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Lighting Recommendations in Operating Theatres

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Abstract

"The eyes lead the body." A good visual environment is important for performance and wellbeing. Unsatisfactory visual conditions often induce a strained posture, more or less unconsciously, in an effort to improve vision. The requirements for the visual environment in an operating theatre are high. Surgeons or assistants who are having visual problems can induce treatment hazards. The purpose of this study was to evaluate the visual environment in operating theatres, and also examine if the surgeon's visual acuity at near work can be improved with better glasses. Thirty percent of the surgeons had eyestrain, and those with eyestrain had three times as much musculoskeletal strain. The measurements of the illuminance and luminance show a low uniformity level on the operating table; the operating lamps give an average of 100.000 lux, while the surrounding area values are much lower. The most important recommendation for lighting intervention in the operating theatre is a more uniform illuminance on the operating table.

INTRODUCTION

A good visual environment is important for performance and wellbeing. Unsatisfactory visual conditions often induce a strained posture, more or less unconsciously, in an effort to improve vision: "The eyes lead the body" (Anshel et al., 2005). Increased tonus in neck and shoulder muscles without altered body postures has also recently been reported as the result of defective visual conditions (Wiholm et al., 2007). The frequency of musculoskeletal pain among persons with incorrect lenses in their glasses is higher than among those with correct lenses. Improved visual performance is often achieved with correct glasses, optimised illuminance and no glare. Incorrect glasses can enhance the musculoskeletal strain and decrease productivity at work. A single vision lens or a work progressive lens is better for working with a VDT (visual display terminals) than a regular progressive lens (Horgen, 2003). Individuals with eyestrain also report musculoskeletal complaints to a higher degree (Knave et al., 1985). Studies show that an optic correction for near distance work affects the accommodation and vergence which reduce muscle activity in the head, neck, and shoulder region (Lie & Watten, 1994; Wiholm et al., 2007). Thus, a pair of working glasses that are adjusted for correct working posture and distances can reduce muscle strain. There are also differences in eyestrain within a working day. It usually increases during the day when the same type of work is performed (Boyce, 2006). Approximately 75-90 % of people who work in front of a VDT have eyestrain (Anshel, 2005); among postmen that amount is about 40 % (Hemphälä, 2008).

Visual fatigue can be multifactorial, induced and/or supported by psychological factors, as well as the intensity and duration of the visual strain, the perceived situation and the physiopathological characteristics of the individual visual apparatus (Piccoli et al., 2003). An increase in illuminance within relevant ranges will often result in improved visual performance. According to Veitch (2001) it is

desirable to have a uniform illuminance over the working area but a non-uniform illuminance in the surrounding areas, but not causing glare. Glare can lower productivity according to a study by Horgen et al. (2007). Luminance contrast that is too high will cause visual fatigue due to continuous readaptation of the eyes, and luminance contrasts that are too low result in a dull and non-stimulating working environment (CIE, 2002). To high luminance will give glare. Luminance within the normal field of view should not exceed 1000 cd/m² (Nutek, 1994).

Boyce (2006) found correlations between productivity and eye fatigue. To enhance productivity and wellbeing, and to reduce eyestrain, the visual environment has to be considered by providing good lighting conditions and good visibility of the tasks (Boyce, 2003). Illuminance is one way to influence productivity that might have an underlying cause in improved visual performance or psycho-biological effects (Juslén, 2007).

There are standardised recommendations for the illuminance in operating theatres, 1000 lux for the general lighting and 10.000 to 100.000 lux from the operating lamp in the operating cavity (CIE, 2002). This may cause another problem with glare when the luminance from the operating cavity becomes too high. Surgery requires a high level of intellectual preparation, an efficient and controlled workspace, fine motor skills, physical endurance, problem-solving skills, and emergency response skills (Berguer, 1999). The requirements for the visual environment in a surgery room are high. Surgeons or assistants who are having any visual problems can make serious treatment mistakes. Surgeons often use headlamps to enhance the illuminance in the visual field. This causes problems for the surgeons with increased risk for musculoskeletal strain and a deteriorated visual situation for the assistants and scrub nurses when the surgeons move their heads. The VDT's or displays, and in some circumstances the keyboard, can suffer from reflections causing disability and discomfort glare. It is therefore necessary to select, locate and manage the luminaries to avoid disturbing high brightness reflections (CIE, 2002). In Sweden there are recommendations that the amount of illuminance hitting the VDT's or displays should not exceed 200 lux (Nutek, 1994) otherwise the contrast on the screen decreases and makes it harder to see.

