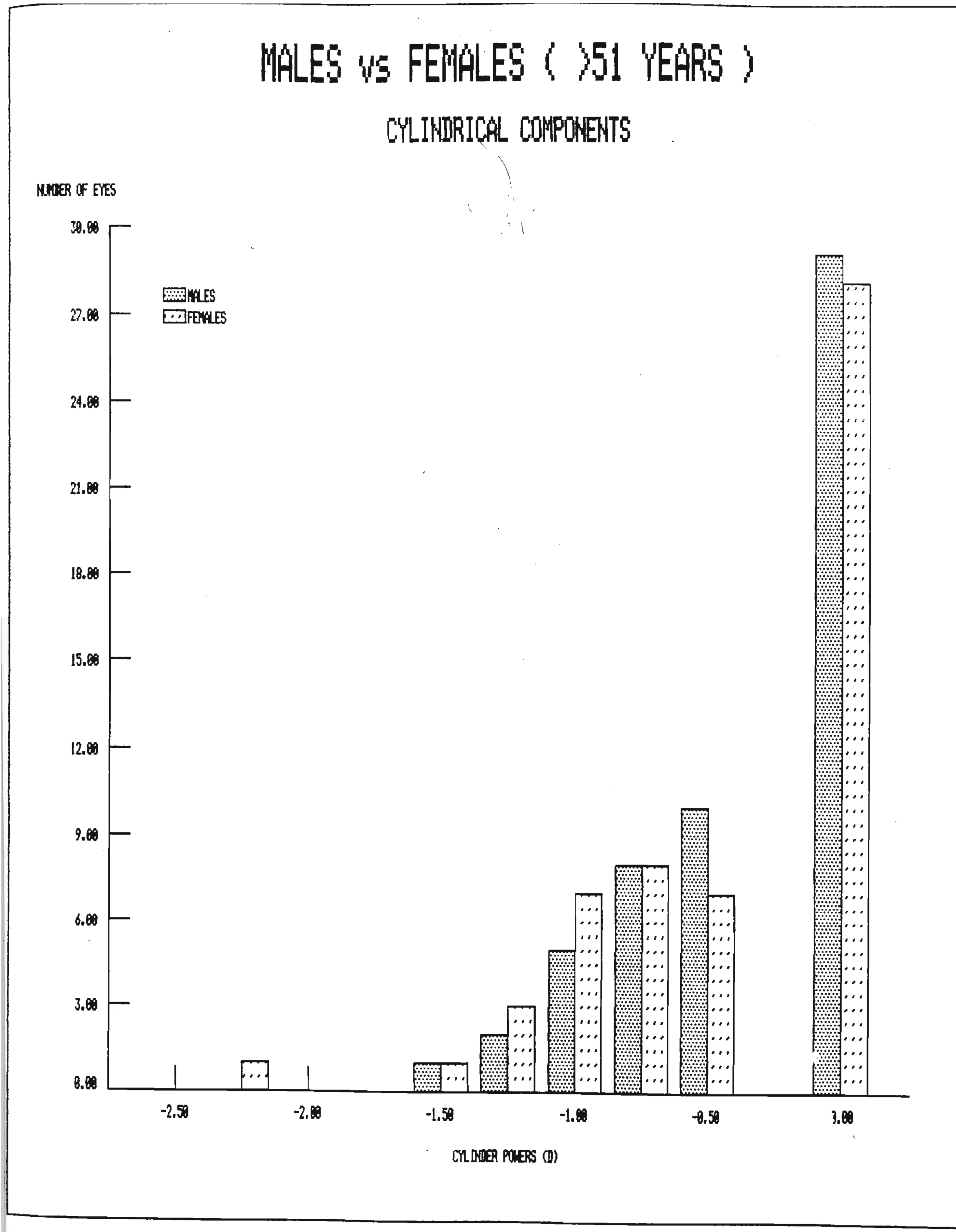

Figure 13: Distribution of the cylindrical components in the fifth age group

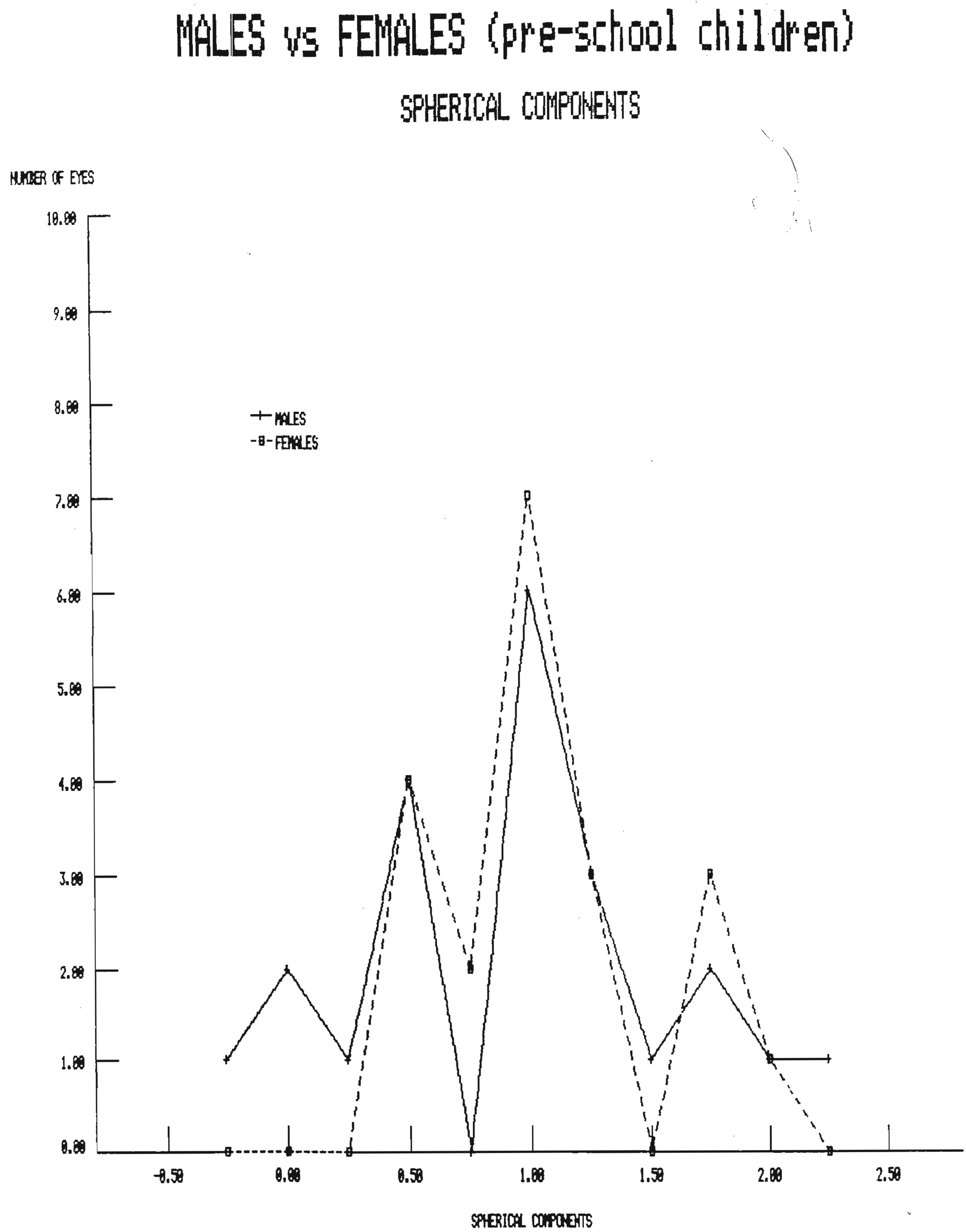

