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Work with video display terminals among office employees

IV. Refraction, accommodation, convergence and binocular vision

by Karl G Nyman, MD, Bengt G Knave, MD, Margaretha Voss¹

NYMAN KG, KNAVE BG, VOSS M. Work with video display terminals among office employees: IV Refraction, accommodation, convergence and binocular vision. *Scand J Work Environ Health* 11 (1985) 483–487. The present study is the fourth of a major epidemiologic health investigation on work with a video display terminal (VDT). The other studies showed that VDT operators replying to questionnaires have more eye discomfort than a reference group of office employees not employed in VDT work and that women have more eye discomfort, musculoskeletal complaints, headache, and skin disorders than men. Routine ophthalmologic examinations failed to establish any appreciable differences between the groups; for example, the prevalence of myopia was the same. In the present study, the VDT operators and referents were examined before and at the end of work sessions for changes in refraction, accommodation, convergence capacity, and binocular vision such as heterophoria and fusion range. No differences could be established between the VDT operators and the referents.

Key terms: epidemiologic study, eye discomfort, fusion range, heterophoria.

In several previous studies, work with a video display terminal (VDT) has been related to asthenopic ocular discomfort (11, 12, 13, 14), cataracts (15), myopia (5, 6), and changes in accommodation and convergence capacity (4, 9, 10). In other studies, no ocular changes have been demonstrable. [See the review of Bergqvist (1).] The present specialized ophthalmologic study is the fourth part of a major epidemiologic health investigation on VDT work in which changes in refraction, accommodation, convergence capacity, and binocular vision of the eyes were studied during office work with and without VDT use.

Subjects and methods

Subjects

The structure of the material as regards “exposed” VDT operators and “unexposed” referents is shown in tables 1 and 2 in the first report of our investigation (7). 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 (7).

Methods

The overall design of the epidemiologic investigation and its various stages have already been described, and

so too, in greater detail, have the questionnaires and documentation underlying the compilation of discomfort indices and duration of workhours (7). In the present study, an orthoptist (MV) determined refraction, accommodation, and convergence capacity and studied binocular vision immediately before or at the commencement of work and, in the case of the exposed subjects, immediately prior to the conclusion of VDT work (and at the corresponding time for the referents).

The average interval between the two examinations was about 5 h. The results of the two measurements were compared, and the differences obtained were studied with standard statistical methods. [See our first report (7).]

Refraction. Ocular refraction was measured, without cycloplegia, with an automatic refractometer (Dioptron II: Coherent Dioptron Ultima Diagnostic Eye Computer). The measurements obtained (spherical equivalents; the spherical equivalents of an eye having a refraction of $-1.0-1.0 \times 90^\circ$ will be -1.5) agreed very closely with the examination results obtained by the ophthalmologists (2). Figure 1 shows the age distribution for refraction according to the ophthalmologists' examinations (solid line) and according to the refractometer (broken line). For the material as a whole (figure 1A) it was observed that the refractometer gave values that were approximately 0.2 dioptres more “myopic” than the ophthalmologists' refraction determinations. The difference was above all demonstrable in the case of ophthalmologist 3 (difference -0.3 dioptres and ophthalmologist 1 (-0.2 dioptres) (figures 1D and B, respectively). In the case of ophthalmologist 2 (figure 1C), the two curves were almost identical.

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Figure 1. Spherical refraction, age-related, for the whole material (A) and for the three ophthalmologists (B—D). (Solid lines = ophthalmologists' refraction values, broken lines = refractometer values)

Accommodation. Accommodation was studied from the determination of the accommodation near point with an RAF Near Point Ruler (RAF = Royal Air Force) (8). Size N5 text was used. Persons with refractive errors had the errors corrected, and those with presbyopia lenses wore their own reading glasses.

Convergence. Convergence was studied from the determination of the convergence near point with a fixation object and a ruler. Persons with refractive errors had them corrected, and those with presbyopia lenses wore their own reading glasses. According to the orthoptist's instructions, both the convergence and accommodation near points were determined by a single measurement so as to avoid learning effects.

