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A study of subjective visual disturbances in jewellery manufacturing

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Abstract. Subjective Visual Disturbances are silent adversaries that appear over a period of continued exposure and arise when the visual demands of the tasks exceed the visual abilities of the user. Jewellery manufacturing activity involves precision designs, setting the metal and stones, polishing and filing which requires higher visual demand. Therefore, it is expected that the jewellery manufacturing workers may experience subjective visual disturbances. This study was taken up with the following objectives 1) To study the presence of subjective visual disturbances among jewellery manufacturing workers and compare the same with VDT operators 2) To study the effect of work exposures on subjective visual disturbances and 3) to ascertain whether subjective visual disturbances have any permanent vision related problems. The study was carried out on jewellery manufacturing workers, VDT operators and on graduate students. The symptoms of subjective visual disturbances were identified using a questionnaire developed by Sheedy (2003). Viewing distances were measured and visual angles were calculated. The eye check - ups were also carried out. The subjective visual disturbances were higher in jewellery manufacturing workers. The findings suggest that work exposure has an impact on the causation of subjective visual disturbances. No pathological conditions of the eyes were observed.

Key words: asthenopia, near point task, Ocular –ESF, Ocular – ISF

1. Introduction

Visual disturbances are silent adversaries that only appear over a period of continued exposure. In modern life, one of the visually demanding activities is working with a computer or visual display terminal (VDT). The users of the computer experience visual problems, collectively known as Computer Vision Syndrome (CVS) (3, 16). World Health Organization has classified these syndromes as asthenopia under subjective visual disturbances (18). The causes of asthenopia are a combination of individual visual problems, poor workplace conditions, improper work habits (prolonged work exposure, sitting in non optimal posture), higher visual concentration, continuously looking at a fixed object and lesser blinking of eyelids (2, 15). Sheedy (6, 8) categorized the subjective visual disturbances into a) visual b) ocular c) asthenopia (eye strain) d) photophobia

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(sensitivity to lights) and e) musculoskeletal symptoms. Later on in 2003, Sheedy et al (7) proposed a new classification; visual, ocular- external symptom factors and ocular – internal symptom factors.

There are no special hazards or risks inherent in computer work that is different from reading a printed text or performing near point tasks. Soderberg *et al* (4*)* had observed that the operators engaged in microscopic work had experienced symptoms of visual strain. Mao-Jiun *et al (*9) reported that the workers of a semiconductor manufacturing industry, working in 12-hour shifts using microscope, had experienced eye fatigue. Woods (17) had observed that the data processing workers had experienced eye problems such as tired eyes, headache, impaired visual performance, red or sore eyes. Studies had also shown that the workers of the electronics industries had suffered from visual discomforts (10). The workers engaged in salt production experienced visual problems such as eye redness, glare sensitivity, watery eyes, burning eyes, dimness of vision and photophobia (14).

Jewellery manufacturing activity involves precision designs, setting the metal as well as the stones, polishing and filing. At every stage of manufacturing, checking the quality and precision of the product are very important. As any rework increases the labour and material costs, the workers need to pay a higher attention towards the quality of the product. In such a case, the workers may require to pay a higher visual attention for performing jewellery manufacturing activities. Therefore, it is expected that the workers engaged in jewellery manufacturing may also experience visual discomfort at their workplace. Keeping this in mind this study was taken up with following objectives:

1. To study the presence of subjective visual disturbances among jewellery manufacturing workers and compare the same with VDT operators and graduate students.

2. To study the effect of work exposures on subjective visual disturbances**.**

3. To find out whether subjective visual disturbances have any permanent vision related problems.

2**. Methods**

The study was carried out in three phases.

2.1 Phase one: study of visual disturbances in jewellery manufacturing workers

2.1.1 Subjects

Two hundred fifteen young male subjects involved in jewellery manufacturing and one hundred VDT operators from IT enabled organizations had voluntarily participated in this study. Signed informed consents were obtained from all the participants. Minimum one year of work experience on the same job was the inclusion criteria for this study. The study was carried out in Zaveri Bazar region of Mumbai - one of the jewellery manufacturing hubs in India and at IT enabled organizations at Mumbai.