Figure 14: Distribution of the spherical components in pre-school children

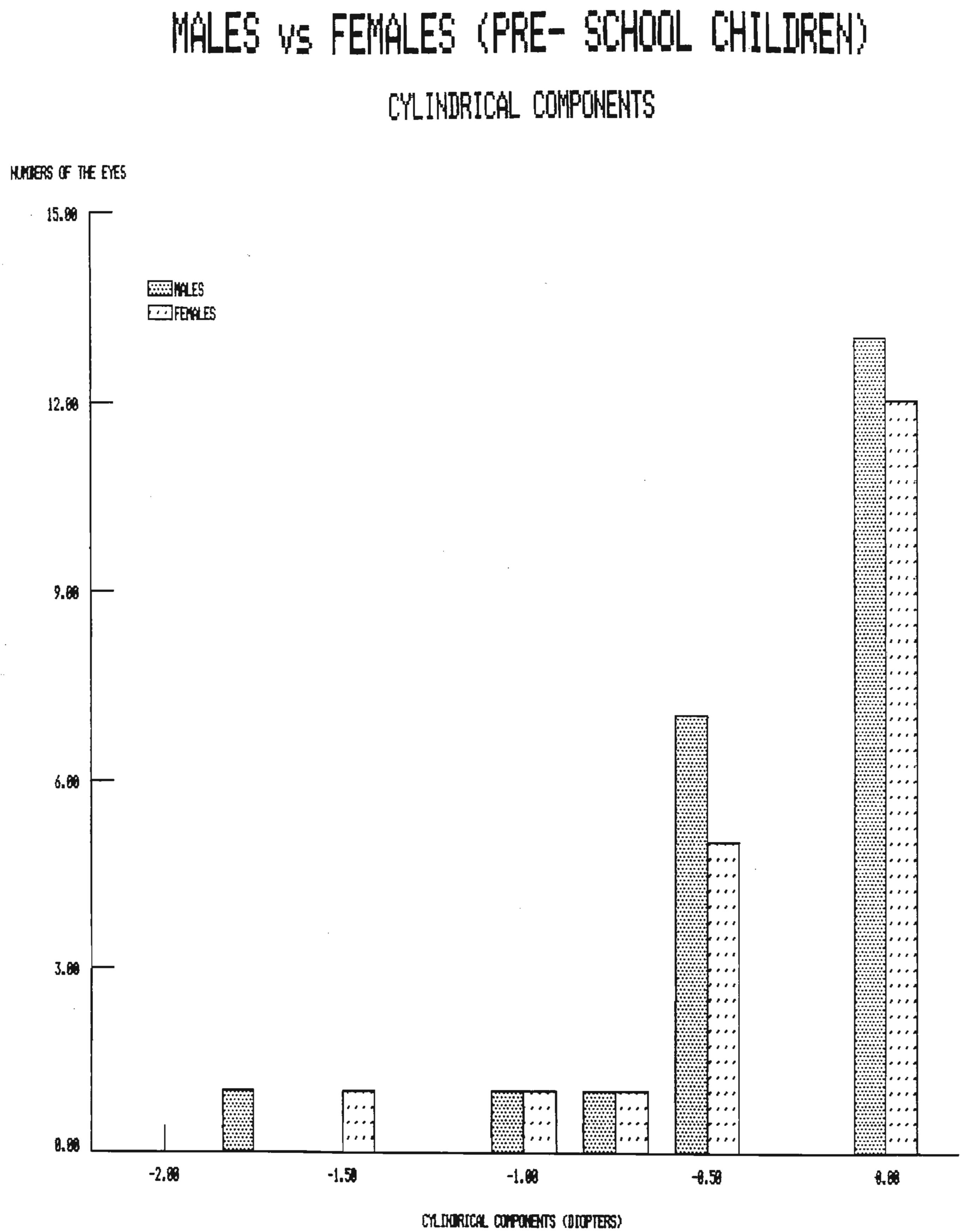

Figure 15: Distribution of the cylindrical components in pre-school children

