Scand J Work Environ Health 1985;11(6):457-466

<https://doi.org/10.5271/sjweh.2200>

Issue date: Dec 1985

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Work with video display terminals among office employees

I. Subjective symptoms and discomfort

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KNAVE BG, WIBOM RI, VOSS M, HEDSTRÖM LD, BERGQVIST UOV: Work with video display terminals among office employees: I Subjective symptoms and discomfort. *Scand J Work Environ Health* 11 (1985) 457-466. Subjective symptoms and discomfort were evaluated by means of a questionnaire and compared between approximately 400 video display terminal (VDT) operators and 150 selected referents. Previous and current illnesses, educational status, and smoking and drinking habits were also studied. The results showed the VDT operators to have more eye discomfort and possibly also more musculoskeletal discomfort in the shoulders, neck, and back than the referents. The VDT group also reported more skin disorders. In addition, women reported consistently more disorders than men, regardless of whether or not they were employed in VDT work. Women in general displayed greater morbidity than men. Eye discomfort, musculoskeletal discomfort, headache, and skin disorders were found to be significantly correlated in the material. The results also indicated that total daily workhours and time spent looking at the VDT screen were related to the degree of discomfort. Even when the subjects were divided into subgroups with reference to the various enterprises, the types of work and the makes of VDT, the differences obtained in the degree of discomfort appeared to be due to variations in the length of work-hours.

Key terms: epidemiologic study, eye discomfort, headache, musculoskeletal complaints, skin disorders, VDT make, workhours, workplace, worktask.

Various subjective symptoms, eg, ocular discomfort, musculoskeletal complaints, and headache, have been related to work at a video display terminal (VDT) ever since the VDT was first introduced to worklife. (See references 1, 2, 8, 11, 13.) Certain facial skin disorders have also been described (9).

The present epidemiologic health investigation involved about 400 VDT operators and 150 selected referents (ie, office employees without VDT work) in the Stockholm region. Various occupational exposure factors were measured from the screen itself, from the workstation, and from the work routines. Subjective symptoms and discomforts in relation to the eyes, arms, back, and skin and headache were evaluated from questionnaires, as well as previous and current diseases. Information on eye status was obtained by means of routine ophthalmologic examinations. Certain special studies were made of accommodation, convergence, and refraction during the workday. Those subjects complaining of skin disorders on the face, the neck, and the hands were examined by dermatologists.

The aim of the investigation was to compare the occurrence of subjective symptoms and discomfort between VDT operators and referents and to study the

relationship of these symptoms and discomforts to different physical exposure factors and findings in ophthalmologic and dermatologic examinations. This first report presents questionnaire findings on subjective symptoms and discomfort and on previous and current illnesses. Other reports deal with the occupational hygiene measurements and the various eye and skin examinations.

Subjects and methods

Subjects

Groups investigated. The exposed group comprised all office employees doing more than 5 h of VDT work daily at an insurance company (A), an airline and a post office (B), and personnel from three daily newspapers (C). To make up the reference group, persons whose worktasks were as similar as possible to those of the exposed subjects but which did not include VDT work were selected from each of these enterprises. The sample was taken with the assistance of a group comprising representatives of employers, trade unions, and occupational safety and health services. A preliminary estimate of the size of the material, following an initial contact with the enterprises, indicated some 450 exposed employees relatively evenly distributed between the three enterprise groups (A, B, C). It was therefore decided that the reference group was to include about 150 persons and that, preferably, these per-

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Table 1. Number of persons in the investigation.

Subjects in different phases of the investigation ^a	Examined groups ^b							
	A		B		C		Total	
	Exposed	Reference	Exposed	Reference	Exposed	Reference	Exposed	Reference
1	156	29	168	75	114	46	438	150
2	151	29	154	75	109	45	414	149
3	149	27	144	72	102	42	395	141
4	142	21	140	68	97	37	379	126

^a 1 = those reported by the enterprises before the investigation, 2 = those examined in one or more of the substudies, 3 = those replying to the questionnaire, and 4 = those completing all substudies.

^b A = subjects from an insurance company, B = subjects from an airline and a post office, C = subjects from three daily newspapers.

Table 2. Number of persons and the mean, median and standard deviation of the mean of the age of the examined groups by sex.