Orthoptic examination of binocular vision. This investigation began with the cover-uncover test for far and near distance. If the test indicated a fixation movement of the uncovered eye, a "prism and cover test" was performed in order to determine the magnitude of convergent or divergent deviation in the horizontal plane

(and, where relevant, in the vertical plane). Persons with refractive errors had the errors corrected, and those with presbyopia lenses wore their own reading glasses for near distance. Fusion was measured with prisms, "base out" and "base in," ie, in the convergent and divergent directions. The sum of both measurements constituted the fusion range. The orthoptic methods which were used have been described in detail by Burian & von Noorden (3).

Results

Refraction, accommodation, and convergence

The results of the investigations are presented in the age distribution curves in figure 2. It may be noted that the correlation coefficients for both eyes were very high (> 0.95). The refraction differences (figure 2A) before and after the work session were very small and did not vary between the exposed and reference groups. Essentially the same results were obtained for both accommodation (figure 2B) and convergence (figure 2C),

although the differences in convergence before and at the end of the work session were greater in the reference group than in the exposed group in the oldest age range (though without statistical significance). We should add that the values obtained did not differ between the men and women and they were not correlated with the eye discomfort scores of the questionnaire or any of the measurements of the duration and intensity of work (7).

Binocular vision

Heterophoria/heterotropia. Figure 3 shows the frequency of exo- and esophoria tropias and vertical deviations in the exposed and reference groups. The figure shows that in both the near and the far distance measurements (figures 3A and B, respectively) exophorias dominated as a group, followed by esophorias. There were, however, no appreciable differences

in the measurements obtained before and at the end of the work session. The relations between the exophoria, esophoria, and tropia groups on the one hand and eye discomfort scores on the other were also studied. Exophorias appeared to have the most discomfort and tropias the least, both in the group as a whole and in the group comprising exposed women.

Fusion range and eye position in the dissociated state.

Figure 4 shows the results of the fusion range measurements (figure 4A) and measurements of the position of the eyes in the dissociated state (figure 4B), at both near and far distances. There was only one difference between the measurements obtained before and at the end of the work session. In the reference group, the near distance "prism and cover test" value declined at the end of the work session ($p < 0.05$). No relation could be established between the measurement results obtained and the eye discomfort scores.

Figure 2. Refraction (A), accommodation (B), and convergence capacity (C), related to age, in the exposed and reference groups (broken line, scale to the left) and the differences between the values obtained at the end of and before a 5-h work session (solid lines, scale to the right; exposed group = filled circles, reference group = unfilled circles). The refraction values are the means of the right and left eyes. The absolute values (scale to the left) are the means of values obtained before and at the end of the work session.

A

B

Figure 3. Frequency of heterophoria and heterotropia at near (A) and far (B) distances before and at the end of a 5-h work session in the exposed (E) and reference (R) groups.

A

FUSION RANGE,
prism dioptres

B

EYE POSITION IN
DISSOCIATED STATE,
degrees

Figure 4. Fusion range (A) and eye position in the dissociated state (B) at near and far distances before and at the end of a 5-h work session in the exposed (E) and reference (R) groups. As in figure 3 the two columns of a group represent measurements made before (left) and after (right) a work session. (* $p < 0.05$)

Discussion

In the present work we did not find that VDT operators or other office employees develop myopia during the workday. Haider et al (5) found transitory myopia corresponding to about 0.2 dioptres. Kajiwarra (6) put forward the hypothesis that VDT work leads to myopia, since 37 % of the VDT operators in his epidemiologic study were nearsighted, as against only 26 % of the referents. Our investigations have failed to confirm this finding. [See Böös et al (2).] The reason may be due to insufficient age-matching in the Japanese study. The study by Haider et al (5) was conducted along completely different lines than our epidemiologic study of exposed and reference subjects.

In the present study we found no differences in accommodation and convergence capacity between the VDT operators and the referents. Thus our study does not corroborate the findings of Östberg (10) or Gunnarsson & Söderberg (4), but its results agree with the epidemiologic study of workers at the *Baltimore Sun* (13). It is not surprising, then, that we were unable to find any differences between the exposed and reference subjects in the orthoptic binocular vision studies.

Some of the findings, however, are interesting from the ophthalmologic point of view. The distribution of various heterophorias and tropias, the implied relations to eye discomfort scores, and the spherical refraction age curve deserve closer study. The varying adjustment of the three ophthalmologists to the refractometer curves is an interesting finding and bears witness to the importance of standardized methods of measurement for epidemiologic studies.

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