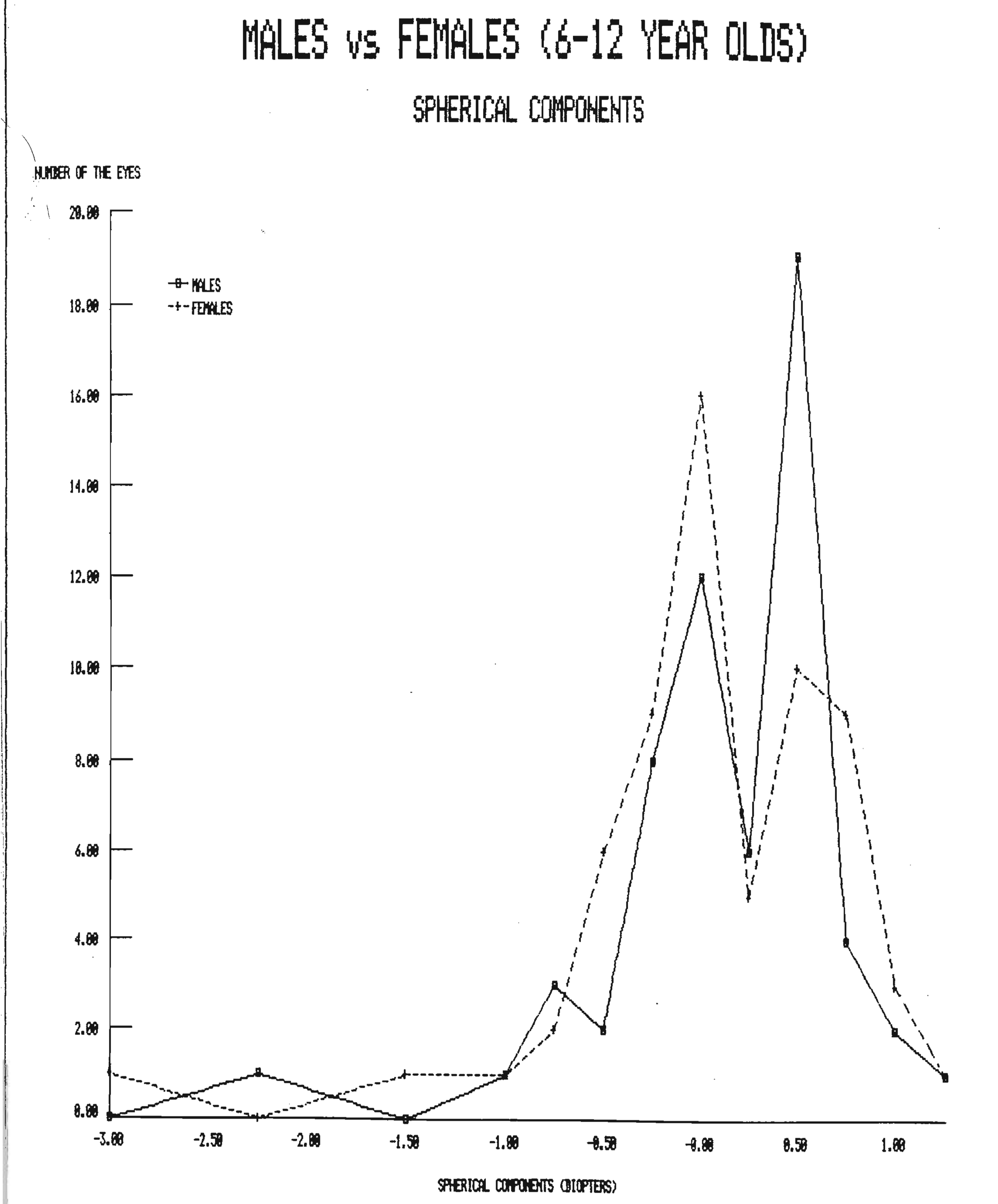

Figure 16: Distribution of the spherical components in primary school children

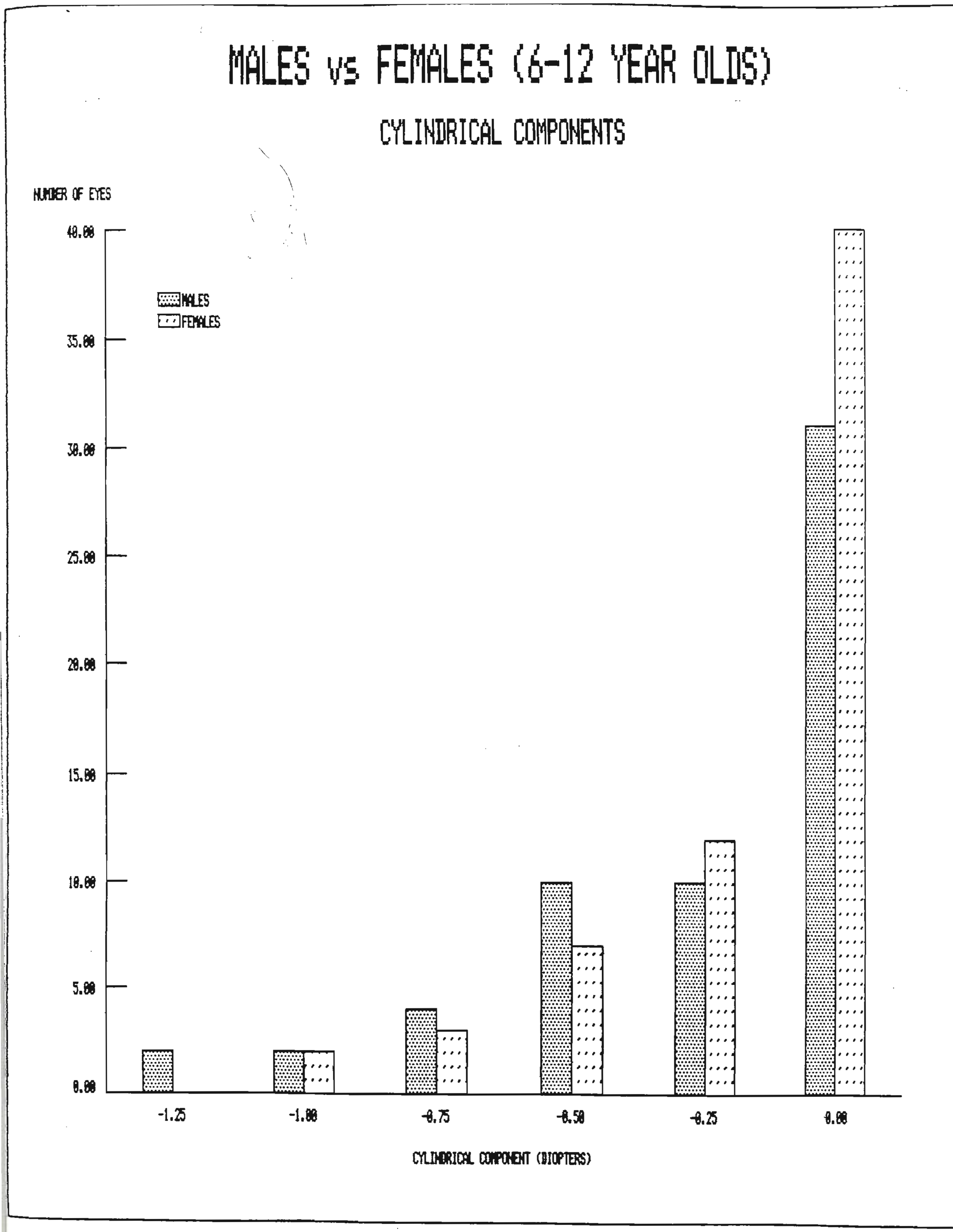