Sex	Examined groups ^a							
	A		B		C		Total	
	Exposed	Reference	Exposed	Reference	Exposed	Reference	Exposed	Reference
Male								
Number of subjects	41	6	16	16	57	8	114	30
Age (years)								
Mean	36	33	39	45	43	34	40	40
Median	34	31	35	48	43	34	39	40
Female								
Number of subjects	108	21	128	56	45	34	281	111
Age (years)								
Mean	39	37	40	43	42	45	41	42
Median	39	38	40	42	41	45	40	43
Total								
Number of subjects	149	27	144	72	102	42	395	141
Age (years)								
Mean	38	36	41	43	43	43	41	42
Median	38	35	40	44	42	44	40	42
Range	.	.	.	.	.	.	19-64	23-62
SD	.	.	.	.	.	.	11.2	10.9

^a A = subjects from an insurance company, B = subjects from an airline and a post office, C = subjects from three daily newspapers.

sons ought to be evenly distributed between the three enterprise groups and matched with the exposed subjects in terms of age and sex. The aim of this grouping was to create about 150 "quartets," each including one representative of the three exposed enterprise groups and one representative of one of the three reference groups. In practice, this grouping and matching was not feasible for all the groups, but it worked fairly well for the exposed and reference groups as a whole (tables 1 and 2).

The match between the exposed and reference subjects was relatively good in group A, could be termed fair in group B, and, as regards the balance between the sexes, unsatisfactory in group C. (See figure 4 in the Results section and table 2.) The male predominance of the exposed subjects in group C was essentially due to the majority of newspaper VDT operators being printing workers who were retrained a couple of years ago to use VDT-based computer techniques instead of lead typesetting for newspaper printing.

The exposed groups were also classified according to the following worktasks, as recommended in a report from the National Academy of Science in the United States (11): (i) data entry, (ii) data acquisition, (iii) interactive communication (ie, a combination of data entry and acquisition), (iv) word processing, and (v) programming. Our investigation only included the first three of these five categories. The group was also divided according to VDT make and model. Six subgroups could be defined in this way.

Nonresponse. Table 1 shows the dropout of persons who did not attend the examinations. Only 1 of the 25 persons distinguishing between those reported by the enterprises and those examined in one or more of the substudies refused to be examined. Otherwise the nonresponse between the subjects in its various phases (see table 1) was due to incorrect particulars concerning the nature of work, changing duties within the enterprise, vacations, and sickness absence.

Methods

The investigation as a whole involved the following stages: questionnaire concerning subjective symptoms and discomfort, special examinations of certain eye functions during the workday, determination of the ophthalmologic routine status, occupational hygiene measurements of relevant environmental factors, and dermatologic examination of persons reporting skin disorders in the questionnaire. The questionnaire was collected and the special eye examinations were conducted the same day at the workplace, by an orthoptist. The ophthalmologic examinations, performed at the offices of specialists, and the occupational hygiene measurements took place on another day. The dermatologic examinations were performed at the workplaces.

Questionnaire. The questionnaire included questions concerning the occurrence, frequency, and intensity of ocular discomforts (smarting, itching, gritty feeling, aches, sensitivity to light, redness, teariness, and dryness) and headache. The frequency and intensity of pain or discomfort from the musculoskeletal system (hands, forearms, elbows, upper arms, shoulders, neck, and back) were obtained, as well as the occurrence of skin rashes and disorders on the face, neck, hands, and arms. Questions were also included concerning previous and present illnesses or symptoms diagnosed by physicians and any current medication, together with questions concerning smoking and drinking habits, education, present and previous employment (eg, number of years and hours per week in VDT work). Special questions concerned the use of self-copying (carbonless) paper and the extent to which work was regarded as "interesting" and to which the respondent took a "positive" or "negative" view of work or worktasks. The replies to the question on the subject's interest in his or her work were ranked as follows: "Yes, definitely" = 1, "Yes, to some extent" = 2, "No, hardly" = 3, "No, definitely not" = 4. The answers to the question on attitudes were ranked as follows: "Definitely positive" = 1, "Moderately positive" = 2, "Moderately negative" = 3, "Definitely negative" = 4. On the day of the special eye examinations, the subjects were asked to state the occurrence of eye discomfort and headache and also to specify the hours at which they did VDT work, did other work, or took breaks.

