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Work with video display terminals among office employees

III. Ophthalmologic factors

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BÖÖS SR, CALISSENDORFF BM, KNAVE BG, NYMAN KG, VOSS M. Work with video display terminals among office employees: III Ophthalmologic factors. *Scand J Work Environ Health* 11 (1985) 475—481. The present ophthalmologic study is the third part of a major epidemiologic health investigation on work with a video display terminal (VDT). An initial study showed that VDT operators replying to a questionnaire reported more eye discomfort than a reference group not employed in VDT work and that women reported more eye discomfort, musculoskeletal discomfort, headache, and skin disorders than men, irrespective of whether or not they were employed in VDT work. In the present study the ophthalmologic history of eye diseases and eye discomfort yielded a much lower percentage response for symptoms and discomfort than the questionnaire, and, just as with visual acuity and refraction, there was no difference between the exposed and reference groups or between the men and women. The exposed subjects were found to be overcorrected in terms of presbyopia addition in relation to work distance. As regards ocular examination findings, low frequency rates were noted for pathological lens opacities. Opacities of this kind were slightly more frequent among the VDT operators than among the referents, but the difference was not statistically significant. There were no other differences in the ocular findings of the exposed and reference groups.

Key terms: conjunctival findings, epidemiologic study, eye discomfort, glasses, lens opacities, refraction, visual acuity.

The present ophthalmologic study is the third part of a major epidemiologic health investigation on work with a video display terminal (VDT). An initial report showed that VDT operators replying to a questionnaire reported more eye discomfort than a reference group not employed in VDT work and that women reported more eye discomfort, musculoskeletal discomfort, headache, and skin disorders than men, regardless of whether they were employed in VDT work or not (5). A second report presented the results of occupational hygiene measurements of indoor climate, lighting, and electrostatic conditions (6). Substantial differences were found between the VDT operators and the referents and also between the sexes. With the possible exception of increasing eye discomfort at high luminance contrasts in the work vision fields, no correlations could be established, however, between the occupational exposure factors and the subjective discomfort.

Previous works by other authors have related asthenopic ocular discomfort (12, 13, 15, 17), cataracts (18), myopia (3, 4), and changes in accommodation and convergence capacity (2, 9, 11) to VDT work. In other studies, however, no changes in vision or in the eyes have been found. [See the review by Bergqvist (1).] Thus, in the present epidemiologic study, the results of routine ophthalmologic examinations are reported.

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Subjects and methods

Subjects

The structure of the material in terms of "exposed" VDT operators and "unexposed" referents is shown in tables 1 and 2 in the first report of our study (5). The present report is based on "subject group 4" in table 1, comprising 505 persons (379 exposed and 126 referents) with sex and age distributions almost identical to those presented earlier (5).

Methods

The overall design of the epidemiologic study and its various stages have already been presented, together with a more-detailed description of the questionnaire and the documentation underlying the assessment of the discomfort indices, duration of workhours, and the statistical methods used (5). The methods used in the ophthalmologic studies will now be described. Three experienced ophthalmologists (referred to as ophthalmologists 1, 2, and 3) carried out the studies using the same standardized methods. Discomfort and symptoms currently and previously reported by the persons examined were recorded, together with the refractive power and use of glasses. Refractioning was performed with Donder's method, with a test chart up

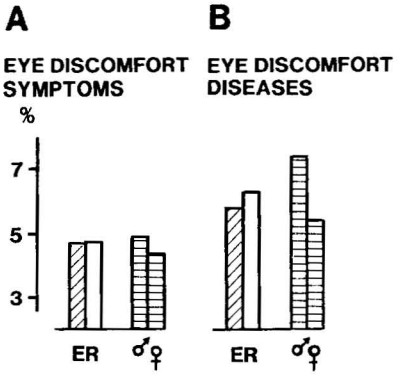

Figure 1. Frequency of eye discomfort (A) and eye diseases (B) according to the ophthalmologists' case histories of the exposed (E) and reference (R) groups and of the men (♂) and women (♀) of the two groups combined.