Figure 17: Distribution of the cylindrical components in primary school children

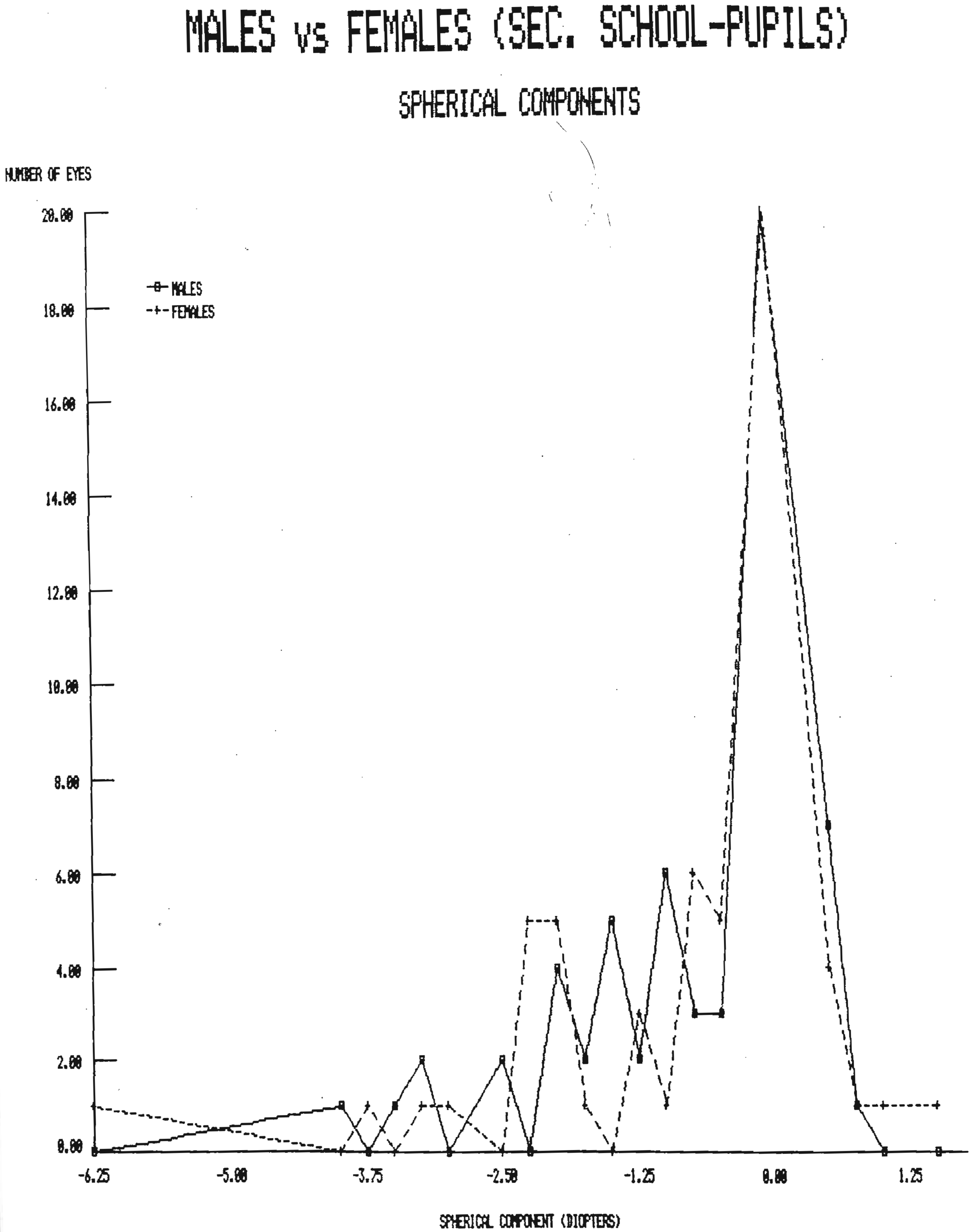

Figure 18: Distribution of the spherical