There have been studies on laparoscopic surgery evaluating and comparing neck posture in relation to monitor position in a dedicated minimally invasive surgery (MIS) suite and a conventional operating room (Det et al., 2008). Complaints concerning the neck and back can be caused by an uncomfortable and static posture in relation to the position of the monitor. In one study, 89 % of the MIS surgeons reported musculoskeletal strain (Wauben et al., 2006). Studies examining the most comfortable posture advise a viewing direction straight ahead and at a slightly downward angle (Zehetner et al., 2006; Helland et al., 2008). Ergonomic interventions can reduce the strain on the body (Aarås et al., 1998; 2001). Ergonomic solutions minimising ergonomic risks associated with laparoscopic assistance should be considered (Lee et al., 2009a). A new type of operation lamp is being developed for MIS with a Light Emitting Diods (LED) light source. The most common type of lamps used – arc-lamps – become very warm, a problem that does not exist with LED lamps, making them easier to use (Lee et al., 2009b).

The purpose of this study was to evaluate the visual environment in operating theatres, and also examine if the surgeon's visual acuity at near work can be improved with better lighting and better glasses. The first step was to formulate recommendations for the lighting levels in a operation room to improve the visual environment starting with an evaluation of the present levels of both illuminance and luminance. The second step was visual examinations of all the surgeons to see if their glasses were sufficient for their work and, if possible, to find more suitable lenses such as work progressive lenses.

MATERIALS AND METHODS

Twenty surgeons participated in the study, seven females and 13 males. They were between 32 and 66 years of age, with an average of 49.

A questionnaire on eyestrain, musculoskeletal strain, together with an assessment of lighting developed by Knave et al. (1985) were administered. The questionnaire was modified to

match the surgeons' work. The questionnaire made it possible to evaluate the visual working environment subjectively together with the problems and discomfort perceived by the participant regarding their eyes, headaches, and musculoskeletal strain. The questionnaire has been used in other studies mainly in Sweden, see for example Hemphälä (2008) and Håkansson (2007).

Eyestrain is, according to Knave et al. (1985), a syndrome that covers eight different symptoms: smarting, itching, gritty feeling, aches, sensitivity to light, redness, teariness, and dryness. Work-related eyestrain was defined as the reporting of three symptom or more. Eyestrain values for each symptom is calculated by multiplying, the degree of occurrence by the degree of difficulty (maximum 3 x 3= 9 points, see Figure 1).

			Occurrence				**Difficulty**		
			few times	every weekday	every day		negligible	slight	pronounced
	Yes	**No**							
			(1)	(2)	(3)	x	(1)	(2)	(3)
Smarting	O	O	O	O	O		O	O	O
Itching	O	O	O	O	O		O	O	O
Gritty feeling	O	O	O	O	O		O	O	O
Aching	O	O	O	O	O		O	O	O
Sensitivity to light	O	O	O	O	O		O	O	O
Redness	O	O	O	O	O		O	O	O
Teariness	O	O	O	O	O		O	O	O
Dryness	O	O	O	O	O		O	O	O
Eye fatigue	O	O	O	O	O		O	O	O
Headache	O	O	O	O	O		O	O	O

Figure 1. Calculation of eyestrain.

The sum of the values for the eight symptoms is the participant's eyestrain value. This value has its maximum at (9 x 8 symptoms) 72 points, showing the ratio of the participant's experience of eyestrain. An eyestrain index is defined as the average value for the participants in the study, also including those who experience no strain. In this way, different groups of workers could easily be compared. Eye fatigue and headaches are other workplace related problems but were not included in the eyestrain index (see Knave et al., 1985).

A similar index was calculated for the different musculoskeletal symptoms (MSD) from the upper body. In this index the parts of the body included were divided into right and left: hand, lower arm, elbow, upper arm, shoulder, neck, and back, a total of 14 parts, with a maximum of 126 points (9 x 14).

Eye examinations were performed on the surgeons to check their visual acuity and the status on their habitual glasses.

The illuminance and luminance of all of the operating theatres included in this study were measured. The equipment used was a Hagner Universal Photometer S2. The operating theatres were also photographed.