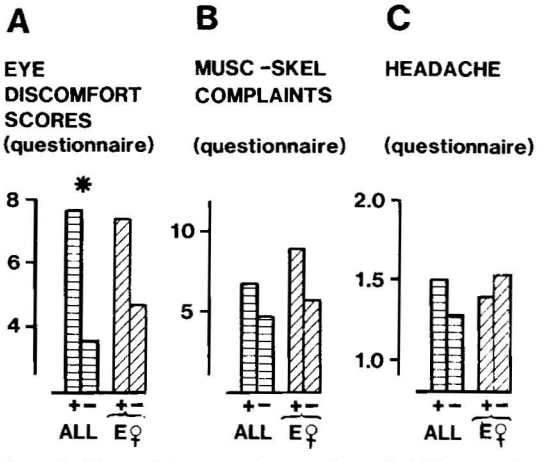

Figure 2. Discomfort scores for eye discomfort (A), musculoskeletal complaints (B), and headache (C) in relation to the presence (+) or absence (−) of eye discomfort symptoms according to the ophthalmologists' case histories for the material as a whole, ie, the exposed and reference groups combined (horizontally striped columns) and for the women in the exposed group (E ♀). (Musc-skel = musculoskeletal, * $p < 0.05$)

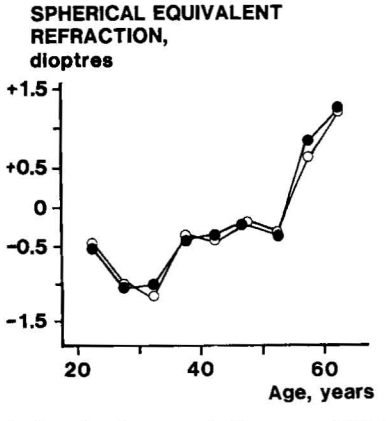

Figure 3. Ocular refractive power in the exposed (filled circles) and reference (unfilled circles) groups in relation to age.

to a visual acuity of 2.0. Definite pathological changes in ocular findings were noted as 2, other recorded changes as 1, and normal, physiological findings as 0. Pathological lens changes were the opacities seen with the use of an incident beam of light in an undilated pupil. Intraocular pressure was determined by means of applanation tonometry. Axial bulb, anterior chamber, lens thickness, and vitreous body length were determined ultrasonographically (Kretz 7200 MA apparatus) in a limited number of the subjects (N = 58, including 42 exposed subjects and 16 referents, average ages 40.3 and 37.3 years, respectively) examined by ophthalmologist 3.

Results

History

The three ophthalmologists took the usual case history and entered particulars concerning eye symptoms and diseases in the subjects' case records. The occurrence of the eight eye symptoms comprising eye discomfort in the first part of the investigation (5) are shown in figure 1A for the exposed and reference subjects and for the men and women of both groups combined. The occurrence of eye diseases (strabism, eye injury, cataract, glaucoma, etc) is shown in figure 1B. No statistically significant differences were found between the exposed and reference groups or between the men and women. There was no correlation between the duration and intensity of VDT work (5) and the eye symptoms and eye diseases observed by the ophthalmologists.

In figure 2 the material has been divided into groups with and without eye discomfort symptoms noted by the ophthalmologists. The subjects with eye discomfort noted by the ophthalmologists were found to have more eye discomfort [according to the standardized questionnaire in the first part of the investigation (5)] than those without such complaints ($p < 0.05$) (figure 2A). There was a certain difference for exposed women only, but it was not statistically significant. There were no differences with regard to musculoskeletal complaints or headache (figures 2B and C).

Visual acuity and refraction

As can be seen from figure 3, there was no difference in the refractive power of the eye (expressed in spherical equivalence for the average of the right and left eyes) between the exposed and reference groups. It is a well-known fact that refractive power is related to age, but it has not previously been shown in the case of office employees that myopia continues to increase beyond the age of 30 years, and that the onset of senile hyperopia comes just after age 50. The figure clearly demonstrates the importance of age-matching different groups for purposes of comparison. Furthermore, uncorrected and corrected visual acuity and spherical and astigmatic refraction did not differ between the

exposed and reference groups or between the men and women.