components in secondary school children

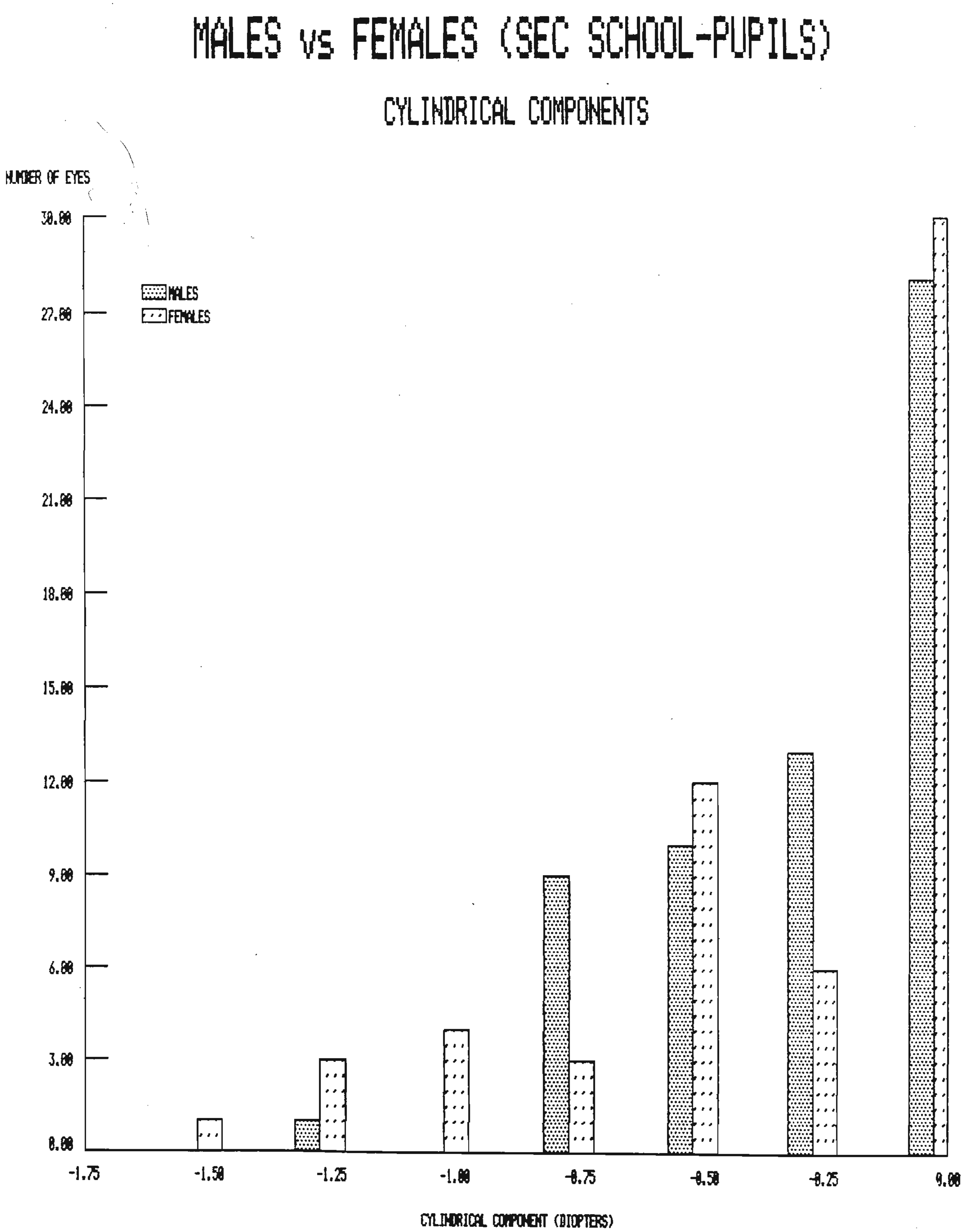

Figure 19: Distribution of the cylindrical components in secondary school children