Discomfort index. Special discomfort indices were constructed for eye discomfort and for headache and musculoskeletal discomfort. Symptom scores were obtained for the eight eye symptoms and for headache by multiplying the frequency score (occasionally = 1, weekly = 2, daily = 3) by the intensity score (negligible = 1, slight = 2, pronounced = 3). Asymptomatic subjects scored 0. The eye discomfort index was the sum of the eight various eye symptom scores. The

symptom score for musculoskeletal complaints was based on intensity scores alone.

Duration of workhours. The number of years in VDT work and the number of hours of VDT work done during past years were obtained from the questionnaire. Total workhours and time spent in VDT work were noted by the employees themselves on the day of the special eye examination. On another occasion, 132 randomly selected VDT operators were followed during a normal workday by means of a special gaze direction instrument. A small infrared transmitter was fitted on one side of the frames of spectacles (persons not normally wearing spectacles were given "hollow" glasses for the day of the experiment) in such a way that the time which the wearer spent looking at the screen was recorded on a special receiver on the top of the VDT. In this way it was possible to determine total workhours and the length of time spent looking at the VDT screen.

Statistical methods. The two-sample t-test, the chi-square test, and the Wilcoxon rank-sum test were used in the statistical evaluations of differences between the various groups. Normal probability plots were used to decide whether or not to use parametric tests. All tests were two-sided.

The use of other statistical methods was also attempted, eg, linear regression analysis. However these methods did not lead to any further conclusions based on the present material. The character and size of the material precluded attempts of multidimensional stratification.

In this first and also the second paper of the investigation (5), a large number of comparisons were made, some of them without an a priori hypothesis. For this reason, reliable conclusions should be limited to statistical tests with $p < 0.001$.

Results

Eye discomfort

One or more of the eight eye discomfort symptoms were reported by 64 % of the exposed employees as against 46 % of the referents ($p < 0.001$). The exposed group had a higher level of discomfort with reference to all symptoms, and the differences were significant for five of them (one with $p < 0.05$ and four with $p < 0.01$) (figure 1).

When the material was separated by enterprise (A, B, and C) differences in discomfort were found for enterprises A and B but not for C (figure 2). Enterprise C also differed from the others as to sex distribution (figure 3). The relative number of men in the exposed group was 55 % in enterprise C compared to 16 and 12 % in enterprise A and B, respectively.

The frequency of discomfort was also found to vary between the men and women, for both the exposed and

Figure 1. Frequency of eye discomfort (one or several eye symptoms) and the various eye symptoms in the entire exposed (diagonally striped columns) and reference (unstriped columns) groups. (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Figure 2. Frequency of eye discomfort in the material as a whole (E = exposed group and R = reference group) and in the three different types of enterprise (A = insurance company, B = airline and post office, C = three newspapers, diagonally striped columns = exposed group, unstriped columns = reference group). (** $p < 0.01$, *** $p < 0.001$)

Figure 3. Sex (δ = men, ϕ = women) distribution of the material as a whole (E = exposed group, R = reference group) and in the three types of enterprise (A = insurance company, B = airline and post office, C = three newspapers, diagonally striped columns = exposed groups, unstriped columns = reference groups).

reference subjects (figure 4). This was true of all the symptoms, the difference being statistically significant ($p < 0.01$) for four of them, and for eye discomfort in general (one or more of the eight symptoms) ($p < 0.001$). The sex-related differences in discomfort could have been the reason no differences in discomfort could be established between the exposed and reference subjects in enterprise C.

Subjective discomfort and attitudes

Various discomfort scores, separated with reference to VDT use and nonuse and to sex, are presented in figure 5. As has already been mentioned, the exposed subjects had significantly higher eye discomfort than the referents, and the women experienced more discomfort than the men (figure 5A). The musculoskeletal discomfort scores were also found to be higher for the women, but they did not differ between the exposed subjects and the referents. However, there was a tendency towards higher discomfort scores for proximal locations (shoulder, neck and back) among the exposed group when it was compared to the reference group (figure 6).