2.1.2 Identification of visual disturbances

General information like age, working hours per day, years of experience were collected through structured questionnaire. The symptoms of subjective visual disturbances were identified using a questionnaire proposed by Sheedy et al (7). Responses of any two of the symptoms were considered as the presence of subjective visual disturbances.

2.1.3 *Measurement of viewing distance, viewing angle and illumination level*

Viewing distances from the eye to the objects were measured for both jewellery manufacturing workers and VDT operators using a flexible measuring tape.

Measurements were taken nearest to 0.1 cm. Object sizes were measured (nearest to 0.1 mm) using a Vernier caliper.

2.2 Phase two: Effect of work exposure

The effect of work exposures were recorded using eye discomfort questionnaire (mentioned in phase one) on 26 jewellery manufacturing workers and on 26 graduate students - control group subjects (sedentary, involved in reading, writing and occasional VDT operations). This group was selected as control group as they were not predominantly involved in near point visually demanding tasks. The study was carried out before beginning of the day's work and after end of the day's work. Difference of scores of before and after the exposures between the experimental and control groups were then compared.

2.3 Phase three: Eye check-up and measurement of Eye blink rate

2.3.1 Eye check-up

Head posture, ocular movement, convergence, visual accommodation, fundus, ocular positions were examined by a qualified ophthalmologist. Tension of the sclera (intraocular pressure) was measured by tonometer. The eye check-ups were carried out twice in a day; in the morning before the beginning of the work and in the evening, after the completion of the day's work.

2.3.2 Measurement of Eye blink rate

Eye blink rates of the workers while performing the jewellery manufacturing activities were recorded using a Handycam (Model No. DCR–PC108E–Sony Corporation, Japan). The recording was carried out for 15 minutes. The camera was focused on the worker's eyes to record the blinking of eyes while working. The recorded videos were replayed and using an event marker, numbers of blinking were counted for the entire period of fifteen minutes. Using a stopwatch with a recording facility of $1/100^{th}$ of a second, eye focus times were then calculated.

2.3.3 Statistical analysis

Odds ratios and confidence intervals were calculated using the methodology of Bland and Altman (5). Mann –Whiney U tests for independent samples were carried out using SPSS version 16.0

3. **Results**

3.1 Phase one: Study of visual disturbances in jewellery manufacturing workers

Table 1
Demographic data of the subjects (Mean ±SD) of Phase one study

Parameters	Jewellery workers (N=215)	VDT operators (N=100)
Age(yrs.)	22.98 (±4.40)	29.50 (±8.35)
Weight (kg)	63.58 (±10.03)	68.47 (±10.98)
Height (cm)	170.88 (±6.32)	170.31 (±7.23)
Work Experience(yrs.)	6.73 (±4.51)	3.48 (±4.70)
Working hours per day (hrs.) (Including all the break)	14.3 (±1.10)	8.64 (±0.98)

Table 1 shows that the mean age, height and weight of the workers engaged in jewellery manufacturing were 22.98 (±4.40) yrs, 170.88 (±6.32) cm and 63.58 (±10.03) kg respectively. The mean age, height and weight of the VDT operators were 29.5 (±8.35) yrs., 170.31 (±7.23) cm and 68.47 (±10.98) kg respectively.

Table 2

Symptoms of subjective visual disturbances among jewellery workers and VDT operators

Symptoms	Symptoms of subjective visual disturbances	
	Jewellery workers (N=230)	VDT operators (N=115)
Visual	132 (57.4%)	17 (14.78%)
Ocular - ESF	159 (69.1%)	42 (36.52%)
Ocular - ISF	143 (62.2%)	57 (49.57%)
Overall	164 (71.3 %)	40 (34.78%)

Table 2 shows 71.3% of jewellery manufacturing workers had symptoms of subjective visual disturbances. Whereas 34.78% of VDT operators reported the symptoms of visual disturbances. Individual Visual symptoms such as visual component, Ocular- ESF and Ocular – ISF components were observed to be higher for jewellery workers.