Glasses

Occurrence. In figure 4 the group comprising "spectacle wearers" (glasses for nearsightedness) has been compared with "nonspectacle wearers." The relative occurrence was the same among the exposed and reference subjects. The spectacle group had more musculoskeletal complaints ($p < 0.01$) and a tendency towards more eye discomfort and headache (not significant).

Bifocals. Figure 5 shows the occurrence of bifocal wearers in the 45- to 65-year age group (N = 202) and the relation to various types of subjective discomfort among these subjects in comparison with nonusers of bifocal glasses. There were no differences between the exposed and reference groups or between the sexes regarding the use of bifocal glasses. The bifocal wearers had slightly more eye discomfort and musculoskeletal

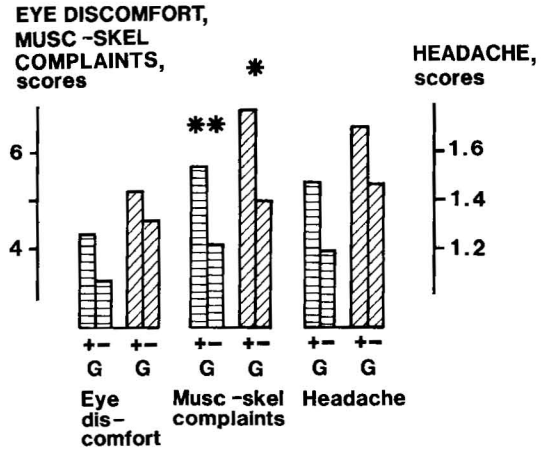

Figure 4. Use of glasses (for nearsightedness) in relation to the discomfort scores (eye discomfort, musculoskeletal complaints, and headache) for the exposed and reference groups combined (horizontally striped columns) and for the women of the exposed group (diagonally striped columns). (+ = use of glasses, − = no use of glasses, G = glasses, musc-skel = musculoskeletal, * $p < 0.05$, ** $p < 0.01$)

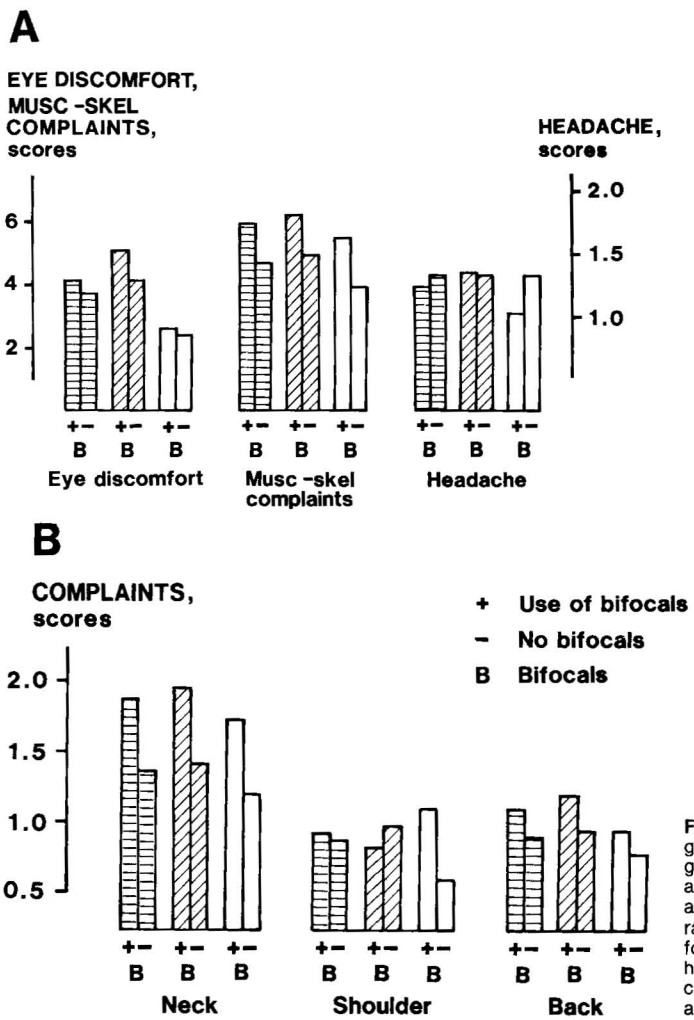

Figure 5. Use of bifocal glasses (B) in the age group 45—65 years of the exposed and reference groups combined (horizontally striped columns) and of the exposed (diagonally striped columns) and reference (unstriped columns) groups separately in relation to the scores of eye discomfort, musculoskeletal (Musc-skel) complaints, and headache (figure A) and in relation to the musculoskeletal complaints from the neck, shoulders, and back (figure B).

complaints, especially from the neck, than nonusers of bifocals, but the differences were not statistically significant. (Progressive and executive lenses were not evaluated since they were used by very few subjects on the whole.