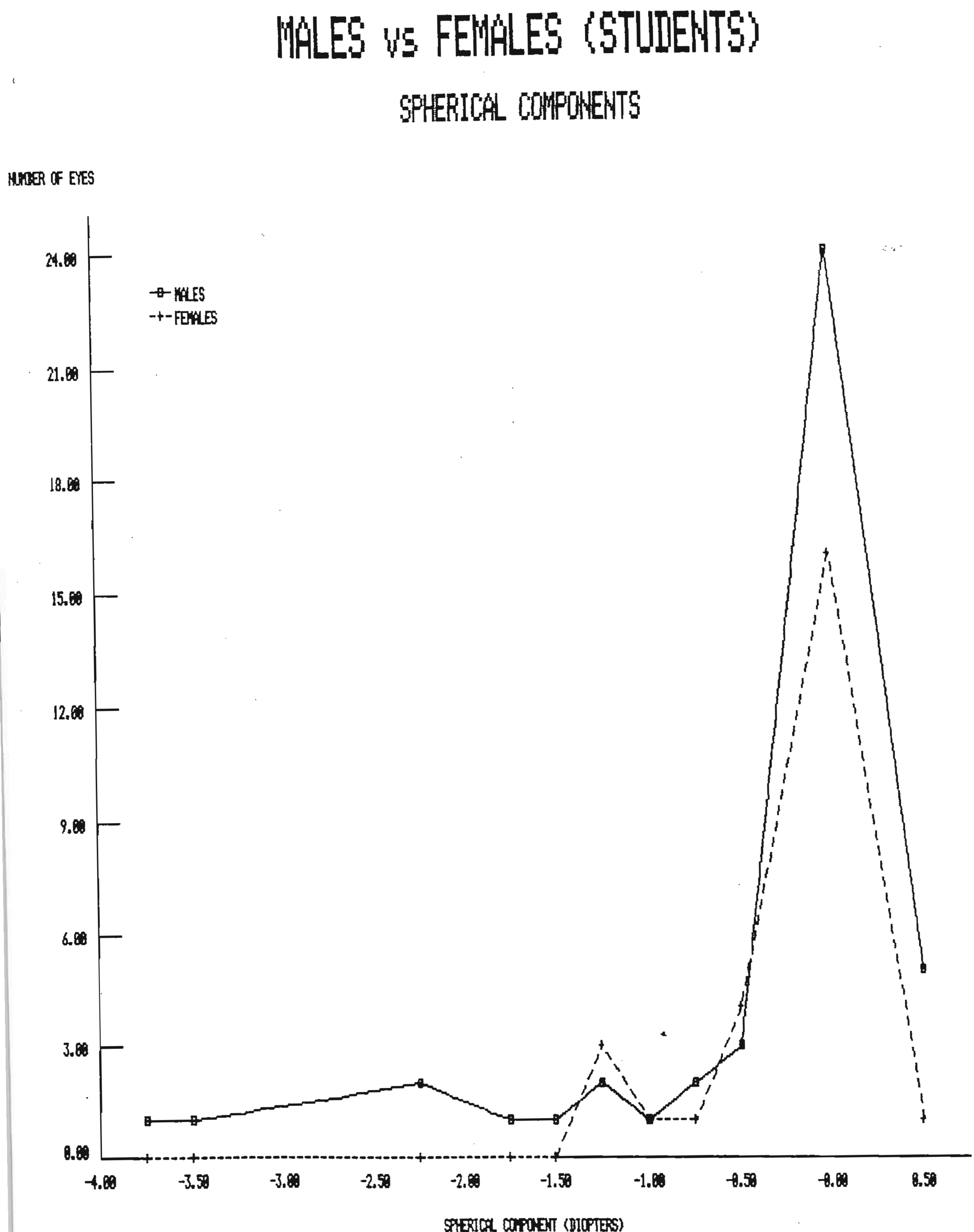

Figure 20: Distribution of the spherical components among students

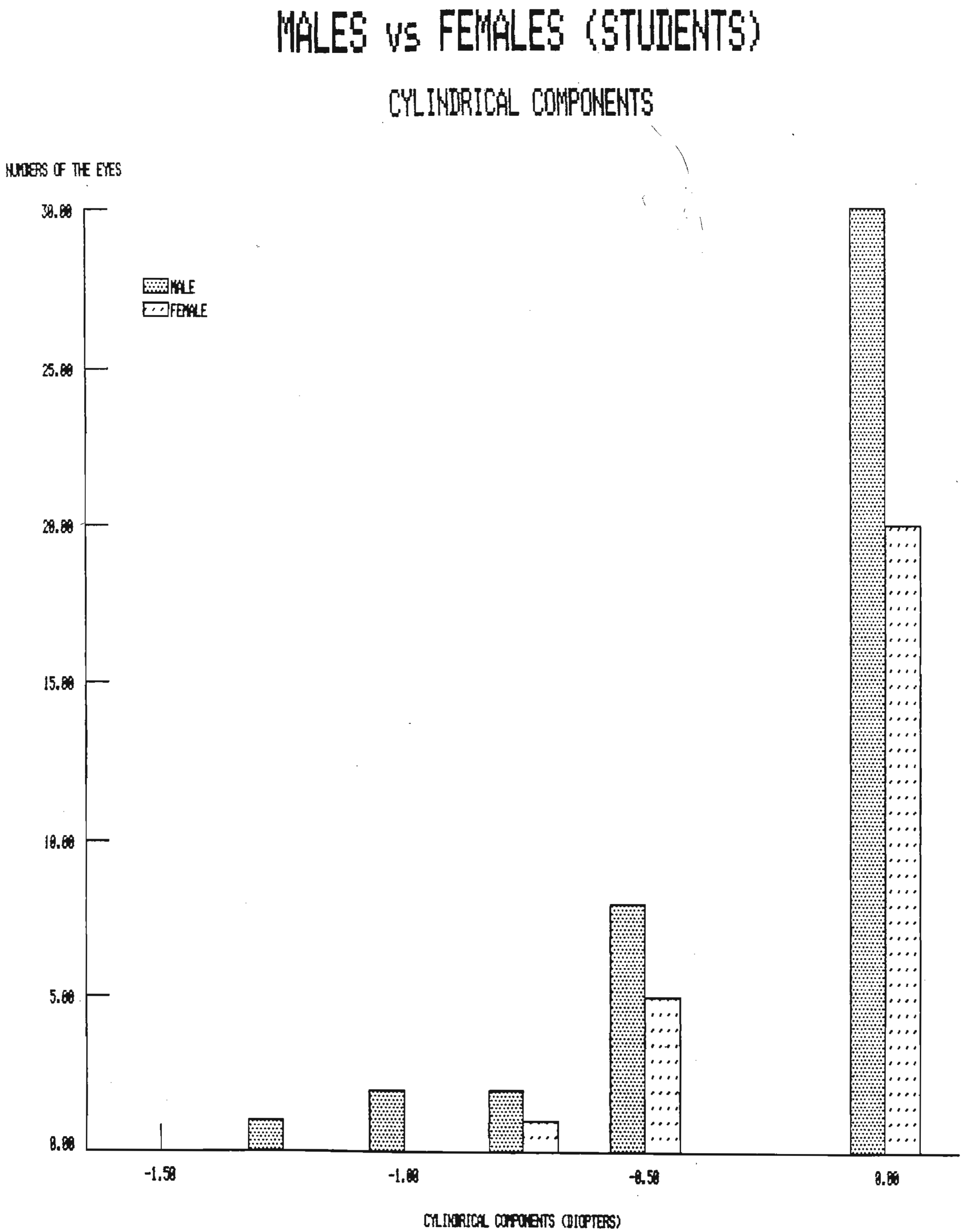

Figure 21: Distribution of the