The women reported more headache and a higher frequency of skin disorders than the men (figures 5C and D). Skin disorders were more widely reported by the exposed employees than the referents, especially where women were concerned.

Significant correlation coefficients (0.38–0.45, with $p < 0.001$) were found between the scores of eye discomfort, headache, and musculoskeletal discomfort. The frequency of skin disorders was also associated ($p < 0.001$) with the other discomfort scores.

The answers obtained for the "interest" and "attitude" questions, ie, questions as to whether the employees found their work "interesting" and to what extent they took a "positive" or "negative" attitude towards it, did not reveal any differences between the exposed and reference employees or between the sexes. There was, however, a strong association between the scores of the attitude and interest questions (indicating that the two questions probably measured the same expression of "attitude/interest").

Age did not correlate with the subjective discomforts, but interest and a positive attitude towards work increased with advancing age, to reach a maximum at age 40–50 years.

General health status

There was no significant difference between the VDT group and the referents with regard to the occurrence of current and previous diseases or to prescribed medication. There was a general increase in morbidity among the women, a finding reported also in other investigations. The use of oral contraceptives was not related to high scores.

Figure 4. Frequency of eye discomfort and the various eye symptoms in the exposed (diagonally striped columns) and reference (unstriped columns) groups distributed according to sex (δ = men, $\varnothing$ = women). The significance indications refer to comparisons between the women in the exposed and reference groups. (** $p < 0.01$, *** $p < 0.001$)

Smoking and drinking habits

As usual, a relation was found between alcohol consumption and smoking, and also alcohol consumption was higher among the men. There was no difference in smoking or drinking habits between the VDT group and the reference group, and there was no relation between smoking or drinking and the subjective complaints studied.

Educational status

The subjects were divided into the following six educational groups: elementary school, junior high school, senior high school, compulsory comprehensive school, vocational school, and university or college. These groups did not differ in terms of discomfort frequencies or scores. The results revealed one difference connected with educational status, ie, the higher the level of education, the higher the rate of alcohol consumption, but this difference was not related to age, sex, or exposure.

Duration of workhours for the exposed groups

Figure 7 shows the duration of workhours for all the VDT operators and for the female VDT operators in relation to sex and occurrence of subjective symptoms and discomforts. (See the Methods section.)

As regards duration (figure 7A), the subjects reporting eye discomfort were found to have worked somewhat longer than those without eye discomfort (not significant), but otherwise there were no observable differences worth mentioning. More substantial differences were noted with regard to the number of hours per week devoted to VDT work (figure 7B). Women worked slightly fewer hours per week than men (not significant), and, where eye discomfort and musculoskeletal complaints were concerned, those with complaints worked longer hours at the VDT ($p < 0.05$).

Figures 7C and D show, respectively, the number of hours per day spent in VDT work and the workday as a whole. Again women were found to have shorter workhours. Otherwise no remarkable differences were revealed.

Figure 5. Discomfort scores for eye discomfort (A), musculoskeletal complaints (B), and headache (C) and the frequency of skin disorders (D) for the exposed (diagonally striped columns) and reference (unstriped columns) groups [whole group (ALL) and men (δ) and women ($\varnothing$), respectively] and for the men and women in the two groups combined (horizontally striped columns). (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Figure 6. Location of musculoskeletal complaints. Score differences between the entire exposed (VDT) and reference groups and between the men and the women of the two groups (* $p < 0.05$, *** $p < 0.001$)

The measurements undertaken with the special gaze direction instrument (figure 7E) revealed several significant differences of interest. Subjects with eye discomfort and musculoskeletal discomfort spent more time looking at the screen and had longer workhours on that particular day. Those reporting headache also had longer workhours than the others (figure 7F).

Figures 7E and F are based on registered work duration, in contrast to the (subjective) reported work duration in figures 7A–D. Thus, eg, the data on workhours given in figure 7F are considered more reliable than the data on workhours in figure 7D. The results in figures 7E and F must still, however, be interpreted with some caution, because they concern a subgroup with possibly a shorter worktime (figure 7F: 6 h, registered) than for the whole exposed group (figure 7D: slightly above 7 h, reported).

An overall assessment of the results suggests a dose-effect relationship, especially as regards the measurements obtained with the gaze direction instrument.