Astigmatism. The occurrence of astigmatism, according to the ophthalmologists' refractioning, and actual spectacle astigmatism, ie, whether the glasses used were astigmatic or not, were also studied. There were no differences between the exposed and reference groups or between the men and women. In the ophthalmologists' astigmatism group the degree of discomfort was of the same order of magnitude as that of the nonastigmatics. When the subjects were classified according to actual spectacle astigmatism (into "yes" or "no"), the astigmatics were found to have more discomfort, the difference being statistically significant for eye discomfort and headache.

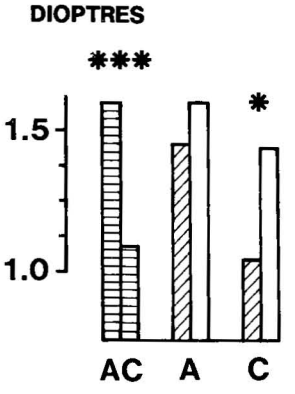

Figure 6. Actual presbyopia additions (A) and the calculated presbyopia addition from the actual work distance to the manuscript (C) for the age group 45—65 years of the exposed and reference groups combined (horizontally striped columns) and for the exposed (diagonally striped columns) and reference (unstriped columns) groups separately. (* $p < 0.05$, *** $p < 0.001$)

Spherical refraction. Comparisons were made between the spherical equivalent refraction of the exposed and reference groups and for the men and women. No remarkable differences were found between the groups.

Presbyopia addition. In the 45- to 65-year age group, an attempt was made to evaluate the accuracy of the actual presbyopia addition with reference to the actual work distance (the manuscript reading distance) (figure 6). It was found that the actual addition was half a dioptre greater than the calculated addition, ie, that the presbyopia addition involved an excess correction of approximately 0.5 dioptre. In an examination of the distribution of the two presbyopia additions between the exposed and reference groups, it was found that the excess correction was almost entirely confined to the exposed subjects. After the