Table 3

Results of Mann- Whitney U test for subjective visual disturbances of jewellery workers and VDT operators

	Visual	Ocular - ESF	Ocular - ISF	Overall
Mann-Whitney U	7688.00	8877.00	11586.50	8395.00
Z score	7.387	5.812	2.188	6.496
Asymp. Sig. (2-tailed)	0.000	0.000	0.029	0.000

Table 3 shows that symptoms of subjective visual disturbances were higher among the jewellery manufacturing workers. P values for Visual, Ocular – ESF, Ocular – ISF, and overall were less than 0.000, 0.000, 0.029 and 0.000 respectively.

Table 4

Mean (±SD) Viewing distance, visual angle and illumination levels

Variables	Jewellery workers	Computer operators	t value and level of significance
Distance (cms)	37.68 (±7.59)	66.4 (±11.81)	12.771 (P<0.0001)
Visual angle (min)	10.29 (±3.68)	12.4 (±3.67)	2.616 (P<0.01)
Illumination level (Lux)	183.9 (±70)	324.9 (±140.41)	9.469 (P<0.001)

Note: Visual angle in min = (3438 x height of the object in mm) / (viewing distance in mm)

The results presented in Table 4 shows that the visual angles for the jewellery manufacturing workers were significantly smaller (P<0.01) in spite of the shorter viewing distances (P<0.0001). The illumination levels were also observed to be lower (P<0.001) in jewellery manufacturing.

3.2 *Phase two: Effect of work exposure*

Table 5

Demographic data of the subjects (Mean ±SD) of phase two study

Parameters	Jewellery workers (N=30)	Control group (N=30)
Age (yrs.)	29.2 (±6.08)	23.85 (±2.48)
Height (cm)	162.6 (±5.71)	171.58 (±7.79)
Weight (kg)	55.36 (±7.68)	66.88 (±11.88)

Data presented in Table 5 shows that the mean age, height and weight of the workers engaged in jewellery manufacturing were 29.2 (±6.08) yrs., 162.6 (±5.71) cm and 55.36 (±7.68) kg respectively. The mean age, height and weight of the control group subjects were 23.85 (±2.48) yrs., 171.58 (±7.79) cm and 66.88 (±11.88) kg respectively.

Table 6

Results of Mann- Whitney U test for subjective visual disturbances of jewellery workers and control group

	Visual	Ocular -ESF	Ocular - ISF	Overall
Control group - before and after	435.00	420.00	431.50	435.00
Mann-Whitney U	0.587	0.640	0.364	0. 331
Z value	0.557	0.552	0.716	0.741
Asymp. Sig. (2-tailed)				
Control group before and Jewellery workers before	435.00	285.00	435.00	375.00
Mann-Whitney U	0.463	2.856	0.296	1.420
Z value	0.643	0.004	0.767	0.155
Asymp. Sig. (2-tailed)				
Control group before and Jewellery workers after	240.00	135.00	315.00	195.00
Mann-Whitney U	3.911	5.453	2.370	2.370
Z value	0.000	0.000	0.018	0.018
Asymp. Sig. (2-tailed)				
Jewellery workers - before and after	255.00	300.00	330.00	270.00
Mann-Whitney U	3.578	3.027	2.091	3.100
Z value	0.000	0.002	0.037	0.002
Asymp. Sig. (2-tailed)				
Control group after and Jewellery workers after	225.000	105.000	330.000	180.000
Mann-Whitney U	4.261	5.919	2.091	4.619
Z value	0.000	0.000	0.037	0.000
Asymp. Sig. (2-tailed)				

Results of the Mann – Whitney U test indicated:

- No differences in visual disturbances factors (Visual, Ocular –ESF, Ocular – ISF and Overall) due to work exposure were observed in the control group.
- Differences before the work exposures were not observed in visual disturbances (except for Ocular –ESF) between the groups.
- There were significant differences between 'control group – before work exposure' and 'the workers engaged in jewellery manufacturing – after work exposure' for all visual disturbances factors.
- There were significant differences between 'control group – after work exposure 'and 'the workers engaged in jewellery manufacturing – after work exposure' for all the visual disturbances factors.
- There were significant differences between 'the workers engaged in jewellery manufacturing – before and after the work exposure for all the visual disturbances factors.