Group classification of the material

The various enterprises. The enterprise classification is a modified version of the group classification described in the Subjects section and used in describing the findings on eye discomfort. Thus group B has been divided into B_1 (= the post office) and B_2 (= the airline). Enterprise A is the insurance company, and C represents the three newspapers. As can be seen from figure 8 on subjective symptoms and discomfort, there were certain differences between these enterprises. Almost invariably, enterprise A had the highest and enterprise C the lowest discomfort scores, in comparisons both between enterprises generally and between the exposed women employed by them. The differences between enterprises A and C were statistically significant. Figure 9 shows the results of the gaze direction measurements undertaken at the various enterprises. It was found that both the length of time for which the gaze was directed at the screen and the total number of workhours were significantly shorter in the newspaper enterprises (C) than in the other enterprises. What is more, enterprise A obtained relatively high scores for total number of workhours.

In summary, the various enterprises obtained different discomfort scores, but these differences may be related to the various durations of workhours.

Different types of work. The types of VDT work included in our investigation were confined to data entry (type 1), data acquisition (type 2), and the combination of data entry and acquisition, ie, interactive communication (type 3). The newspaper enterprises (C) had data entry only and the airline (B_2) data acquisition only. Therefore, it was relevant to compare data acquisition (type 2) with interactive communication (type 3) since both types of work occurred to the same extent in the insurance company (A) and at the post office (B_1). On account of the sex differences in subjective symptoms and discomfort, we have chosen to confine our comparisons to the largest group (women) having these two different types of job. The results can be seen from figure 10. The discomfort scores were consistently higher for job type 3 (musculoskeletal complaints $p < 0.05$, otherwise not significant). Job types 2 and 3 also differed with regard to registered number of workhours. Employees doing a combination of data entry and acquisition work had a much longer workday than those with acquisition work only ($p < 0.01$). As might be expected, however, acquisition involved more time looking at the screen (not significant). Thus one cannot discount the possibility of the differences in subjective disorders between types of work obtained in our study being referable to differences in the duration of workhours.

Different makes and models of video display terminals. Altogether the operators taking part in our investigation used 11 different makes or models of VDT.

Figure 7. Duration of work with a video display terminal (VDT) and different measures of VDT work and total worktime for the exposed subjects reporting (+) and not reporting (—) discomforts. The two left-hand columns for each discomfort are for both the men (♂) and the women (♀), and the two right-hand columns are for women only. E and F refer to a subgroup only, 132 randomly selected VDT operators. In A through D reported work duration is used, while E and F use registered work duration measures. (musc-skel = musculoskeletal, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

Figure 8. Eye discomfort (figure A), musculoskeletal complaints (figure B), headache (figure C), and skin disorders (figure D) among the exposed subjects (entire group on left and women only on right) at the different enterprises (A = insurance company, B₁ = post office, B₂ = airline, and C = three newspapers).

For reasons already stated, only the results obtained for the women at the insurance company and the post office were used when the different screens were compared. Thus the comparison included six different types of screen, marked K, L, M, N, O, and P in figures 11 and 12. This comparison revealed certain differences. Screen K, for example, was definitely more "discomfort prone" than screen P ($p < 0.001$), but there were other differences as well (eg, screens K and L were associated with more discomfort than screens O and P). In the determination of the duration of workhours (figure 12) both shorter total workhours and shorter duration of gaze at the screen were recorded for screen P in comparison with the material as a whole (both $p < 0.001$). Thus, again, the differences between certain screens as regards the degree

Figure 9. Hours per day with gaze directed towards the screen (figure A) and the total workhours per day (figure B) for the exposed subjects (entire group on left and women only on right) at the different enterprises. The figures refer to a subgroup of 132 randomly selected operators from the same enterprises as in figure 8.

of discomfort may have been related to variations in the duration of workhours. [The possibility that the degree of discomfort is related to display and lighting parameters is examined in another report from this study (5).]

Self-copying (carbonless) paper

Since the use of self-copying paper has been reported as being related to skin and eye discomfort (6), questions were included concerning the frequency with which self-copying paper was handled and the approximate number of sheets with which the employees came into contact every day. There was no difference between the sexes, but the exposed subjects had more contact with paper of this kind than the referents. The subjective disorders reported were not, however, related to the use of self-copying paper.