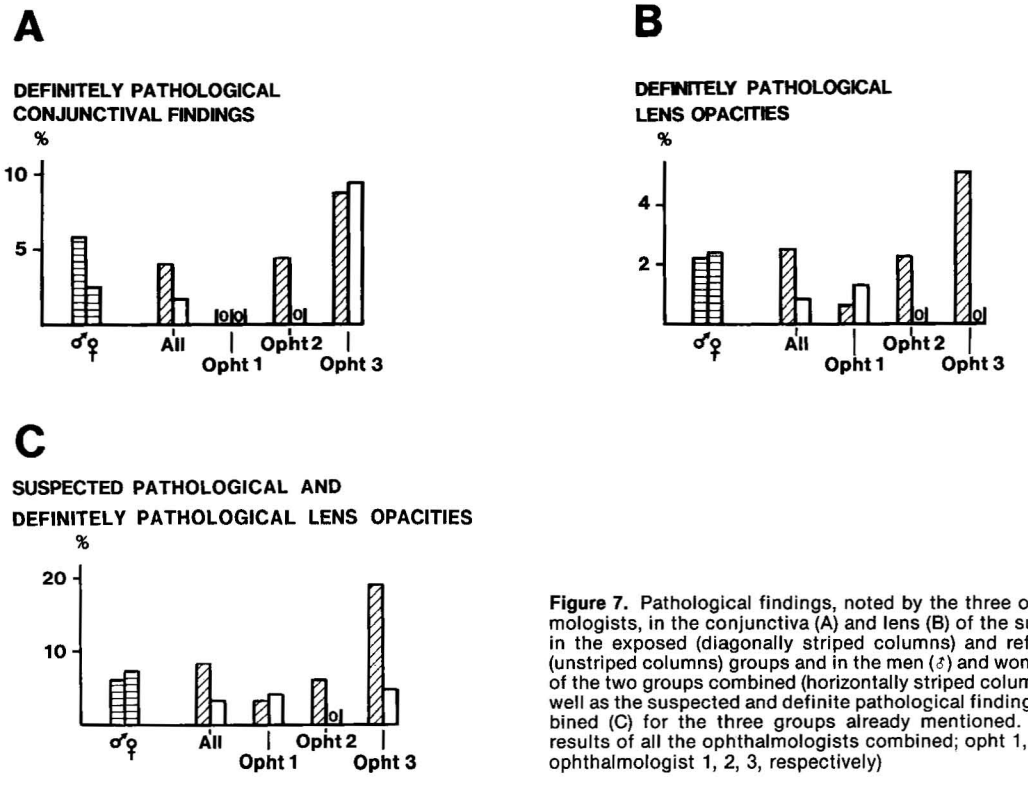

Figure 7. Pathological findings, noted by the three ophthalmologists, in the conjunctiva (A) and lens (B) of the subjects in the exposed (diagonally striped columns) and reference (unstriped columns) groups and in the men (♂) and women (♀) of the two groups combined (horizontally striped columns), as well as the suspected and definite pathological findings combined (C) for the three groups already mentioned. (All = results of all the ophthalmologists combined; opht 1, 2, 3 = ophthalmologist 1, 2, 3, respectively)

ophthalmologic examination, but prior to the questionnaire session, the examinees were given prescriptions and opportunities to obtain correct glasses.

Eye examination

Conjunctiva and lens. Eye discomfort and lens opacities have been pivotal questions in the current discussion of various effects of VDT work on ocular health. (See the Introduction.) In the standardized ophthalmologic study, special attention was therefore paid to changes in the conjunctiva and lens. Pathological changes such as conjunctival vascular injection, swelling, etc, and lens opacities are presented in figures 7A and B. There were no significant differences in conjunctival changes between the sexes or between the VDT operators and the referents. It was quite clear, however, that ophthalmologists 1, 2, and 3, in successive order, noted a progressively higher extent of conjunctival changes. As regards the pathological lens opacities (figure 7B), no difference was observed between the sexes or between the VDT operators and the referents. It is worth noting that ophthalmologist 1 found the changes to occur more frequently in the referents, unlike ophthalmologists 2 and 3. For ophthalmologist 3 the difference was particularly noticeable. If the assessment of lens opacity was made to include "type 1" changes, ie, changes which were not definitely pathological, these tendencies still hold good, and the difference between the exposed and reference subjects becomes nearly statistically significant ($p = 0.05$) (figure 7C). It should be made clear that, in all three parts of figure 7 (A—C), the same trend can be found, ophthalmologist 1 diagnosing the relatively smallest number and ophthalmologist 3 the relatively largest number of changes.

The three ophthalmologists. Although steps were taken (standardized methods, etc) to ensure that the three ophthalmologists' assessments would be as uniform as possible, we have evidence of certain methodological differences between them, eg, in refractioning — see our report IV (10). But these interexaminer differences in the findings could also be due to the ophthalmologists having examined three different sets of subjects. In figures 8A and B, therefore, the eye discomfort scores obtained from the questionnaire on subjective disorders and symptoms have been presented for the three ophthalmologists, both as total scores (figure 8A) and divided according to exposure and nonexposure (figure 8B). It should be emphasized that the ophthalmologists had no connection with or knowledge of the results in the questionnaire, which was administered separately and on a different occasion. As can be seen from the figures, the subjects which ophthalmologist 1 examined had the least eye discomfort, while ophthalmologist 3 examined the subjects with the most eye discomfort. The same applied to the differences in eye discomfort between the exposed and reference groups, ie, the difference was the least in the case of ophthalmologist 1 and greatest in the case of ophthalmologist 3 ($p < 0.001$).