cylindrical components among students

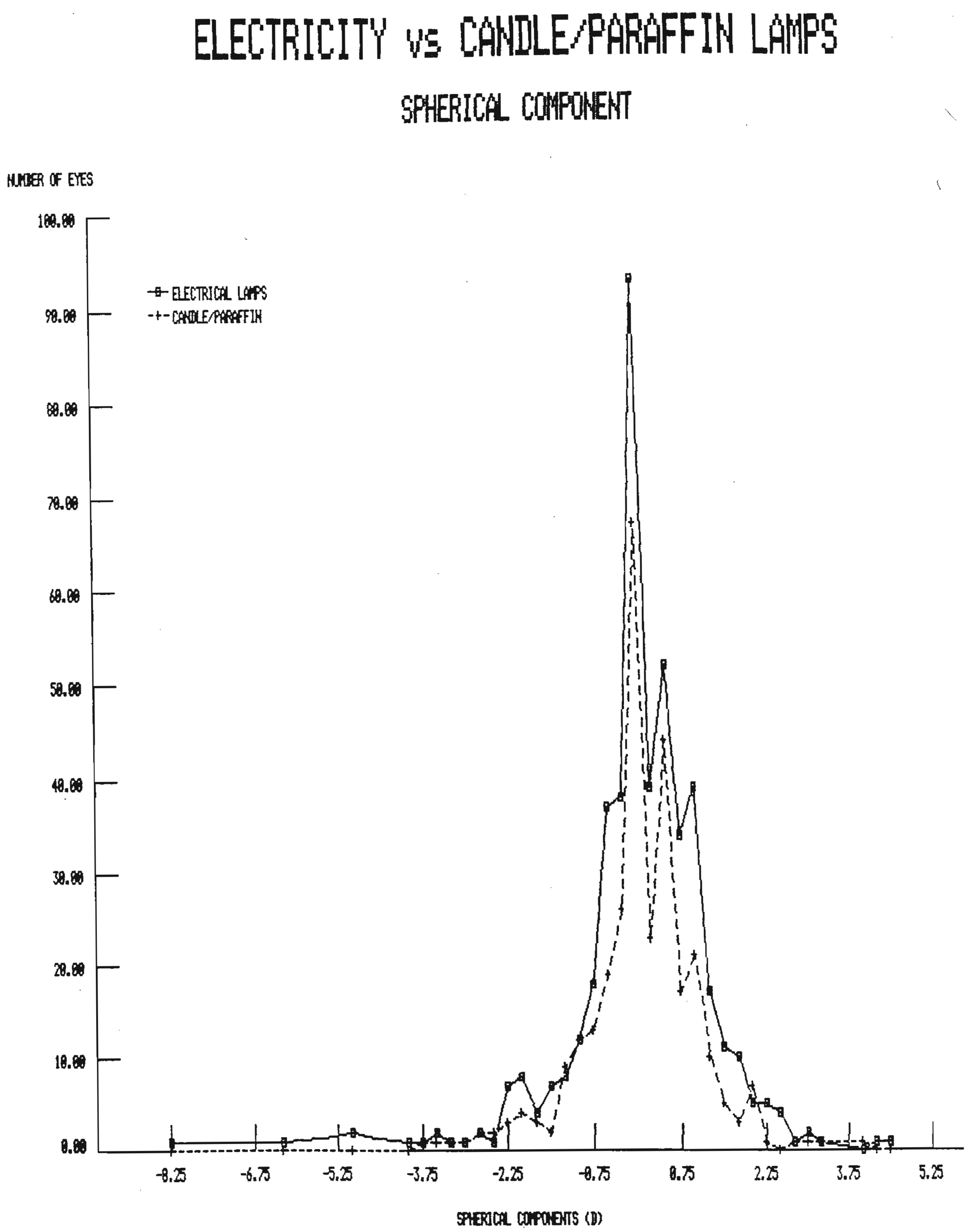

Figure 22: Distribution of the spherical components for people using electricity and candle/paraffin lamps