Discussion

The results of the present study showed the VDT operators to suffer from more eye discomfort and possibly also more musculoskeletal discomfort in their shoulders, neck, and back than the referents. The VDT group also reported more skin disorders. In addition, women reported consistently more complaints than men, regardless of whether they were doing VDT work or not, and women displayed greater morbidity than men.

These findings agree closely with results from a number of other studies, eg, concerning the frequency of eye discomfort (2, 10, 12, 15). Starr (16), however, did not find the frequency of eye complaints to be significantly higher among exposed subjects than among

Figure 10. Discomfort scores for eye discomfort, musculoskeletal (musc-skel) complaints, and headache and the frequency of skin disorders (A), as well as screen gazing time and workhours (B), of the operators exposed during different types of work (2 = data acquisition, 3 = data entry and data acquisition, ie, interactive communication). (* $p < 0.05$, ** $p < 0.01$)

Figure 11. Discomfort scores for eye discomfort (A), musculoskeletal (musc-skel) complaints (B), and headache (C) and the frequency of skin disorders (D) for women working with different makes and models (denoted K, L, M, N, O, P) of video display terminals at the insurance company and the post office.

Figure 12. Hours per day with the gaze directed towards the screen and the total number of workhours for different makes and models (denoted K, L, M, N, O, P) of video display terminals for a random selection of women employed by the insurance company and the post office.

referents. An elevated frequency of musculoskeletal complaints for the shoulders, neck, and back has been reported in several studies (2, 4, 16), whereas no difference was reported by Gould & Grischkowsky (3). As regards skin disorders, a significantly higher frequency has been reported by Murray et al (8), though only at one of three workplaces investigated, while Frank (2) did not report any differences between exposed and reference subjects. A higher frequency of discomfort among women than men as regards musculoskeletal and eye complaints has been reported by Wallin et al (17) and is implied by the results of another investigation (8).

Both the total number of workhours per workday and the time spent at the VDT screen seemed to be related to subjective disorders. Similar results have been reported by Wallin et al (17) concerning eye dis-

comfort, musculoskeletal discomfort, and headache; by Mellner & Moberg (7) concerning eye and musculoskeletal complaints; and by Rey & Meyer (12) concerning eye discomfort. Other studies (13, 14, 15) have failed however to reveal such relations. When the subjects in our study were divided into groups according to enterprise, type of VDT work, and make of VDT, it seemed that the differences thus obtained were also referable to variations in the duration of workhours.

There were significant correlations between the scores of the different types of discomfort studied. Thus, for example, persons with eye discomfort tended also to report headache and/or musculoskeletal complaints. Similar results have been obtained, for example, by Smith et al (14) and, as regards the correlation between eye discomfort and musculoskeletal complaints, by Wallin et al (17). There are several possible explanations for these relations, eg, the aforementioned correlations with the duration of workhours. It is also possible that suboptimal reading conditions on the screen could cause eye discomfort and musculoskeletal discomforts due to attempts to compensate for poor image quality. There are indications of a relationship of this kind in an investigation by Smith et al (14). Special mechanisms of a psychological nature may also contribute to differences in the discomfort reported by exposed subjects (ie, VDT operators) and reference subjects.

Little is known today about the causes of the elevated discomfort-proneness and the morbidity of women. Are women constitutionally more sensitive than men, and is this why they react more vigorously to environmental hazards? Do women have more strenuous work, even though there is supposed to be equality between the sexes? Is the total living situation of women today more conducive to discomfort? Many women work part-time (see figure 7, duration of workhours) so as to adjust to the needs of the home and family, and, at the same time, have to measure up to high standards at work.

In addition to these psychosocial uncertainties, we do not know enough about occupational hygiene aspects and medical factors with a bearing on the occurrence of discomfort in connection with VDT work and differences in this respect between men and women. Our continuing studies will be concerned with these problems.

Acknowledgments

The authors wish to thank Ms G Linder for the skillful preparation of the figures.

This work has been supported by grants from the Swedish Work Environment Fund and the reinsurance company Folksam International.

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Received for publication: 19 March 1985