Thus the three ophthalmologists would appear to have been given essentially different sets of subjects to examine. This presumption is corroborated by the fact that the use of different VDT makes and company identity correlated with the differences in the ophthalmologists' results, ophthalmologist 1 examining persons from companies with low discomfort scores and also persons who used VDT makes with low discomfort scores and ophthalmologist 3 examining people from companies with high discomfort scores and people who used VDT makes with high discomfort scores (figures 8C and D). [See also figures 11 and 12 in report I (5).] There were, however, no correlations between the sets of subjects examined by the three ophthalmologists and the physical exposure factors. [See report II (6).] Nor did the subjects' interest and attitude ratings of their work or the duration and intensity of VDT work correlate with the ophthalmologists' ratings. [See report I (5).]

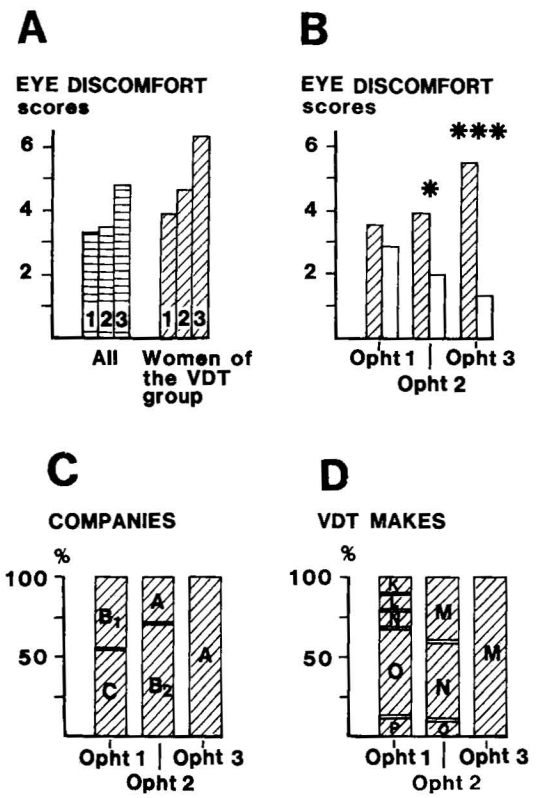

Figure 8. Distribution of the examined subjects according to the ophthalmologists (1, 2, 3) who examined them in relation to (i) the eye discomfort scores from the questionnaire (figures A and B), (ii) the different enterprises (A = insurance company, B_1 = post office, B_2 = airline, C = three newspapers (figure C), and (iii) the different makes and models (marked K, L, M, N, O, P) of video display terminals (figure D). (* $p < 0.05$, *** $p < 0.001$)

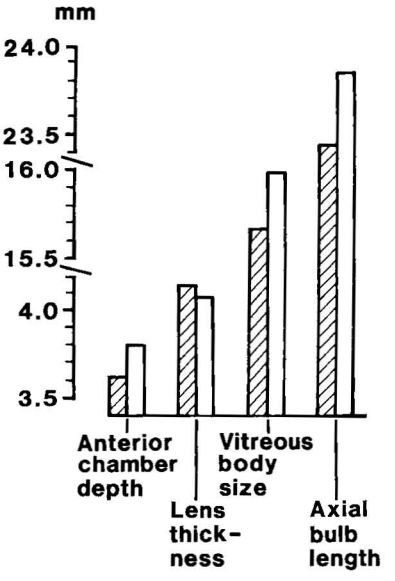

Figure 9. Results of the anterior chamber depth, lens thickness, vitreous body size, and axial bulb length measurements made with ultrasonography for the exposed (diagonally striped columns) and reference (unstriped columns) groups.

Ultrasonography. All the subjects undergoing the ultrasonographic examination were tested by ophthalmologist 3. As can be seen from figure 9, no differences were obtained between the exposed and reference groups as regards anterior chamber, lens thickness, vitreous body, and total bulb length.

Other findings. As regards pathological changes in the other parts of the anterior segments of the eye, the ciliary body, the vitreous body, the optic disc and macula in the fundus of the eye, and intraocular pressure, no differences were observed between the VDT operators and the referents or between the men and the women. "Physiological" age-related changes could be observed for several examined parameters, but since the various groups examined were age-matched, this result had no bearing on the assessment of possible differences between the exposed and reference groups (or between the sexes).