3.3 *Phase three: Eye check-up and eye blink rate*

3.3.1 Eye check- ups

Table 7

Results of evaluation of fundus condition and intraocular pressure

Transients	Right eye	Left eye
Fundus condition (Normal)	92.16 %	95.45 %
Intraocular pressure	15.65 (±2.52)	15.95 (±2.64)

The result of ophthalmologic tests carried out on jewellery manufacturing workers (presented in Table 7) showed that the fundus condition was normal (92.16% right eye and 95.45% left eye), the intraocular pressures were found to be within the normal range of the workers engaged in jewellery manufacturing (11).

Table 8

Percentage of eye related problems based on ophthalmologic evaluation carried out in the morning and evening

Visual Problems	Morning	Evening	Odds Ratio	95% CI	Significance level
Head Posture (not normal)	5.07 %	8.36 %	1.6864	0.5587 to 5.0902	ns
Ocular Position (not normal)	20.07 %	23.65 %	1.2319	0.6310 to 2.4049	ns
Ocular Movements (not full range)	1.50 %	3.00 %	1.9711	0.3055 to 12.7175	ns
Convergence (not good)	21.78 %	23.93 %	1.1290	0.5844 to 2.1810	ns
Visual Accommodation (not good)	15.57 %	23.98 %	1.6946	0.8464 to 3.3927	ns

The result of ophthalmologic tests (presented in Table 8) further showed that there was no difference between the result of morning and evening head posture (OR: 1.6864 ; 95% CI: 0.5587 – 5.0902), ocular position (OR: 1.2319; 95% CI: 0.6310 – 2.4049), ocular movement (OR: 1.9711; 95% CI: 0.3055 – 12.7175), convergence (OR: 1.1290; 95% CI: 0.5844 - 2.1810) and visual accommodation (OR: 1.6946; 95% CI: 0.8464 - 3.3927) among the workers engaged in jewellery manufacturing activity.

3.3.2 Eye blink rate

Table 9

Comparison of Eye Blink Rate (EBR) of the workers engaged in Jewellery manufacturing with normative data available in literature

Average EBR while working in Jewellery manufacturing (bpm) (N=36)	Normative value of EBR (bpm)* (N=37)	t value	Level of significance
6.95 (±1.54)	21.6 (±9.7)	8.939	P<0.0001

* blinks per minute (bpm)

Table 9 shows that the average eye blink rate of the workers engaged in jewellery manufacturing while performing their tasks was significantly lower (P<0.0001) than the normative value of EBR available in the literature (1, 12).

4. Discussion

Near point accommodation, convergence and longer eye focus time can contribute to eyestrain or visual disturbances (2, 15). The work of the jewellery manufacturing is precise; the gold and metal/stone pieces used are very small in size and jewellery manufacturing also requires longer duration of work exposure. Therefore, the requirement on visual demands due to work increases substantially. The above conditions might be the reason for the higher visual discomfort in comparison to the VDT operators and the control group. The nature of visual activities in jewellery manufacturing was similar to that of video display terminal (VDT) activities. The differences were in the levels of visual difficulties. Sheedy et al (7) had reported that inducing conditions for Ocular-ESF were dry eyes, glare, up gaze, small font and flicker. They had further reported that inducing conditions for Ocular-ISF were lens flipper, close viewing distance and mixed astigmatism. The visual angles in jewellery manufacturing activities were found to be smaller as compared to VDT operations. The viewing distances were found to be significantly shorter. The sensation of glares (from subjective responses) and requirements of concentration were found to be high. The above conditions might be the reasons for higher subjective visual disturbances. Neilson et al (13) reported that ocular surface area (OSA) and the eye blink frequency (BF) were affected by a high versus a low-monitor position during visual display terminal (VDT) work with varying cognitive demands. Dumery *et al* (1) observed a relationship between blinking rate and eye strain (dry eyes) in VDT users. They had indicated that longer duration close viewing might be the cause of this syndrome. In the present study, it was observed that eye blinking rates were significantly lower as compared to data available in literature (1). Since the activity of the jewellery manufacturing involves extended period of close viewing and lower eye blink rate, these might be also the reasons for the higher subjective visual disturbances. The result of ophthalmologic tests showed that the fundus conditions were normal and the intraocular pressures for both the eyes were also within the normal range. Therefore, there was no permanent effect on the workers' eye condition.