RESULTS

According to the results from the questionnaires, the eyestrain index for the entire group was 2.8, and 6 out of 20 (30 %) had an eyestrain value of ≥3. Dryness was the most common eyestrain. The individuals with eyestrain had more than three times as much musculoskeletal strain compared to those without eyestrain. Strain from the right shoulder was particularly overrepresented among those with eyestrain.

Most of the surgeons think that it is important to improve the lighting in the operating theatres. The surgeons rate the overall assessment of the general lighting between fairly bad and acceptable. The rating of the lighting is lower among individuals with eyestrain. There are small differences between the sexes: the females have more eyestrain and headaches, but less musculoskeletal strain.

The hospital at which this study was performed had 14 operating theatres with four different types of operating lamps. Each operating table usually had two operating lamps, placed at two angles; the values presented are the total amounts. The measurements of the illuminance show a low uniformity level on the operating table, there was an average of 100.000 lux in the centre of the beam of light, while the surrounding areas have an average of 7000 lux, just 20 cm outside of the centre. The average diameter at the centre of the beam of light is 15 cm. The average luminance from a white paper on the operating table was 30.000 cd/m² in the centre and 3300 in the surrounding areas. The general lighting in the operating theatres had an average between 500 – 1000 lux and the luminances were between 200 – 350 cd/m². Eleven of 20 surgeons use headlamps while performing surgery sometimes or always, depending on the type of surgery. The headlamp is attached by wires to a trolley and via that plugged into the wall. The headlamp weighs about 0.3 kg. All of the TVs and displays used in the operating theatres had too much illuminance up close to the screen, an average of 500 lux.

The eye examinations show that all of the surgeons have good visual acuity at near distance, good colour and stereo vision. A few of the presbyopic surgeons had functional working glasses, but most of them did not have any specific glasses while working. Some of the surgeons complained about being in static positions while in surgery, due to insufficient optic design in their glasses.

DISCUSSION

The percentage of individuals with eyestrain in this group is fairly low, compared to other occupations. On the other hand the requirements for good visual environments for surgeons are huge. If they make mistakes it can be disastrous. The individuals with eyestrain had more than three times as much musculoskeletal strain compared to the individuals without eyestrain. The eye leads the body – so if their glasses are not sufficient for the working posture they have to adapt their body and especially their head and neck in order to see clearly. The most common musculoskeletal strain was from the right shoulder, and most of them were right handed. Working as they do at times for many hours in a static position can explain this type of strain, but strain can also be increased by having the wrong type of lenses. A pair of work progressive lenses may ease the strain on their bodies. In the next part of the study this factor will be examined more closely.

Many of the surgeons complained about the lighting in the operating theatres. Some of the operating lamps gave too much illuminance which resulted in glare and made it harder to see; others gave too little illuminance. Compared to lighting recommendations for other working groups the level of illuminance was much higher at the operating table. How much illuminance is really needed? That depends on the amount of illuminance in the entire room as well. The lighting recommendations do not take into consideration the risk of glare from the high luminance in the operating cavity.

The operating lamps are heavy and difficult to move making it hard to find the correct focus, especially for non-invasive surgery. This is one of the reasons why so many of the surgeons use headlamps: the light is exactly where they want it and it improves the depth of field. But the

downside is that it adds to a static head position and when they look up the light hits the surrounding people giving them glare. If there are two or more professionals involved in the surgery it also makes it harder when the surgeon with the headlamp looks up – the operation cavity suddenly becomes darker and harder to see clearly. The other big complaint about the operating lamps is that the gradient from the beam of light is bad; if the operation cavity is larger than 15 cm the edges becomes darker. The luminance contrast between the centre and the surrounding areas under the operating lamps was bad with some operating lamps. One had 40 % of the luminance in the surrounding areas compared to the centre, but other lamps only had 3 %. This makes it so much harder for the surgeons to see clearly.

CONCLUSION

These results show that the visual environment in operating theatres can be improved. This may enhance the surgeons' productivity and reduce strain with secondary positive effects on patient safety. A pair of work progressive lenses is probably needed for the presbyopic surgeons. In the next part of the study the importance of work progressive lenses will be examined. The lighting in the operating theatres would benefit from a more uniform illuminance under the operating lamps. A third, smaller, easier manoeuvred, operating lamp could be developed instead of the headlamps. The luminance within the visual field is important to considerate, because of the worsened effect on the visual acuity in the operating cavity. To improve the visibility of the VDT's or displays, some sort of cap can be placed on top of the screens to shadow the displays.

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