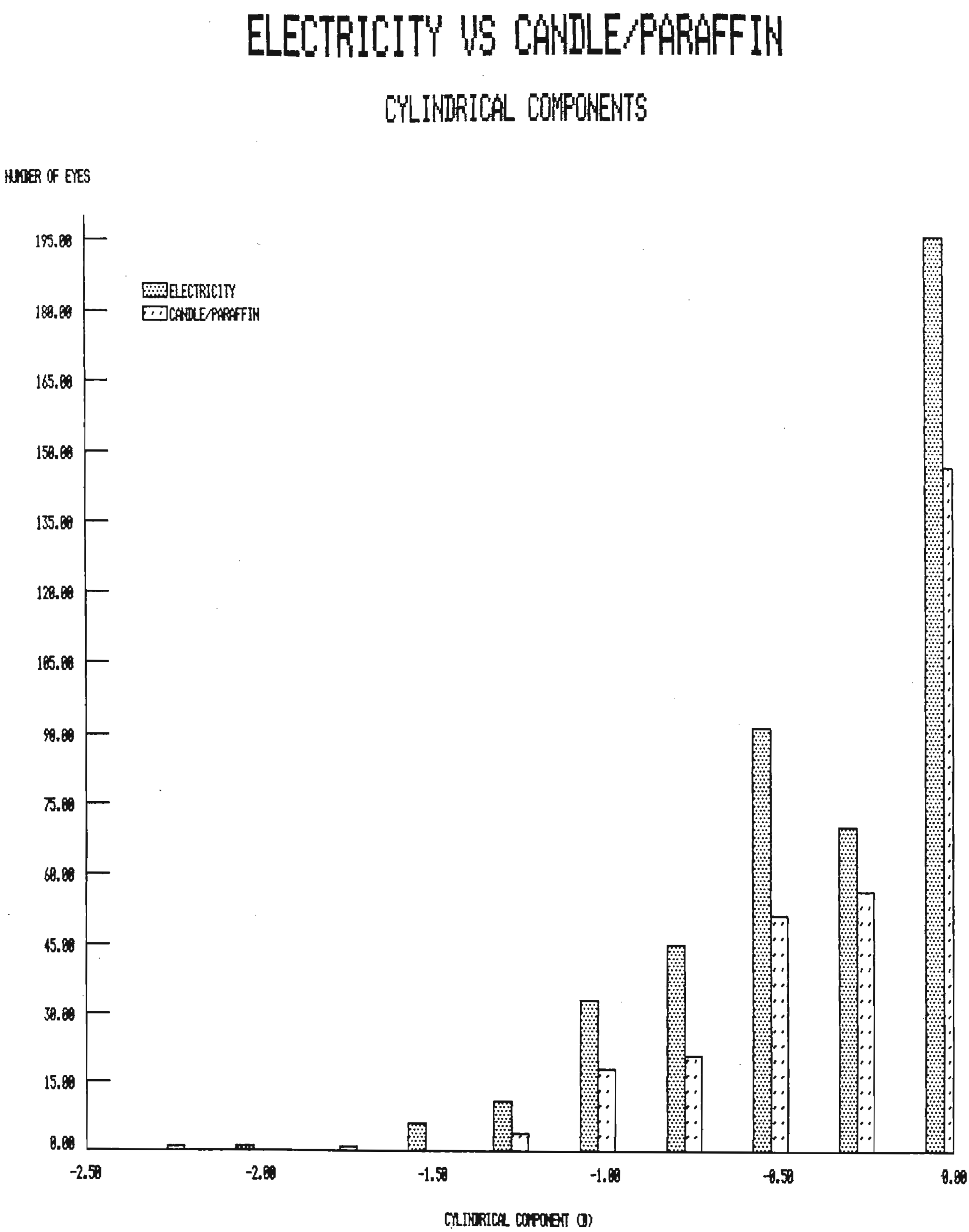

Figure 23: Distribution of the cylindrical components for people using electric and candle/paraffin lamps

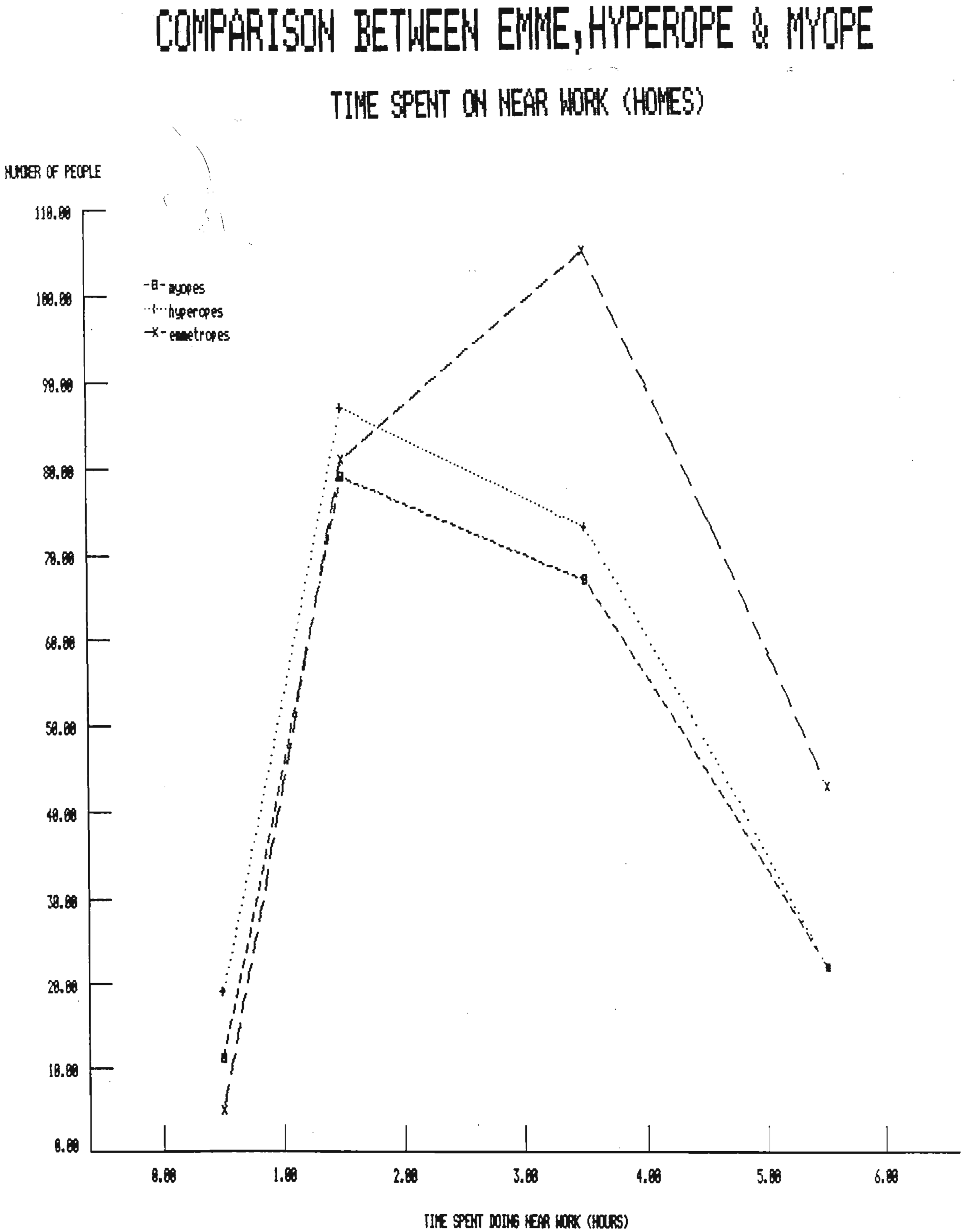

Figure 24: Comparison between emmetropes, hyperopes and myopes on the amount of time spent doing near work (homes)

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