Discussion

Case history

The differences in eye discomfort which emerged so clearly between the exposed and reference groups and between the men and women on the questionnaire (5) could not be established in the medical case histories. For the comparison of the men and women, however, the frequencies in the various sets of subjects were only one-tenth of the corresponding figures from the questionnaire. For obvious reasons, a medical history concentrates on purely pathological states, while in a questionnaire the difference between "minor discomfort" and "no discomfort at all" is probably fairly insignificant. It is worth noting, however, that the persons with eye symptoms determined by the ophthalmologists had much higher eye discomfort scores, according to the questionnaire, than those who were "symptom-free" ($p < 0.05$).

Visual acuity and refraction

As was pointed out in the introduction, some research groups have related myopia to VDT work. [See the review of Bergquist (1).] In one study (4), for example, a higher frequency of increased myopia during past years was reported for exposed subjects (37 %) than for referents (26 %). It should be made clear at this point that the VDT group examined was, on the whole, relatively young (78 % being under 35 years of age), whereas no information was presented concerning the age of the reference group. Our study has not yielded any results to corroborate a hypothesis of this kind. The age curves for the equivalent refraction of the VDT operators and the referents were more or less identical. It is worth pointing out that the progress of myopia does not appear to be concluded until age 35 and that the onset of "senile hyperopia" does not come before age 55. It must be emphasized that these figures refer to office employees doing a great deal of close work. It is not known whether occupational categories doing less close work have a similar age curve.

Glasses

It was not surprising that the VDT operators were overcorrected in their presbyopia addition in relation to their actual work distance (to the manuscript on their desks). This occurrence was due to the presence of the VDT at the workstation which, for practical reasons of space, causes working distances to exceed normal reading distance. This overcorrection, however, could not be related to discomfort, be it eye discomfort, musculoskeletal discomfort, or headache. In other respects there were no appreciable differences between the VDT operators and the referents. With respect to the material as a whole, it is perhaps worth noting that the spectacle users reported more discomfort, as has also been observed in other studies (7, 8, 14, 16). The results concerning astigmatism were not straightforward. It was only the persons using astigmatic lenses, and not those found by the ophthalmologists to be astigmatic, who reported discomfort. It may be that the astigmatics complaining of discomfort are more frequently given glasses than those who do not complain.

Eye examination

The findings made by the ophthalmologists in their studies concerning conjunctiva and lens are interesting in respect to what has been reported in previous liter-

ature. [See the introduction and the review by Bergqvist (1).] Conjunctival changes did not distinguish the exposed subjects from the referents or the men from the women, but their incidence was the lowest with ophthalmologist 1 and greatest with ophthalmologist 3. The pathological lens changes did not differ significantly between the exposed and reference subjects, or between sexes, but there was a slight change when also nonpathological changes were included ($p = 0.05$). The prevalence was the least with ophthalmologist 1 and the greatest with ophthalmologist 3. Ophthalmologists 2 and 3 noted all their pathological cases among the VDT operators. These findings may be due to real differences between the groups or to randomly obtained differences (the levels of significance were not impressive; in the region of 10 and 5 %). One possible argument in favor of a real effect is that the three ophthalmologists were given different types of subjects to examine. This occurrence is reflected by ophthalmologist 1 receiving subjects with low eye discomfort scores (from the questionnaire), ophthalmologist 2 receiving subjects with a higher eye discomfort score, and ophthalmologist 3 being given subjects with the relatively highest score. Interesting differences also emerged when the eye discomfort scores were divided between the exposed and reference groups in that ophthalmologist 1 had the smallest and ophthalmologist 3 the largest difference between the groups. The fact that the persons examined by ophthalmologists 1, 2, and 3 were referable to companies and VDT makes with (on the whole) rising eye discomfort scores could also suggest a real effect. On the other hand, all attempts at relating the described differences between the findings of the three ophthalmologists to the exposure factors studied (physical, ergonomic, psychosocial) and the duration and intensity of VDT use were unsuccessful. Another argument against a real VDT effect is the very low frequency rates, ie, about 2.5 % for the exposed group and 1 % for the referents. Therefore we do not believe that the findings obtained have any relation to VDT work. In a new study of the entire material, planned for 1987, ie, five years after the study to which this report refers, lens opacities will be investigated once more.

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