5. Conclusion

Subjective visual disturbances were higher in jewellery manufacturing workers. The jewellery manufacturing workers were exposed to lower illumination level and longer duration of work; and had lower eye blink rate, shorter viewing distances, smaller visual angles and low contrast jobs. These might have resulted in the higher levels of subjective visual disturbances. Present study also revealed that such disturbances did not result in pathological condition of the eyes.

References

[1] B. Dumery, P.A. Grounauer and V.V. Toi , Eye strain, blinking rate and dry eye syndromes of video display terminal users, Proc. 3rd International Conference on IFBME in Vietnam, 11-14 Jan, 2010, pp270-274.

[2] C. Collins, D. O'Meara and A. B. Scott, Muscle strain during unrestrained human eye movements, Journal of Physiology 1975, pp 351 – 369.

[3] C. Blehm, S. Vishnu, A. Khattak, S. Mitra, R.W. Yee, Computer Vision Syndrome: a review, Survey of Ophthalmology 2005, pp 253 – 262.

[4] I. Soderberg, B. Calissendorff, S. Elofsson, B. Knave, and K.G. Nyman, Investigation of visual strain experienced by microscope operators at an electronics plant, Applied Ergonomics 1983, pp 297 – 305.

[5] J. M. Bland, D. G. Altman, Statistics notes: the odds ratio, BMJ, 2000, 1468p.

[6] J.E. Sheedy (ed), Vision and computer displays, 2nd ed. Walnut Creek CA, Vision Analysis, 1995.

[7] J.E. Sheedy, Is all asthenopia same? Optometry and Vision Science 2003, pp 732-739.

[8] J.E. Sheedy, Vision problems at video display terminals: A survey of optometrists, Journal of American Optometry Association 1992, pp 687 – 692.

[9] J.W. Mao-Jiun and H.Chung-Lun, Evaluating the eye fatigue problem in wafer inspection, IEEE Transactions on Semiconductor Manufacturing *2004*, pp 444 – 447.

[10] L.J. Lu, Perceived job stress of women workers in diverse manufacturing industries, Human Factors and Ergonomics in Manufacturing 2005, pp 275–291.

[11] J.H.S. Miler, Pearson's Diseases of Eye, ed 18th, Butterworth & Heinemenn 1990, 17p.

[12] M.J. Doughty and N. Taher, Further Analysis of the human spontaneous eye blink rate by a cluster analysis-based approach to categorize individuals with 'normal' versus 'frequent' eye blink activity, Eye & Contact Lens: Science & Clinical Practice 2006, pp 294– 299.

[13] P.K. Nielsen , K. Søgaard, J. Skotte, P. Wolkoff, Ocular surface area and human eye blink frequency during VDU work: the effect of monitor position and task, European Journal of Applied Physiology, 2008 ,pp 1-7.

[14] R. Sachdev, M. L. Mathur, K.R. Haldiya, H.N.Saiyed, Work-related health problems in salt workers of Rajasthan, India, Indian Journal of Occupational and Environmental Medicine 2006, pp 62 – 64.

[15] R.F. Fisher, The force of contraction of the human ciliary muscle during accommodation, Journal of Physiology 1977, pp 51 – 74.

[16] S.C. Chiemeke, A.E. Akhahowa and O.B. Ajayi, Evaluation of vision related problems amongst computer users: a case study of University of Benin, Nigeria, Proc. World Congress on Engineering, July 2-4, 2007.

[17] V.Woods, Musculoskeletal disorders and visual strain in intensive data processing workers, Occupational Medicine 2005, pp 121 – 127.

[18] World Health Organization, Subjective visual disturbances, International Classification of Diseases (ICD), World Health Organization, 2007.